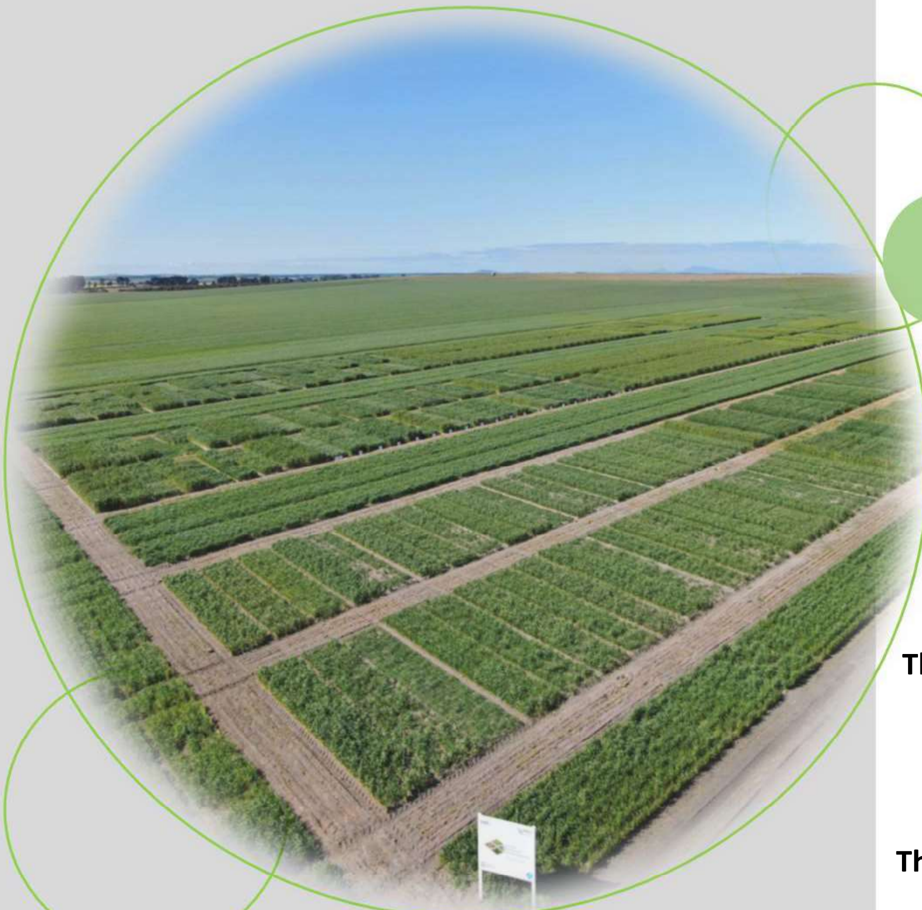
WA CROP TECHNOLOGY CENTRE (ALBANY)

FIELD DAY

INCREASING PRODUCTIVITY IN THE SOUTH-WEST HRZ

Thursday 15th September 2022



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SOWING THE SEED FOR A BRIGHTER FUTURE

WA CROP TECHNOLOGY CENTRE (ALBANY)

TIMETABLE

WA CROP TECHNOLOGY CENTRE FIELD DAY (ALBANY): THURSDAY 15 SEPTEMBER 2022

Featuring the GRDC's High Ranfall Zone Farming Systems Project

Thanks to our keynote speaker sponsor:

Seed Force AN RAGT COMPANY

In-field presentations	Station No.	9:30am-11.30am	12:30	1:15	1:30	2:00	2:30	3:00	3:30	4:00	4:30
Rohan Brill, Brill Ag, Heping Zhang, Canola Researcher ***Hy** per yielding canola - what have we learnt so far?* ***Sam Flottmann, CSIRO*** *Key research findings, successes in HRZ canola cropping across WA, and where future gains might come from.*	Canola research site	ALL	Lunch kindly sponsored by AGLINK DAVID GRAYS Locals Supporting Locals	Opening address by Peter Bird, GRDC's Senior Regional Manager West followed by Andrew Rice, FAR Australia's Panel Chair and Dr Kenton Porker FAR Australia's Research Director for an introduction to the cereal research programme.							HYPER YIELDING CROPS AWARDS GRDC HYC Awards presentations & closing address followed by refreshments kindly sponsored by AGLINK DAVID GRAYS Locals Supporting Locals
Rohan Brill, Brill Ag and Dr Kenton Porker, FAR Australia *Building fertile farming systems for hyper yielding crops and removing n limitation.*	1				1					2	
Chao Chen, CSIRO *What does modelling suggest about our yield potential in the Albany Port Zone?*	2				2	1					
Dave Moody, Intergrain *Prospects for longer season barley varieties in the high rainfall districts.*	3					2	1				
Kenton Porker and Jayme Burkett, FAR Australia *Management to achieve higher yields in wheat and barley in WA - what's possible and pratical?*	4						2	1			
Jon Midwood, Techcrop and Dan Fay, Stirlings to Coast Farmers *Hyper Yielding Crops: Capturing yield potential through innovation and benchmarking.*	5							2	1		
Jeremy Curry *Which main season wheat cultivars stood out in terms of quality and which early sown wheats were hyper yielding?*	6								2	1	
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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

FAR AUSTRALIA

For the afternoon's presentations, would be obliged if you could remain within your designated group number.

Thank you for your cooperation.

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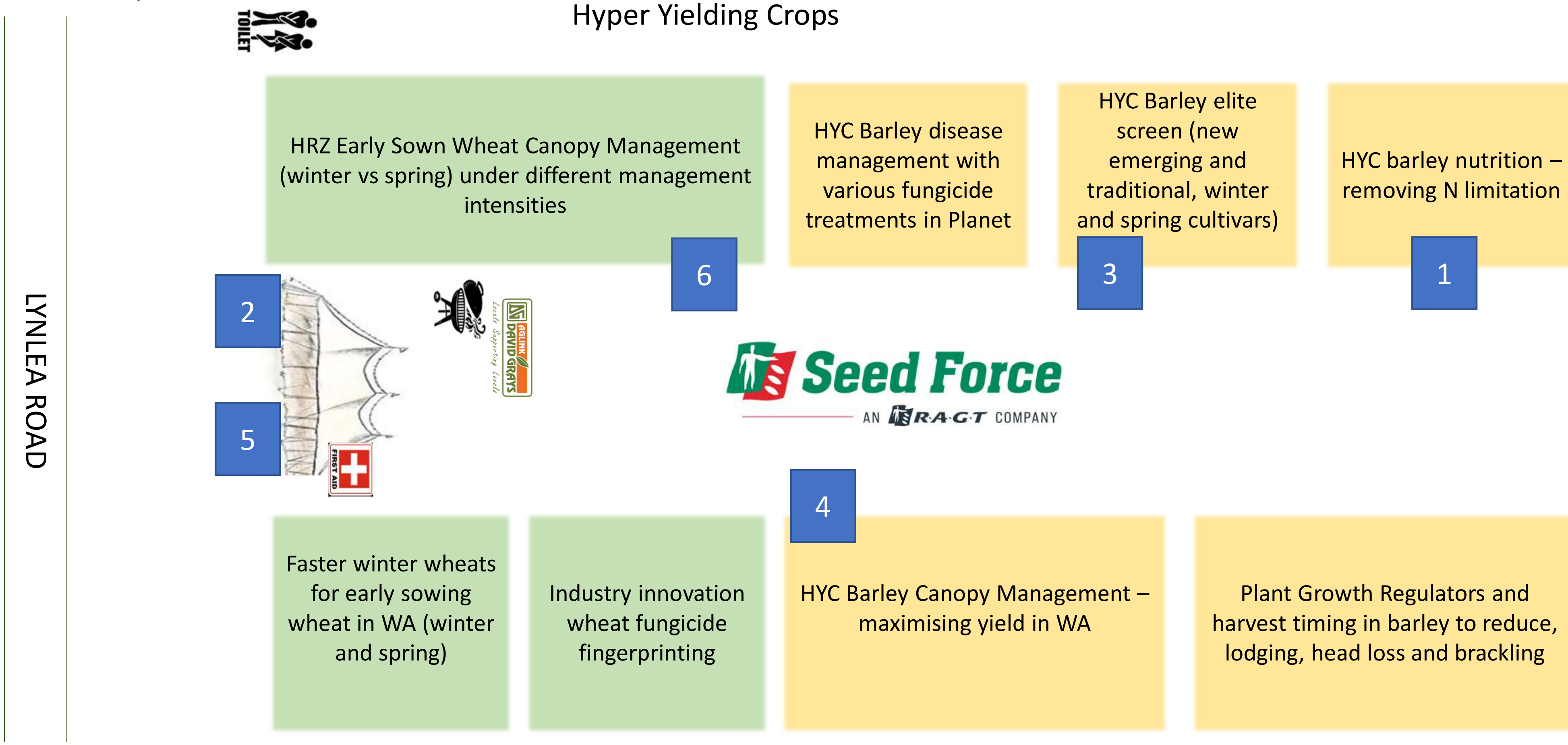
WA CROP TECHNOLOGY CENTRE (ALBANY)

2022 SITE MAP: WA CROP TECHNOLOGY CENTRE (ALBANY)

Featuring the GRDC's High Rainfall Zone Farming Systems and Hyper Yielding Crops



WA CROP TECHNOLOGY CENTRE (ALBANY)

VISITOR INFORMATION

We trust that you will enjoy your day with us at the WA Crop Technology Centre (Albany) 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

- 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 Australia 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

- We have a number of First Aiders on site. Should you require any assistance, please ask a member of FAR Australia staff.

LITTER

- Litter bins are located around the site for your use; 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 infection with COVID-19:

- 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 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.

INCREASING PRODUCTIVITY IN THE SOUTH-WEST HRZ

FEATURING THE GRDC'S HIGH RAINFALL ZONE FARMING SYSTEMS AND HYPER YIELDING CROPS

On behalf of our investor, the **Grains Research & Development Corporation** along with both project teams, I am delighted to welcome you to our 2022 Albany Crop Technology Centre Field Day featuring High Rainfall Zone (HRZ) Farming Systems and Hyper Yielding Crops (HYC).

The HRZ Farming Systems project is led by the Department of Primary Industries and Regional Development (DPIRD) in collaboration with FAR Australia and Commonwealth Scientific and Industrial Research Organisation (CSIRO). This project has the objective of optimising cropping in the western HRZ regions.

Hyper Yielding Crops is a national project led by Field Applied Research (FAR) Australia. Over the past three years, the HYC project has aimed to push the economically attainable yield boundaries of wheat, barley and canola. As well as the five research centres across the HRZ's of Australia, the project has been successful in engaging with growers to scale up the results and create a community network with the aim of lifting productivity. If you are interested in getting involved in 2023, then please get in touch (see contact details in this booklet).

To make the programme as diverse as possible I would like to thank all our speakers who have helped to put today's programme together; in particular our keynote speaker Rohan Brill who has made the trip from NSW to join us today. Rohan is one of the industry's most influential canola research agronomists who will be sharing some key tips on how we can achieve hyper yielding canola crops.

Finally I would like to thank the GRDC for investing in these research programmes. Also a big thanks to Kellie Shields and Terry Scott our host farmers for their tremendous practical support given to the team and to today's Keynote speaker sponsor SeedForce and our lunch sponsor David Grays.

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

Dr Kenton Porker
Research Director
FAR Australia

HRZ Farming Systems

Over the past decade there has been a trend towards more cropping in the High Rainfall Zone (HRZ) but yields are typically 1-3 t/ha below water-limited yield potential for wheat and 0.5-1.5 t/ha for canola in an average season. This presents a significant opportunity to lift the profitability of cropping systems in the HRZ, defined in Western Australia as arable areas with annual rainfall above 450mm. This GRDC project was created to support growers to overcome major constraints, adopt superior long-season varieties and develop management packages to express superior yield potentials. In this project, DPIRD, CSIRO and FAR Australia have combined their expertise in farming systems, bio-economic modelling, disease management, and systems agronomy to work with growers to develop high production packages for the HRZ.

Over the three years of the project, the team has focussed on supporting growers to increase the value of the cropping phase in the HRZ farming system by 10%. This is being done by addressing both crop yield potential and the gap between potential and realised yield in wheat and canola crops grown in the HRZ of the Albany and Esperance port zones.

In 2019 the project team ran workshops at Dandaragan, Green Range and Esperance with farmers and advisers to help define the key elements of the HRZ and R&D needs to support increased productivity and profit. Issues, opportunities and priority questions identified guided the establishment of the experimental program in 2020. Key priorities coming from these workshops included how to best manage agronomy when potential is increased with soil amelioration, how to lift production through a combination of early sowing, improved genotypes and appropriate agronomy in cereals, how to manage nutrition to target high yields in HRZ environments, and how to improve the harvest index (achieved yield from established biomass) in large and bulky HRZ crops.

The project team is also working closely with SEPWA and Stirlings to Coast Farmers who are running paddock-scale demonstration projects (under PROC-9175784). This provides regular engagement with growers and consultants and ensures promising results from small-plot trials are validated at a paddock scale using commercial machinery.

This project will deliver a better understanding of the yield potential of different combinations of germplasm (i.e. winter vs spring germplasm) and farming systems inputs, identify options to reduce the yield gap, and quantify the economic risks associated with potentially higher input farming systems. The intensively monitored field experiments and paddock-scale demonstrations provide a focus for extension activities to improve grower knowledge and cropping aspirations. We are working with leading growers and consultants to develop guidelines about the profitability and risks of incorporating new agronomic practices and more diverse crop sequences into HRZ farming systems.

By working together, we can refine and transform HRZ farming systems towards increasing the average yield by 2t/ha in cereals and 1t/ha in canola (i.e. the five-year stretch target set by GRDC for the HRZ).

For more information on cereals contact Nick Poole from FAR Australia. (nick.poole@faraustralia.com.au)
For more information on canola contact Jens Berger from CSIRO (jens.berger@csiro.au) or
Jeremy Curry from DPIRD (jeremy.curry@dpird.wa.gov.au).

Scan the QR code for 2021 HRZFS project results

WA CROP TECHNOLOGY CENTRE (ALBANY)

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 (Dan Fay from Stirlings to Coast farming group here in the West) are working with innovative grower networks to set up paddock strip trials on growers' properties with assistance from the national extension lead Jon Midwood.

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

For more details on the project contact:

Rachel Hamilton – HYC Communications and Events, FAR Australia
Email: rachel.hamilton@faraustralia.com.au

Nick Poole – HYC Project Lead and HYC wheat research lead, FAR Australia
Email: nick.poole@faraustralia.com.au

Dr Kenton Porker – HYC barley research lead
Email: Kenton.porker@faraustralia.com.au

Rohan Brill – HYC canola research lead
Email: rohan@brillag.com.au

Jon Midwood - HYC extension coordinator, TechCrop
Email: techcrop@bigpond.com

Dan Fay, WA HYC Project Officer, Stirling to Coast Farmers
Email: dan.fay@scfarmers.org.au

Scan the QR code for 2021 HYC project results

Frankland Crop Technology Centre 2022 Climate Update

Growing Season Rainfall to date:

The current 2022 rainfall at Frankland is consistent with long term trends, up until the start of September the March – September rainfall was 339 mm compared to long term median of 362mm for the same time period.

Long-term growing season rainfall and yield potential

The long-term median rainfall for Frankland from April – October is 442mm of rain. Using a French and Schulz equation, assuming 60mm is lost to evaporation, ignoring fallow rainfall, and a water use efficiency of 25kg/ha/mm in cereals a yield potential of > 9.5t/ha should be possible in more than 50% of years.

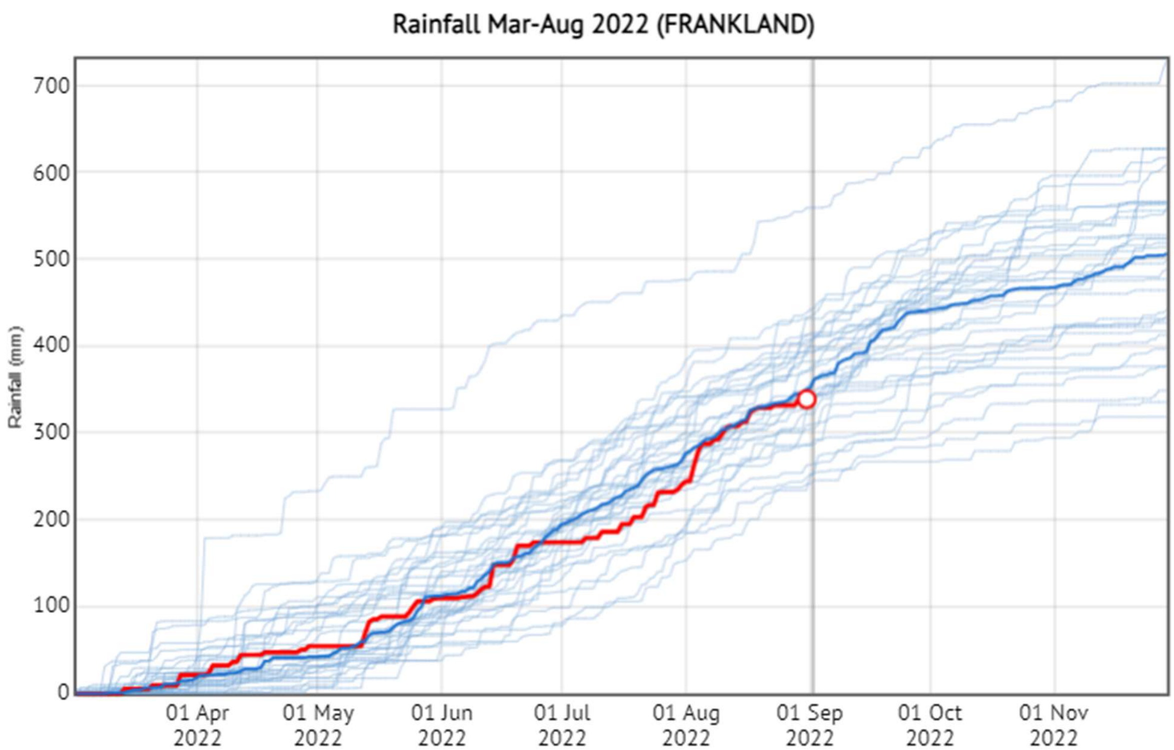


Figure 1. Long term rainfall (mm) trends for Frankland in the period from Apr – Nov. The dark line represents the **long-term median,** and red line the 2022 season tracking relative to other seasons light blue deciles. (DATA Source: Australian CLIMATE online 2022).

Solar Radiation and Temperature (figure 1 and 2)

In parts of the high rainfall zone solar radiation and temperature during the critical period (15 Aug – 20 Sep in WA) are the limiting factors to yield more often than water supply. This was a defining feature of 2021, with temperature consistent with long term trends, however solar radiation lower than average leading to reduced photosynthesis and grain number potential. As of Sep 1 in 2022 this looks to be case again in 2022.

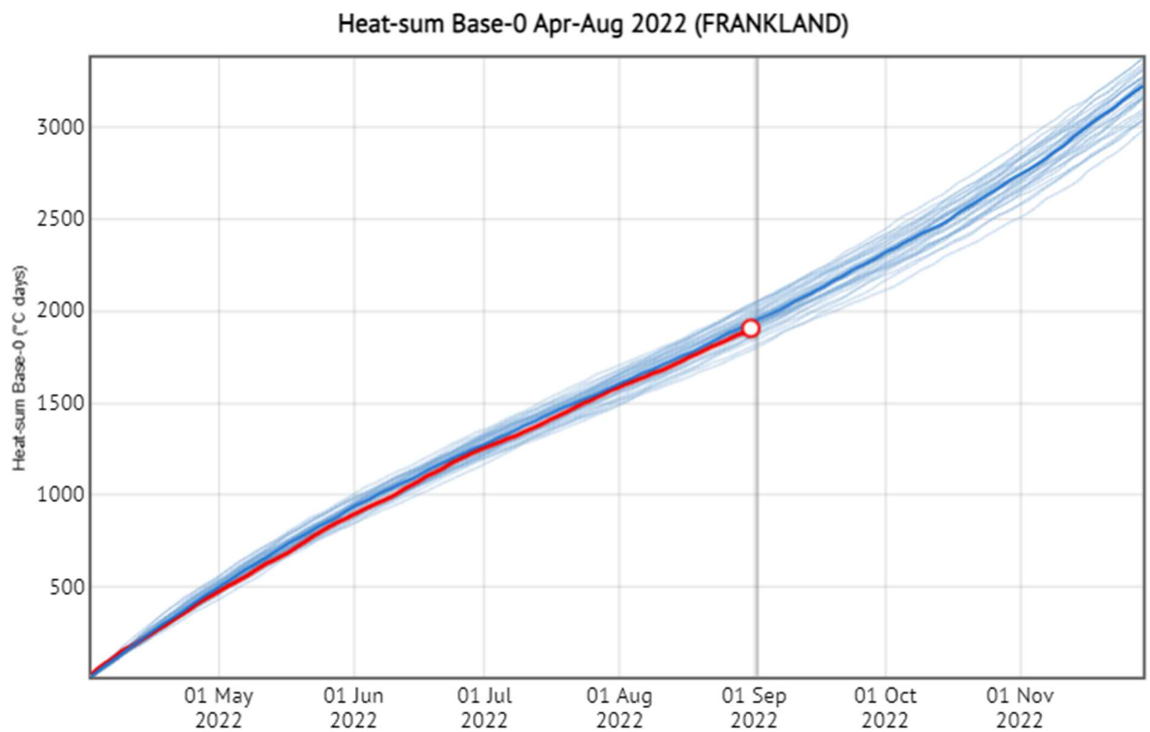


Figure 2. Long term **accumulated temperature** trends for Frankland in the period from Apr – Nov. The dark line represents the **long-term median,** and red line the 2022 season tracking relative to other seasons light blue deciles. (DATA Source: Australian CLIMATE online 2022).

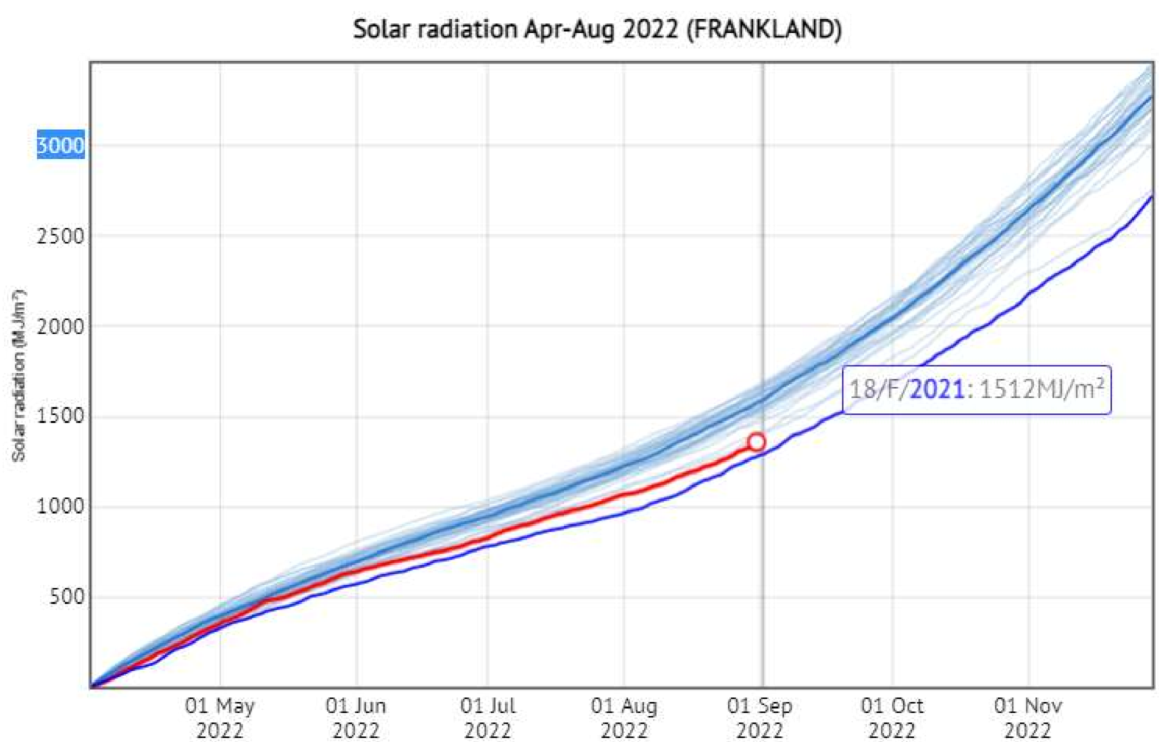


Figure 3. Long term **accumulated Solar Radiation** trends for Frankland in the period from Apr – Nov. The dark line represents the **long-term median,** and red line the 2022 season tracking relative to other seasons light blue deciles. 2021 is marked for comparison (DATA Source: Australian CLIMATE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

Hyper Yielding Canola – more than just urea and fungicide

Rohan Brill and Heping Zhang

Key Points

- At Hyper Yielding Canola sites in four states in 2021, canola yield was improved where animal manure (chicken or pig) was applied.
- At Kojonup, chicken manure (applied pre-sowing) lifted yield by 0.8 t/ha where it was applied with a high rate of N, versus where N was applied without manure.
- 2022 trials will provide a better understanding of the reasons for the manure response.
- Trials will also determine if the response can be replicated through matching inorganic inputs with that of the manure.
- Variety choice was also an important factor, and with a soft finish to the season winter canola (Hyola Feast CL) was the highest yielding in the GEM trial series at 3.7 t/ha with Nuseed Condor TF the best of the springs at 3.4 t/ha.
- There was no response to fungicide in disease management trials on the two varieties 45Y28 RR and HyTTec Trifecta at Kojonup. In fact, a fungicide response was measured in only two of seven trials across four states in the HYC canola program in 2021.

Importance of nutrition for Hyperyielding Canola

The aim of the canola component of the Hyperyielding Crops project is to determine management practices that achieve 5 t/ha canola grain yield in high yield potential environments. At Kojonup in 2021 the highest yield was close to this figure, with 4.7 t/ha of 45Y28 RR fertilised with 225 kg/ha N + Chicken Manure. The nitrogen response saturated at 75 kg/ha N applied, potentially as the kind spring drove mineralisation of N from the organic pool (3.4% Organic Carbon). Animal manure may not be readily available and/or the cost may be prohibitive, so 2022 trials are looking further into the reasons for the response to manure. The trials will determine if a similar response can be achieved by matching the nutrition supplied in manure with inorganic inputs.
The response to manure was mirrored at all four HYC Canola sites in 2021, including:

- Gnarwarre, Victoria (pig manure)
- Millicent, SA (pig manure)
- Wallendbeen, NSW (chicken manure)

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

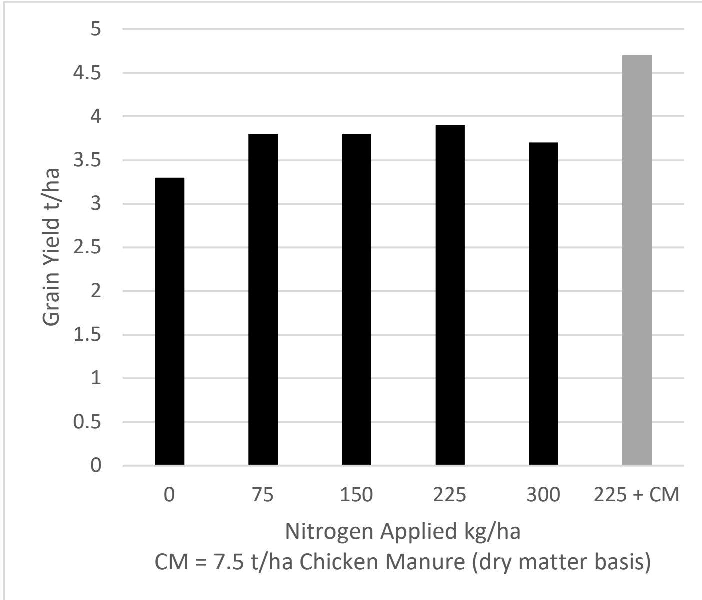


Figure 1 – *Response of 45Y28 RR canola to nutrition treatments at Kojonup in 2021. Chicken manure was 3.0% N and 0.9% P. L.s.d = 0.31 t/ha.*

Variety Choice 2021

Winter and spring GEM (Genotype * Environment * Management) trials were conducted at each HYC canola research site in 2021. The response to management was often small (due to lower than expected disease pressure and fertile paddocks limiting N response), but there were large differences between varieties. Kojonup was the only site where the best variety in the winter GEM trial had higher yield than the best spring variety. At Gnarwarre in Victoria, the yield of Hyola Feast CL was close to 45Y28 RR whereas at the NSW and SA sites, the yield of the best spring variety 45Y95 CL was at least 2 t/ha above the best winter variety.

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

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

Table 2. Yield of two winter canola varieties at four national HYC canola sites in 2021.

	Gnawarre Vic	**Kojonup WA**	**Millicent SA**	**Wallendbeen NSW**
Hyola Feast CL	4.3	3.7	4.1	3.8
Hyola 970 CL	4.0	3.3	3.1	3.4
l.s.d. (p<0.05)	n.s.	0.23	0.36	0.34

Detailed assessment of 45Y95 CL at the Wallendbeen site showed that 45Y95 CL had high maturity biomass but also a high harvest index, with 36% of final biomass being grain. 45Y95 CL also maintained a very high number of seeds per pod with a high number of pods/m^2. Experiments and measurements will be completed again in 2022 as subtle differences in final biomass and harvest index can magnify into large differences in crop profitability.

Hyperyielding canola results

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

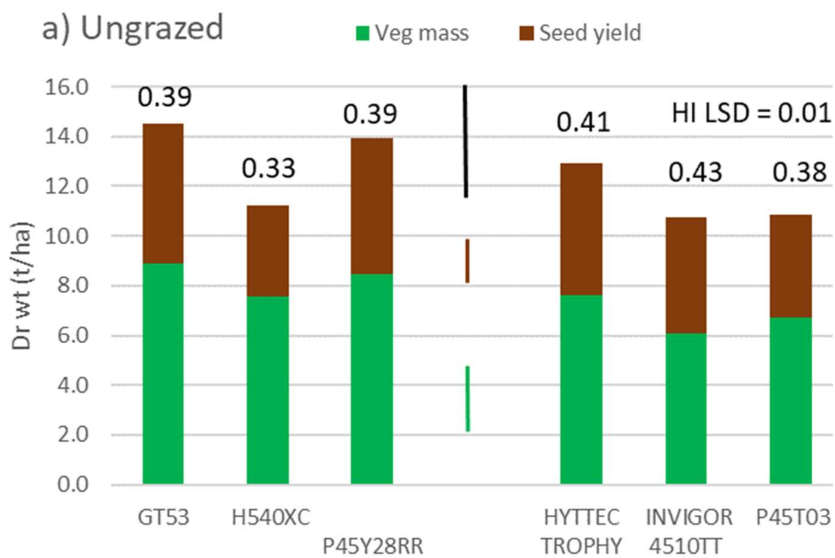
Canopy size & harvest index in HRZ canola

Jens Berger, Sam Flottmann, Adam Brown & Andrew Fletcher (CSIRO)

Canola productivity in the HRZ is determined primarily by biomass accumulation, trading off against harvest index (Zhang *et al.*, 2020; Zhang *et al.*, 2016). Typically, hybrid canola accumulates high biomass at a reduced harvest index (HI) to produce a high yield, which is rarely matched by the higher harvest index, lower biomass OP cultivars. However, input management strategies aimed at producing high biomass carry greater financial risk, particularly if the growing season rainfall does meet the HRZ norms. Moreover, high biomass production can have negative consequences for growers, including harvesting difficulties associated with tall crops, high stubble loads and in-season water use, and an increased Sclerotinia risk. These tensions promote serious discussion among canola growers as to the optimal strategy that balances risk against reward, biomass against harvest index, captured in the so-called 'fat versus fit crops' debate.

Using on-farm trials near Qualeup CSIRO has been investigating the extent to which growers can manipulate canola canopy size and harvest index using a combination of genetics and management. We focused on hybrids, given their proven track record in the HRZ, and contrast Roundup Ready (high vigour/biomass, lower HI) with Triazine Tolerant types (lower vigour/biomass, higher HI). Management interventions are used to increase (N, S, and/or manure treatments, density) or retard growth (grazing, PGR application). The experiments are designed in a balanced, factorial way so that we can isolate the effect of treatments in the absence of confounding effects. These factorial G x M treatments have a huge effect on canopy size (yield: 2-3 fold differences, biomass 2-fold differences, plant height 1.2-1.8 m), but a comparatively smaller impact on HI (Fig. 1). Moreover, HI is much more influenced by genetics than by management because it is largely explained by the ratio of seed/pod weight, a stable ratio that is unaffected by agronomic intervention. RR types tend to have significantly lower HI than TT types, particularly in an ungrazed crop (Fig. 1a). As a result, in an ungrazed crop there are no yield differences between the 2 types, even though RR types tend to produce more biomass (Fig. 1a). Grazing changes things. While harvest index rises consistently across both TT and RR types after grazing (Fig. 1b), it tends to reduce yield more in TT than in RR types. PGR application had strong effects on plant height, but little impact on HI and inconsistent effects on yield and biomass (data not presented). Our data demonstrates the flexibility of canola. While high vigour/biomass RR types are less efficient at converting biomass into yield than TT types, they are better suited to a dual-purpose grazing use. Growers can choose whichever option suits them best. While there is no yield penalty in growing the higher vigour RR types, if stubble load is of concern, then perhaps TT types will be the better choice. Alternatively, when biomass production is important (eg. dual purpose crop), then RR types appear to have the edge.

In season 2022 we are investigating how far we can push the system into biomass overload to explore the utility of 'braking' management intervention under these conditions. To this end we have widened the cultivar pool to include Clearfield early winter types and are exploring the impact of inputing N through manure or traditional bag fertilizer options. To date we have not been able to flatten the biomass-yield relationship and are hopeful that the combination of long season winter growth and high N inputs will test the system to its limits. So far, the seasonal rainfall distribution is looking good to adequately test this hypothesis.



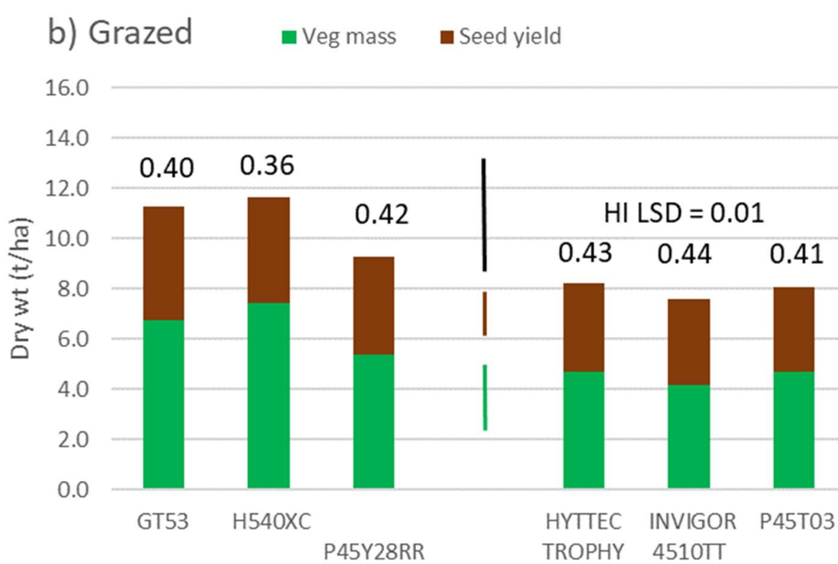


Figure 1: Vegetative mass, seed yield and harvest index (figs above the column) for: a) ungrazed and grazed Roundup Ready (GT53, H540Xc, P45Y28) and Triazine tolerant canola (HyTech Trophy, Invigor 4510, P45T03) grown at Ben Webb's property near Qualeup in season 2021. Colour coded interaction LSD (P<0.05) values are presented as bars, upper LSD is for total biomass, the sum of the vegetative and seed mass columns.

Zhang H, Berger J, Herrmann C, Brown A, Flottmann S. 2020. Canola yield and its association with phenological, architectural and physiological traits across the rainfall zones in south-western Australia. Field Crops Research **258**, 107943.

Zhang H, Berger JD, Seymour M, Brill R, Herrmann C, Quinlan R, Knell G. 2016. Relative yield and profit of Australian hybrid compared with open-pollinated canola is largely determined by growing-season rainfall. Crop and Pasture Science **67**, 323-331.

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What does simulation modelling tell us about yield potential in the Albany Port Zone?

Andrew Fletcher, Chao Chen, Jens Berger

Our objective was to investigate yield potential and the factors leading to improved yield potential in the HRZ with a particular focus on exploiting early sowing opportunities. A central hypothesis being tested was that we could improve wheat yield potential by utilising early sowing opportunities with long-season wheat cultivars that required vernalisation compared to the more commonly used mid and late-spring types.

We used APSIM-Wheat to simulate potential yields of wheat. Initially, the model showed a poor agreement of observed and simulated yields which improved markedly after calibrating flowering time. Thereafter, long-term simulation studies were undertaken for Albany using the calibrated APSIM-Wheat model with relatively recent climate data (1990-2021).

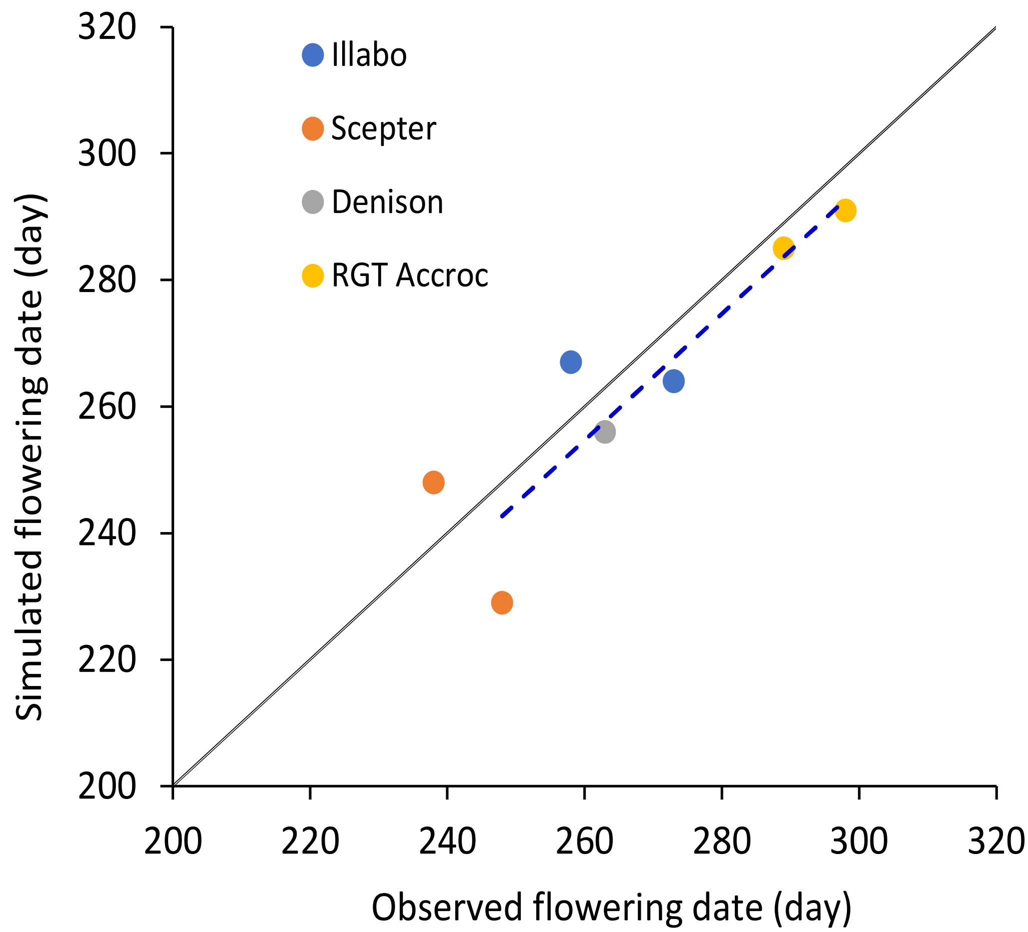

Figure 1. Observed and simulated flowering date at Albany

WA CROP TECHNOLOGY CENTRE (ALBANY)

TIMETABLE

WA CROP TECHNOLOGY CENTRE FIELD DAY (ALBANY): THURSDAY 15 SEPTEMBER 2022

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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

FAR AUSTRALIA

For the afternoon's presentations, would be obliged if you could remain within your designated group number.

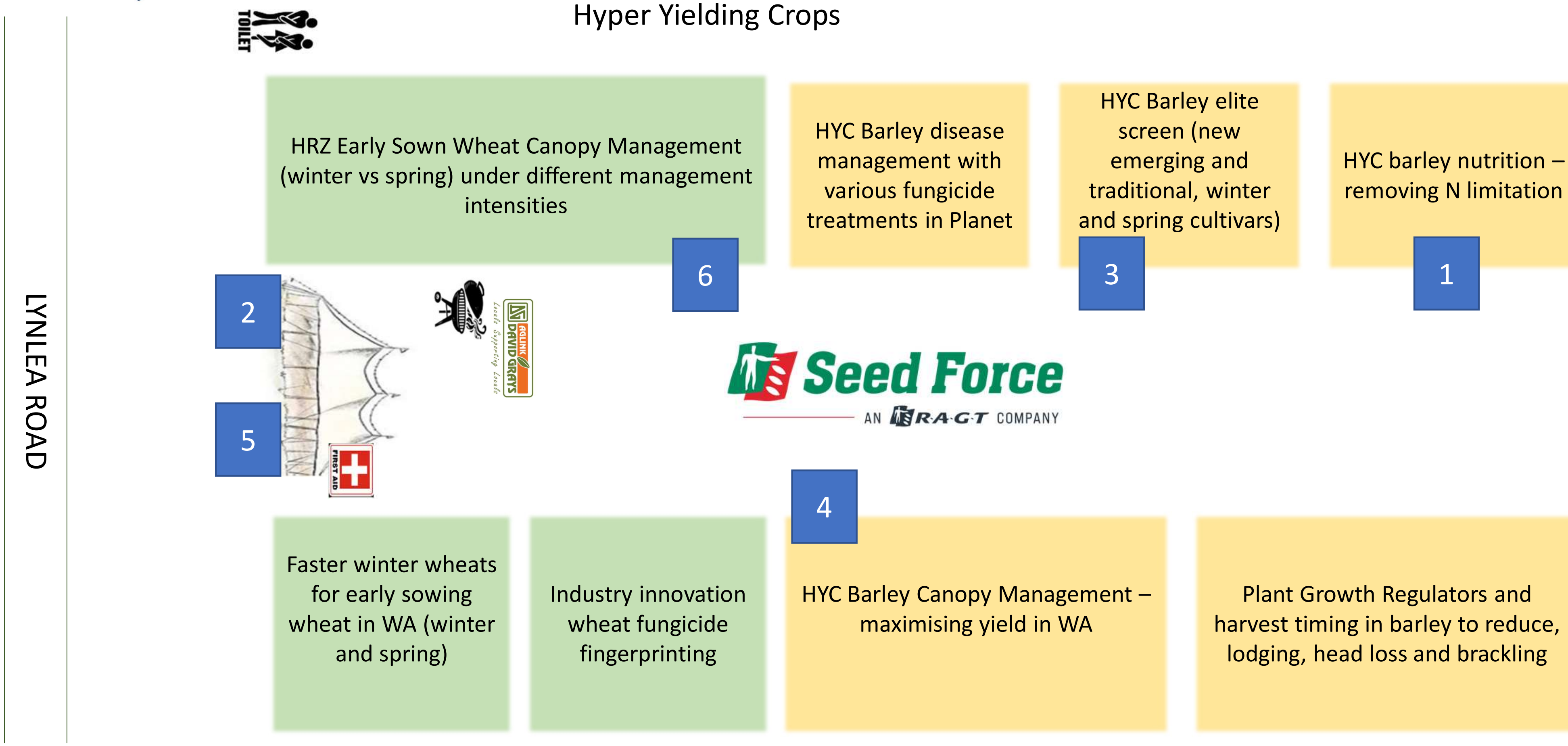
Thank you for your cooperation.

1	(green)
2	(blue)

WA CROP TECHNOLOGY CENTRE (ALBANY)

2022 SITE MAP: WA CROP TECHNOLOGY CENTRE (ALBANY)

Featuring the GRDC's High Rainfall Zone Farming Systems and Hyper Yielding Crops



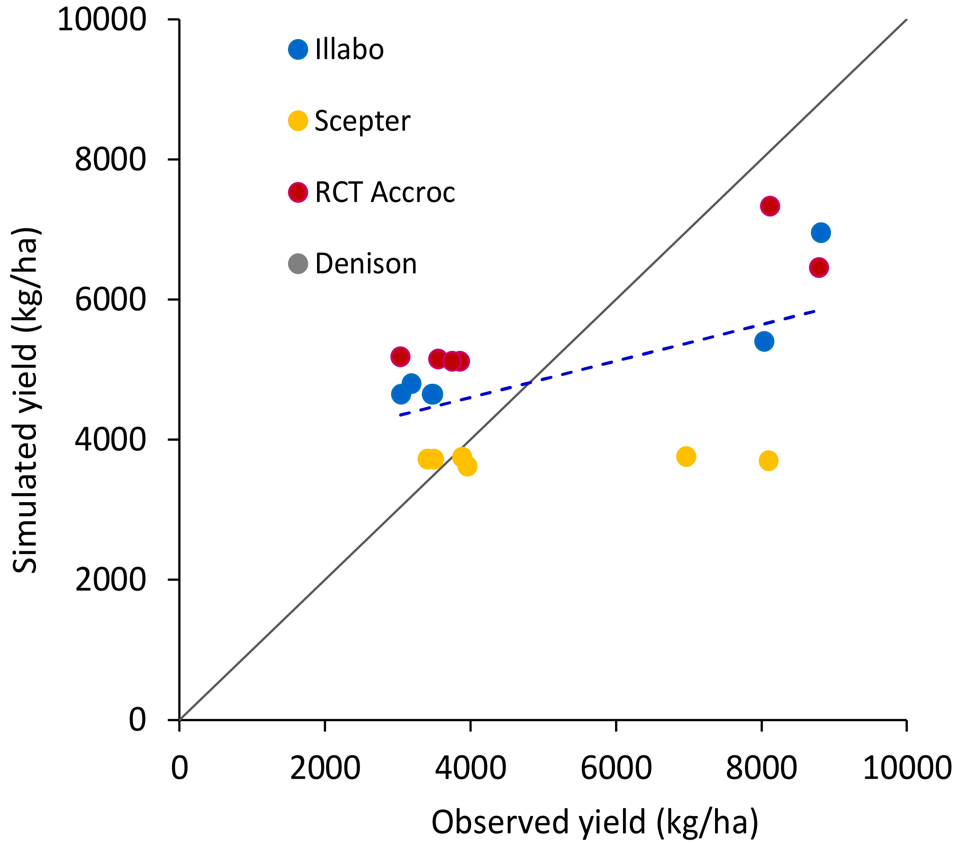


Figure 2. Observed and simulated yield at Albany.

We identified optimal combinations of sowing date and cultivar from six times of sowing (10 Apr, 20 April, 30 Apr, 10 May, 20 May and 30 May) under unlimited N supply. The four cultivars covered a wide range of flowering time, from RGT Accroc (most vernalisation sensitive mid-winter type), Illabo (early winter type), Denison (late spring type) and Scepter (least vernalisation sensitive mid spring type). For early winter type and late spring type cultivars (Illabo and Dension), the greatest yield was achieved when sown around 20 April. Among the four cultivars, the strong winter genotype (RGC Acrocc) achieved the highest yield when sown around 10 April, while for least vernalisation sensitive mid spring type (Scepter), yield had no obvious difference when sown during 10 Apr – early May. Regardless of sowing time, winter cultivars would outperform spring cultivars. And when an early sowing opportunity was available (before 20 April), winter cultivars would achieve higher yields compared to sowing late.

While the calibrated APSIM model has a reasonable agreement between observed and simulated yields, there were still a number of situations where observed yield exceeded the simulated yields. This highlights that farmers in the Albany HRZ are doing a great job and producing yields close to the potential.

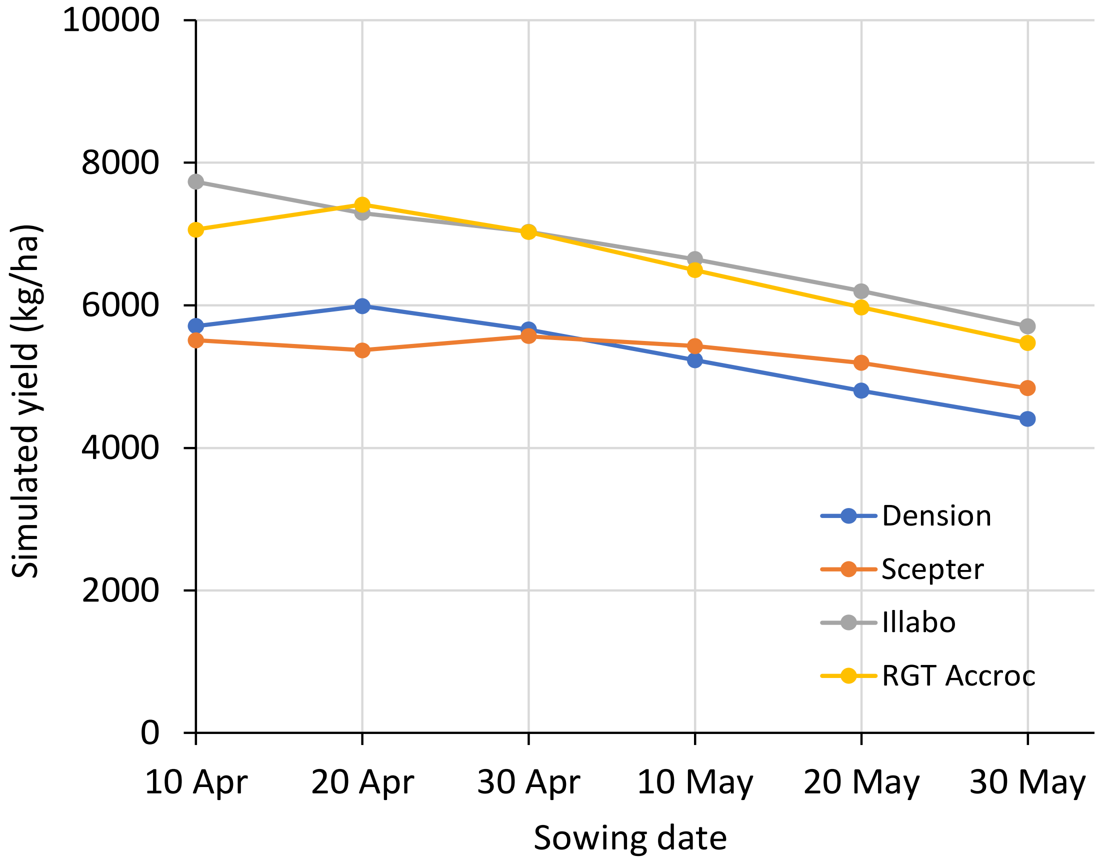


Figure 3. Simulated mean yield at Albany for a range of sowing dates and cultivars.

APSIM underestimation of yield may have been due to:

- Imperfect knowledge of initial starting conditions of the model. (i.e. soil water and N, potential root depth)
- Poor soil characterisation. We made our best estimates of the appropriate soil type but may not have fully captured the impacts of soil.
- Imperfect knowledge of plant growth processes/seasonal responses.

HRZ cropping is a dynamic exercise with growers changing soil characteristics through amelioration and trying out new cultivars that are increasingly sown relatively early compared to traditional practices. To apply models like APSIM in a meaningful way requires lots of data that describes soil conditions and plant growth throughout the season so that the model can be thoroughly validated, and unexpected mismatches between observed and expected used to drive hypotheses that will improve our understanding of the system. We suggest that the yield benefit from long season cultivars sown early is far from settled and needs further investigation.

Breeding barley for the high rainfall production zones

David Moody, Senior Barley Breeder, InterGrain

Breeding barley varieties for the high rainfall production zones have three major challenges:

1. Plant architecture capable of supporting yields in excess of 7t/ha
2. Plant phenology that allows exploitation of the longer growing season provided by these environments.
3. Plant disease resistances that provide plant protection through a long growing season conducive to plant foliar pathogens.
4.

Plant semidwarf genes, generally developed through mutation breeding techniques, are available for reducing plant stature. The major semidwarf gene, sdw1, has been widely deployed globally but still results in a range of plant height possibly due to non-characterised semi-dwarfing genes also occurring in different varieties genetic make-up. Consequently, even with the use of the sdw1 mutation, plant growth regulators may be required to reduce plant height, improve head retention and reduce lodging. Plant varieties also require resistance to brackling, which is a distinct trait independent of lodging and head retention. Brackling occurs when the straw bends or breaks about 30cm below the spike. Varieties possessing semidwarf genes may still be susceptible to brackling. Growers selecting varieties for the HR production zones should consider all of these traits, plant height, plant lodging resistance, head retention tolerance and brackling tolerance, when selecting a variety.

Plant development is driven by three factors: vernalisation requirement, photoperiod requirement and temperature sensitivity.

In general, all barley varieties requiring vernalisation are considered as winter types. This differs from wheat varieties due to the difference in chromosome ploidy levels between the crops. Barley has a relatively simple genetic structure: it is a diploid with a single pair of each of its 7 chromosomes. Hence for each vernalisation gene, there is only a single copy. Wheat is a hexaploid with 3 homeologous pairs of chromosomes. There are three copies of vernalisation genes in wheat, providing wheat with a plasticity that is not present in barley: wheat can have one, two or three copies of the vernalisation genes, providing a range in vernalisation responses. For barley, due to the strong effect of a single vernalisation gene, the relatively mild temperatures in Australia result in a very long duration of vegetative growth and hence a very long period from sowing to flowering. Trial results conducted by FAR indicate the very late maturity of the winter types is not conducive to producing the highest grain yields.

The second mechanism of developing later maturity varieties occurs through selection for a lack of photoperiod sensitivity in the period after an autumn sowing (when daylength is relatively long). This period of plant development prior to a barley plant becoming sensitive to long days, and moving from a vegetative to a reproductive stage of development, is called the basic vegetative phase (BVP). Spring barley varieties developed for European spring sowing conditions typically have a BVP in excess of 30 days duration; spring varieties selected for drier conditions and late autumn/early winter sowing in Australia tend to have a BVP of less than 10 days. The duration of the BVP is also related to the number of leaves on the main stem, the number of nodes on the stem, and, importantly, the number of spikelets per head. Long BVP varieties tend to have a much greater number of grains per spike, giving them higher yield potential under favourable conditions. Once a plant becomes responsive to photoperiod, other genes influence the rate of response to long days. The major photoperiod response gene in barley, PpdH1, occurs in the vast majority of the early flowering Australian varieties but is largely absent in European varieties. PpdH1 accelerates plant development once day-length reaches a minimum critical duration which probably occurs during mid August in Australia. This gene has the effect of causing flowering to occur within a relatively narrow windows, regardless of sowing date. This flowering window may be too early to optimise yield potential in the HRZ cropping system and hence barley varieties without this gene may be preferred – ultimately it depends on the duration of the growing season and soil available water.

The third mechanism of altering the rate of development is through variation in temperature sensitivity. Varieties that lack temperature sensitivity will be slower to develop.

Of these mechanisms, the genetics of vernalisation and photoperiod response are well understood, whereas the genetics of temperature response is complex.
Perhaps the most difficult requirement of high rainfall zone barley breeding is the development of suitable packages of resistance genes capable of alleviating the pressure of multiple pathogens: net form of net blotch, spot form of net blotch, leaf rust, powdery mildew, scald, virus resistance and emerging diseases such as ramularia. The majority of these pathogens require multiple resistance genes to combat evolving race changes. In addition, evolution of fungicide tolerance is a significant problem, particularly amongst the necrotropic (feeding on dead leaf tissue) diseases such as the Spot and Net forms of Net Blotch but also in Powdery Mildew, which is a biotrope (feeding on live leaf tissue).

European varieties tend to be strong in terms of resistance to cooler climate diseases such as powdery mildew and, to a lesser extent, leaf scald. These varieties also tend to have good resistance to leaf rust. In contrast, the European varieties tend to be weak in terms of resistance to the warmer temperature diseases such as the SFNB and NFNB. For the high rainfall production zones in Australia, breeders need to focus on breeding for resistance for those pathogens that are most likely to evolve fungicide resistance, and which are both most prevalent and most damaging. Currently the disease of most concern in the HRZ production environments is the Net Form of Net Blotch. This disease has a very large number of pathotypes, making the assignment of resistance ratings to varieties very difficult. In addition, it is evolving tolerance to commonly grown fungicides.

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SOWING THE SEED FOR A BRIGHTER FUTURE

Achieving hyper yielding barley crops in Southern WA HRZ
Is it different to the Eastern states? Yes, it is.

Kenton Porker[1], James Rollason[1], Jayme Burkett[1], Daniel Bosveld[1], Nick Poole[1], Jeremy Curry[2]
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Take home messages:

- The fundamental principles of canopy management for high productivity **do not change across rainfall zones.**
- The timing of aligning critical yield forming periods and timing and intensity of management inputs **changes with high rainfall environments.**
- Slow winter barley cultivars are not yet well adapted to WA HRZ.
- Yield responses to tactical agronomy management is magnified in the HRZ, and in seasons of better potential, more than any other agroecological zone.
- Increased expenditure on fungicide pays more than plant growth regulators in Planet barley.
- Harvest logistics and variety choice is more important than plant growth regulators for head loss retention.
- Late applications of PGR will help buy time at harvest time in head-loss susceptible cultivars.

Background

We have an aspirational target to reliably achieve 10t/ha grain yield in all regions of the Australian High Rainfall Zone and make barley competitive with wheat. However, the WA climate is warmer, growing season shorter and soil types are typically much less fertile than South-eastern Environments. After the first two seasons of results there are distinctive differences between regions that help us to dissect the management and genetics required for each high rainfall zone.

The first factor is that the critical period is matched to environment; this is earlier in WA than eastern high rainfall zones. Aligning the critical period 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 28 days before awn emergence in barley.

Across all hyper yielding environments, 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. One of the most important differences between WA and other HRZs is that the required flowering dates are earlier in WA. Flowering time responses to yield depended on environment and early flowering was favoured in WA.

Slower developing barley for WA?

Some key observations from 2020 and 2021 are included below.

- Six row winter barley (ie Pixel) and slower 2 row winters such as Newton were 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 centres but were too late in WA.
- The yields achieved by the highest yielding 2 and 6 row winter barley were higher than spring varieties in SA in 2021 but have been comparable with the spring barley control RGT Planet in Vic and SA across other seasons, but not in WA due to flowering too late and thus heat and drought in WA (see 2020 Figure 1)
- The 6-row winter Pixel was the most consistent performer across all environments but is particularly susceptible to lodging, head loss and shattering making harvest timing and PGR use more important than any other management factor.
- 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.

One of the starkest differences between environments is the fact that winter cultivars flowered much later than the spring cultivars in WA relative to other environments and there is a significant gap between the flowering time of spring germplasm compared to winter types in WA; this is reflected in the yield responses (figure 1). The other noticeable feature from the data is that the spring types develop too quickly in WA from April sowing dates, and leave crops vulnerable to frost damage, and or insufficient biomass accumulation. The spring germplasm also flowered much earlier in WA compared to the Eastern states (data not presented).

What these findings mean that if winter or slower developing cultivars are to be successful in WA from earlier sowing, it is unlikely that current Australian varieties or introduced germplasm from Europe will be sufficient, and

- **There will need to be a targeted breeding effort to develop germplasm with a development pattern suited to early sowing.**

- **The alternative solution is to sow slightly later (5 May – 15 May) to optimise the flowering time of high performing spring cultivars**.

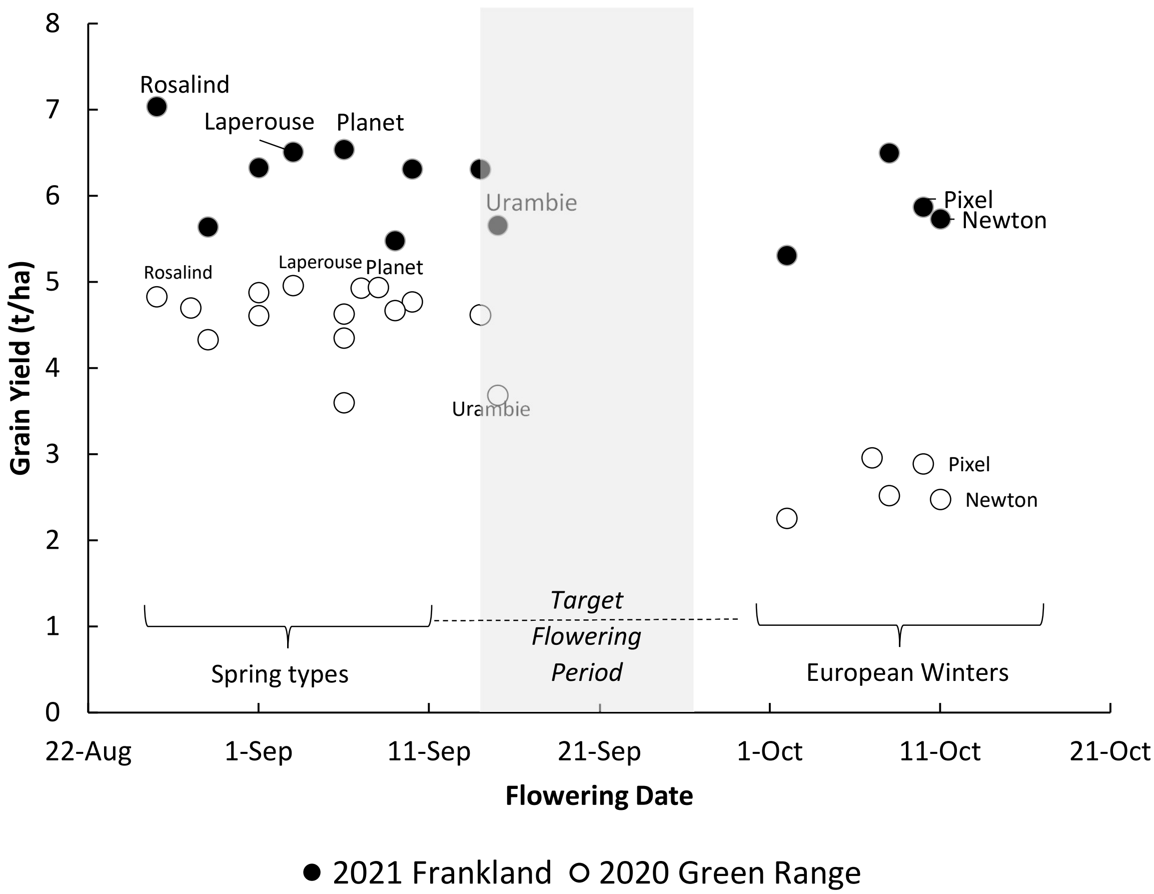

Figure 1. Barley Grain yield response to flowering date at WA Green Range in 2020 at Frankland in 2021 from early sowing (April 20 – 1 May).

The reason for the difference in WA compared to other states, is environmental. Not because a lack of vernalising (or cold) temperatures in WA but due to the fact that daytime daily maximum temperatures are much warmer in WA compared to the eastern states. For example in the graph below daily minimum temperature in July and August are similar at Green Range WA, and Millicent South Australia, but there is a much bigger gap in daily maximum temperatures. Warmer temperatures will accelerate development in spring types during this period, whereas winter types will still be accumulating their cold requirement and thus less affected creating a large gap between germplasm types.

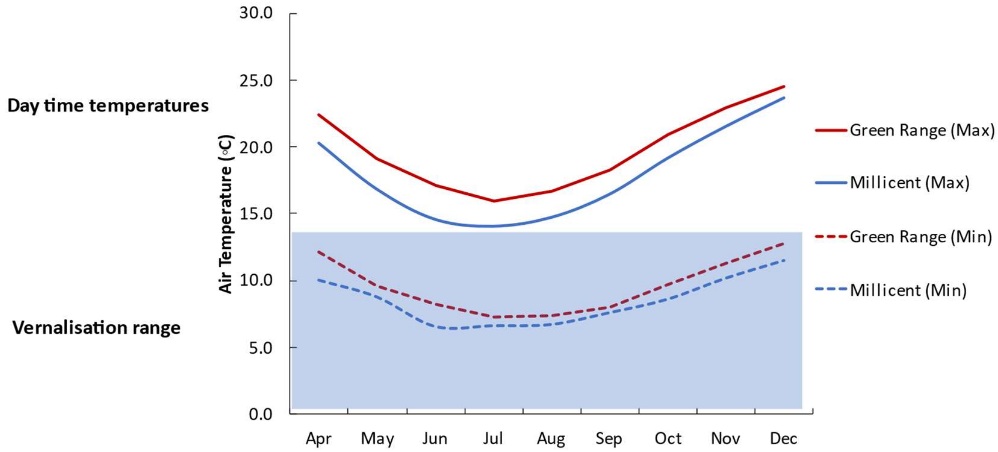

Figure 2. Mean Min and maximum temperature differences between Millicent SA, and Green Range WA (Bom Data 1990 – 2020).

The other important reason quicker winters/slower springs will be required for early sowing in WA is the fact that grain fill conditions are more hostile, drier and warmer compared to eastern high rainfall zones. Varieties or management that maintain grain weight under a more hostile grain filling environment will lead to improved harvest index and yield. Often grain number is the focus at cooler sites, however maintaining grain weight was equally as important for yield in WA in 2020 (figure 3).

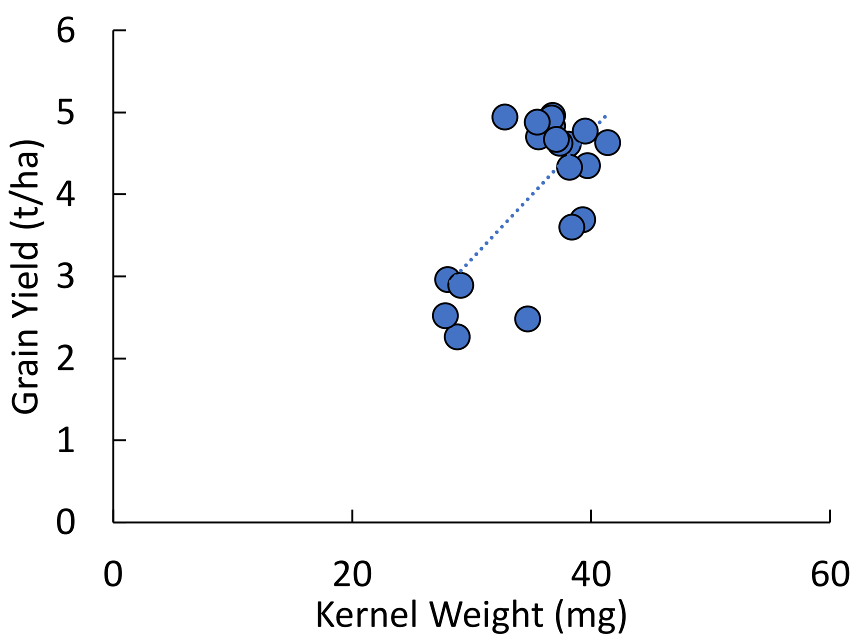

Figure 3. Relationship between grain weight and grain yield at Green Range 2020 WA.

What else can we achieve with crop management? Exploiting management to better match genetics to environment

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 six different management intensities from early sowing (Late April) at two levels of fungicides. Other management factors included canopy intervention such as the addition of a PGR, defoliation and additional Nitrogen highlighted below.

Table 1: Fungicide package, canopy intervention and nitrogen (N) rate applied to each of the six management treatments.

Management Treatment	Fungicide[1]	Canopy Intervention[2]	Total N applied[3]
1. Standard fungicide & no intervention	Standard	None	126 kg N/ha
2. Standard fungicide & PGR	Standard	PGR	126 kg N/ha
3. Higher input fungicide & no intervention	Higher input	None	126 kg N/ha
4. Higher input fungicide & PGR	Higher input	PGR	126 kg N/ha
5. Hyper-yield system	Higher input	PGR	219 kg N/ha
6. Dual-purpose system	Higher input	Defoliation	219 kg N/ha

[1]Standard: GS31 – 500ml/ha Tilt (500g/L propiconazole), GS39 – 290ml/ha Folicur (430g/L tebuconazole).
Higher input: Seed dressing – 150ml/100kg Systiva (333g/L fluxapyroxad), GS31 – 300ml/ha Prosaro (210g/L prothioconazole + 210g/L tebuconazole), GS39 – 840ml/ha Radial (75 g/L azoxystrobin + 75g/L epoxiconazole).
[2]Plant growth regulator (PGR): GS31 – 200ml/ha Moddus Evo (250g/L trinexapac-ethyl).
Defoliation: Prior to GS31 – defoliation with lawn mower to height of 6cm.

The data from the GEM confirms findings above for WA and highlights the effect of cultivar compared to management. The spread between box plots in the visual demonstration below (figure 4) 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. In WA the effect of cultivar was greater or equal to the variation possible with management, **The effect of tactical in season management influenced grain yield by + or – 0.5 t/ha, and a 1 tonne difference between best and worst management in WA in Planet and Rosalind in 2021.**

Whereas at the other cooler and longer season environment management effects are magnified and more important than cultivar and yield responses of up to 5t/ha were observed between treatment 1 and 5.

Defoliation (simulated grazing) increased yields compared to the Hyper yield system in 2021 that relied on PGRs for canopy management. This is important as defoliation delays flowering time and shifts the critical period into more optimal conditions from early sowing, and reduces lodging risk.

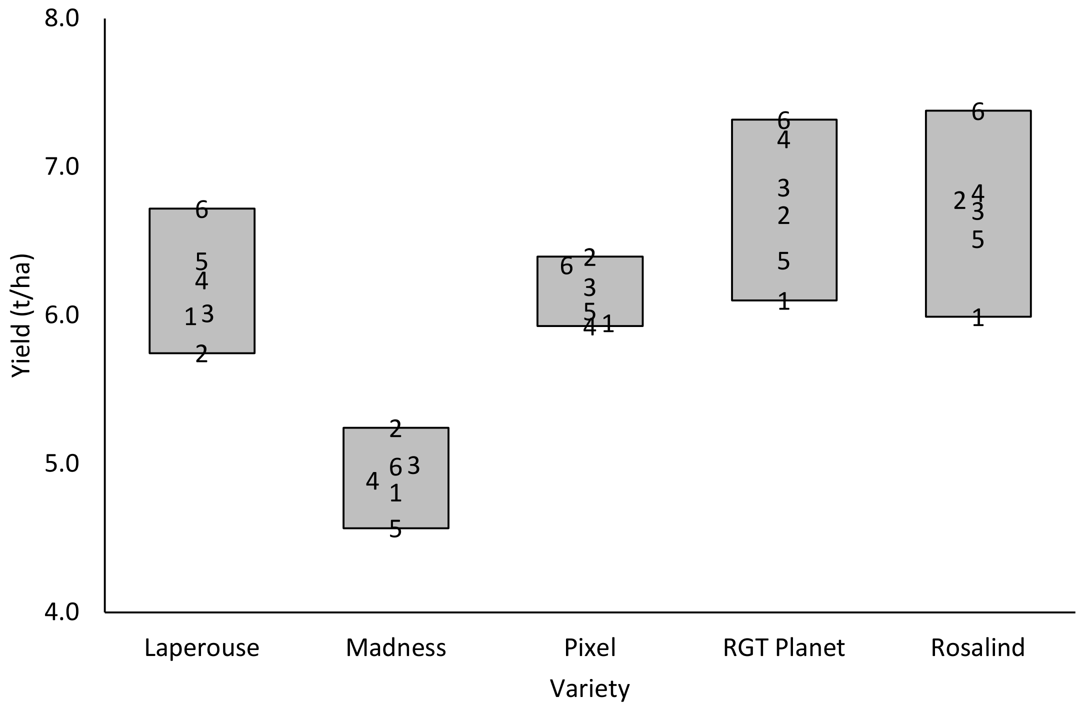

Figure 4: Grain yield of five barley varieties at Frankland in 2021. Shaded area represents range of yields for each variety across the six management treatments which are indicated by treatment number (as per Table 1).

Variety, plant growth regulators and harvest timing to reduce yield losses in barley. What is the difference between lodging, brackling and head loss?

We have a series of national experiments to assess the value of PGRs with delayed harvest in HRZ regions for its effect on grain yield losses due to lodging, head loss and brackling.

Definitions of key barley constraints:

Lodging: Root and Stem - stems bending at the ground node or basal stem near the ground surface. Lodging prior to flowering is usually more damaging to yield but it can also occur after flowering.

Brackling - plants snapping and bent (often in multiple directions) from higher in the plant (typically near nodes). This occurs during late grain fill and when the crop is drying down. Brackling will only typically cause yield losses if whole stems snap off and harvest operations cannot pick up heads.

Headloss - occurs when whole heads (often with or without peduncles attached). This occurs post physiological maturity and can lead to large yield losses.

Results:
In the cultivar Planet there is little evidence to suggest an economic response to plant growth regulators in the high rainfall zones when crops are harvested on time compared to untreated (figure 5). This suggests Planet is relative nonresponsive to PGRs and there has been little evidence of pre flowering lodging in this variety. Importantly PGRs are also not overregulating and not resulting in yield penalties for Planet. **When harvest was delayed there was no additional benefit of PGRs in Planet (data not shown)**

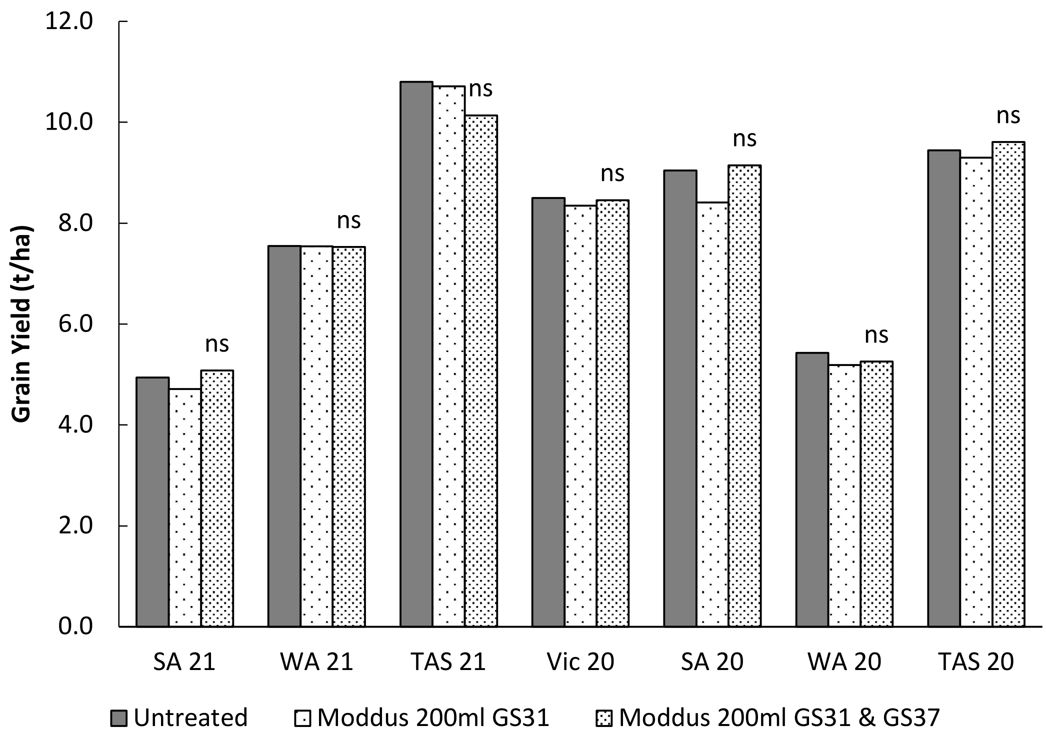

Figure 5. The yield responses to plant growth regulation (Moddus Evo applied at GS31) in barley in the Australian High rainfall Zone for Planet Barley when harvested on time.

Cultivars more susceptible to head loss such as Buff are more likely to benefit from late applications of a PGR to retain heads and improve harvest logistics. For example in 2021 at Frankland the sequence PGR treatment that included a later application of Moddus achieved similar yields to harvesting on timing. However, harvesting on time was more important but PGRs may assist in harvest logistics (Figure 6).

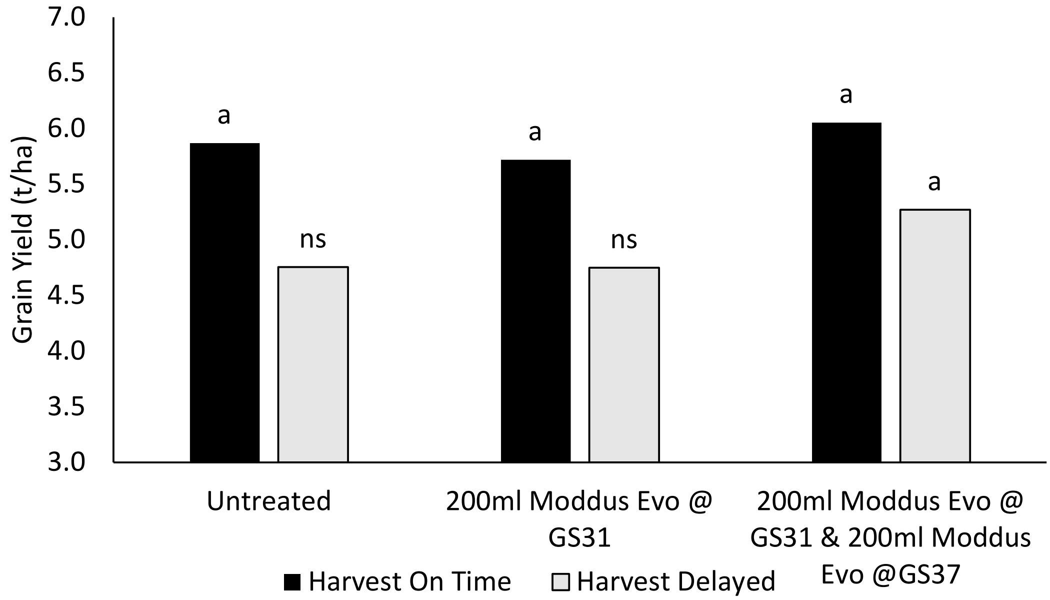

Figure 6. The yield responses to plant growth regulation in Buff barley at Frankland in 2021 when harvested on time and when delayed by two weeks.

Lessons for wheat growers from the High Rainfall Zone (HRZ) Farming Systems projects in Western Australia

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- Early sown slow developing cultivars can produce more biomass but are not yet converting it as efficiently as spring wheat into grain yield due to a later flowering time.
- There is room to move to convert more biomass into yield in WA with other aspects of management such as disease management and better adapted winter wheats.
- Faster winter wheats than Illabo are included in WA for the first time in 2022 experiments.
- Other yield and biomass improvements are likely to come by increasing crop water supply (through soil amelioration) and increasing farm fertility.

Using management to build and protect high yielding crops in wet environments (seasons)

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

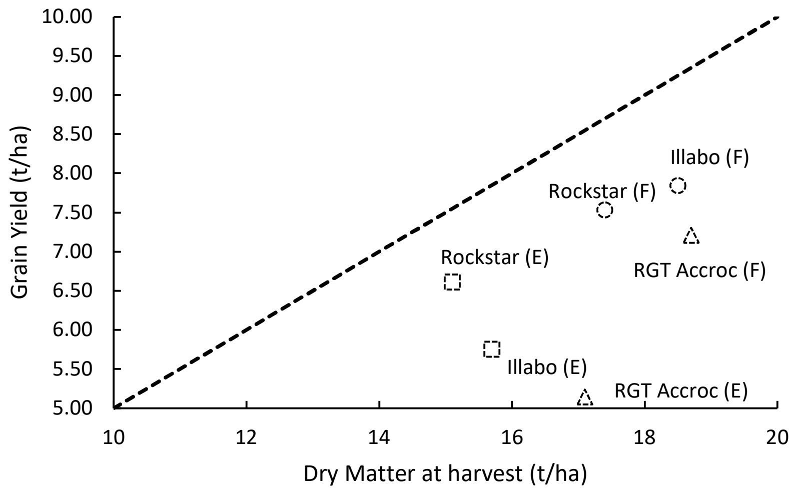

Figure 1. Relationship between dry matter and grain yield (t/ha) at 0% moisture across spring and winter wheat types at Esperance (E) and Frankland River (F), FAR WA Crop Technology Centres. The dotted line represents aspirational yields that are possible with a harvest index of 50%.

While canopy management techniques can improve harvest index, they should not be done at the expense of reduced final biomass. For example, grazing (mowing) spring and winter wheats has been noted to increase harvest index (HI) at some of the HYC trial sites (e.g., Wallendbeen, NSW) but grain yields were not increased due to lower final dry matter at harvest. Effects of grazing on HI in WA cereal trials have been largely neutral. Equally, increases in dry matter at harvest associated with late developing wheats that spend too long in the vegetative period and have flowering windows past the optimum for the region do not maximise grain yield. For example, at Esperance, RGT Accroc⦶ (a red grained feed wheat) flowered in mid-October and had a harvest index of 30% (Figure 1 & Table 2). In contrast, at Frankland River where grain yields were higher, RGT Accroc ⦶ was able to translate a greater proportion of its harvest dry matter into higher grain yield with an HI of 39% (Table 3).

Table 2. Influence of cultivar on grain yield (t/ha) under different canopy management regimes – FAR Esperance Crop Technology Centre 2021 sown 16 April.

	Canopy Management (Grain Yield t/ha)						
	Standard Input		**"Grazed" Standard**		**High Input**		**Mean**
Cultivar (Type)	t/ha		t/ha		t/ha		t/ha
Illabo⦶ (Winter)	5.63	fgh	5.95	efg	6.47	b-e	**6.02**
Rockstar⦶ (Spring)	6.24	c-g	6.04	efg	7.44	a	**6.57**
LRP19-14347 (Winter)	6.22	c-g	6.09	efg	6.93	abc	**6.41**
Cutlass ⦶ (Spring)	5.91	efg	4.98	hi	6.49	b-e	**5.79**
Denison⦶ (Spring)	6.36	b-f	6.14	d-g	7.00	ab	**6.50**
RGT Accroc⦶ (Winter)	5.67	fgh	5.58	gh	5.78	efg	**5.67**
Scepter⦶ (Spring)	5.02	hi	4.56	i	6.85	a-d	**5.47**
Mean	**5.86**	**b**	**5.62**	**b**	**6.70**	**a**	
LSD Cultivar p = 0.05 b		0.43		P Value		0.026	
LSD Management p=0.05 a		0.28		P Value		<0.001	
LSD Cultivar x Management P=0.05		0.74		P Value		<0.001	

Standard Input – 182kg N/ha and two fungicides, Grazed + Standard Input – standard input with mechanical defoliation, High input – 223kg N/ha, three fungicides (including a strobilurin & a SDHI) and a PGR.

Trial results to date at Esperance have indicated no yield advantage of winter wheats relative to spring in a relatively frost-free environment. This is despite spring wheats flowering in August prior to the recognised optimal flowering window of mid-September. Similar findings have been observed at the Frankland site (which did not suffer frost or waterlogging) where Rockstar (spring wheat) and Illabo (winter wheat) both yielded just under 9t/ha from a 29 April sowing (Table 3). Despite achieving similar yields to spring wheats, low harvest indices have been a consistent theme with winter genetics that are not as well adapted to the environment. Breeding efforts for WA have historically focussed on spring wheats that have been selected for a higher harvest index and faster development that suit WA's shorter grain filling period (relative to the HRZs in other states). While management can improve HI to some extent, it is likely that quicker winter types and more breeding selection are required to improve before some of the modelled yields can be realised. These are included in 2022 experiments utilising faster winter wheats developed in a PhD by David Cann at LaTrobe University.

Table 3. Influence of cultivar on grain yield (t/ha) under different canopy management regimes - Frankland River FAR Albany Crop Technology Centre 2021 sown 29 April.

	Canopy Management (Grain Yield t/ha)						
	Standard Input		**"Grazed" Standard**		**High Input**		**Mean**
Cultivar (Type)	t/ha		t/ha		t/ha		t/ha
Scepterⓓ (Spring)	6.97	gh	5.83	i	8.10	bcd	**6.97**
Illabo ⓓ (Winter)	8.04	cde	6.96	gh	8.82	a	**7.94**
LRPB19-14347 (Winter)	7.11	fgh	6.79	h	8.47	abc	**7.46**
Rockstar ⓓ (Spring)	8.12	bcd	6.72	h	8.93	a	**7.92**
Vixen ⓓ (Spring)	6.80	h	5.79	i	7.73	def	**6.77**
Cutlass ⓓ (Spring)	7.36	e-h	6.91	gh	8.02	cde	**7.43**
RGT Accroc ⓓ (Winter)	8.79	ab	7.57	d-g	8.12	bcd	**8.16**
Mean	**7.60**		**6.65**		**8.31**		
LSD Cultivar p = 0.05		0.40			**P Value**	<0.001	
LSD Management p=0.05		0.95			**P Value**	0.015	
LSD Cultivar x Management P=0.05		0.70			**P Value**	0.006	

Standard Input – 130kg N/ha and two fungicides, Grazed + Standard Input – standard input with mechanical defoliation prior to GS30, High input – 223kg N/ha, three fungicides (including a strobilurin & a SDHI) and a PGR

Plot yields: To compensate for edge effect a full row width (22.5cm) has been added to either side of the plot area (equal to plot centre to plot centre measurement in this case).

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