SA CROP TECHNOLOGY CENTRE

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Hyper Yielding Crops (HYC) and Pulse Agronomy Field Day

28th October 2021

FAR Australia SA Crop Technology Centre, Millicent SA

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

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

SOWING THE SEED FOR A BRIGHTER FUTURE

VISITOR INFORMATION

We trust that you will enjoy your day with us at our SA 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 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:

- 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 SA 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 SA 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 SA we are working closely with regional partner Mackillop Farm Management Group.

The GRDC's Pulse Agronomy project in SA is led by SARDI in collaboration with FAR Australia and Mackillop Farm Management Group.

Today you will have an opportunity to discuss the following:

PULSES (9.30am)
Dr Nigel Wilhelm, Senior Scientist, Agronomy Group, SARDI, Waite Campus
Understanding nutritional constraints on highly calcareous soils and managing them to achieve high performance pulses.

CANOLA (11am)
Andrew Ware, Director, EPAG Research Trust
What are the key management levers for a high yielding canola crop?

CEREALS (1.30pm)
Speakers include Terry Horan and Quenten Knight (keynote speakers); Nick Poole and Max Bloomfield, FAR Australia; Jen Lillecrapp, HYC Project Officer MFMG.
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 with our two key note speakers.

- 12t/ha plus – pipe dream or practical possibility.
- What are the practical steps at the farm level to achieve higher yields Genotype x Environment x Management (G.E.M) trial - What level of management maximised margins in crops yielding 7 – 11t/ha?

GRDC GROWER FORUM:
Randall Wilksch and Tom Blake, GRDC
Update on GRDC investments and review of opportunities for local research, development and extension.

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 Brett and Mel Gilbertson for all their support throughout the season. Finally thank you to Seedforce for sponsoring today's lunch.

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

Hyper Yielding Crops

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

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

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

HYC project officers in each state 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)
Jen Lillecrapp, SA HYC Project Officer, Mackillop Farm Management Group, (jen@brackenlea.com)

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.

The focus this season at the Millicent CTC is autumn sown Broad and Faba beans, the former being the most dominant pulse in the lower SE region. We are also looking at spring sown chickpeas and lentils at this site. Can we boost the yield potential of these legumes. For example, with 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)
Kat Fuhrmann – Senior Field Research Officer, FAR Australia (kat.fuhrmann@far Australia.com.au)
Max Bloomfield – Field Trials Officer, FAR Australia (max.bloomfield@faraustralia.com.au)

SA CROP TECHNOLOGY CENTRE

TIMETABLE

SA CROP TECHNOLOGY CENTRE FIELD DAY: THURSDAY 28 OCTOBER 2021

Featuring the GRDC's Hyper Yielding Crops (HYC) and Pulse Agronomy projects

In-field presentations	Research site	9.30	11.00
Dr Nigel Willhelm, Senior Scientist, Agronomy Group, SARDI *Understanding nutritional constraints on highly calcareous soils and managing them to achieve high performance pulses.*	Pulses	All	
Andrew Ware, Director, EPAG Research Trust *What are the key management levers for a high yielding canola crop?*	Canola		All

In-field presentations	Cereals Station No.	12.30	1.15	1:30	2:00	2:30	3:00	3:30	4:00
Terry Horan, Senior Agronomist, Tasmanian HRZ and Irrigated Regions *What are the on farm and in field practicalities of achieving cereal yields in excess of 10t/ha?*	1	Lunch kindly sponsored by Seed Force	Welcome and opening address, John Bennett, GRDC Southern Panel Chair and Nick Poole, Managing Director FAR Australia	1		2			Closing address and refreshments Seed Force
Nick Poole and Max Bloomfield FAR Australia *12t/ha plus – pipe dream or practical possibility? What are the practical steps at the farm level to achieve higher yields Genotype x Environment x Management (G.E.M) trial - What level of management maximised margins in crops yielding 7 – 11t/ha?*	2				1		2		
Jen Lillecrapp, HYC Project Officer (SA), MFMG *Hyper Yielding Crops: Capturing yield potential through innovation and benchmarking.*	3					1		2	
Quenten Knight, Agronomy and Precision Ag Consultant (WA) *Role of precision ag, improved agronomy and soil amelioration in underpinning greater cropping productivity and profitability?*	4			2			1		
Randall Wilksch and Tom Blake, GRDC *Update on GRDC investments and review of opportunities for local research, development and extension.*	5				2			1	
In-field presentations	**Station No.**	**12.30**	**1.15**	**1:30**	**2:00**	**2:30**	**3:00**	**3:30**	**4:00**

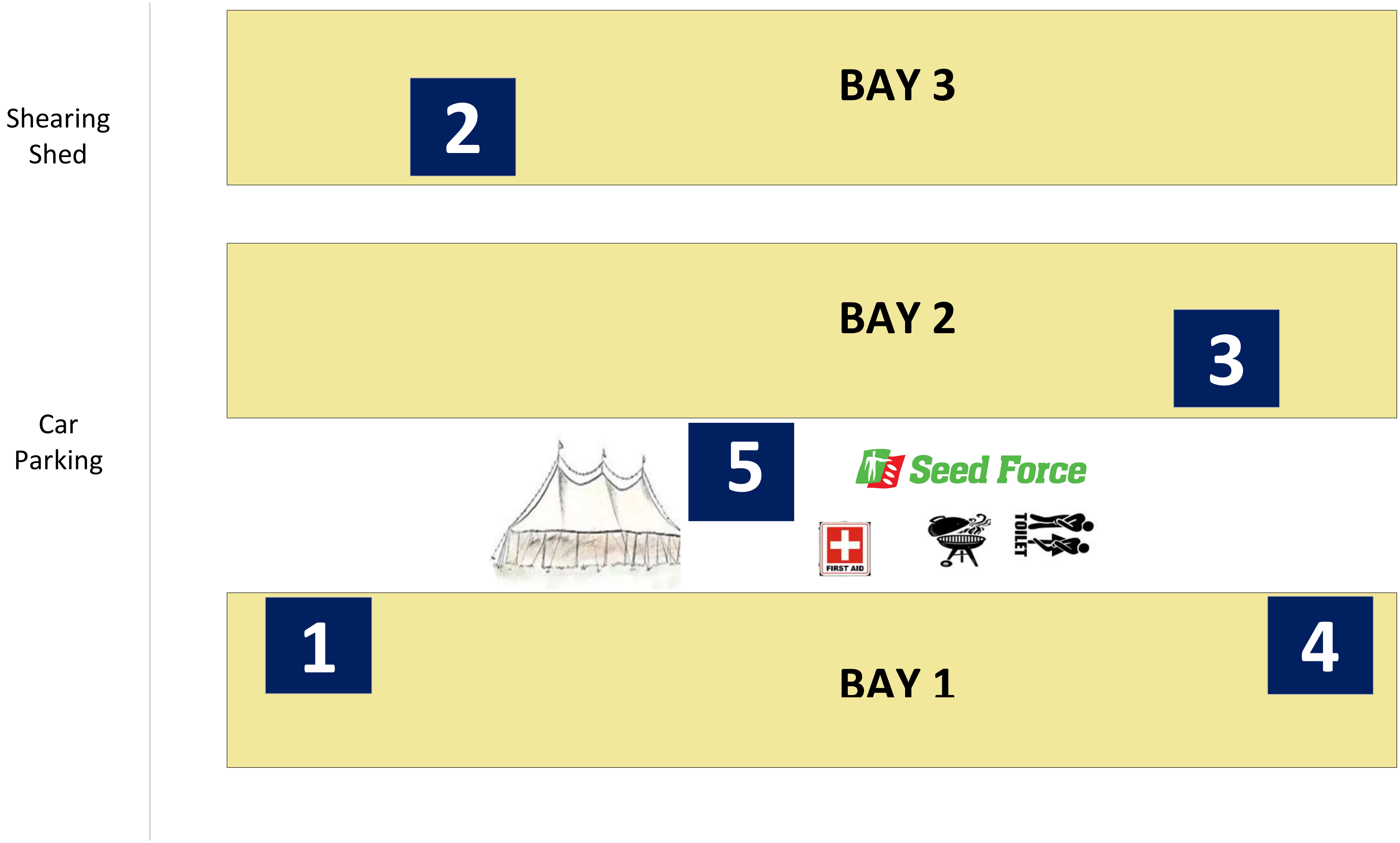
We would be obliged if you could remain within your designated group number throughout the day.
Thank you for your cooperation.

1	GROUP 1
2	GROUP 2

SA CROP TECHNOLOGY CENTRE

SITE MAP: SA CROP TECHNOLOGY CENTRE

Featuring the GRDC's Hyper Yielding Crops project



Understanding nutritional constraints on highly calcareous soils and managing them to achieve high performance pulses

Dr Nigel Wilhelm, Senior Scientist, Agronomy Group, SARDI, Waite Campus.

Dr Nigel Wilhelm has been a research agronomist for over 35 years in South Australia, specialising in crop nutrition and fertiliser management. Dr Wilhelm has a particular interest in trace element nutrition and has been involved in a number of research projects over his career investigating trace element deficiencies and approaches to managing them in broad-acre crops. Currently, he leads a large project investigating poor crop performance on highly calcareous soils on the upper Eyre Peninsula and in the South-East. He is the holder of a GRDC Seed of Light award for communication to the industry.

The South-East region has a rich heritage in trace element disorders which continues to this day. In the early 20th century, the first ever recording of a trace element deficiency in the world was confirmed near Penola. This was manganese (Mn) deficiency in oats, exacerbated by limestone blowing in from the nearby road.

In the middle of the 20th century, CSIRO led pioneering work into livestock nutrition in the South-East which resulted in the development of copper (Cu), cobalt and selenium bullets to prevent those deficiencies in livestock.

Despite this pioneering work nearly one century ago, trace element deficiencies continue to be a production constraint for crops in many situations in the South-East. These problems include:

- Mn and Cu deficiencies on deep infertile sands and highly calcareous soils.
- Iron (Fe) deficiency on highly calcareous soils.
- Zinc (Zn) deficiency on a range of soils.
- Molybdenum deficiency on acid sands.

While many strategies have been developed to not only detect trace element deficiencies but also to manage them, trace element deficiencies continue to be a production constraint for many broad-acre crops in the South-East. In recognition of that, the Cooperative Research Centre for High Performance Soils and GRDC have commissioned an initiative to investigate and hopefully solve some of these problems. This initiative involves teams of researchers from PIRSA, CSIRO and NSW DPI with expertise in soils, agronomy and crop nutrition and is investigating issues with poorly performing crops on highly calcareous soils of the upper Eyre Peninsula and in the South-East.

This year, the initiative is investigating poor performance of broad beans on the highly calcareous dark clays in the Robe/Conmurra district. A field trial is being conducted with Aquadulce broad beans at Lake Hawdon with a wide range of strategies to overcome Mn and Fe deficiencies in the crop. The logic behind these strategies was to apply Mn and Fe to the crop early in its development to avoid the deficiencies developing. A range of seed dressings, applications at seeding and foliar sprays were implemented. While the yellowing and poor vigour typical for beans on this soil type developed during winter in the trial, none of the strategies implemented appear to be correcting those problems.

The option of using fluid fertilisers at seeding as an improved approach to managing phosphorus (P) deficiency is also being investigated. Fluid P fertilisers are substantially more effective than granular products on highly calcareous soils on upper Eyre Peninsula and have shown merit on the highly calcareous soils of the South-East as well.

Investigations are continuing into soil properties and novel management approaches which might improve the availability of nutrients in these soil types and make management of them more effective. These activities include monitoring of the tools used routinely for managing nutrient supply to crops for their relevance to South-East environments, namely soil and plant testing.

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. We are excited to present to you a new Pulse spoke site at Millicent in 2021.

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.

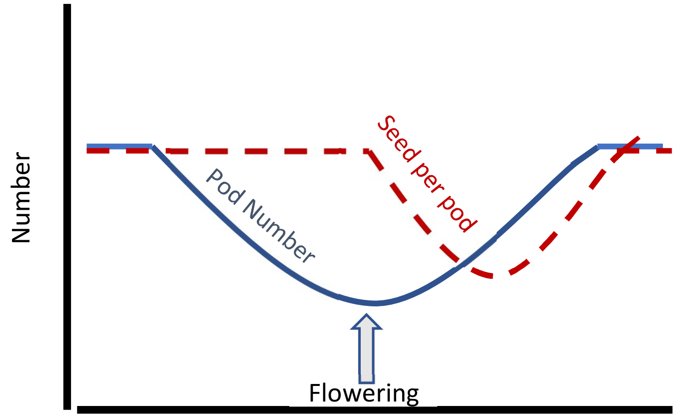


Figure 1. *Effect on the timing of stress on (a) pod number and (b) seed per pod adapted image and based on shading experiments conducted and published by Lake et al 2019.*

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.

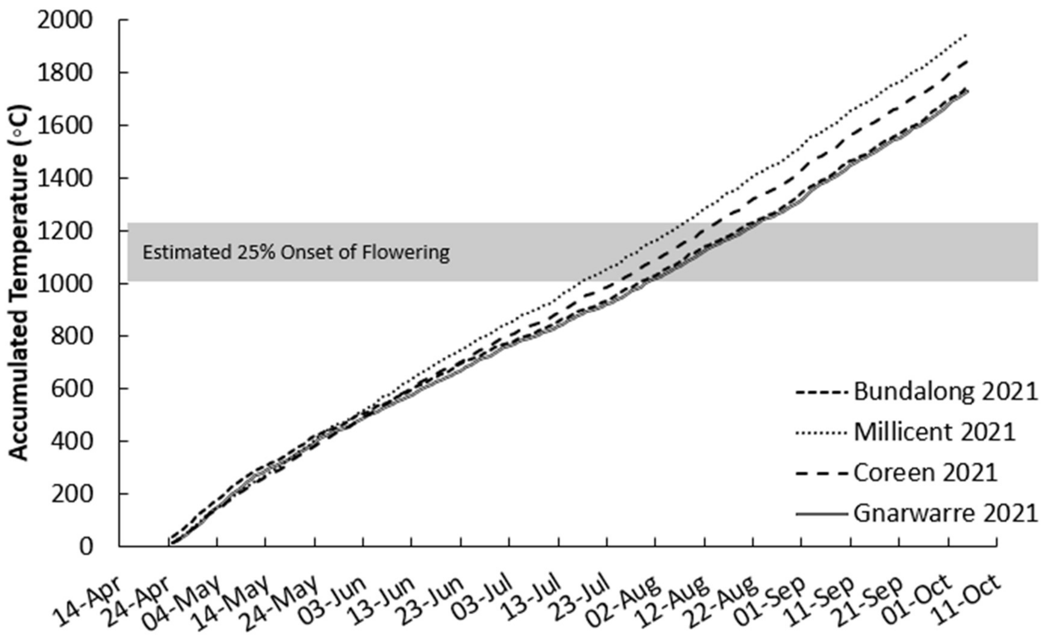


Figure 2. *Differences in accumulated temperature (growing degree days) from 25 April emergence across legume sites in 2021 at Bundalong NE Vic, Gnarwarre SW Vic, Coreen NSW, Millicent SA*

FAR Australia Millicent Grain Legume Spoke Site 2021

Site Focus:

1. Disease Management in Faba Beans
2. Nutrition and N Fixation in Faba Beans and benchmarking Cf. Broad beans
3. Spring sown chickpeas and Lentils

Current Pulse situation: Pulse crop adoption has generally been either Faba beans, or broad beans in this region. While there are some longer term legume pastures. The region can successfully grow Faba beans and the main production constraint is disease. This spoke site aims primarily to address disease management in Faba beans. However, there is a trend towards higher values crops including spring sown chickpeas and autumn sown broad beans. Growers choose to grow broad beans due to adaptation to acid soils, water logging, and market opportunities. Local growers have expressed desires to investigate different trace element formulations in pulses. This presents an opportunity to benchmark broad beans with Faba Beans for the HRZ.

Our Objectives:

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.

Maximise Faba bean productivity and benchmark Faba bean production (Biomass and N fixation) with other higher value crops such as Broad beans and spring sown chickpeas.

2021 Proposed approach and rationale:

Trial 1. Disease trial:

Fungicide treatments will be aimed at critical growth stages and protecting key segments of the canopy from a physiology perspective. This information will be used to enhance best practice guidelines for disease management in accordance with current AFREN principles and label recommendations.

Trial 2. SA Broad bean vs Faba bean nutrition:

Compare the relative yields of faba bean and broad bean and the impact of crop nutrition prior to the onset of flowering.

Trial 2. Spring sown Chickpeas and Lentils

Benchmark the yield performance of higher value grain legume crops sown in spring at Millicent as alternatives to Autumn sown beans

Please help us address your constraints for Grain Legumes.

We are thrilled to be a part of a new GRDC project which aims to provide growers with locally relevant information to improve the profitability and farming system benefits of grain legume crops in South Australia. FAR Australia has established a Spoke Site at Millicent.

Development and extension to close the economic yield gap and maximise farming systems benefits from grain legume production in South Australia

This project is funded by the Grains Research and Development Corporation (GRDC). A component of this project is to undertake monitoring and evaluation so that we can clearly identify growers' issues and constraints to grain legume production. This information will be used to ensure that local project activities are targeted to address local priorities. Please take the time to help us with the following survey by using the QR code below or via the link https://www.surveymonkey.com/r/PulsEv21

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

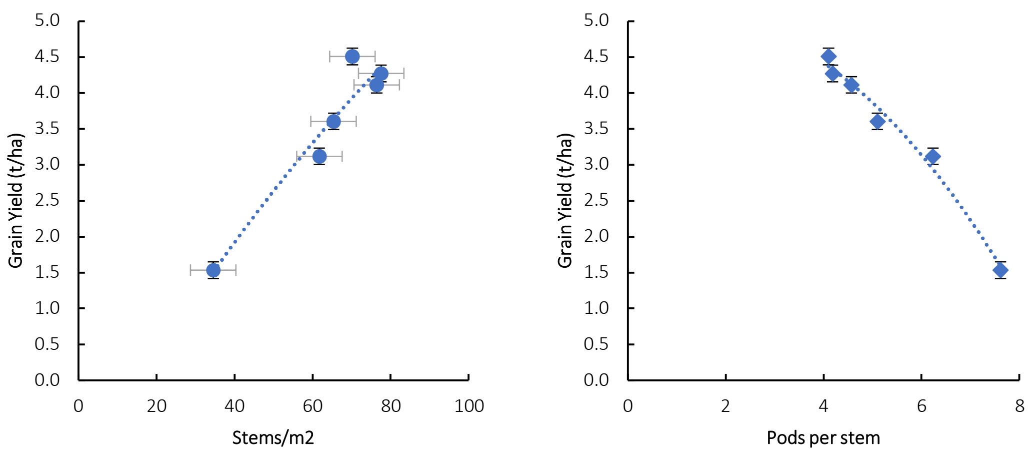


Figure 3. *The relationship between the number of stems per metre square, and the number of pods per stem with grain yield (t/ha) average across all cultivars at Dookie in 2020.*

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.

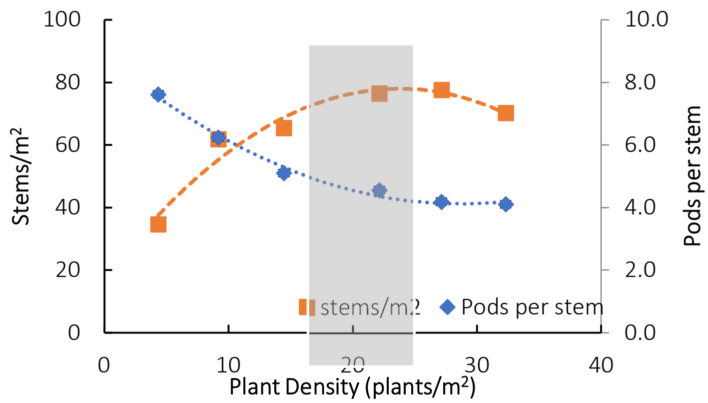


Figure 4. *The relationship between plant density and the number of stems per metre square, and the number of pods per stem averaged across all cultivars at Dookie in 2020. The shaded area represents the sweet spot between maximum stem number and pods per stem required to achieve 4t/ha.*

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.

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).

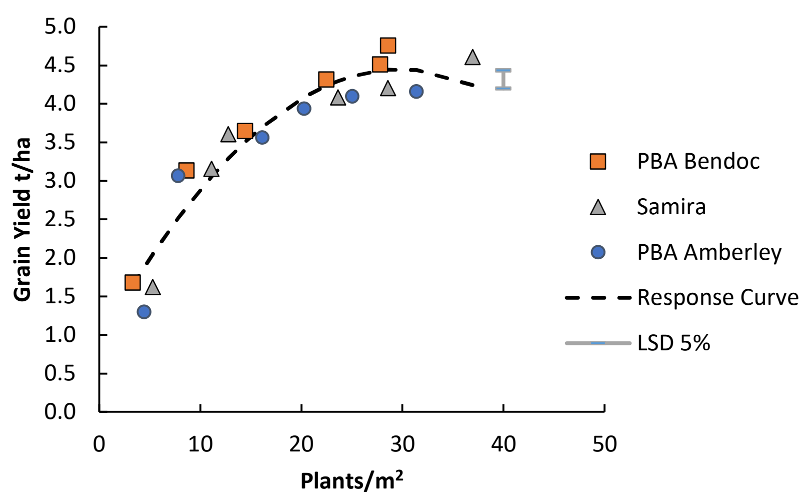


Figure 5. *Relationship between plant density (established plants/m2) and grain yield in three cultivars PBA Bendoc, PBA Amberley, Samira in 2020 at Dookie.*

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

Hyper Yielding Canola – results from 2020 and research going forward

Rohan Brill, Agronomist – Brill Ag

Key Points

- Where a high level of input was applied in Millicent G*E*M trial, the best winter, Phoenix CL yielded 4.5 t/ha and the best spring canola, 45Y93 CL, yielded 4.3 t/ha.
- The growth and development of Phoenix CL and 45Y93 CL were very different, but final yield was similar.
- In 2020, variety choice was the most important factor affecting yield at Wallendbeen NSW, Gnarwarre Victoria and Millicent SA.
- Applied nutrition was the second most important factor, but trials were sown on fertile soil with high mineralisation potential, and with favourable spring conditions, the soil supplied a large portion of the grain yield.
- Fungicide management and seeding rate had small effects on yield outcomes in 2020.

Yield targets and yields achieved in 2020

The aim of the canola component of the Hyper Yielding Crops project is to determine management practices that achieve 5 t/ha canola grain yield in high yield potential environments. 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 at all sites. 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.

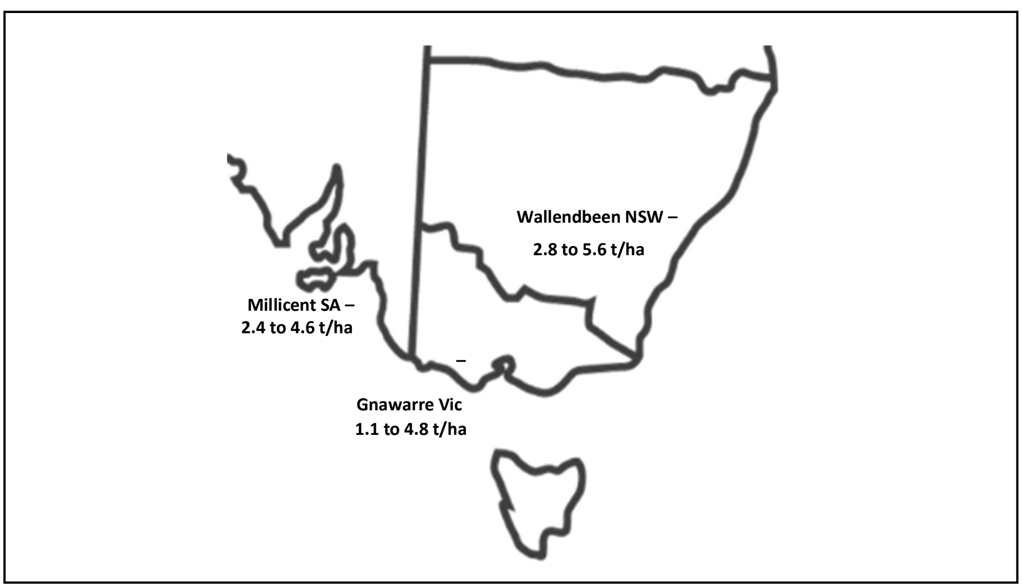


Figure 1. *Yield of the highest and lowest yielding treatments at three Hyperyielding canola sites in 2020.*

Winter versus spring canola at Millicent

At Millicent in 2020 in the canola G*E*M trial, Phoenix CL and 45Y93 CL had grain yield of 4.5 and 4.27 t/ha respectively (Table 1) but achieved these grain yields in vastly different ways.

Table 1. *Grain yield of nine canola cultivars sown with a low and high input management system at Millicent, 2020.*

	Management Level					
	Low input		High input		Mean	
Cultivar	Yield t/ha		Yield t/ha		Yield t/ha	
Hyola 970CL (Winter)	3.64	-	4.08	-	**3.86**	**ab**
SF Nizza CL (Winter)	3.66	-	4.23	-	**3.95**	**ab**
Phoenix CL (Winter)	4.00	-	4.50	-	**4.25**	**a**
SF Ignite (Spring)	3.14	-	3.08	-	**3.11**	**c**
HyTTec Trifecta (Spring)	3.55	-	3.57	-	**3.56**	**b**
ATR Wahoo (Spring)	2.64	-	3.04	-	**2.84**	**cd**
45Y93CL (Spring)	4.01	-	4.27	-	**4.14**	**a**
Diamond (Spring)	2.58	-	2.50	-	**2.54**	**d**
44Y90CL (Spring)	3.79	-	3.94	-	**3.86**	**ab**
Mean	**3.69**	**-**	**3.45**	**-**	**3.57**	
LSD Cultivar p = 0.05	0.42		**P val**		<0.001	
LSD Management p=0.05	0.28		**P val**		0.073	
LSD Cultivar x Man. P=0.05	0.59		**P val**		0.687	

Winter cultivars flowered in late September to early October, whereas mid-season spring cultivars such as 45Y93 CL flowered in late August. Phoenix CL had grown 6.5 t/ha biomass by the start of flowering, which is enough to capture all available light for the ensuing critical reproductive period. 45Y93 CL had only grown 3.5 t/ha biomass at the start of flowering, lower than what is required (5 t/ha) to achieve full capture of light during the critical reproductive period (see figure 2). Although Millicent in winter seems cold, it is relatively mild compared to most dryland cropping environments in southern Australia as there are relatively high night-time temperatures. Combined with cloudy days/low light in winter, spring canola reaches flowering without enough biomass to fully capture radiation during the crop critical period (approximately 1 to 4 weeks after the start of flowering).

By the time these plots were harvested at maturity, Phoenix CL had grown 14.3 t/ha biomass compared with 11.3 t/ha for 45Y93 CL. 45Y93 CL had a better conversion of biomass into grain yield but was effectively biomass-limited compared with Phoenix CL (see figure 2). Future trials in the Hyper Yielding Crops project will seek to determine management factors that will either:

1. Increase growth both pre- and post-flowering in the spring canola hybrids such as 45Y93 CL, while maintaining a high conversion of biomass into grain.
2. Increase the conversion of biomass into grain in winter canola and ideally reduce crop height to improve harvestability.

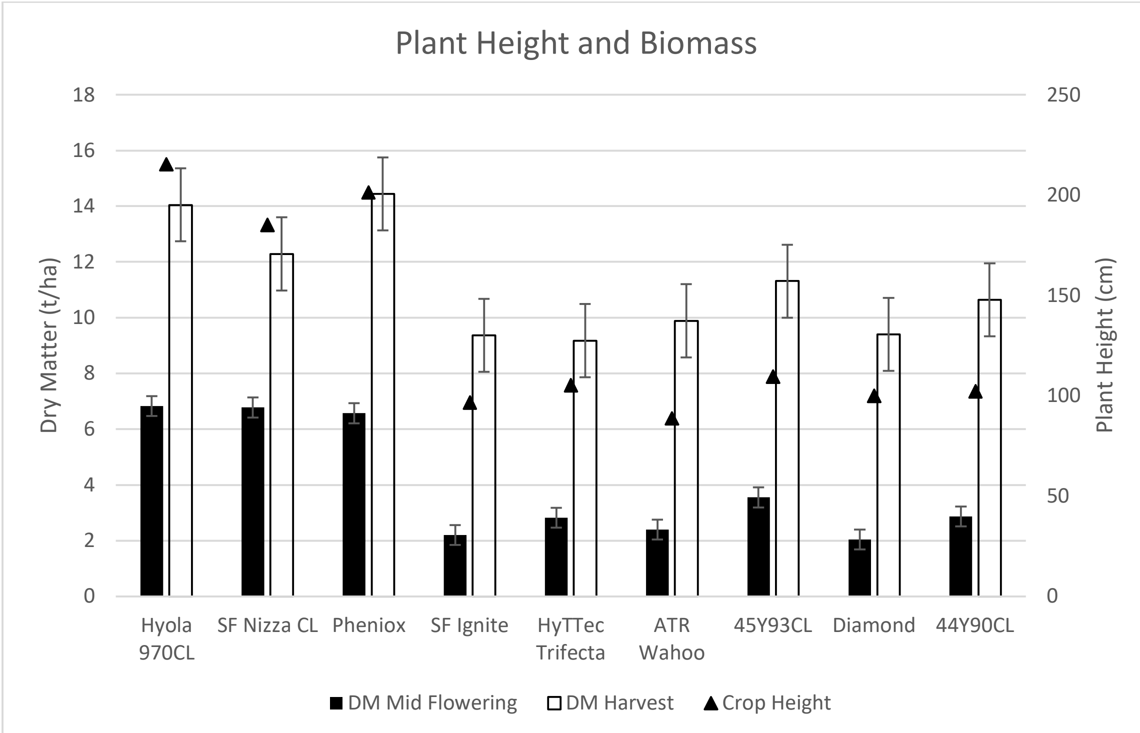


Figure 2. Flowering biomass, maturity biomass and crop height of 9 canola varieties in the GEM trial at Millicent in 2020.

Porker et al. 2021 report that the optimum flowering date for canola is ~15 September. Identifying varieties that come close to the target is an aspirational goal of the project as generally May sown spring hybrids flower too early, and winter hybrids are generally later.

The introduction of GM canola into South Australia will be a step up for most growers, as they have to date been the highest yielding group of spring hybrids in Hyperyielding Crops project activities in NSW and Victoria.

Hyper Yielding 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.

What are the on farm and in field practicalities of achieving cereal yields higher than your long-term average and even better than the best crop you have grown in your farming lifetime?

*Terry Horan: 40 years professional agronomy experience, working with mixed farming and supply business' in the MRZ & HRZ/Irrigation Regions. Having had 20 years in SNSW & 20 years in Tas*mania.

Some thoughts:
Firstly, you must be farming in an environment where natural rainfall and or supplementary irrigation can theoretically & realistically realise cereal yields of 10t/ha and above, fortunately Millicent and some other areas in SA are capable.

Secondly you must have the passion, desire, flexibility and budgeting comfort to want to achieve well above average district yields and even beat personal or competition records.

Question - Is chasing hyper yielding cereal crops a financially prudent risk v's return, compared to your budgeted "Sweet Spot" year in, year out? I think it is, based on FAR Australia's HYC results and grower experiences.

Ideally you have surrounded yourself with high quality positive people (employees, contractors, agronomists, researchers, farming systems groups, marketers, financiers, peers and many more). This is important, and so is having astute and respected anchors.

As I've predominantly worked in mixed farming, livestock & cropping operations I do appreciate the delicate balance between decisions that affect the positive and negative outcomes for each enterprise. But timing & timeliness is everything in achieving high yielding crops. The livestock manager and cropping manager must work very closely together and at times may need arbitration, or if you're both, create internal turmoil.

Flexibility, empathy and understanding is needed. This season both enterprises are big hitters, so robbing Peter to pay Paul may be a win win.

It's not easy growing very high yielding cereals in a high rainfall/irrigation/ livestock operation but it can be very successful, and in the long-term, sustainable. I personally think this is the most sustainable farming system in Australia, but I may be biased.

Growing Wheat & Barley at 10t/ha and above.
No matter what your break-even point is, everything above break-even relies not only on nature but astute planning and implementation of the plan. Again timing is everything, but flexibility to reset & go again is required.

Tick off list:
Cropping in a HRZ/Irrigation system with livestock enterprises normally means more complicated systems, with weeds, diseases & pests all seemingly on steroids. Try to have an annual soil, weed, crop, sampling plan to know what's happening on your farm now and in the coming seasons.

Pre crop

- Soil test for diseases (Take All, Rhizoctonia, Fusarium, Eyespot) and plant/seed testing weeds for herbicide resistance status, especially ryegrass, and crop leaf/straw sampling for fungicide resistance status. All necessary for a roadmap to success. Or have trials and visiting research groups on your farm and let research answer your questions.
- Soil testing for nutrients & amelioration - applied as necessary, with reaction times achieved in advance (lime, gypsum, base fertility, ripping, reefinating, delving, raised beds etc). Have a strong understanding of soil constraints and answers if possible.
- Drainage - completed and working effectively. Do everything you can to even paddocks up. Critical for livestock and soil compaction, paddock trafficking, slug pressure, weedy patches. Wet areas end up slug havens and full of weeds. Your paddock average plummets. To grow a cereal of 10t/ha and above the paddock will need a lot of passes. Your AB lines will get a real workout so you must be able to traffic the paddock right through the growing period.
- Rotation. Get disease and weed risk down and fertility up. Cereals following a break crop, legumes are best (especially at high N fert prices) but any broadleaf crop is good eg, Canola, Carrot Seed, Poppies, Potatoes, specialist seed crops etc.
- Varietal Selection. Proven performers and new releases. Marketing seems to influence variety as much as genetics, unless of course you release Planet Barley and then the market has no choice but to make it malt locally.
- If possible once you pin down your market options choose the best genetics for yield & maturity matched to your sowing/harvest window, disease resistance, straw strength and harvestability. This is very difficult for HRZ growers as the majority of the focus for cereal breeding in Australia is targeted at the LRZ and MRZ. The HRZ growers have had to rely largely on seed companies bringing in already established lines from largely Europe and the UK. Planet and Accroc being great examples. The HYC project has been a major vehicle for grower and advisor confidence in adopting these direct imports.
- Do germination and 1000 grain weights on seed to determine desired seeding rate.
- Have all inputs budgeted and approx time required planned and communicated and if favourable, terms locked away or set aside. Before you get to planting the information you have gained and the budgeting done will establish the majority of all inputs to grow your target yield. If you have irrigation this needs budgeting as well. All good plans need refinement on the go once the crops underway.

Strategies for high yield crops:
Sowing Time: has the greatest influence for both wheat and barley for planting densities & physiological maturity. Sowing time directly affects in crop strategies for:

- Weed pressure and control with herbicides, disease pressure and fungicides, growth regulators and timing, WUE, irrigation requirements and harvest schedules.
- Main sowing times Tas: Grazing/Grain planted Feb, March.
- Grain only crops are planted, April, May, June.
- Spring wheat and Barley planted Aug to end Sept.
- Variety selection. Tas. Grazing/Grain: Manning the main variety. It has broken down to leaf rust, septoria tritici and powdery mildew, but BYDV protection still holding up. Our best growers are getting 100 to 120 days grazing and then grain yields of 8-12t/ha. Irrigation necessary to get 10t/ha and above. Approx 1-2meg supplemented on a 500mm av annual rainfall.
- Grain only main season varieties. Accroc, Calabro, Bennett, Trojan, Rockstar & Anapurna.
- Barley: Main variety is Planet. Sown from April to September.
- Agronomy: Soil test results to determine fertiliser choice and use rates at planting.

Typically:

- All P at seeding, some N & K and in some cases S & trace elements.
  In crop Deep N testing and plant tissue testing assist with in crop macro & micro nutrition programs, N,K,S, Cu,Zn, Mn, B, Mo
- Aphids: BYDV protection - Seed treatment, follow up in crop if necessary unless variety has genetic tolerance to BYDV.
- Weed control programs: we must control ryegrass.
- Fungicide strategies: fungicide seed treatments. In crop, most wheat crops get 3 fungicides, sometimes 4 with “dog” varieties(T1, T 11/2, T2, T3)
- Main foliar diseases in wheat are Septoria tritici, Leaf rust, Powdery mildew, Stripe rust. Septoria nodorum and Fusarium head blight can also be a problem with long season finishes and no fungicide head protection. There are no cereal breeding programs in Australia looking at plant resistance traits for Eyespot, Fusarium or Septoria nodorum.
- In barley: Leaf rust, Spot and Net form of Net blotch, Barley Scald and Ramularia (Sleeping giant)
- Growth Regulator programs. Differ between wheat and barley and between variety being grown, grazing, sowing time, plant density, prior crop and fertility and fert programs.

In Summary:
Some things that I’ve noted, to manage and avoid things going pear shaped and bringing your potentially best crop back to the pack include:

Not the right rotation, poor drainage, soil constraints, ryegrass competition, BYDV,

SA CROP TECHNOLOGY CENTRE

TIMETABLE

SA CROP TECHNOLOGY CENTRE FIELD DAY: THURSDAY 28 OCTOBER 2021

Featuring the GRDC's Hyper Yielding Crops (HYC) and Pulse Agronomy projects

In-field presentations	Research site	9.30	11.00
Dr Nigel Willhelm, Senior Scientist, Agronomy Group, SARDI *Understanding nutritional constraints on highly calcareous soils and managing them to achieve high performance pulses.*	Pulses	All	
Andrew Ware, Director, EPAG Research Trust *What are the key management levers for a high yielding canola crop?*	Canola		All

In-field presentations	Cereals Station No.	12.30	1.15	1:30	2:00	2:30	3:00	3:30	4:00
Terry Horan, Senior Agronomist, Tasmanian HRZ and Irrigated Regions *What are the on farm and in field practicalities of achieving cereal yields in excess of 10t/ha?*	1	Lunch kindly sponsored by Seed Force	Welcome and opening address, John Bennett, GRDC Southern Panel Chair and Nick Poole, Managing Director FAR Australia	1		2			Closing address and refreshments Seed Force
Nick Poole and Max Bloomfield FAR Australia *12t/ha plus – pipe dream or practical possibility? What are the practical steps at the farm level to achieve higher yields Genotype x Environment x Management (G.E.M) trial - What level of management maximised margins in crops yielding 7 – 11t/ha?*	2				1		2		
Jen Lillecrapp, HYC Project Officer (SA), MFMG *Hyper Yielding Crops: Capturing yield potential through innovation and benchmarking.*	3					1		2	
Quenten Knight, Agronomy and Precision Ag Consultant (WA) *Role of precision ag, improved agronomy and soil amelioration in underpinning greater cropping productivity and profitability?*	4			2			1		
Randall Wilksch and Tom Blake, GRDC *Update on GRDC investments and review of opportunities for local research, development and extension.*	5				2			1	
In-field presentations	**Station No.**	**12.30**	**1.15**	**1:30**	**2:00**	**2:30**	**3:00**	**3:30**	**4:00**

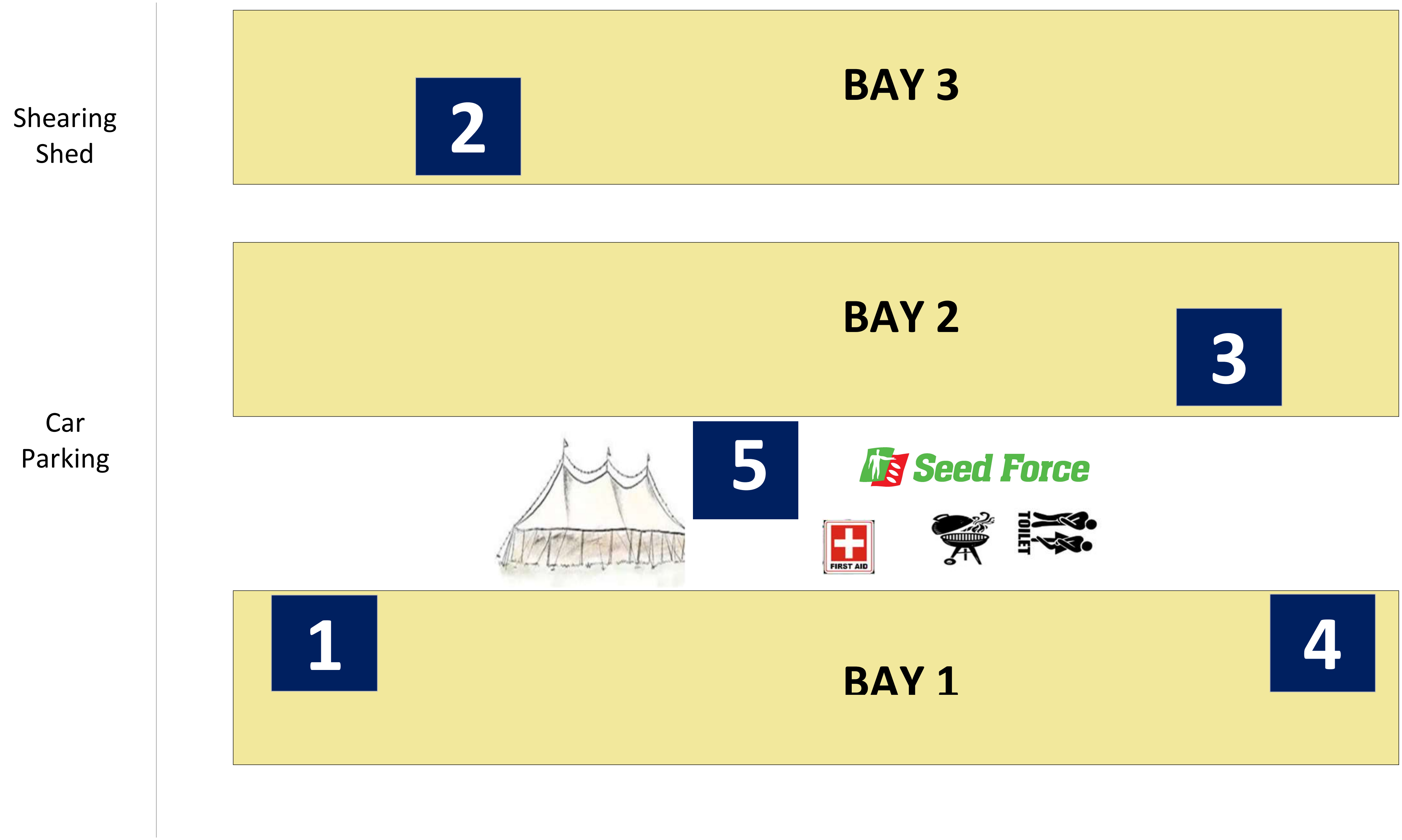
We would be obliged if you could remain within your designated group number throughout the day.
Thank you for your cooperation.

1	GROUP 1
2	GROUP 2

SA CROP TECHNOLOGY CENTRE

SITE MAP: SA CROP TECHNOLOGY CENTRE

Featuring the GRDC's Hyper Yielding Crops project



Terry Horan:

foliar disease outbreaks, root disease, crop lodging, high harvest loss's, nutritional deficiencies both macro and micro and poor timing of time critical operations.

A late great mate and true champion farmer always told me: "Terry, In the HRZ, a little often is the key to growing a great crop."
Michael Chilvers, Nile Tas.

Another great farming mate of mine tells me: "Freddy, we've learnt that to grow a big grain crop, we need to grow a lot of dry matter, if it's not a grain year it's a hay year, at worst it's open the gate and a paddock feed lot."
Pete Reardon,Temora NSW.

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

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

Key Points:

- *Over the last three years at Millicent, 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 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).*
- *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 SA 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 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;

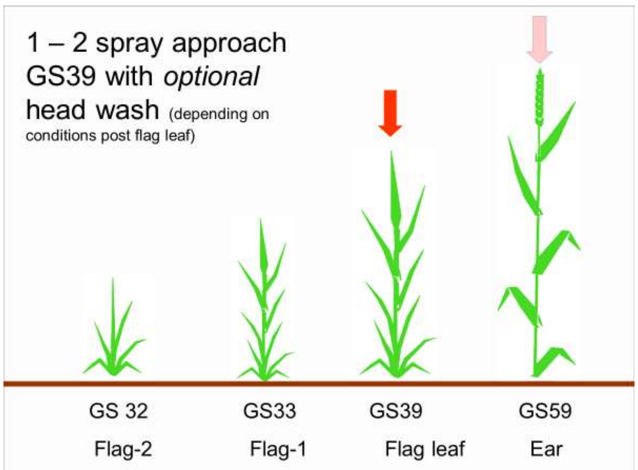
i) It reduces fungicide and application cost expenditure leading to more profitable crops by reducing from three to two or even one application;
ii) it would allow a much better appraisal of whether the seasonal conditions have the potential to support fungicide expenditure (since decisions on rates 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)

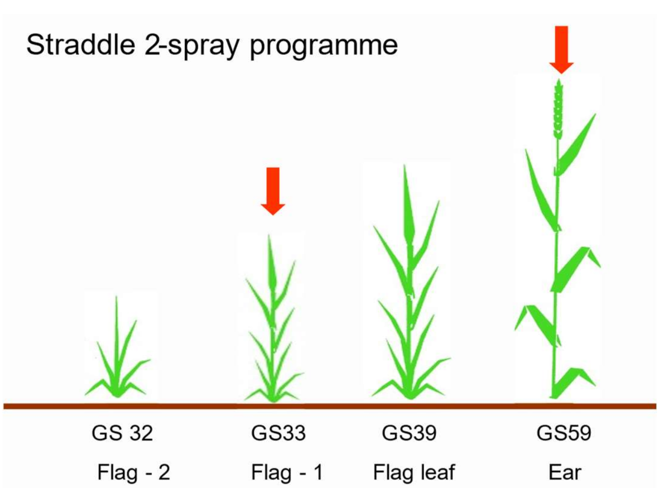
Currently it’s difficult to suggest a cultivar choice in the Millicent region that doesn’t need fungicides to produce the most profitable crops but newer more resistant cultivars to STB may allow us to apply the first fungicide either at GS33 when flag -1 (F-1) emerges or later at GS39 when the flag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



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.

Contact us

NEW SOUTH WALES
97-103 Melbourne Street,
Mulwala, NSW 2647
+61 3 5744 0516

VICTORIA (HEAD OFFICE)
Shed 2/ 63 Holder Road,
Bannockburn, Victoria 3331
+61 3 5265 1290

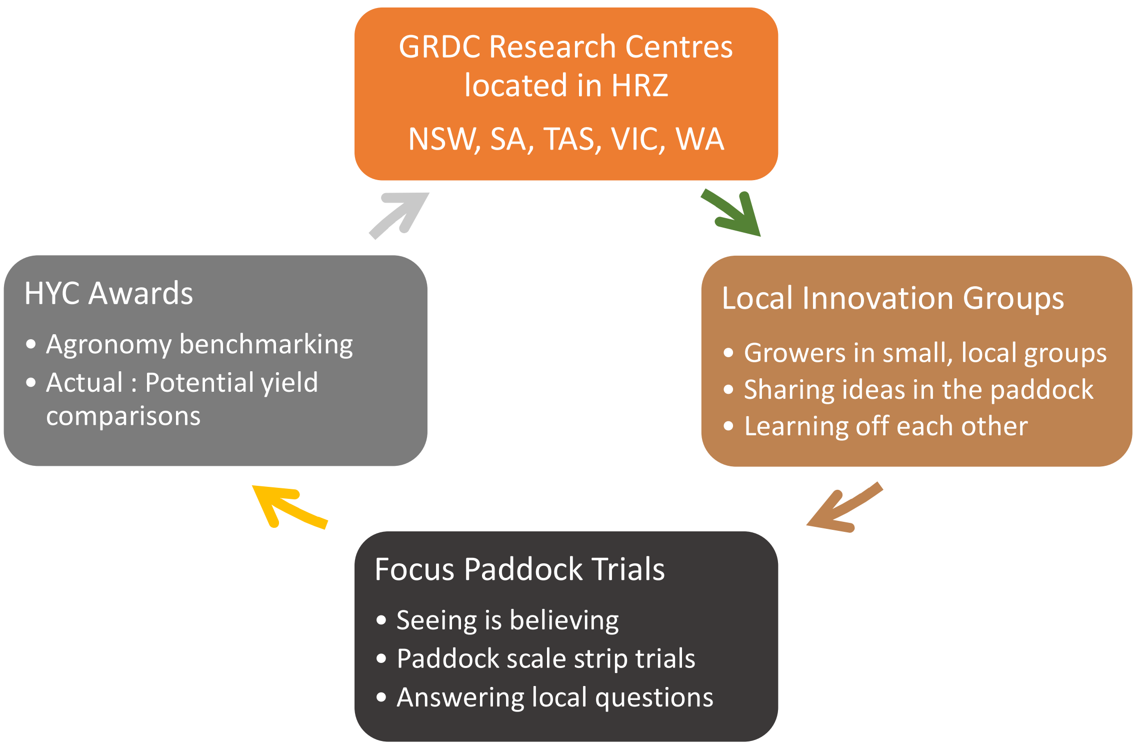
WESTERN AUSTRALIA
9 Currong Street
Esperance, WA 6450
0437 712 011

SOWING THE SEED FOR A BRIGHTER FUTURE

GRDC Hyper Yielding Crops SA

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 SA, Mackillop Farm Management Group (MFMG) 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 MFMG set up two innovation groups in the southeast SA 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 MFMG project officer – Jen Lillecrapp and as a result a number of different trials were setup.

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

Focus paddock trials:

1. ***Millicent paddock trial 2020***

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

<u>Paddock details</u>

Crop	Cereal: Wheat
Variety	Accroc
Sow Rate	150.00 kg/ha
Sow Date	16-05-20
Harvest Date	31-01-21
Harvest Yield	10.93 T/ha
Stubble Management	Incorporated
Grazed – Start date	15-07-20
Grazed – End date	06-08-20
Previous crop	Broad beans
Row spacing	229mm

<u>Fungicide Treatments</u>

Treatment	Product	Rate/ha	Growth Stage
1. Control - Grower practice	Prosaro	0.4	GS32
	Aviator Xpro	0.5	GS39
2. Trial treatments	Prosaro	0.4	GS32
	Aviator Xpro	0.5	GS39
	Avior Gold	0.32	GS60

Results

Measurement type	Control (Grower)	Treatment 2	Significant Diff
Yield (t/ha)	10.93	11.84	Yes
Protein (%)	9.5	9.0	na
Screenings (%)	1.94	2.18	na
Test weight (kg/hL)	76.6	76.6	na

Conclusion

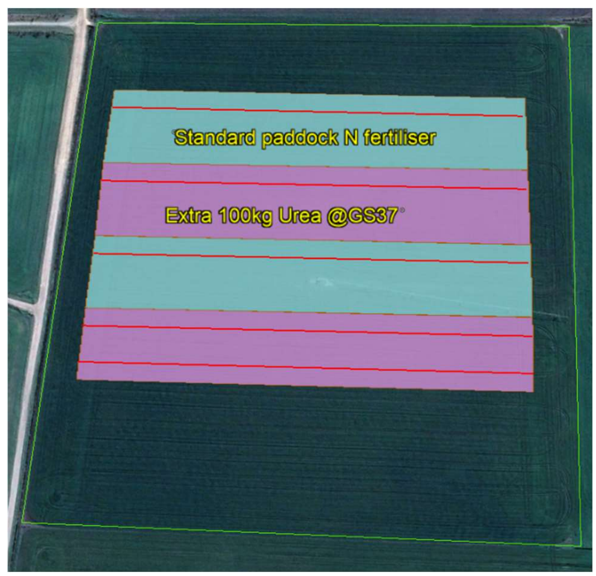
In the 2020 season, which was a decile 6 and rainfall exceeded the long-term average in each month during the spring the application of Avior Gold (Azoxystrobin and Epoxiconazole) at the start of flowering gave a significant yield increase of nearly a tonne per ha.

2. *Bool Lagoon Focus paddock trial – 2020*

Research question: What is the yield response to a standard compared to a higher rate of in-crop N applied in wheat at GS37 following clover?

Paddock details

Crop	Wheat
Variety	Accroc
Sow Rate	90 kg/ha
Plant Population	179/m2
Sow Date	18-05-20
Stubble Management	Incorporated
Harvest Yield	8.9 T/ha
Harvest Date	23-01-21
Seeder type	Tyne (Knife Point)
Row spacing	305mm



Nitrogen Treatments

Treatment	Product	Timing	Rate kg/ha	Total N kg/ha
1. Control	MAP	Sowing	200	
	Urea	GS23	200	**112**
2. Trial	MAP	Sowing	200	
	Urea	GS23	200	
	Urea	GS37	200	**204**

Results

Treatment	Yield (t/ha)	Protein (%)	Screenings (%)	Test Wt (kg/hl)
Control	8.9	9.8	3.1	74.0
Extra N at GS37	10.0	12.4	4.4	70.7

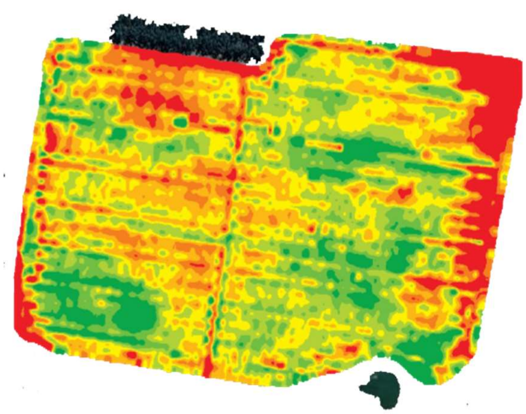
Conclusion

The application of an additional 92kg N/ha at GS37 gave a 12.3% increase in grain yield and well and truly gave a positive return on the additional investment in urea. It also increased the grain protein from 9.8 to 12.4% suggesting that some of the additional N applied for yield was not required by the plant and it was laid down in the grain as protein.

HYC Awards

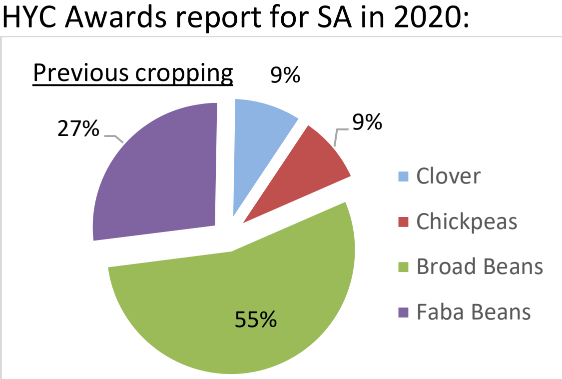
Award paddocks were nominated from the Innovation groups initially, with the aim being to collect and record specific wheat paddock information and to provide an agronomic benchmarking report which compares that paddock to all the others entered, both regionally and nationally. Nominated paddocks had 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 MFMG. 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.

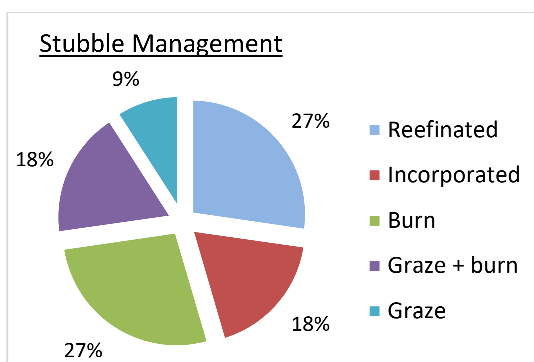
The winner for the highest yield in SA in 2020 was James Fitzgerald from Hatherleigh with a 10.59 t/ha crop of Accroc wheat sown on 17 May following Broad Beans.



James also won the award for the highest yield as a percentage of the potential yield in SA. His 10.59 t/ha crop of Accroc wheat was 99.3% of the 10.67 t/ha potential for his paddock. This was also 2nd highest % of potential nationally!

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



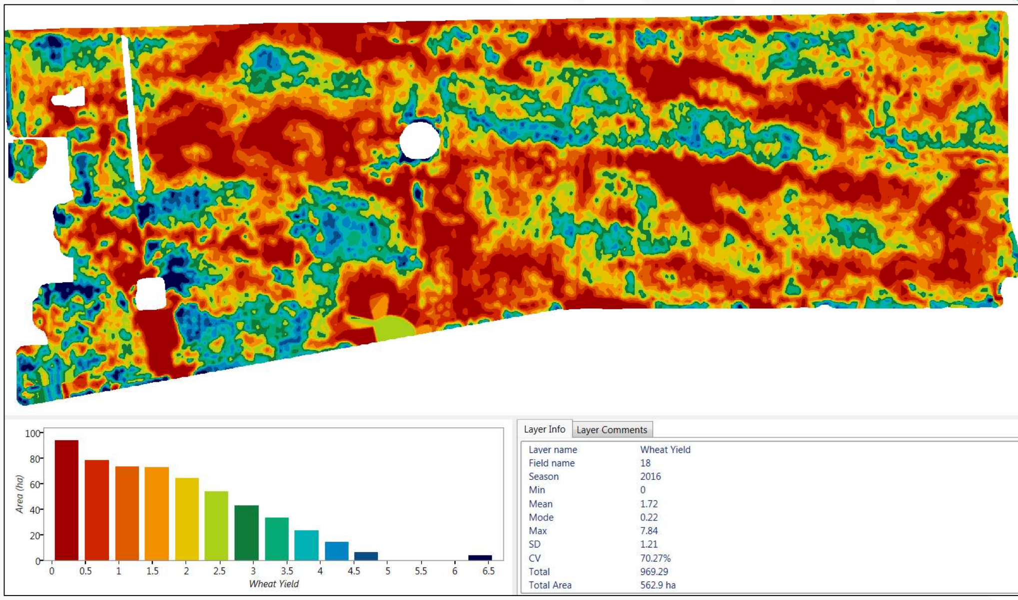


Agronomic Factor	Top 25% Award paddocks	Remaining 75%
Yield (t/ha)	9.7	8.0
N applied (kg N/ha)	140	139
Fungicides ($/ha)	$55	$57
Fungicides ($/t)	$5.6/t	$7/t
Number of applications	3.7	3
Head fungicide (%)	100%	50%
Dry Matter (t/ha)	22	21
Harvest index	51%	51%
Head count (m2)	655	590
Grains per head	36	31
1000 grain weight	41.6	40.9

Please contact Jen Lillecrapp (0427 647461) for information about being part of this exciting project or to enter a wheat crop as a HYC award paddock in 2021.

Yield Data – Highlights the problem….not the solutions

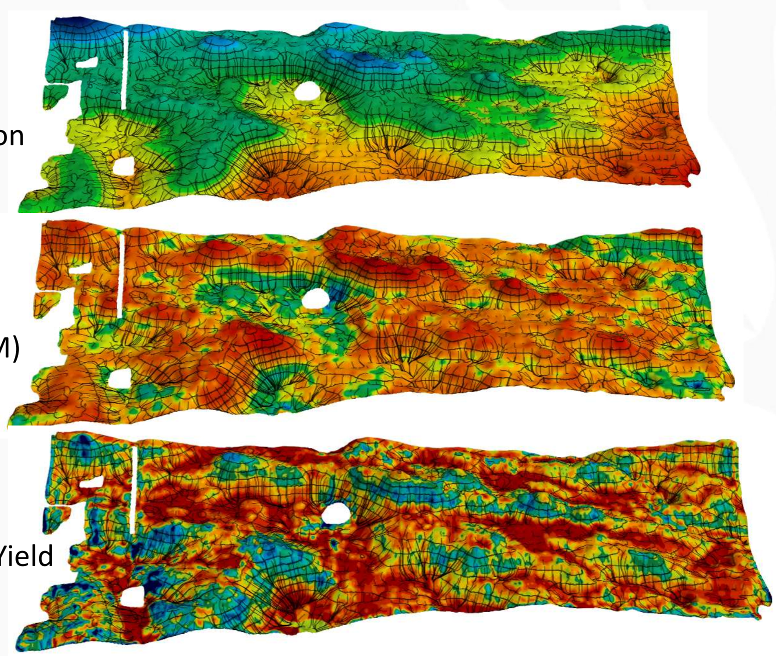
GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION



1

Agronomic decisions using data

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION



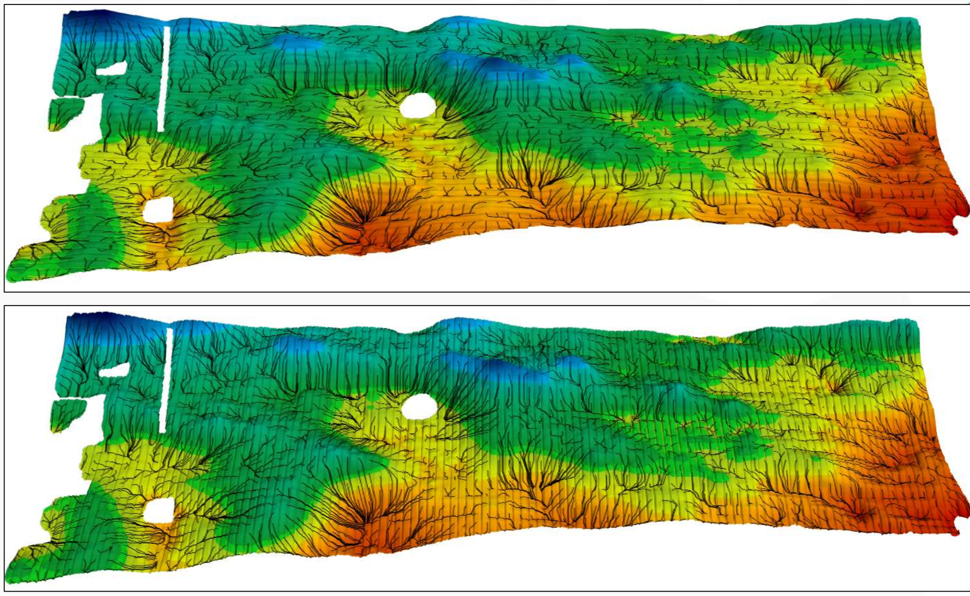
Elevation

Soil (EM)

Wheat Yield

2

Change farming direction



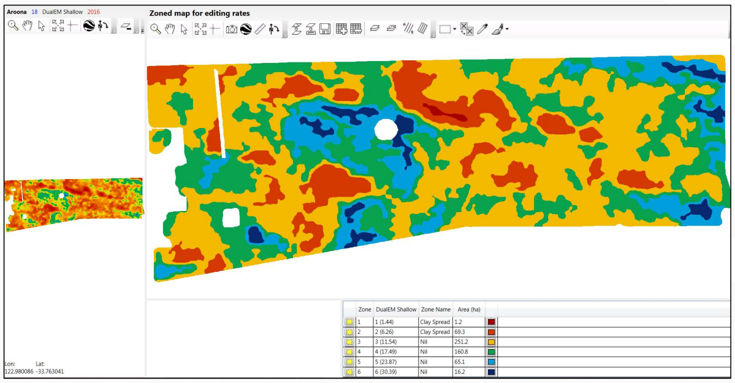
3

Shallow farm through surface drains

4

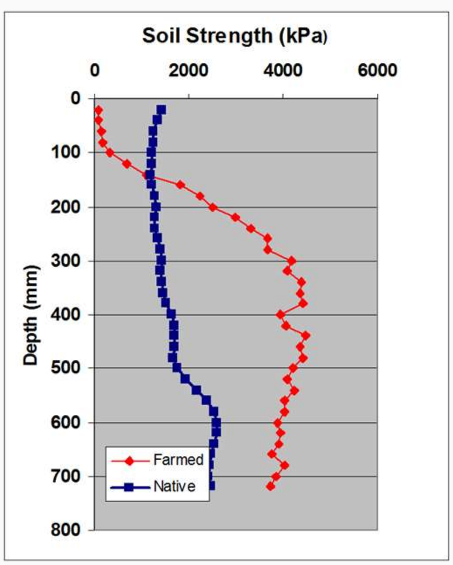
Quenten Knight

Clay spreading non-wetting deep sand



5

Remove soil compaction – Deep ripping



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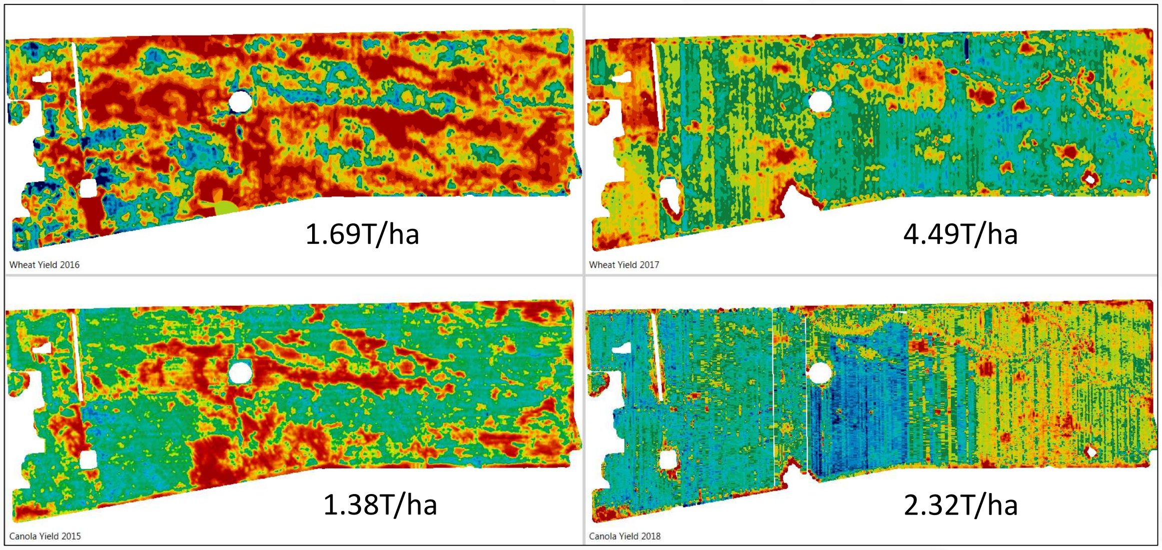
Results



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Financial Performance

	Year	Paddock	Operating Return	Crop	Yield	3-Year Rolling
	2013	18	-8.8%	Canola	0.44	
Pre	2014	18	12.5%	Wheat	3.74	
	2015	18	-2.3%	Canola	1.38	0.5%
	2016	18	-9.0%	Wheat	1.69	0.4%
Post	2017	18	6.2%	Wheat	4.49	-1.7%
	2018F	18	12.1%	Canola	2.32	3.1%

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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 with grain feeders 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 at Millicent – learnings from research to close the yield gap and raise potential

Kenton Porker, *Nick Poole, Tracey Wylie, Max Bloomfield, Kat Fuhrmann*

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 and previous experiments within the GRDC HYC project where water is non limiting to redefine our yield potentials for Millicent.

These data reveal It is possible to aspire on average to achieve grain yields of 12.2t/ha in Wheat, 10.6t/ha in barley, and 4.5t/ha in Canola at Millicent (Table 1). However, this will depend on management to be discussed.

The key feature of Millicent is that yields are **more likely to be limited by light and temperature during the critical growing period rather than by water limitation**, and crops will need to see more than 400kg N of supply to realise their yield potential.

Table 1. *Long term average photothermal yield potentials, water limited potential yields, and the N supply required to achieve yield potential at Millicent over the last 10 years (2010 – 2021). Formula used are based on Porker et al 2021 (Wheat and Barley), Kirkegaard et al 2021 (Canola) and updated yield frontier lines. The shaded cells represent the average potential yield available with current best practice.*

	Flowering Target	Potential Yield Based on PTQ* (PYPTQ)	Water-Limited Potential Yield (PYW)	N supply required (kg/ha)
Wheat	20-Sep	9.9	13.5	488
	24-Oct (Optimal)	12.2		
Barley	20-Sep	9.7	13.5	424
	15-Oct (Optimal)	10.6		
Canola	15-Aug	3.3		
	15-Sep (Optimal)	4.5	8.1	360

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 10 tonne potential?
For a cereal cultivar to achieve 10t/ha or Canola cultivar to achieve 5t/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 21 days before awn emergence in barley and flowering in wheat, and the 1 – 4 weeks after flowering in Canola (see previous paper).

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. 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.

Winter Wheat yields are consistently achieving >10tonne:
At Millicent early sowing (Mid – late April) of well adapted Australian spring cereal cultivars such as Scepter, Trojan, and Barley cultivar Rosalind are typically flowering in mid-September and while yields of up to 10tonne have been achieved they have not exceeded it. Whereas, slow developing winter feed wheats such as RGT Accroc and Annapurna are flowering around the 20 – 25th of October and consistently achieving yields greater than 10t/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 10t/ha and they flower in the week from the 20th October. Based on long term data, this date is the period in which highest yields could be achieved based on the photothermal quotient (light and temperature in the critical period) (figure 1). 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 the 24th October minimises losses to all three stresses frost, heat, and drought.

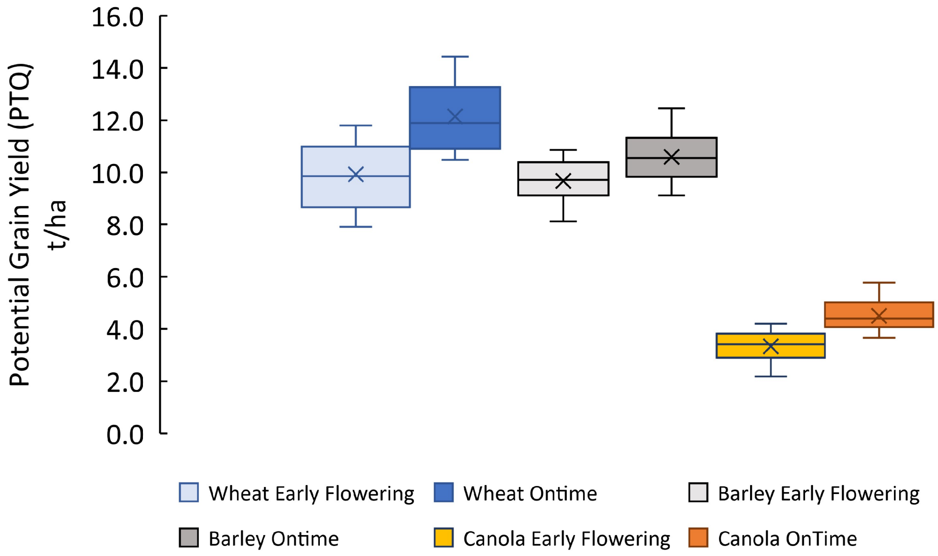

Figure 1*. Potential photothermal yields for Wheat flowering early (20 Sep) and Ontime (24 October), barley flowering early (15 Sep) and On time (10 Oct), and Canola early (15 August) and Ontime (10 Sep).*

Learnings - Early sowing winter or later spring barley at Millicent? Achieving 10 tonnes is harder in barley than wheat

Currently the data suggests that ***later planting dates (Early – mid may) of RGT Planet is the benchmark and best practice for lower southeast barley production***, provided its yield potential is maintained with disease control, PGRs, timely harvest and water logging risk is considered.

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. Despite yield increases observed in winter wheat this has not been the case in our winter barley research. Even when experimental winter barley cultivars flowering at the start of October have failed to achieve 10t/ha, this is due to other constraints such as head loss and lodging.

- 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 2 shows the relative flowering date of spring germplasm versus winter germplasm from late April sowing in 2020 in Millicent, with Rosalind and RGT Planet being typically earlier, while winter barley flowered at a more optimal time (similar to the highest yielding wheats) but yielded less than spring barley planted later.
- Despite differences in flowering time the best yielding winter cultivar yielded less than RGT Planet and Rosalind. This was due to other yield constraints such as lodging and head loss.

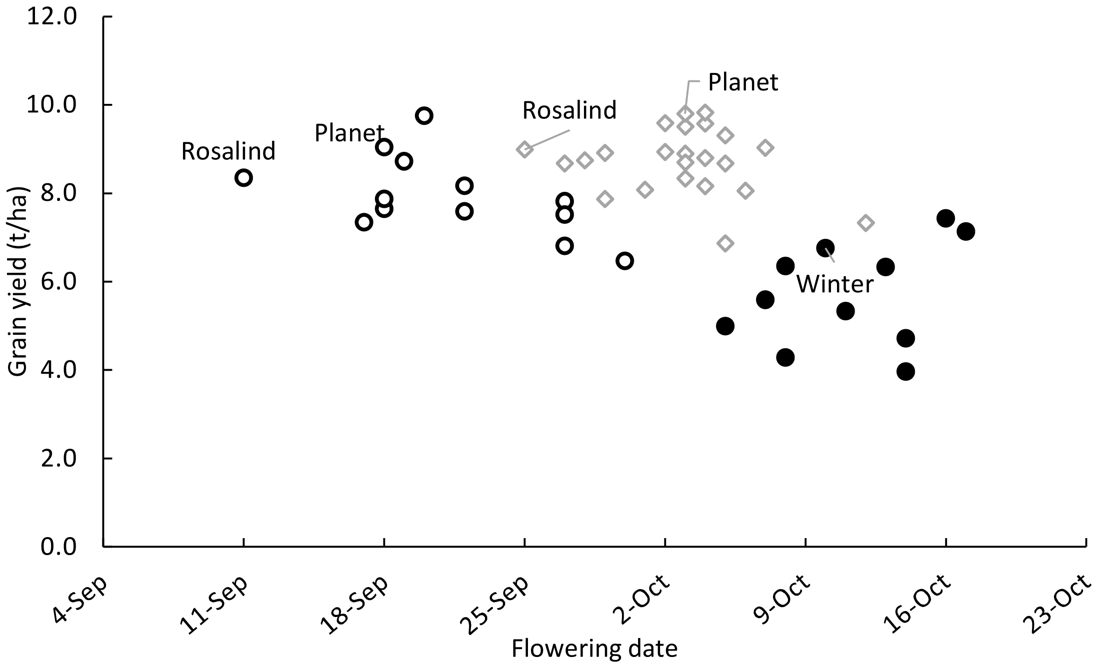

Figure 2. *Flowering time and grain yield responses of spring cultivars (◦) and winter cultivars (•) in the elite screen from late April sowing, and from early May sowing (◊) at Millicent in 2020.*

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 2. *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.

Other Considerations:

- Winter barley should in theory work well for the lower south east, due to its superior disease resistance and preferred development pattern for earlier sowing. 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.
- 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 develop quickly (eg Planet) 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. Slower developing cultivars would enable earlier sowing (prior to wet conditions) and remain vegetative and more tolerant for longer in the growing season. Genetic solutions such as more waterlogging tolerant Planet is under development but is yet to be validated in yield experiments.
- 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.

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 spread between box plots in the visual demonstration below (figure 3) 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.

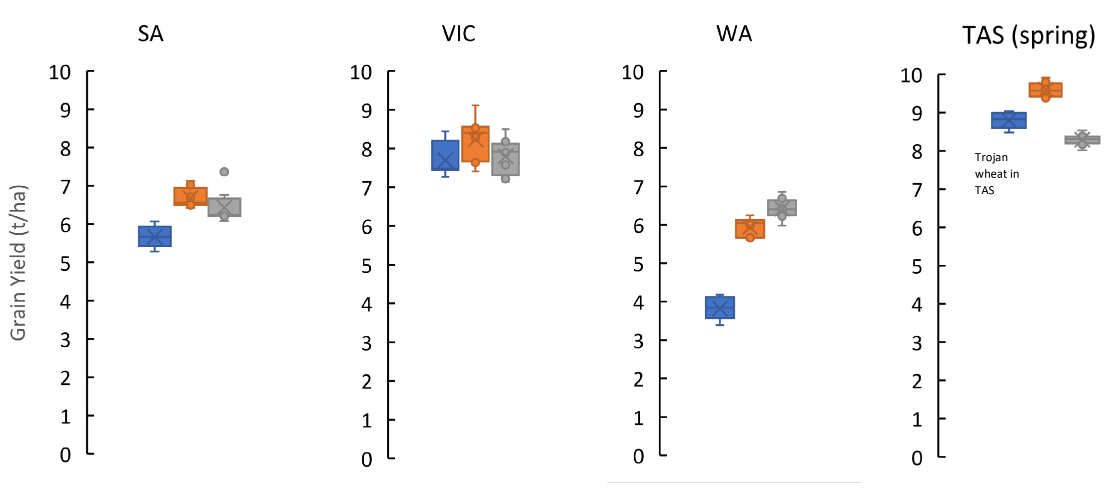

Figure 3. *Boxplot representation blue (•Cassiopee winter barley (Trojan in Wheat in TAS), •RGT Planet, and •Rosalind) grain yields across all management combinations (n = 8 per box plot) and environments (blue = trojan wheat in TAS spring sown).*

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 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). Time of sowing was also a big factor in disease management and our SA suggests similar high yields can be achieved by later sowing with cheaper fungicide programs.

SOWING THE SEED FOR A BRIGHTER FUTURE

Field Applied Research (FAR) Australia

HEAD OFFICE: Shed 2/ 63 Holder Road
Bannockburn
VIC 3331
Ph: +61 3 5265 1290

97-103 Melbourne Street
Mulwala
NSW 2647
Ph: 03 5744 0516

9 Currong Street
Esperance
WA 6450
Ph: 0437 712 011

Email: faraustralia@faraustralia.com.au
Web: www.faraustralia.com.au