Trial Report

Technical Summary

NGN – N Banking strategies to manage variable and unpredictable nitrogen demand in the MRZ of the Southern Region

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Key Messages

- 2022 was the first season comparing the N bank management strategy on different soil types to more conventional methods.
- Multiple years are needed for a valid comparison – at the moment they are just N rate experiments.
- At the N responsive sites Yield Prophet® treatments resulted in more applied fertiliser than the N Bank treatments in a favourable (>decile 7) season and thus outperformed N bank treatments.
- Post harvest soil sampling indicated that soil mineral N either remained the same or increased under the increasing rates of N fertiliser applied.

Background

Australian wheat yields are only half what they could be for the rainfall received (Hochman *et al.* 2017). Nitrogen (N) deficiency is the single biggest factor contributing to this yield gap. This is also likely to be true for other non-legume crops (barley, canola and oats) and this reduces farm profitability. Alleviating N deficiency has the potential to increase national wheat yields by 40 per cent (Hochman and Horan 2018).

On farms with no legume pastures, most of the crop N supply must come from N fertiliser. Grain legumes do not provide enough N to support yield of subsequent crops at the intensity at which they are currently grown. N fertiliser is a costly input, and its use increases the cost of production and value-at-risk for growers. Growers fear over-fertilisation will result in 'haying off', which reduces both yield and quality. There is also concern that overapplied fertiliser not used by crops is lost to the environment through–leaching, volatilisation, and denitrification. Consequently, efforts are made to match N fertiliser inputs to seasonal yield potential. This is difficult in southern Australia due to the lack of accurate seasonal forecasts for rainfall. The difficulty in matching N supply to crop demand and a tendency for growers to be conservative in their N inputs is responsible for a large proportion of the yield gap explained by N deficiency.

In 2022, as part of the GRDC's NGN process, growers identified that current approaches utilised to determine tactical N applications utilise N crop demand (i.e., yield potential) to estimate N supply. This has a high level of uncertainty linked with it due to errors associated with prediction of August to October rainfall. The GRDC thus invested in a one-year research project across six different sites within the medium rainfall zone (MRZ) to evaluate the potential for different N management systems (i.e., N banking) to simplify the approach to N management and profitably close the yield gap for non-leguminous crops, with the view that work around N management approaches will continue to be pursued through the National Risk Management Initiative.

The N banking approach aims to maintain a base level of soil mineral N that is topped up each season to a target N bank level that is most appropriate for a given location to achieve the water-limited yield potential in most seasons. Through previous work undertaken by Hunt et al. (2022) this strategy has been identified as a promising approach to manage N in crop production areas with low environmental losses (i.e., leaching, denitrification).

Aim

To validate a range of 'N banking targets' (and respective N budget scenarios) and compare to traditional 'N crop demand driven strategies' to establish potential profits and risks associated with both.

Trial Details

Table 1. GPS coordinates, crop type, sowing and harvest dates for the six MRZ trial sites.

Site	GPS Coordinates	Crop Type	Variety	Sow Date	Harvest Date
Bute	-33.873200, 138.076990	Wheat	Scepter	3/06/2022	7/12/2022
Cockaleechie	-34.19822, 135.90968	Wheat	Scepter	12/05/2022	15/12/2022
Dookie	-36.382193, 145.715842	Canola	45Y929	10/11/2022	10/11/2022
Gnarwarre	-38.177056, 144.014369	Wheat	Rockstar	10/05/2022	05/01/2023
Kybunga	-33.898300, 138.527452	Wheat	Scepter	28/05/2022	23/12/2022
Longerenong	-36.677559, 142.302400	Wheat	Scepter	24/05/2022	23/12/2022

Trial Inputs

These experiments were kept free of weeds, pests and diseases as per current best management practices. Nitrogen fertiliser at each site was applied as per table 2.

Table 2. Nitrogen fertiliser (starter and top-dressed urea) applied to different treatments in 2022 across the six MRZ sites.

	Total N fertiliser applied (kg N/ha)					
Treatment	**Bute**	**Cockaleechie**	**Dookie**	**Gnarwarre**	**Kybunga**	**Longerenong**
Nil N	0	14	71	0	8	6
District Practice	121	150	186	150	29	111
YP Lite Decile 1	0	85	71	0	8	6
YP Lite Decile 2-3	15	125	123	68	8	8
YP Lite Decile 5	55	173	211	108	48	56
YP Lite Decile 7-8	99	229	323	152	104	104
YP Lite BoM	143	229	323	152	104	104
N Bank Conservative	22	28	125	62	16	38
N Bank Optimal Profit	47	53	150	87	41	63
N Bank Optimal Yield	72	78	175	112	66	88

***Note: 14 kg N/ha in the form of DAP was applied at sowing and 150 kg/ha urea was applied in season by the grower at the Gnarwarre site prior to trial establishment. This N was accounted for in the soil test data and not in the nitrogen fertiliser applied.**

Method

All six experiments established in 2022 used a randomised complete block design to evaluate the performance of the different N management systems. The three systems being tested are below and within systems one and two there were different treatments targeting different yield potentials:

1. Matching N fertiliser to seasonal yield potential (Yield Prophet® (YP) Lite)
    - YP Lite Decile 1
    - YP Lite Decile 2-3

- YP Lite Decile 5
- YP Lite Decile 7-8
- YP Lite BoM (BoM forecast at the time of N application decision making)

2. Maintaining a base level of fertility using N fertiliser (N banks) (see Table 3)
    - N Bank Conservative (25 kg N/ha less than Optimal Profit)
    - N Bank Optimal Profit
    - N Bank Optimal Yield (25 kg N/ha more than Optimal Profit)
3. Current average N application rate for a specific region (District practice)

The N Bank targets were determined by the average economic yield for each specific location and the average annual rainfall using the equation from Meier et al. (2021). A few different targets to evaluate if the relationship was correct (e.g., The N Bank Conservative and N Bank Optimal Yield) were also added. The +/- 25 kg N/ha difference was selected due to what has worked well at the longer-term N Bank trial located at Curyo.

Table 3. N Bank targets for the six experimental sites.

	N Bank Target (kg N/ha)					
Treatment	**Bute**	**Cockaleechie**	**Dookie**	**Gnarwarre**	**Kybunga**	**Longerenong**
N Bank Conservative	135	155	250	250	160	150
N Bank Optimal Profit	160	180	275	275	185	175
N Bank Optimal Yield	185	205	300	300	210	200

All systems were compared to a nil control which received only starter fertiliser except of the Dookie site which had received some in season N (this occurred as result of all trials being established in grower sown crops and site selection occurring in late autumn/early winter). For the N bank treatments there were different target levels of N fertility (N bank targets). N fertiliser rates in these treatments were calculated as the N bank target value minus soil mineral N (kg/ha) measured pre in season urea application.

All gross margins were calculated assuming a N fertiliser cost of $1.60/kg N, grain prices as per the 5-year averages in the 2018-2022 SAGIT Gross Margin Guides as well as the total variable costs for APW wheat, canola – Clearfield hybrid and feed barley from the 2022 SAGIT Gross Margin Guide (SAGIT 2022).

Results

The Gnarwarre and Longerenong yields were not responsive to increasing amounts of N suggesting that something other than water and N was limiting yields (Figure 1). It's worth noting at Gnarwarre that the soil was least likely to be lacking fertility as it had a high initial soil N, high soil organic matter and a history of manure. It also had 83 kg N/ha already applied which may not have been picked up well in the soil tests. For the other sites there was a good relationship between higher rates of N fertiliser and increased grain yield (Figure 1).

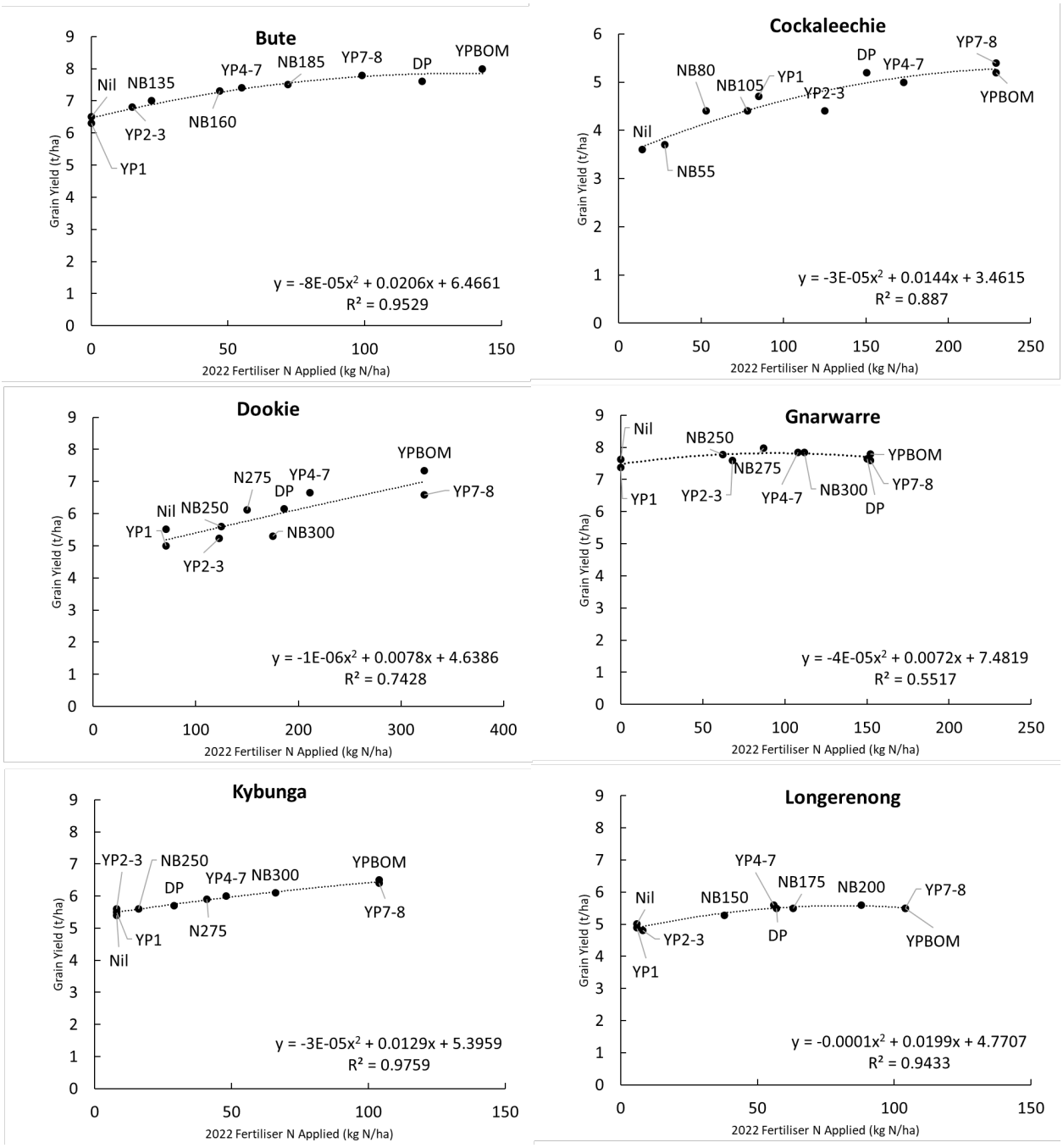

Figure 1. Grain yield (t/ha) response from the different N management strategies (Nil = Nil N, DP = District Practice, YPx = Yield Prophet Lite Decile x, YPBOM = Yield Prophet Lite BoM Forecast, NBx = N Bank Target x) at Bute, Cockaleechie, Dookie, Gnarwarre, Kybunga and Longerenong, 2022.

For all the cereal sites, there was a positive relationship between grain protein and increasing amounts of N applied (Figure 2). For the Dookie site, which was sown to canola, increasing amounts of N applied resulted in a decrease in oil (%) (Figure 2).

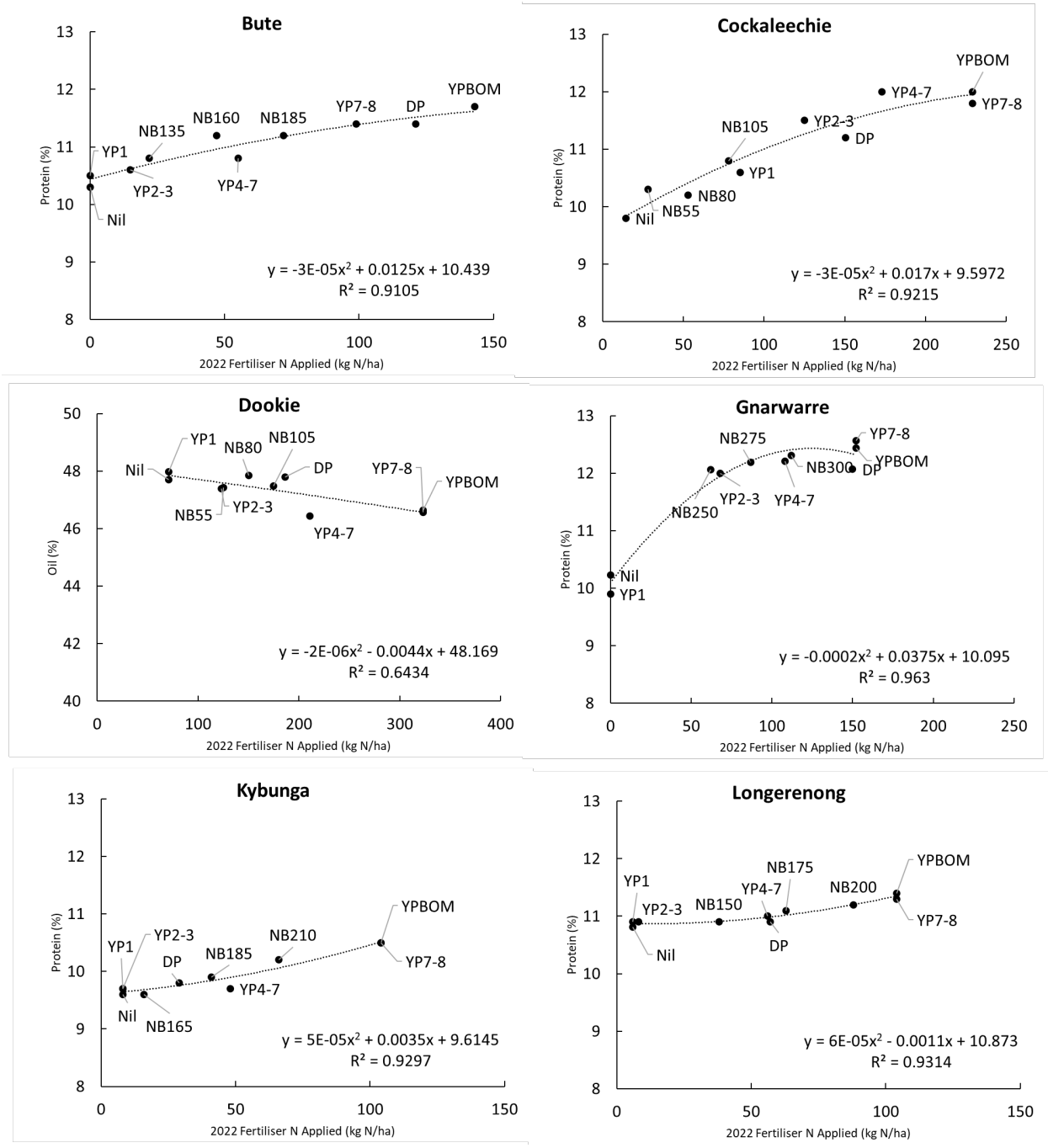

Figure 2. Protein (%) and oil (%) response from the different N management strategies (Nil = Nil N, DP = District Practice, YPx = Yield Prophet Lite Decile x, YPBOM = Yield Prophet Lite BoM Forecast, NBx = N Bank Target x) at Bute, Cockaleechie, Dookie, Gnarwarre, Kybunga and Longerenong, 2022.

At Bute, Cockaleechie, Dookie and Kybunga higher applications of N fertiliser were more profitable in 2022 (Figure 3). For the non-N responsive sites however, at Gnarwarre and Longerenong, the more profitable N systems were the N Bank Optimum Profit (NB275) and Yield Prophet Lite 4-7 respectively (Figure 3).

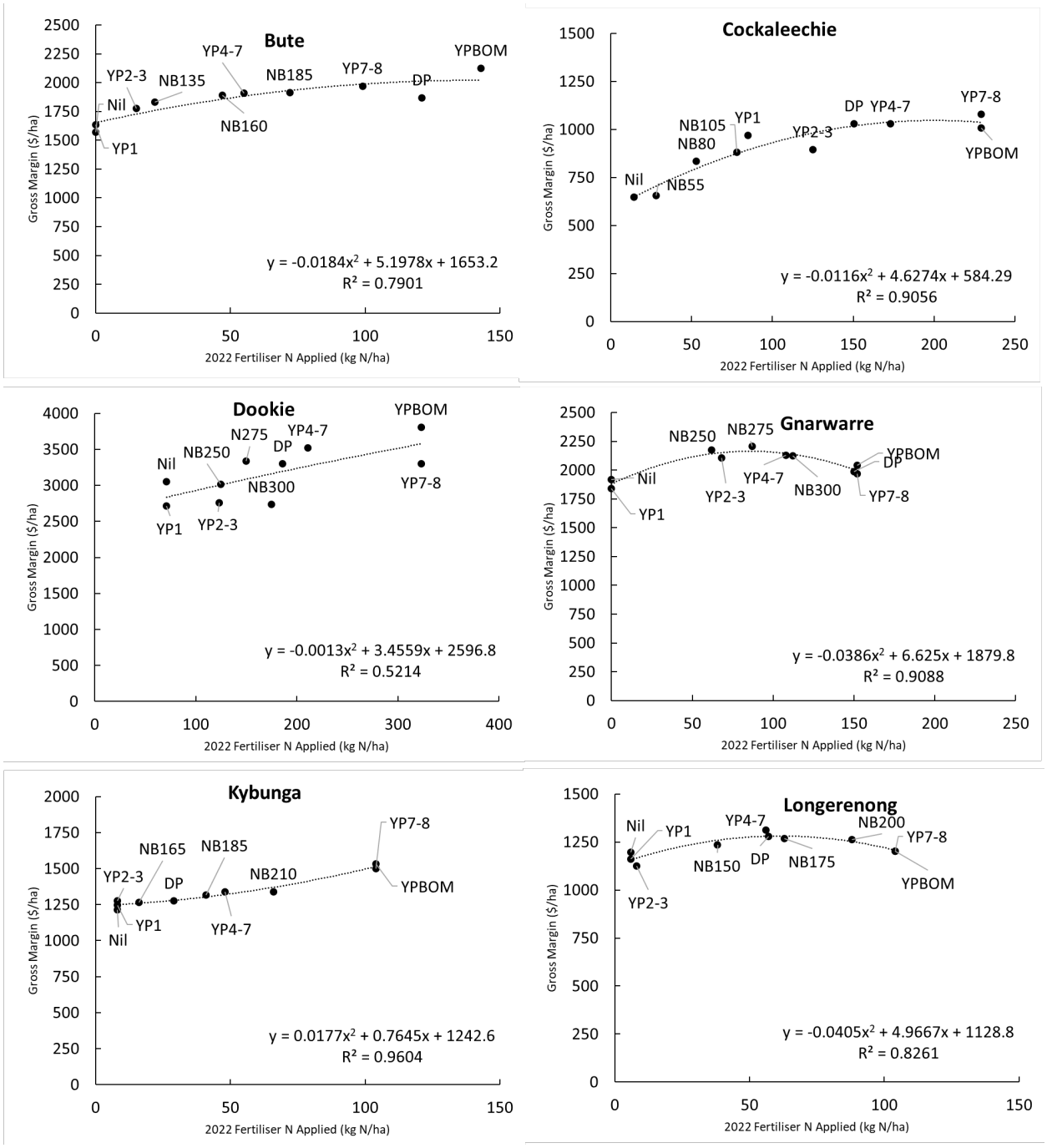

Figure 3. Gross margin ($/ha) impact from the different N management strategies at (Nil = Nil N, DP = District Practice, YPx = Yield Prophet Lite Decile x, YPBOM = Yield Prophet Lite BoM Forecast, NBx = N Bank Target x) Bute, Cockaleechie, Dookie, Gnarwarre, Kybunga and Longerenong, 2022.

Post harvest soil sampling has shown a poor correlation between increased amounts of N fertiliser applied and its impact on soil mineral N across all the MRZ sites (Figure 4).

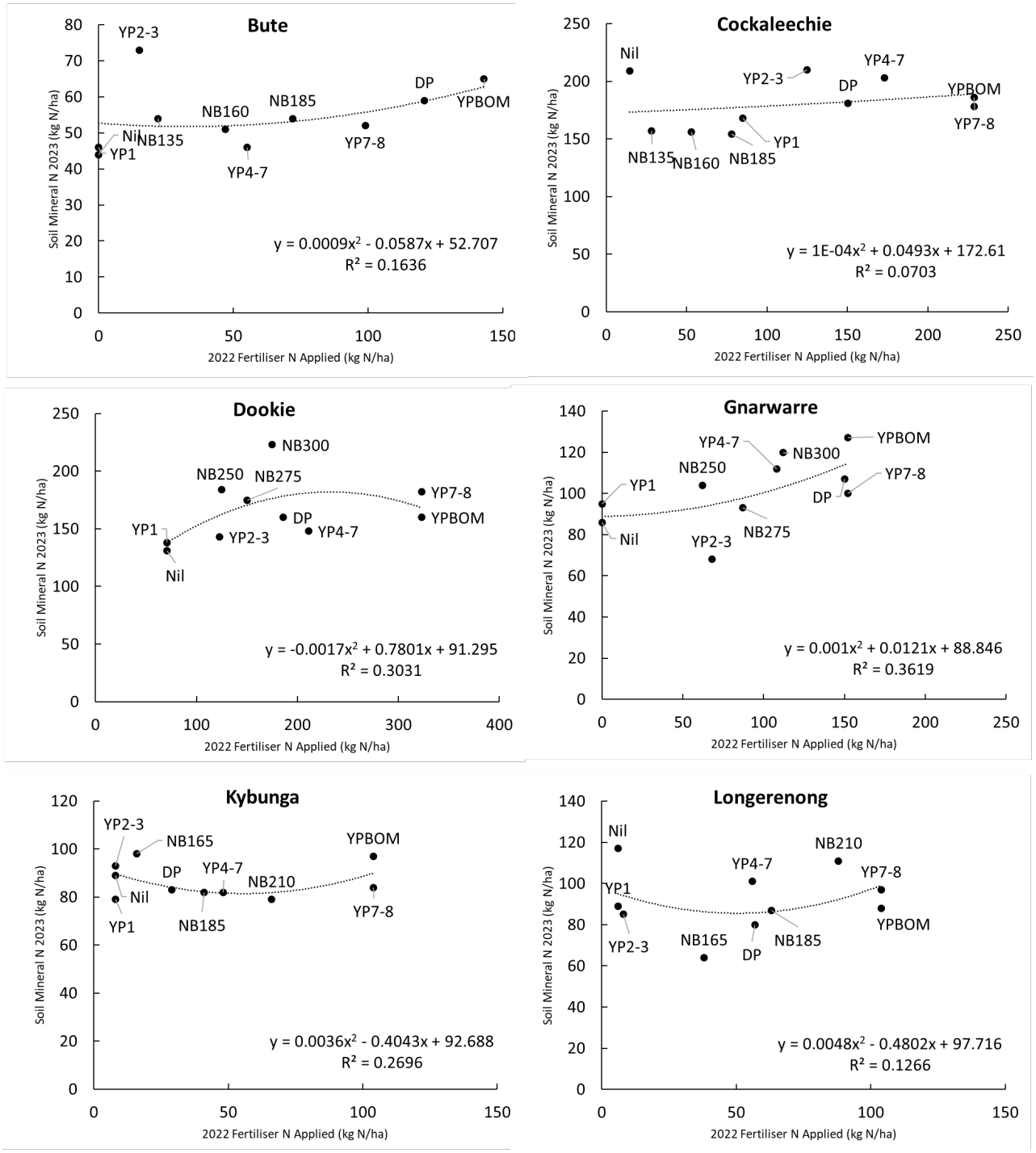

Figure 4. Soil mineral N (kg N/ha) post-harvest in 2023 to depth of 1m under the different N management strategies (Nil = Nil N, DP = District Practice, YPx = Yield Prophet Lite Decile x, YPBOM = Yield Prophet Lite BoM Forecast, NBx = N Bank Target x) at Bute, Cockaleechie, Dookie, Gnarwarre, Kybunga and Longerenong, 2022.

Discussion

2022 was the first season comparing the N bank management strategy to more traditional approaches across several locations in the MRZ of the Southern region. Across all six sites the season was very favourable for crop production with above average rainfall particularly in the lead up to sowing as well as during the grain filling period in spring (see Appendix 1 for individual site rainfall information). All sites received decile 10 rainfall for the growing season (April to October) except Cockaleechie (decile 7). Bute and Kybunga were decile 8 and 7 respectively for crop year rainfall (November to October) with all other sites receiving decile 10.

Overall, the N bank approach performed as expected during year one of these experiments in a favourable season. As water was not limiting, the trials became N rate response experiments and it was those treatments that applied more N fertiliser i.e., Yield Prophet Lite Decile 7-8 and Yield Prophet Lite BoM that outperformed the N Bank treatments, at the N responsive locations (Bute, Cockaleechie, Dookie and Kybunga).

The N bank approach is however a long-term strategy thus these experiments need to be run over multiple seasons to effectively assess the N Bank approach. The 2022 season results suggest that crop N demand is not meet under the N banks in very wet (> decile 7) seasons, this strategy aims to meet the N needs of the crop in most but not all seasons thus how the N bank approach performs under a range of different seasons at these locations and soil types needs to be determined. Further soil analysis is also needed at the non-N responsive sites (Gnarwarre and Longerenong) to better understand the potential drivers behind their lack of response.

References

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Acknowledgments

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We thank all growers who have hosted these experiments.

Appendix 1

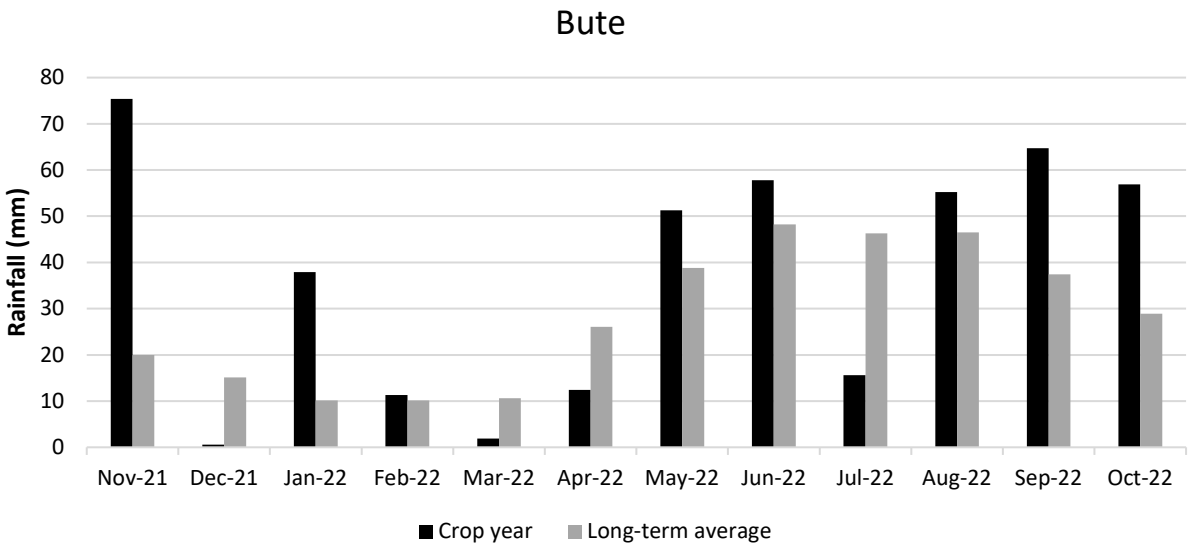

Figure 5. Crop year and long-term average rainfall (mm) for Bute, 2021-2022.

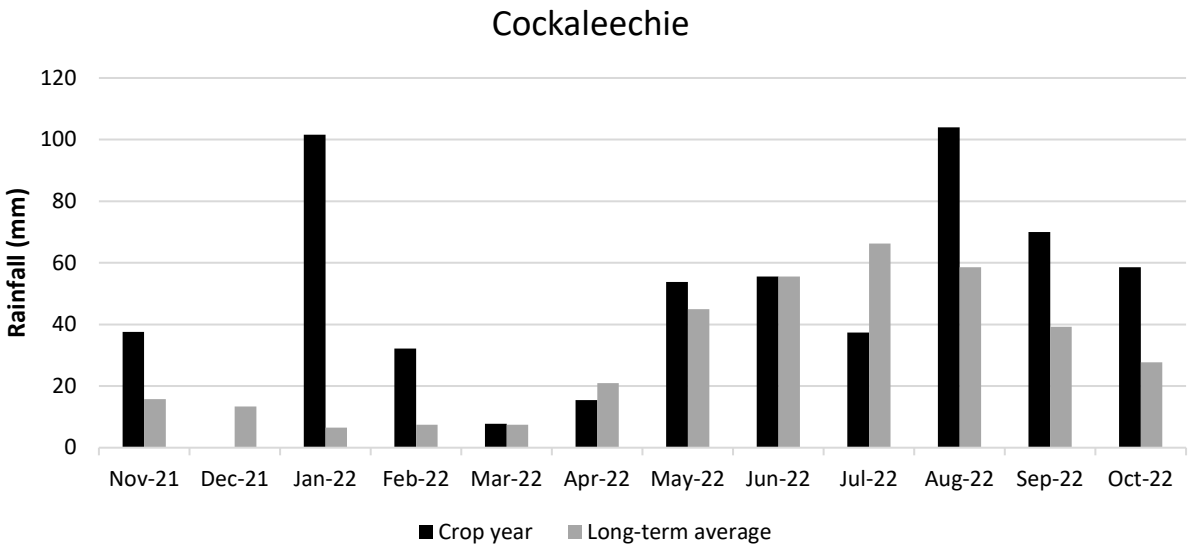

Figure 6. Crop year and long-term average rainfall (mm) for Cockaleechie, 2021-2022.

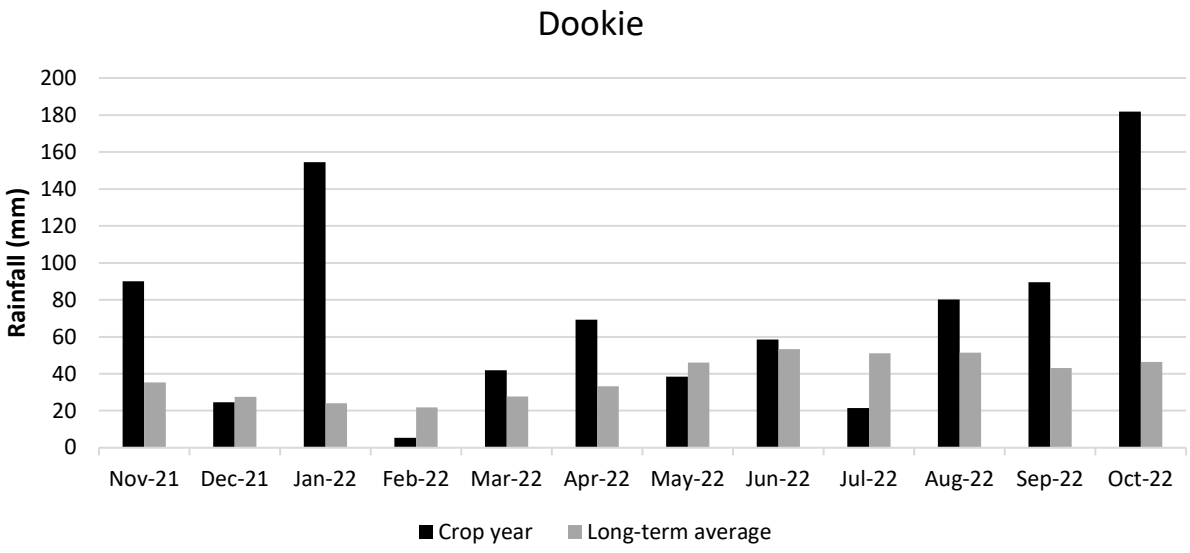

Figure 7. Crop year and long-term average rainfall (mm) for Dookie, 2021-2022.

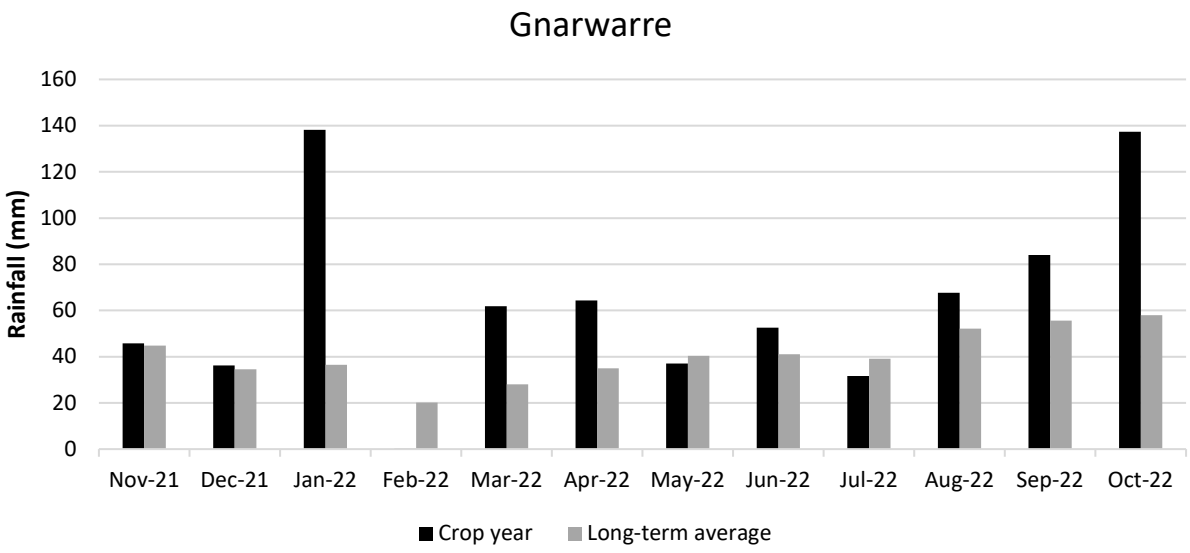

Figure 8. Crop year and long-term average rainfall (mm) for Gnarwarre, 2021-2022.

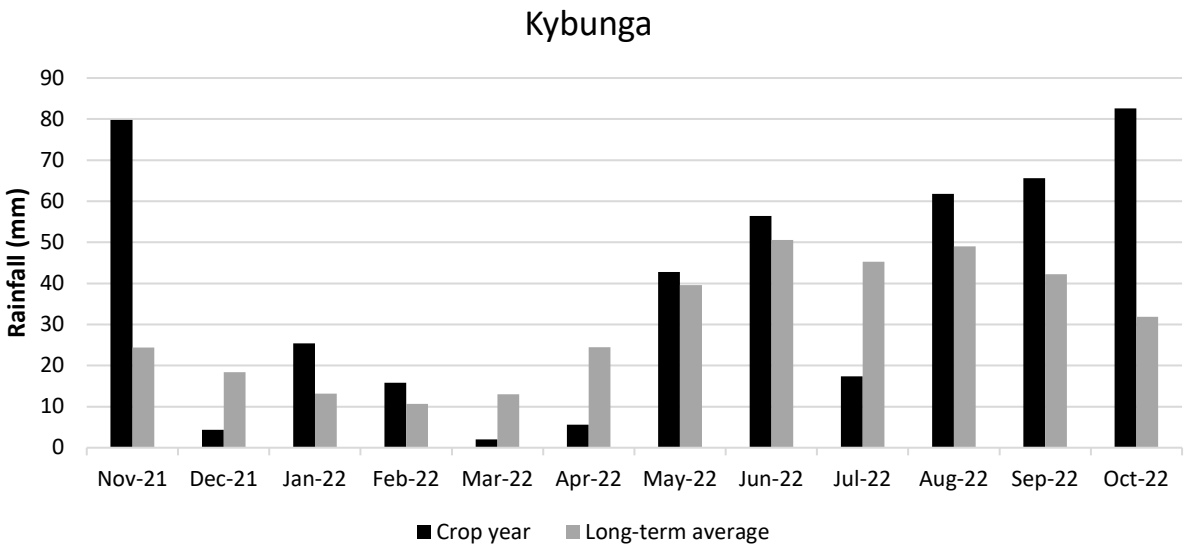

Figure 9. Crop year and long-term average rainfall (mm) for Kybunga, 2021-2022.

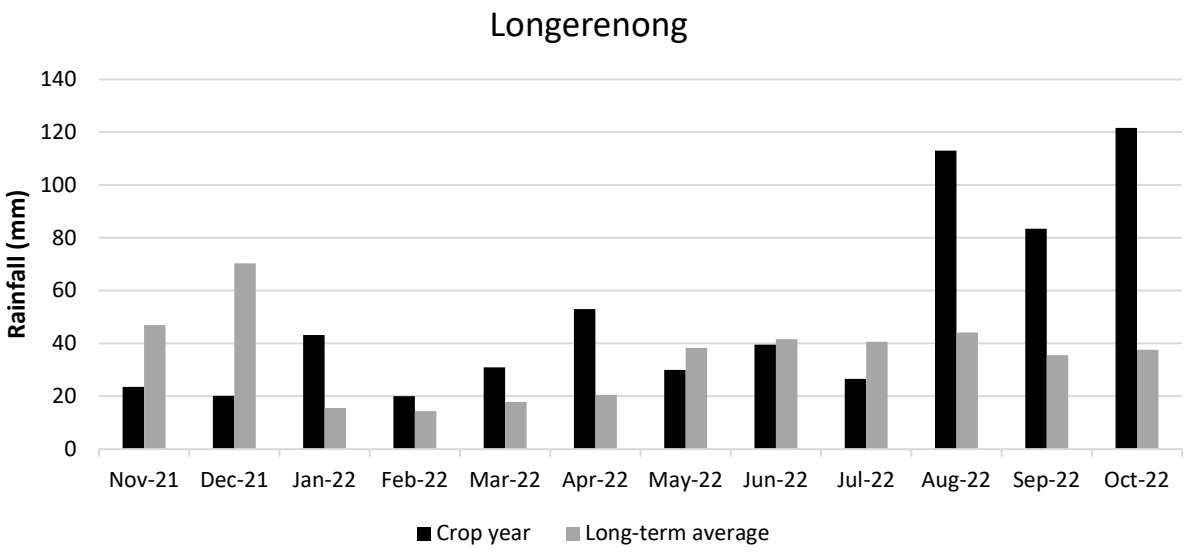

Figure 10. Crop year and long-term average rainfall (mm) for Longerenong, 2021-2022.