June 2023

NGN Barley management options to close the yield gap and reduce pre-harvest losses

FAR BA B22-02 & FAR BA B22-03

FAR2204-002SAX

Hart (South Australia), Nullawil (Victoria)

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Trial Title **Barley Management options to close the yield gap and reduce pre harvest losses**

Reference **FAR2204-002SAX**

Trial Sites Hart, SA (**HART Field-site Group) and Nullawil, Vic (BCG)**

Research Organisation **Field Applied Research (FAR) Australia**

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Report Submitted **14 June 2023**

Key Points

- In 2022, a cooler and wetter than average year, higher intensity of management (through increased nitrogen supply and fungicide use) significantly increased yields.
- RGT Planet was the highest yielding variety at both sites, yielding 5.85 t/ha at Nullawil (BCG) and 6.16 t/ha at Hart (HART).
- Higher average yields were achieved by all cultivars at a later May sowing at the Nullawil site whereas Cyclops and Leabrook averaged higher yields at an earlier time of sowing when grown at the Hart site. This highlights the importance of matching variety and sow date to the critical period to achieve actual yields closer to potential yield.
- Neither site saw a yield response to the application of plant growth regulators (PGRs), however Hart did see a yield increase to simulated grazing.

Background

Growers in the low and medium rainfall zones of the Southern and Northern regions have identified different constraints that prevent maximum attainable yield in barley. These constraints include head loss, brackling and lodging control, and disease management. Management practices which include variety selection, canopy management and crop protection strategies need to be clearly defined to determine the economically attainable yield. Recent research demonstrates that applying canopy management tools in barley such as fungicides, time of sowing and PGRs can lead to yield responses ranging from 3 – 8 t/ha while utilising similar genetics used in the high rainfall zone. These factors have been more important than nitrogen management, where yield potential exceeds 5 t/ha or on fertile soils. These results contrast to recent yield gap simulation studies that have not considered issues of lodging, head loss, brackling and disease but instead suggest sowing time and nitrogen deficit are the biggest factors leading to the yield gap.

OBJECTIVES

This investment will deliver a series of field trials and extension activities to reduce the yield gap between attainable yield and water limited yield potential in barley in the low – medium rainfall zones alongside virtual trial treatments derived by crop models to determine new attainable yield benchmarks for barley growers.

TREATMENTS

Eight levels of increasing management intensity will be applied to each environment that replicates standard through to intensive management (full disease control, canopy controlled, and nitrogen for a decile 9 season).

There are two nitrogen treatments at all fungicide control levels to assess yield gap related to N and disease. There are three canopy interventions at high N to assess yield gap related to canopy control. Each treatment was tested over three differing cultivars and two sow dates.

No.	Treatment	Fungicide	Canopy	Nitrogen
1.	Nil Fungicide - Low N	Nil	Nil	Low – Decile 2-3
2.	Intermediate - Low N	1 Unit	Nil	Low – Decile 2-3
3.	Full Potential - Low N	Full	Nil	Low – Decile 2-3
4.	Nil Fungicide - High N	Nil	Nil	High – Decile 8-9
5.	Intermediate - High N	1 Unit	Nil	High – Decile 8-9
6.	Full Potential - High N	Full	Nil	High – Decile 8-9
7.	Full Potential + PGR	Full	PGR31 & 37	High – Decile 8-9
8.	Dual Purpose System	Full	Defoliation	High – Decile 8-9
9.	Nil N (HART ONLY)	Full	Nil	Nil

Fungicide

Three levels of fungicide management, ranging from nil to 2 units

Trt	Sowing		GS31	GS39-49	GS59
Nil	Standard		---	---	---
1 Unit	Standard		Prosaro 300 mL/ha	---	---
Full	Standard	Systiva 150 mL/100kg	Prosaro 300 mL/ha	Aviator Xpro 500 mL/ha	Opus 500 mL/ha

Canopy Intervention

Canopy Intervention and canopy control consisted of a PGR application and mechanical defoliation (simulated grazing).

Trt	GS16-22 (Vegetative)	GS30	GS33-37
Nil	---		---
PGR	---	Moddus Evo 200 mL/ha	Moddus Evo 200 mL/ha
Defoliation	Yes*	Yes	

*Early vegetative grazing on completed on TOS1 at Nullawil due to lower biomass at other timings.

Nitrogen

Nitrogen was managed based on starting soil water and N using yield prophet lite and targeted yields. All N was applied in a single top-dress as urea at growth stage 32 (5 Aug).

Yield Targets (t/ha)	Nullawil, Vic	Hart, SA
Low N (D2-3 Finish)	3.5	3.6
High N (D8-9)	5.8	5.7
Total N Supplied (kg/ha)*		
Low (D2-3)	143	140
High (D8-9)	243	220

* Includes 77kg N/ha (BCG) and 75kg N/ha (HART) supplied from soil (0-100cm)

Cultivars

1. RGT Planet (High yielding but disease susceptible)
2. Cyclops (High yielding low rainfall erect cultivar, but brackling prone)
3. Leabrook (Vigorous lodging check, compass type).

Sow Date

	Nullawil, Vic	Hart, SA
TOS1	4th May	27th April (effective sow date 30th May after rainfall)
TOS2	20th May	17th June

RESULTS AND DISCUSSION

Nullawil Site

Grain yield varied from 3.6 t/ha to 6.9 t/ha as a result of management strategy. Highest grain yield was achieved when disease was controlled, and higher N rates were used at both times of sowing.

Table 1. Influence of agronomic management and time of sowing on barley grain yield (t/ha) – (mean of three cultivars)

Trt ID	Canopy	TOS 1	TOS 2	Mean
		Yield (t/ha)	Yield (t/ha)	Yield (t/ha)
1	Nil Fungicide, Low N	3.56 g	4.59 e	**4.10 e**
2	Intermediate, Low N	4.57 ef	5.13 d	**4.86 c**
3	Full Potential, Low N	4.94 de	5.92 bc	**5.45 b**
4	Nil Fungicide, High N	4.10 f	4.85 de	**4.49 d**
5	Intermediate, High N	5.18 d	5.75 c	**5.48 b**
6	Full Potential, High N	6.02 bc	6.76 a	**6.41 a**
7	Full Potential, Canopy	5.96 bc	6.87 a	**6.43 a**
8	Dual Purpose System	6.22 b	6.69 a	**6.46 a**
	Mean	**5.07 b**	**5.82 a**	
LSD Management (P=0.05)		0.18	**P-Value**	<0.001
LSD Sow Date (P=0.05)		0.09	**P-Value**	<0.001
LSD Mgmt. x Sow Date (P=0.05)		0.25	**P-Value**	0.017

Fungicide

At both times of sowing, the biggest yield response was seen by increasing fungicide intensity. Yield response to fungicide ranged from 0.50 t/ha from a single application to up to 2.00 t/ha when four fungicide units were applied. Crops were more responsive to fungicide under high nitrogen management at both times of sowing. Both these management strategies were seen to create bigger crop canopy which favoured disease development, requiring a more intensive fungicide strategy to protect potential yield. Early season disease was predominantly spot form of net blotch (SFNB) but later season observations during grain fill indicated that leaf rust infection was high and the probable reason for such significant yield responses to fungicide and brackling differences (data not presented).

Nitrogen

In general, a significant yield response was recorded when N rates were increased from 60 kg N/ha to 160 kg N/ha. Yield response to additional nitrogen ranged from 0.20 t/ha (not significant) to more than 1 t/ha where higher inputs of fungicide were combined. The yield responses to additional N were reduced where disease wasn't controlled and increased where fungicide intensity was increased.

Canopy management

At both times of sowing, there were no yield benefits to applying additional canopy management interventions (PGR application or mechanical defoliation *simulated grazing*) when compared to the high input fungicide and nitrogen rates alone. However this created the scenario where the economic value of grazing during the season came at no cost to final grain yield.

Cultivar

RGT Planet was the highest yielding cultivar at both times of sowing, yielding 5.34 t/ha at TOS1 and 6.33 t/ha at TOS2 (Figure 1). All cultivars yielded higher when sowing date was delayed with an average increase of 0.75 t/ha.

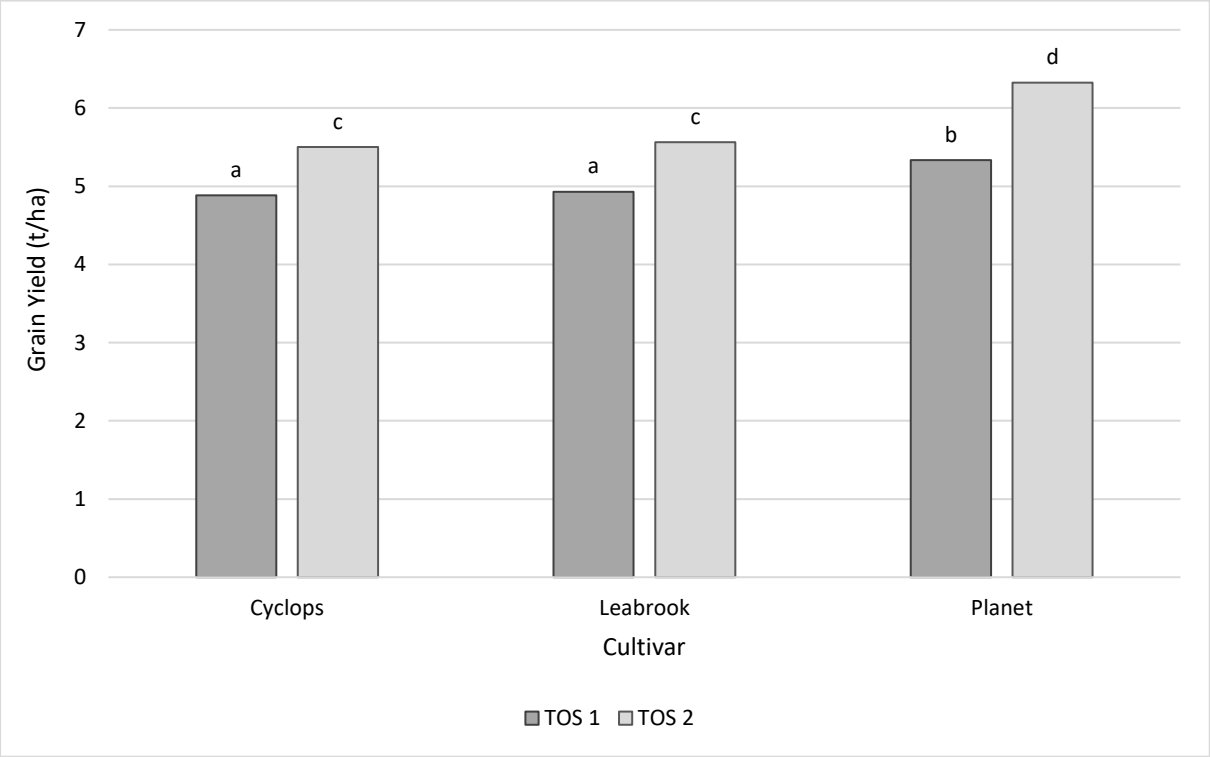

Figure 1. The effect of cultivar and time of sowing on grain yield (t/ha). Figures with different letters show significant difference. LSD=0.16 t/ha, P Value =0.002.

Hart Site

Grain yields varied from 4.09 t/ha to 6.98 t/ha across all treatments in the trial. In 2022, yield was maximised by applying the high rate of N, controlling disease with an intensive fungicide program, growing the high yielding variety RGT Planet and by defoliating the canopy.

Table 2. Influence of agronomic management and variety choice on barley grain yield (t/ha) – Mean of both sow dates.

Nitrogen	Fungicide	Canopy	Cyclops		RGT Planet		Leabrook		Mean	
Low	Nil	-	4.61	l	5.83	fg	4.37	mn	**4.94**	**e**
Low	Low	-	5.07	j	5.99	e	4.87	k	**5.31**	**d**
Low	High	-	5.60	h	6.39	c	5.30	i	**5.76**	**c**
High	Nil	-	4.50	lm	5.67	h	4.35	n	**4.84**	**e**
High	Low	-	5.60	h	6.50	bc	5.30	i	**5.80**	**c**
High	High	-	5.93	ef	6.57	b	5.69	gh	**6.06**	**b**
High	High	PGR	5.95	ef	6.50	bc	5.72	gh	**6.05**	**b**
High	High	Defoliation	6.16	d	6.90	a	6.03	de	**6.36**	**a**
Nil	High	-	4.33	n	5.06	j	4.10	o	**4.49**	**f**
		Mean	**5.30**	**b**	**6.16**	**a**	**5.08**	**c**		
		LSD Management P=.05		0.23			**P-Value**			<0.001
		LSD Cultivar P=.05		0.05			**P-Value**			<0.001
		LSD Man. x Cultivar P=.05		0.15			**P-Value**			<0.001

Fungicide strategy

The fungicide strategies varied from no fungicide, a single foliar fungicide at GS31, and 3 foliar fungicides plus Systiva on the seed. Increasing the fungicide program intensity was most important under a high nitrogen program, for Cyclops and Leabrook in particular. The application of Prosaro at GS31 gave an average of 0.96 t/ha yield response across all varieties. Increasing to three foliar sprays gave an additional 0.33 t/ha and 0.39 t/ha grain yield for Cyclops and Leabrook respectively, however there was no significant increase for RGT Planet (table 2.). This is despite the nil fungicide treatments under both nitrogen regimes having the same levels of disease (table 3).

High levels of disease were assessed in this trial, with leaf rust being the predominant disease, particularly late in the season. Small amounts of net form of net blotch (NFNB) and SFNB were also present in the trial.

No fungicide treatment gave complete control of disease. However, the high intensity fungicide program was required to give the best disease control in a high-pressure year reducing disease infection from 83.3% leaf area infected in untreated Leabrook down to 0.8%.

Table 3. Influence of fungicide management and variety choice on plot disease infection (%leaf area infected of plot) assessed during grain fill. Disease a mix of net blotches and rust.

Nitrogen	Fungicide	Canopy	Cyclops		RGT Planet		Leabrook		Mean	
Low	Nil	-	61.0	d	52.3	e	74.6	b	**62.6**	**a**
Low	Low	-	29.3	g	42.5	f	58.7	de	**43.5**	**b**
Low	High	-	0.7	h	1.8	h	0.4	h	**0.9**	**c**
High	Nil	-	69.7	bc	51.6	e	83.3	a	**68.2**	**a**
High	Low	-	35.1	fg	31.4	g	63.7	cd	**43.4**	**b**
High	High	-	1.5	h	2.3	h	0.8	h	**1.5**	**c**
Mean			**22.5**	**b**	**21.3**	**b**	**32.0**	**a**		
LSD Management P=.05			9.4				**P-Value**		<0.001	
LSD Cultivar P=.05			2.8				**P-Value**		<0.001	
LSD Man. x Cultivar P=.05			8.5				**P-Value**		<0.001	

Nitrogen Management

Nitrogen program was a significant driver of grain yield, yields increased from 4.49 t/ha with no applied nitrogen to 6.06 t/ha with 135kg N/ha applied (table 2). Except for the nil fungicide, each fungicide program implemented was higher yielding under higher nitrogen rates.

Higher nitrogen rates did create more and earlier lodging (figure 2), but scores overall were low (max 163 of a 0-500 score) and were likely not limiting yield. A similar story is shown for brackling, where higher N rates generated higher levels of brackling which resulted in more head loss though a yield penalty isn't evident in the results. However, if harvest was delayed or bad weather was experienced later in the season, the result would be expected to be different.

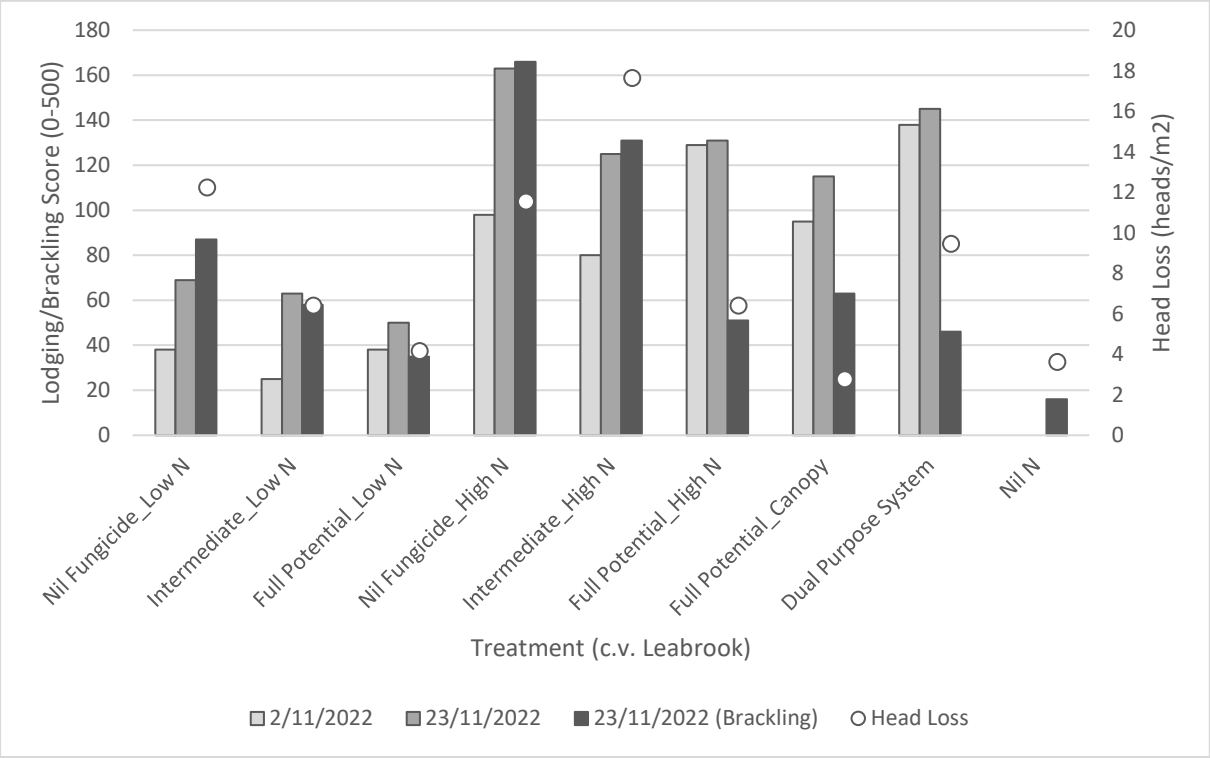

Figure 2. Influence of agronomic management on lodging index (0-500), brackling (0-500), and head loss in Leabrook.

Canopy Management

Canopy management tactics implemented in this trial included defoliation and the use of PGRs. The highest yields were achieved in treatments where the canopy was defoliated pre GS30. This is likely a factor of 2022 being a longer/wetter season than normal where excess growth prior to GS31 can be unproductive and lead to lower yields through lodging and shading. In a more 'normal' or less productive season the response to defoliation may be different.

Canopy management through the use of PGRs helped to reduce lodging and head loss, but as mentioned above, this did not result in yield differences.

Variety Choice

Three varieties were selected for this trial, each with specific traits to be tested, these being RGT Planet (high yielding, disease susceptible), Cyclops (high yielding ow rainfall, erect type, but brackling prone), and Leabrook (vigorous lodging susceptible).

Variety choice accounted for 1.18 t/ha in yield variation (figure 3). RGT Planet was the highest yielding variety with an average yield of 6.16 t/ha, followed by Cyclops yielding 5.31 t/ha and the lowest yielding variety was Leabrook achieving 5.08 t/ha.

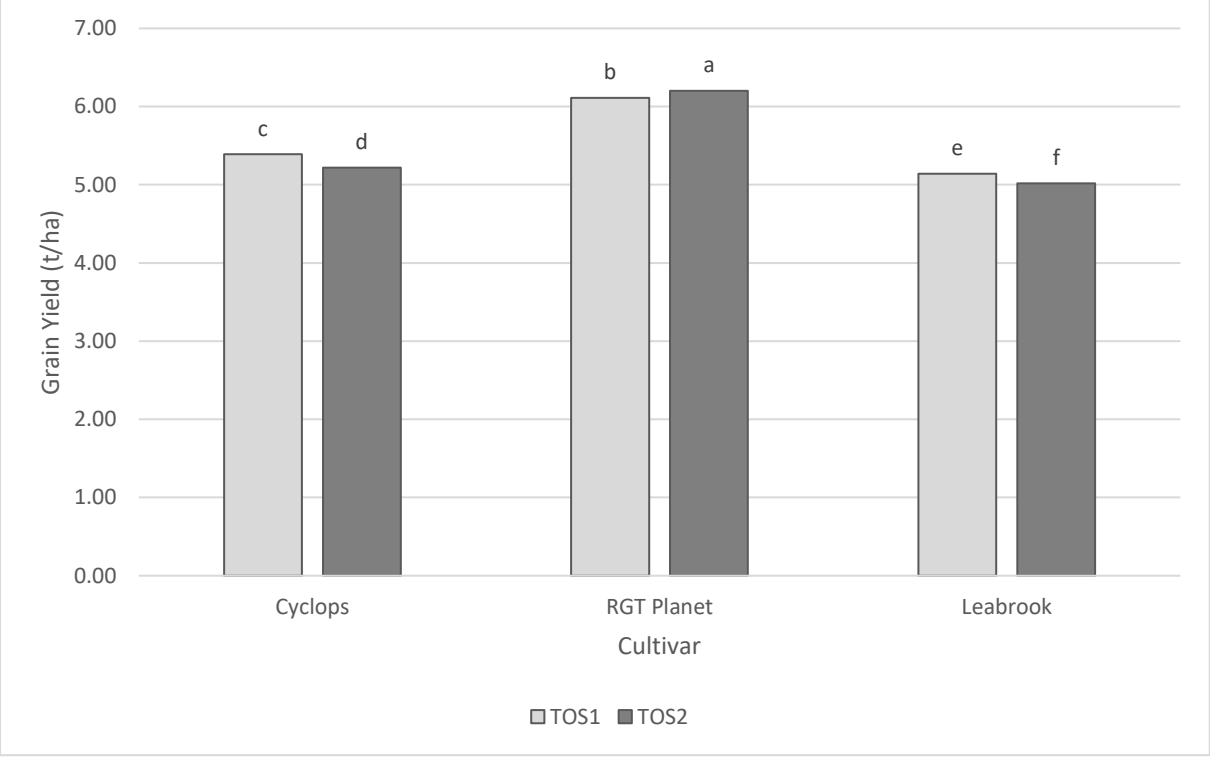

Figure 3. Influence of barley variety and time of sowing on grain yield (t/ha).

Despite RGT Planet being included as a disease susceptible variety (rated s-vs to net blotches) Leabrook experienced the highest disease pressure due to high amounts of rust present in the season. Leabrook also experienced the highest levels of lodging, brackling and head loss of the three cultivars.

Sow Date

Two sow dates were used in this trial to influence flowering date, 27th April (effective sow date 30th May after rainfall), and 17th June. On average, time of sowing didn't affect yield (TOS1 – 5.55 t/ha, TOS2 – 5.48 t/ha) however there was an interaction between sow date and variety. RGT Planet was highest yielding at TOS2 (6.20 t/ha vs 6.11 t/ha) while Leabrook and Cyclops were higher yielding at TOS1 (5.14 t/ha vs 5.02 t/ha and 5.39 t/ha vs 5.22 t/ha respectively) showing the importance of matching sow date with the phenology of the individual cultivar.

Time of sowing also had a significant effect on disease levels present. It is generally expected that early sown crops are more susceptible to disease as they are exposed to pathogens in the environment for longer, however in this trial we saw higher disease infection with later sown crops (Figure 4.). This is likely due to TOS2 canopies staying greener for longer making them susceptible to rust infections later in the seasons as temperatures start to rise.

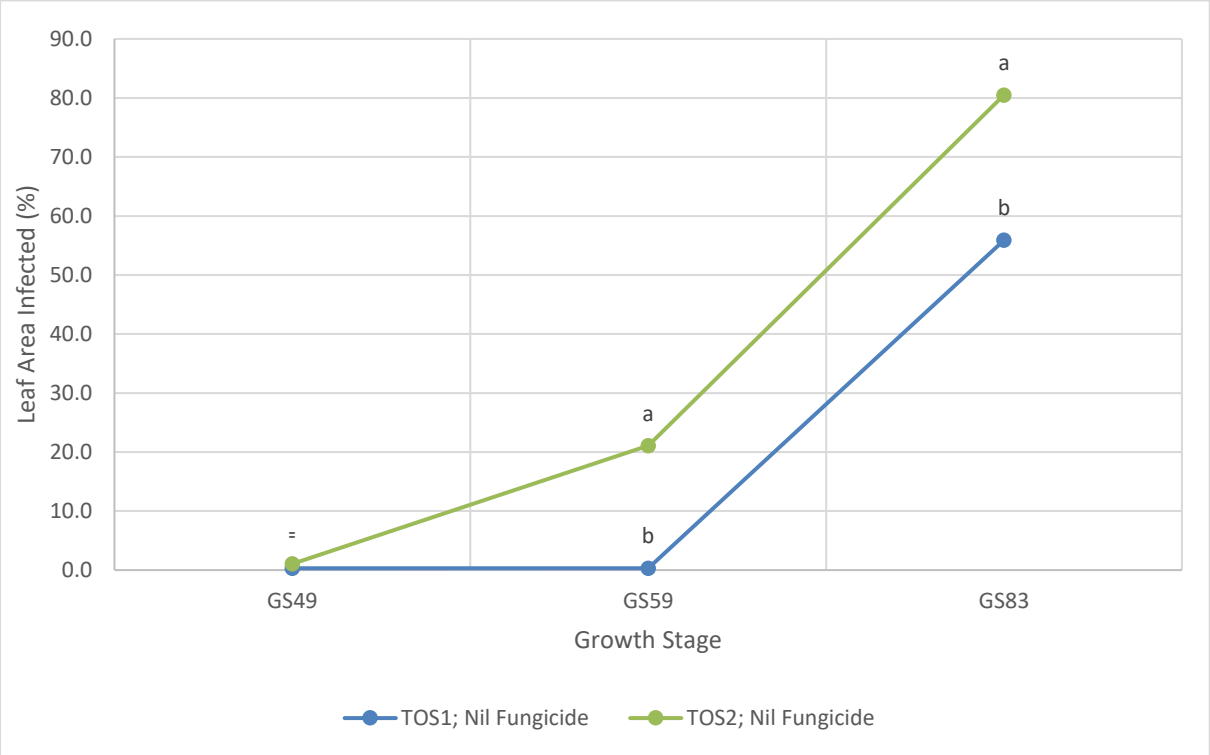

Figure 4. Influence of time of sowing on plot disease infection (% plot disease). Assessed during grain fill. Disease assessed include SFNB, NFNB and leaf rust.

CONCLUSIONS

Trial results from 2022 show what can be achieved in cooler seasons where yield potential is not constrained by soil moisture stress. In 2022, the management decisions that resulted in the greatest yield gap between yield potential and realised yield were those taken on disease management. The importance of protecting the upper portion of the crop canopy to maintain light interception and to protect yield was evident in 0.30 -1.00 t/ha yield losses that occurred with sub optimal (a single spray program and up to 2.00 t/ha yield losses when no disease management was applied. An intensive fungicide strategy consisting of three foliar applications, targeted at protecting key leaves and leaf sheaths of the canopy at GS31, GS39 and GS59, is typically the prerequisite of securing high yields in the southern high rainfall zones (HRZ) of Australia. This trial has illustrated that the same management strategies can be employed in better seasons in lower yielding environments. This intensive strategy was required to maximise yield while a single application at GS39-49 still gave significant protection of the upper canopy resulting in almost 1.00 t/ha yield increase under high N management which is still significant.

Building the right canopy for a high yielding barley crop starts with selecting the right sowing date match with the cultivar being grown to ensure the crop flowers in the optimum window (when the risk of heat, frost and drought is low, and when the critical period for setting yield potential is best aligned with cool and sunny conditions). The cool wet finish to 2022 has reduced the heat risk of such a late sow date at Hart and did not result in a yield penalty.

Selecting the correct level of nitrogen supply to match the rainfall decile builds the correct sized canopy that can produce a high yielding crop in years with better spring rainfall deciles. The data presented suggests more N is required than district practice to ensure yield potentials are met in seasons like 2022. While this was achieved with applied N a more long-term approach would aim to maintain soil fertility and organic matter using pasture or legume phases, crop residues and limited tillage. The results also highlight the need for careful consideration in protecting these larger canopies, resulting from higher nitrogen supply, from disease infection.

While no significant yield response was seen from the use of PGRs in this trial, they can also be an important factor in protecting yield potential in weaker strawed cultivars and through improving harvest logistics, where large acreages reduce the timeliness of harvest. The application of growth regulators combined with good disease control and timely harvest ensures pre harvest yield losses are reduced, particularly in barley where head loss due to brackling can be problematic.

Meteorological data

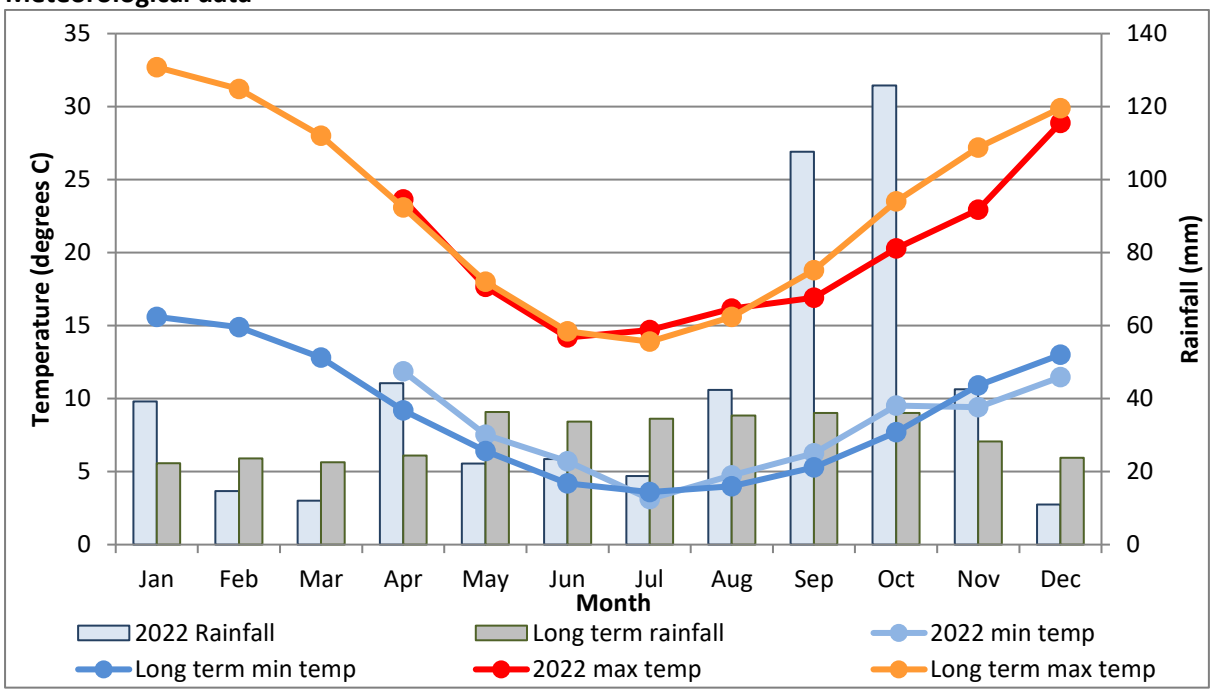

Figure 5. Meteorological data for Nullawil site. April-December data captured on site, January-March and long-term rainfall from Culgoa BOM station (15km), long-term temperatures from Charlton BOM station (50km).

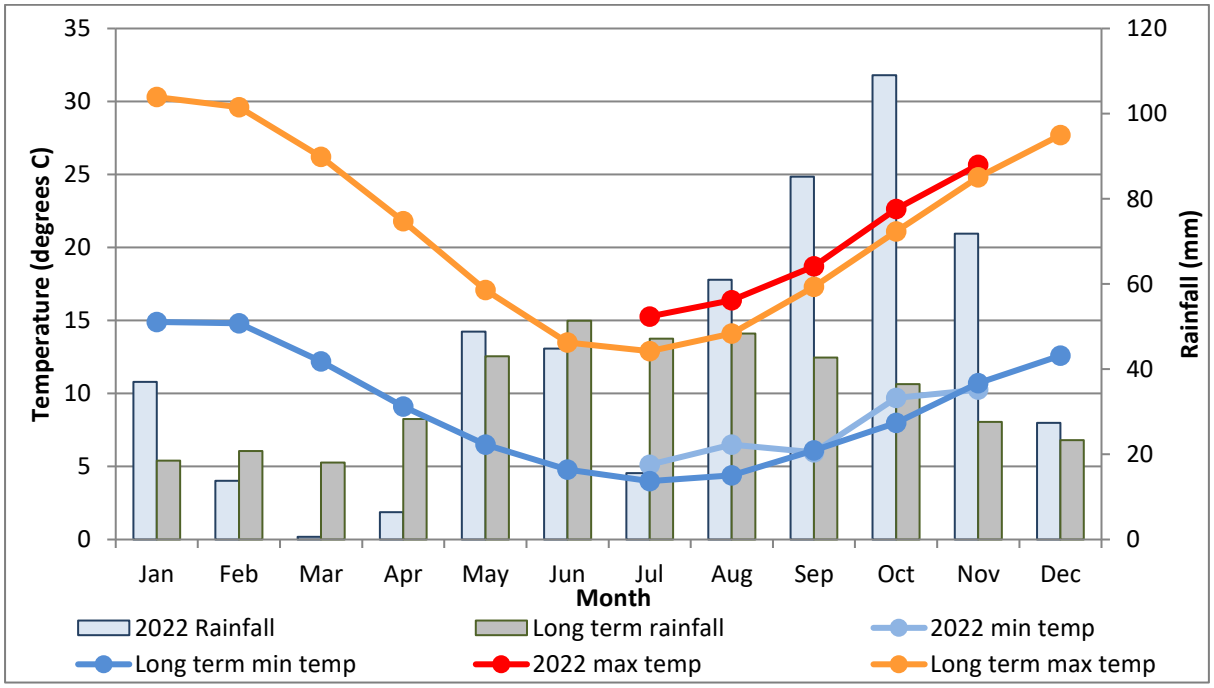

Figure 6. Meteorological data for Hart site. July-November data captured on site, January-June and long-term rainfall from Brinkworth BOM station (8km), long-term temperatures from Clare High School BOM station (16km).