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NGN Comparing barley yield gap and pre-harvest losses under water limiting and non-water limiting conditions

FAR BA B22-01 & FAR BA B22-02

FAR2206-004RTX

Finley, NSW

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Project Title **Comparing barley yield gap and pre-harvest losses under water limiting and non-water limiting conditions**

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Trial Site **Finley Irrigated Research Centre, NSW**

Research Organisation **Field Applied Research Australia**

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Key Points

- Overall yields were lower than expected due to waterlogging experienced on site.
- Yields ranged from 3.73t/ha to 6.22t/ha, with highest yield achieved by RGT Planet.
- There were no yield gains from applying higher rates of N (156kg N/ha soil supply). A fertile farming system is the key to reducing in crop N applications.
- Higher N rates resulted in higher grain protein, but lower test weight and higher screenings.

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

Two production environments were tested; MRZ dryland (3-6t/ha Potential), and non-water limited (Irrigated 10t/ha Potential). Due to the high rainfall experienced in 2022 (508mm Apr-Oct) the non-water limited scenario only required 25mm of irrigation in August.

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

Two nitrogen treatments at each fungicide control level were applied to assess yield gap related to N and disease. There were three canopy interventions at high N to assess yield gap related to canopy control. Each treatment was tested over three differing cultivars.

No.	Treatment	Fungicide	Canopy	Nitrogen
1.	Nil Fungicide - Low N	Nil	Nil	Low - Intermediate
2.	Intermediate - Low N	1 Unit	Nil	Low - Intermediate
3.	Full Potential - Low N	Full	Nil	Low - Intermediate
4.	Nil Fungicide - High N	Nil	Nil	Non-Limiting
5.	Intermediate - High N	1 Unit	Nil	Non-Limiting
6.	Full Potential - High N	Full	Nil	Non-Limiting
7.	Full Potential + PGR	Full	PGR31 & 37	Non-Limiting
8.	Dual Purpose System	Full	Defoliation	Non-Limiting

Fungicide

Three levels of fungicide management, ranging from nil to 3 foliar sprays plus Systiva seed treatment. Due to the wet spring and adverse spraying conditions experienced in 2022, only a single flag leaf fungicide was applied, with different products between treatments.

Treatment no	Sowing		GS39-49
Nil	Vibrance/Gaucho		---
1 Unit	Vibrance/Gaucho		Prosaro 300ml/ha
Full	Vibrance/Gaucho	Systiva 150ml/100kg	Aviator Xpro 500ml/ha

Canopy Intervention

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

Treatment no	GS16-22 (Vegetative)	GS33
Nil	---	---
PGR	---	Moddus Evo 400ml/ha
Defoliation	Yes	

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)	Dryland Finley	Irrigated Finley
Low N (D4-5 Finish)	4	7
High N (D9 - Non-Limiting)	7	10
Total N Supplied (kg/ha)*		
Mid (D5)	156	244
High (Non Limiting)	244	361

* Includes 156kgN/ha supplied from soil (0-100cm, sampled 4 July)

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).

RESULTS AND DISCUSSION

Between the two trials at the Finley Irrigated Research Centre, grain yields ranged from 3.73t/ha to 6.22t/ha. These yields are lower than expected and treatment differences are difficult to interpret due to waterlogging experienced on site.

Table 1. Influence of agronomic management and variety on grain yield (t/ha) of the irrigated trial.

			Yield t/ha							
Nitrogen Input	**Fungicide Intensity**	**Canopy Controls**	**Cyclops**		**Leabrook**		**RGT Planet**		**Mean**	
Low	Nil		4.86	-	4.68	-	5.14	-	**4.89**	**b**
Low	Low		4.78	-	4.05	-	5.08	-	**4.64**	**bc**
Low	High		5.48	-	4.67	-	5.52	-	**5.22**	**a**
High	Nil		4.38	-	3.73	-	5.22	-	**4.44**	**cd**
High	Low		4.27	-	3.88	-	4.66	-	**4.27**	**d**
High	High		4.87	-	3.96	-	5.30	-	**4.71**	**bc**
High	High	PGR	4.48	-	3.98	-	5.40	-	**4.62**	**bc**
High	High	Defoliated	4.87	-	4.52	-	5.37	-	**4.92**	**ab**
Mean			**4.75**	**b**	**4.18**	**c**	**5.21**	**a**		
Cultivar			**LSD p=0.05**		0.40		**P val**		0.002	
Treatment			**LSD p=0.05**		0.31		**P val**		<0.001	
Cultivar x Treatment			**LSD p=0.05**		ns		**P val**		0.231	

Table 2. Influence of agronomic management and variety on grain yield (t/ha) of the dryland trial.

			Yield t/ha							
Nitrogen Input	**Fungicide Intensity**	**Canopy Controls**	**Cyclops**		**Leabrook**		**RGT Planet**		**Mean**	
Low	Nil		4.60	-	3.98	-	5.43	-	**4.67**	**cd**
Low	Low		4.92	-	4.17	-	5.02	-	**4.70**	**cd**
Low	High		5.52	-	4.05	-	5.58	-	**5.05**	**abc**
High	Nil		4.68	-	3.98	-	5.17	-	**4.61**	**d**
High	Low		4.68	-	4.06	-	4.77	-	**4.50**	**d**
High	High		4.81	-	4.39	-	5.36	-	**4.85**	**bcd**
High	High	PGR	5.26	-	4.27	-	5.91	-	**5.15**	**ab**
High	High	Defoliated	5.15	-	4.39	-	6.22	-	**5.25**	**a**
Mean			**4.95**	**a**	**4.16**	**b**	**5.43**	**a**		
Cultivar			**LSD p=0.05**		0.49		**P val**		0.002	
Treatment			**LSD p=0.05**		0.40		**P val**		0.002	
Cultivar x Treatment			**LSD p=0.05**		ns		**P val**		0.345	

Fungicide Strategy

Responses to fungicide application were limited due to reduced capability to apply treatments but also due to the low levels of Net Blotches (table 3) (spot form net blotch (SFNF) and net form net blotch (NFNB)).

Table 3. Influence of agronomic management on plot infection of net blotches (% Leaf Area Infected)

	SFNB (%LAI)		NFNB (%LAI)	
	Flag, -	F-1, -	Flag, -	F-1, -
Low N, 0F	2 -	3 b	1 -	2 -
Low N, 1F	3 -	4 a	1 -	3 -
Low N, 2 F	2 -	2 bc	1 -	2 -
High N, 0F	2 -	2 bc	1 -	3 -
High N, 1F	3 -	2 bc	1 -	3 -
High N, 2F	2 -	2 bc	1 -	3 -
High N, 2F, PGR	3 -	2 c	1 -	3 -
High N, 2F, Grazed	2 -	2 bc	1 -	4 -
Mean	2.4	2.4	1.1	2.9
LSD P=.05	ns	1.2	ns	ns
P value	0.382	0.004	0.996	0.656

Whilst not statistically significant in most cases, there were yield gains from using SDHI chemistry (Systiva and Aviator Xpro) above the untreated control, these range from 0.24 t/ha to 0.38 t/ha. The yield responses were highest under the low nitrogen strategies and in the irrigated scenario provided a statistical yield response. However, there were no reductions in disease levels noted (table 3)

Nitrogen Management

The trials were established on a fertile irrigation block with 156kg of nitrogen already present in the soil. In the dryland trial, increasing the N supply from 156kg N/ha to 244kg N/ha didn't provide any statistical yield gain. In the irrigated trial, increasing N supply from 244kg N/ha to 361kg N/ha gave a significant yield reduction of 0.43t/ha averaged across the 3 fungicide treatments. Lower grain yield coupled with higher nitrogen supply resulted in significantly higher grain protein levels (table 4). The change in nitrogen management increased grain protein from 12.6% under low input, to 14.6% with high N input.

Table 4. Influence of agronomic management and variety on grain protein (%).

			Protein %							
Nitrogen Input	**Fungicide Intensity**	**Canopy Controls**	**Cyclops**		**Leabrook**		**RGT Planet**		**Mean**	
Low	Nil		12.6	-	13.2	-	12.3	-	**12.7**	**b**
Low	Low		12.8	-	13.5	-	11.6	-	**12.6**	**b**
Low	High		13.2	-	11.8	-	13.0	-	**12.7**	**b**
High	Nil		14.7	-	15.4	-	13.8	-	**14.6**	**a**
High	Low		14.5	-	15.1	-	14.2	-	**14.6**	**a**
High	High		15.1	-	15.3	-	13.5	-	**14.6**	**a**
High	High	PGR	14.9	-	14.3	-	13.6	-	**14.3**	**a**
High	High	Defoliated	15.4	-	14.8	-	14.1	-	**14.7**	**a**
Mean			**14.1**	**-**	**14.2**	**-**	**13.2**	**-**		
Cultivar			**LSD p=0.05**		ns		**P val**		0.079	
Treatment			**LSD p=0.05**		0.8		**P val**		<0.001	
Cultivar x Treatment			**LSD p=0.05**		ns		**P val**		0.194	

Increasing nitrogen supply had significant effects on grain quality. Increasing nitrogen supply reduced grain quality, it produced lower test weights (table 5) and higher screenings (table 6) compared to the low N treatments.

Table 5. Influence of agronomic management and variety on grain test weight (kg/hL).

			Test Weight kg/hL							
Nitrogen Input	**Fungicide Intensity**	**Canopy Controls**	**Cyclops**		**Leabrook**		**RGT Planet**		**Mean**	
Low	Nil		63.8	-	62.6	-	61.2	-	**62.5**	**a**
Low	Low		62.8	-	62.2	-	60.4	-	**61.8**	**ab**
Low	High		63.9	-	63.2	-	60.3	-	**62.4**	**a**
High	Nil		61.5	-	59.6	-	60.0	-	**60.4**	**cd**
High	Low		61.4	-	60.6	-	60.8	-	**61.0**	**bcd**
High	High		62.1	-	60.6	-	60.8	-	**61.2**	**bc**
High	High	PGR	62.0	-	58.6	-	59.7	-	**60.1**	**cd**
High	High	Defoliated	61.7	-	59.0	-	59.0	-	**59.9**	**d**
Mean			**62.4**	**a**	**60.8**	**b**	**60.3**	**b**		
Cultivar			**LSD p=0.05**		1.4		**P val**		0.025	
Treatment			**LSD p=0.05**		1.2		**P val**		<0.001	
Cultivar x Treatment			**LSD p=0.05**		ns		**P val**		0.279	

Table 6. Influence of agronomic management and variety on grain screenings (%).

			Screenings %							
Nitrogen Input	**Fungicide Intensity**	**Canopy Controls**	**Cyclops**		**Leabrook**		**RGT Planet**		**Mean**	
Low	Nil		19.5	-	11.9	-	14.2	-	**15.2**	**bc**
Low	Low		18.2	-	15.5	-	12.7	-	**15.5**	**bc**
Low	High		19.9	-	8.5	-	14.6	-	**14.3**	**c**
High	Nil		20.0	-	19.3	-	16.2	-	**18.5**	**ab**
High	Low		26.9	-	16.3	-	17.7	-	**20.3**	**a**
High	High		26.4	-	15.3	-	16.9	-	**19.5**	**a**
High	High	PGR	25.1	-	19.7	-	17.0	-	**20.6**	**a**
High	High	Defoliated	24.5	-	16.7	-	19.0	-	**20.0**	**a**
Mean			**22.6**	**a**	**15.4**	**b**	**16.0**	**b**		
Cultivar			**LSD p=0.05**		3.1		**P val**		0.002	
Treatment			**LSD p=0.05**		3.4		**P val**		<0.001	
Cultivar x Treatment			**LSD p=0.05**		ns		**P val**		0.300	

Nitrogen management as well as fungicide strategy had an influence on crop lodging (figure 1). Higher N rates created a larger canopy making it more prone to lodging. The application of foliar fungicides also helped reduce crop lodging.

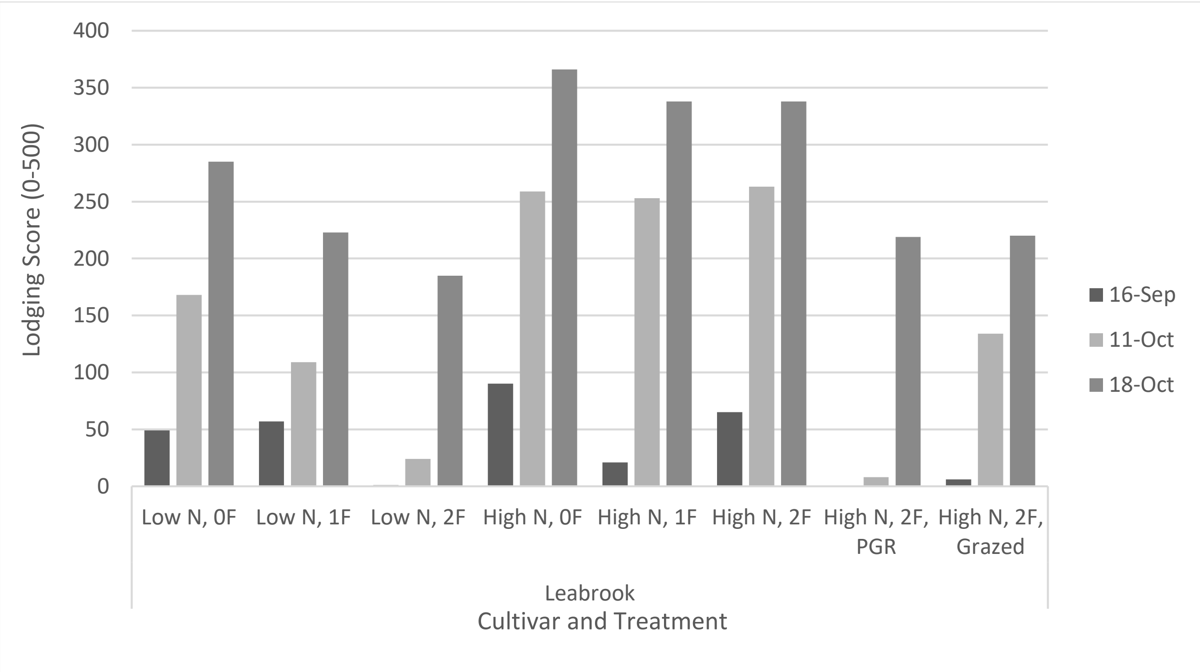

Figure 1. Influence of agronomic management on crop lodging on the weak strawed variety Leabrook.

Canopy Management

Simulated grazing during vegetative growth period was the only canopy management technique that gave a statistical yield benefit, providing a 0.40t/ha yield gain in the dryland trial.

There were no statistical differences between varieties in terms of biomass at the time of grazing or in the amount removed by defoliation (table 7). On average, the process of defoliation removed about 1/3 of the canopy by weight, taking a canopy of 722kg DM/ha and removing 245kg DM/ha.

Table 7. Influence of variety on biomass production at time of defoliation. Plots grazed at GS24 on 30 June

	Dry Matter kg/ha		
Cultivar	**Pre-graze**	**Post-graze**	**DM Removed kg/ha**
Cyclops	756 -	433 -	322 -
Leabrook	750 -	511 -	239 -
RGT Planet	661 -	489 -	173 -
Mean	722	478	245
LSD p=0.05	ns	ns	ns
P val	0.649	0.654	0.337

Plant growth regulators (PGRs) had a significant effect on improving the canopy standability, especially in the lodging susceptible variety Leabrook (figure 2). The application of Moddus Evo substantially delayed lodging in Leabrook and while not statistically significant, there was a trend in lodging reduction across the other varieties.

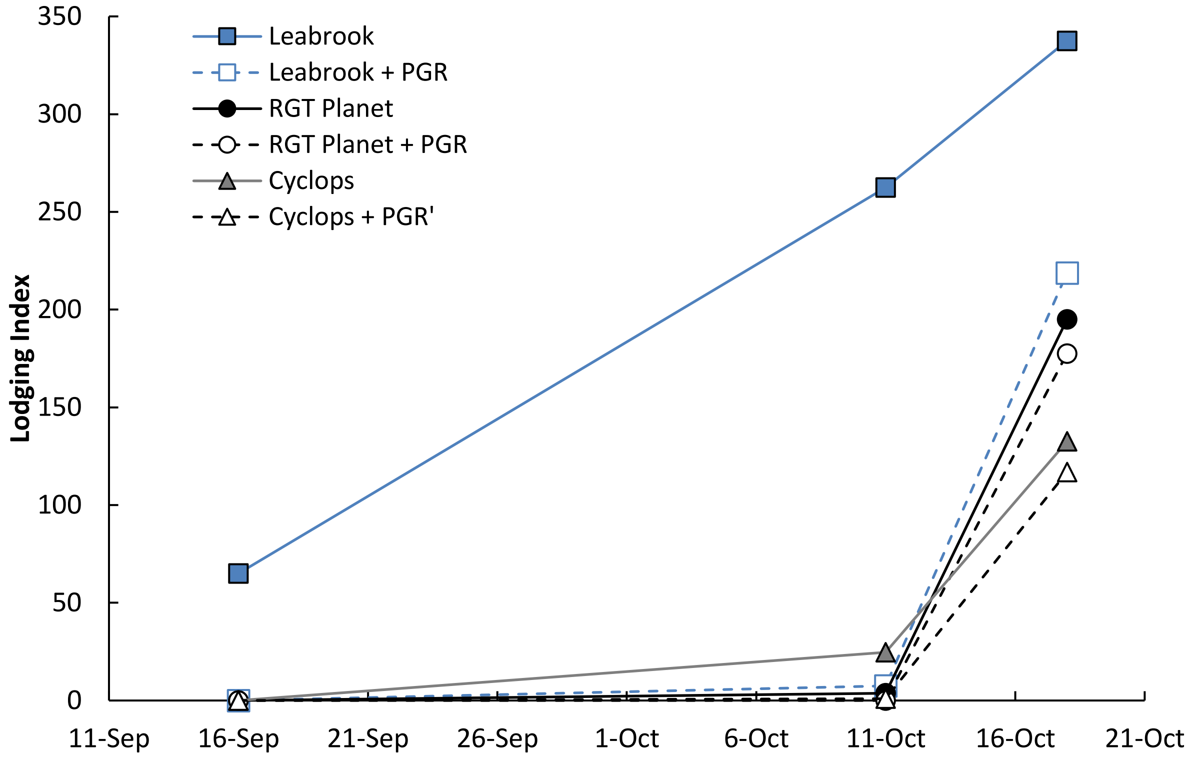

Figure 2. Influence of cultivar choice and PGR application on crop lodging (0-500) during the grain fill period.

Cultivar Choice

RGT Planet was the highest yielding variety in both trials achieving 6.22t/ha, while the lowest yielding variety was Leabrook.

In contrast, head counts made at harvest time show Cyclops having the highest number of heads with 867 heads/m^2 compared to Leabrook and RGT Planet (the highest yielding cultivar) having statistically less with 649 and 698 heads/m^2 respectively. These results suggest that head number isn't an absolute reflection of grain yield with grain number (a combination of heads/m^2 and grains per head) a bigger driver to maximise yield.

Leabrook suffered significantly from crop lodging earlier than other varieties (figure 2) which likely caused shading during the critical growth period, reducing grain yield.

Table 8. Influence of agronomic management and cultivar on head number at crop maturity.

Nitrogen Input	Fungicide Intensity	Canopy Controls	Heads/m^2 Cyclops		Leabrook		RGT Planet		Mean	
Low	Nil		873	-	604	-	614	-	**697**	**-**
Low	Low		711	-	719	-	595	-	**675**	**-**
Low	High		896	-	714	-	653	-	**754**	**-**
High	Nil		810	-	700	-	672	-	**727**	**-**
High	Low		965	-	633	-	640	-	**746**	**-**
High	High		967	-	741	-	669	-	**792**	**-**
High	High	PGR	944	-	752	-	729	-	**808**	**-**
High	High	Defoliated	768	-	720	-	622	-	**703**	**-**
Mean			**867**	**a**	**698**	**b**	**649**	**b**		
Cultivar			**LSD p=0.05**		68		**P val**		0.019	
Treatment			**LSD p=0.05**		ns		**P val**		0.316	
Cultivar x Treatment			**LSD p=0.05**		ns		**P val**		0.763	

CONCLUSIONS

Trial results from 2022, while compromised by waterlogging, provide insight into how management decisions impact barley grain yields. While conclusions around yield gain from increasing nitrogen supply could not be determined the trials demonstrated that in a fertile farming system, lower N rates can be utilised to achieve the same yields or higher than in the presence of an over-supply causing lodging. High nitrogen rates resulted in a larger canopy, but the crop was unable to convert this biomass into higher grain yield.

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 minimised, particularly in barley where head loss due to brackling can be problematic.

In order to maximise grain yield, it is important to firstly select the best variety for your environment and sowing period, to then build the right canopy to support a high grain yield we need to select the right nitrogen supply to match the rainfall decile and or target grain yield. The trials also indicate the importance of protecting the crop canopy from disease infection through timely fungicide applications. Results from the GRDC barley NGN project ‘Barley management options to close the yield gap and reduce pre-harvest losses’ (FAR2204-002SAX) supports the use of 3 foliar applications in high potential seasons similar to what is required in a ‘typical’ high rainfall zone season, and the application of PGRs or opportunistic grazing.

APPENDICES

Meteorological Data

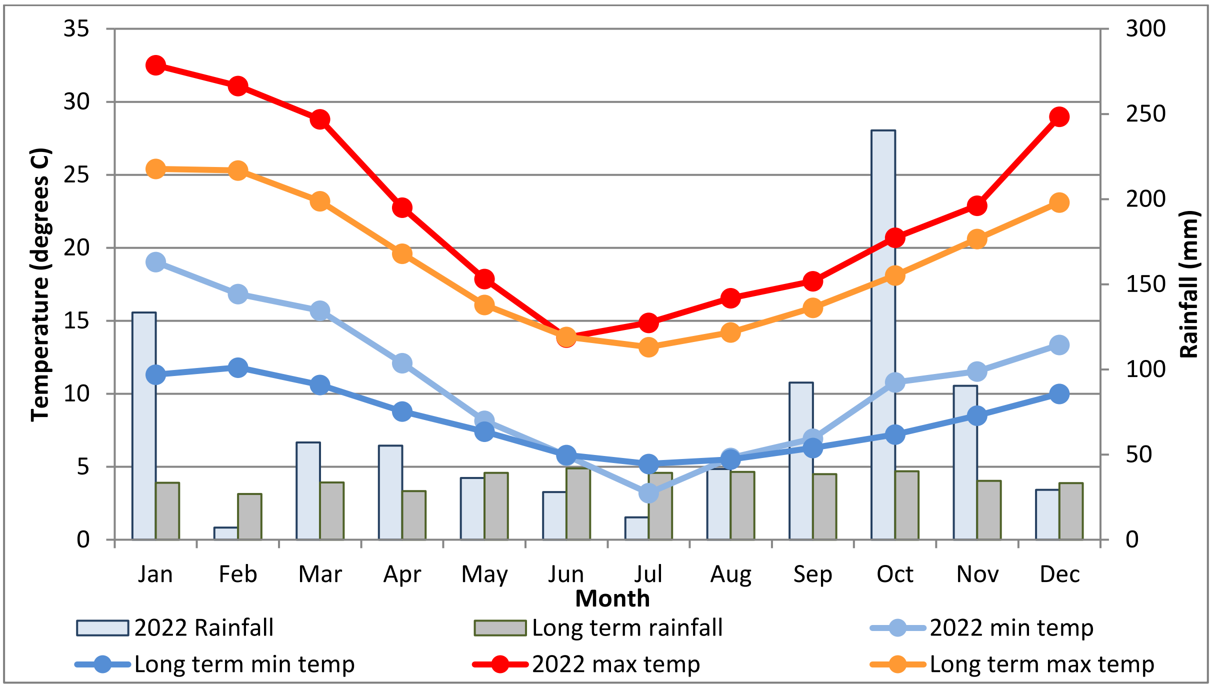

Figure 3. Meteorological data for Finley Irrigated Research Centre. Data collected from on-site weather station, long term means from Finley Post Office BoM station.