Optimising Irrigated Grains
Maize Agronomy in Focus

2019/20 Final Research Results

Field Applied Research Australia
Phone: 03 5265 1290
Post: Shed 2/63 Holder Rd, Bannockburn VIC 3331
Website: www.faraustralia.com.au **ABN:** 33159209480

Trial Series Title **Maize Agronomy in Focus**

Trial Sites **Peechelba East, Boort and Kerang, Victoria**
Hopefield and Yenda, NSW

Project Funder **GRDC**

Study Director **Nick Poole**

Research Organisations **Field Applied Research Australia**
Irrigated Cropping Council

Research Manager **Michael Straight**

Report Written by **Nick Poole/Ben Morris/Michael Straight/Damian Jones/Tom Price**

Report Published **26/02/2020**

The GRDC Optimising Irrigated Grains Project is a collaborative project including the following project partners:

Table of Contents

Results

Applicable to each of the yield tables are the following:
Yields in the Provisional report were provided by ARM software that were based on plot yields recorded. Yield data and key measurements such as harvest index, dry matter at harvest and test weights have now been reanalysed by SAGI to take account of any spatial variation in the trial and are reported as predicted values.
Yield figures followed by the same letter are not considered to be statistically different (p=0.05).

Optimising Irrigated Grains

BACKGROUND

This GRDC investment commenced in spring 2019 to develop and evaluate the effectiveness of novel soil management technologies and crop specific agronomic management practices in irrigated environments on system profitability.

Crop specific agronomic practices were to have a focus on maximising system profitability through:

1. optimising the return on nitrogen through improved nitrogen use efficiency

2. improving the understanding of N-form, timing and rate in the context of irrigation timing and inter-related agronomic decisions

3. understanding how to consistently optimise yield (in the context of water price, input costs and commodity price) for the crops where gaps are most apparent:

Soil management technologies will focus on improving soil structure, infiltration and moisture retention on (i) shallow and poorly structured red duplex soils (ii) sodic grey clays prone to dispersion and waterlogging.

Which Crops?

The crops to be researched as part of the project are:

i) Faba bean (the pulse crop seen with the most potential for irrigated systems), ii) chickpea (an emerging high value pulse, important in crop sequences to provide a cereal disease break), iii) durum (the major option to increase the profitability of the cereal phase under irrigation), iv) canola (higher yields provide scope for significant increase in profitability and potential break effect) and v) **maize (the summer crop with the greatest scope to improve returns under a double cropping system).**

In tendering for the project, the project team added a sixth crop which is barley. This will be based on spring sown barley in Tasmania and winter barley where appropriate on the mainland.

How will the project objectives be achieved?

The objectives of the project will be underpinned by 66 field trials conducted annually at five Irrigated Research Centres (IRCs). The principal Research Centres at Kerang and Finley will cover all four autumn sown crops (faba beans, chickpeas, durum, and canola) with the addition of maize sown in the spring. Satellite centres will be established in Frances, Griffiths and Tasmania with a smaller number of trials per annum. Each year six trials will be reserved for other regions (e.g. Yarrawonga, Coleambally, Corop) that have smaller acreages of irrigated broad acre will be serviced by individual trials covering different crop and agronomic issues. The soil amelioration research to be conducted in collaboration with NSW DPI is based on two large block research trials at Kerang (Grey Clay under flood irrigation) and Finley (Red Duplex under overhead irrigation). It is planned to carry out amelioration this February.

ACKNOWLEDGEMENTS

FAR Australia would like to place on record their grateful thanks to the Grains Research and Development Corporation (GRDC) for providing the majority investment in particular, we would like to thank Alison Pearson (GRDC) for her input and support in the oversight of the project.

In addition, we would like to acknowledge the collaborative support of our trials research partner Irrigated Cropping Council (ICC) and extension grower group partner the Maize Association of Australia (MAA), in particular Charlotte Aves, Damian Jones and Rohan Pay at ICC and Liz Mann at MAA.

Initiatives such as this only work if you have the full collaboration of the land owner and we have been fortunate to have the support of and in making the research site at Peechelba East, Boort, Kerang in Victoria & Hopefield and Yenda in NSW a reality we would like to place on record our grateful thanks to Colin and Geoff Gitsham at Kerang, and Campbell Dalton at Yenda. I would also like to thank all the local cropping community and industry in the region for getting the research and their support of the field days held at the research sites in January 2020.

Finally, can I place on record my thanks for my own trials team for bringing this research programme through to harvest, in particular Michael Straight, Ben Morris, Tom Price and Kat Fuhrmann. These are the final results presented after statistics have been reviewed by SAGI. I would like to thank Sharon Nielsen from SAGI for all of her input to the analysis of the results. Please note that SAGI uses spatial analysis to generate predicted values therefore figures have changed in this document compared to the provisional results where data values and statistical analyses were based on actual data points recorded and analysed without spatial interpretation.

Nick Poole – Managing Director, FAR Australia

26 February 2021

RESULTS SUMMARY

12 irrigated grain maize trials were established at five locations in northern Victoria and southern NSW. The primary focus of the field research was to examine nutrition, looking specifically at the influence of higher levels of nitrogen (N) input on harvest dry matter, grain yield, harvest index and nitrogen offtake. In addition, the research programme also examined the influence of plant population, row spacing and disease management. At the main research sites Peechelba East and Kerang Irrigation was provided by overhead pivot and flood (border check) respectively. Irrigation quantities were as follows, Peechelba East (Pivot 6.08 Mega L/ha applied), Boort (Sub surface drip n/a), Hopefield (Pivot 6.88 ML/ha applied), Kerang (Flood border check 9.8 ML/ha) and Yenda (Flood, beds in bays 9.1 ML/ha). Research was conducted using the Pioneer Hybrid 1756.

Grain yields and harvest dry matter production

At Peechelba East in North East Victoria the highest grain yields (machine harvested plots) were 18 – 19t/ha produced on crop canopies with a final harvest dry matter of typically between 30 – 35t/ha (average 34.6t/ha). At Kerang (machine harvested plots), the highest grain yields were typically between 16-17t/ha, again produced on crop canopies of approximately 30t/ha. Grain yields of 20t/ha were observed at Boort and Yenda from hand harvested quadrats, however it should be noted that smaller quadrats harvested from plots are generally more variable and higher yielding than machine harvested yields.

Nutrition

At Peechelba East on a red loam over clay grain yields of 18.30-18.85 t/ha were produced with applied fertiliser input no greater than 207-252kg N/ha (207 kg N/ha of which was applied as fertigation between V4 and pre – tasselling). 252kg N/ha was the economic optimum. At this site following oaten hay (33kg N/ha was available at sowing (0-60cm)) there was no significant yield difference between applying 0 – 315kg N/ha applied pre-drill (as urea - 46% N solid prill) indicating that N application exceeding 252kg N/ha was uneconomic. At Kerang on a self-mulching grey clay the optimum fertiliser N input was 240kg N/ha with a yield of 16.36t/ha. At Peechelba East and Kerang fertiliser N applications greater than 240 - 252kg N/ha (up to over 500-550kg N/ha) were uneconomic. At both research sites N provided by the soil through mineralisation appeared to have a large effect on the results, since at Peechelba East N offtake at harvest revealed between 415 – 530kg N/ha in crop canopy, whilst at the same time there was no response to N fertiliser above 207-252kg N/ha. Typically, two thirds of the N present in the crop at harvest at Peechelba East was found in the grain with the remainder in the stover. Allowing for N available at sowing the results indicated that 165kg N/ha of the N in the crop at harvest was provided by mineralisation. In Kerang where the maize was grown following a three-year grass pasture phase the optimum level of applied N fertiliser was 240kg N/ha with a nitrogen content of the canopy at harvest of 353kg N/ha, of which approximately 69% was present in the grain. Evidence from the zero N plots at this site indicated that up to 207kg N/ha in the final crop canopy came from soil mineralisation.

Additional Potassium (K) applications (20-80kg K/ha) at Kerang and Yenda on soils with levels of K at 500-600ppm gave no indications of luxury K uptake into leaf tissue or grain and no economic return in terms of yield.

Plant population & row spacing

At Boort decreasing row spacing from 750mm (approx. 30 inch) to 500mm (approx. 20inch) significantly increased grain yield with a 3.46 t/ha yield increase (trials hand harvested). In the same trial there were no significant effects of plant population when 90,000 plants/ha, 105,000 and 120,000 plant populations were compared. At Peechelba East the lowest plant population 79,287 plants/ha resulted in the lowest yields with no grain yield difference between 91,864 and 103,620 plants/ha. At Kerang in a variable trial there was no yield differences between 750 and 500mm row spacing or target plant populations of 85,000 plants/ha or 120,000 plants/ha. Although no grain yield differences were recorded it was noted that narrower row spacing produced more overall harvest biomass at the lower plant population of 85,000 plants/ha.

Disease Management

Three trials looking at experimental treatments based on triazole (Group 3 DMIs) and strobilurin (Group 11 QoI) fungicides produced no economic response to application and no evidence of increased green leaf retention in the maize canopy. No disease was observed in these three trials.

RESULTS

Protocol 3 & 4. Optimum timings and rates for the nitrogen (N) forms applied in irrigated crops of maize.

Trial 1. Nitrogen Use Efficiency Trial – influence of rate

Protocol Objective:
To evaluate nitrogen use efficiency in grain maize under different rates and of applied N fertiliser applied as pre drill urea (46% N) prior to fertigation with an overhead lateral.

Peechelba East, Victoria

Sown: 13 November 2019
Harvested: 31 May 2020
Soil Type: Red loam over clay
Previous crop: Oaten hay
Hybrid: Pioneer Hybrid 1756
FAR code: FAR IRR M19-01-1
Irrigation Type: Overhead pivot

Key Points:

- *Header grain yields averaged 18.2t/ha with no yield benefit observed from applying pre-drill urea in the trial when N was applied post sowing as fertigation.*
- *In a trial with an overall dose of post sowing N of 207 kg N/ha applied via fertigation there was no significant yield increase from the earlier pre-drill N applications of between 0 – 315kg N/ha.*
- *The economic optimum level of nitrogen applied was 252kg N/ha (45N pre-drill + 207kg N as fertigation).*
- *No significant differences were recorded in total dry matter (DM) content at V6 or at harvest with an average DM content of 34.6t/ha.*
- *The N content at harvest revealed an average N content of 462kg N/ha with a range of approximately 415-530kg N/ha in the crop, but there were no statistical differences.*
- *The N offtake at harvest indicated soil mineralisation provided up to 165kg N/ha to grow the crop with lower N efficiency recorded from applied fertiliser at higher overall N rates.*
- *There were no significant differences in test weight (mean 81.1) or harvest index (mean 51.7%).*

Table 1: SAGI analysis of grain yield (t/ha), test weight (kg/hl), harvest index (%) and harvest dry matter (t/ha), 31 May 2020.

				Yield (t/ha)		Test weight (kg/hl)		Harvest index (%)	
	Pre-sow N	Post sow N*	Total N Kg N/ha	PV	SE	PV	SE	PV	SE
1	0	207	**207**	18.3	+/- 0.61	81.19	+/- 0.28	50.7	+/- 0.87
2	45	207	**252**	18.95	+/- 0.75	80.91	+/- 0.37	52.18	+/- 1.16
3	90	207	**297**	17.35	+/- 0.75	81.16	+/- 0.37	53.74	+/- 1.19
4	135	207	**342**	17.51	+/- 0.75	81.19	+/- 0.37	51.17	+/- 1.17
5	180	207	**387**	18.72	+/- 0.76	81.18	+/- 0.37	50.8	+/- 1.17
6	225	207	**432**	17.83	+/- 0.75	81.5	+/- 0.37	52.5	+/- 1.18
7	270	207	**477**	18.48	+/- 0.77	80.89	+/- 0.37	50.22	+/- 1.19
8	315	207	**522**	18.59	+/- 0.75	81.12	+/- 0.37	52.02	+/- 1.17
Mean				**18.2**		**81.1**		**51.7**	

P val	0.383	0.942	0.275
LSD	1.6	1	2.8
CV	9.3	0.9	4.8

PV= Predicted value, SE= Standard error.
** Post sowing nitrogen (207 N) was applied via fertigation with applications on V4 (46N), V8 (60N), pre-tasselling (101 N) on 10 Dec, 26 Dec, 14 Jan and Jan 15*
Available soil N assessed prior to sowing 33 kg N/ha (0-60cm)
Harvest index based on grain and stover recorded at 0% moisture

Dry Matter (DM) offtake

Dry matter off-take at V6 stage averaged 0.55t/ha and showed no significant differences in DM across any rate of nitrogen applied pre-drill (data not shown). At early development stages V4 there were small differences in visual appearance and NDVI that suggested zero N pre-drill was not as green, however by V8 there was no difference in NDVI as fertigation application became available to the plant.

At harvest (Figure 1) there were some significant differences in DM content at harvest when the average dry matter of the three plant components were compared, the indication being that the majority of the DM offtake was associated with the grain. There appeared to be minimal differences in DM total due to nitrogen rates that were significant although there was a trend indicating 135kg N/ha pre-drill (total 342kg N/ha applied) had greater DM than all other N rates.

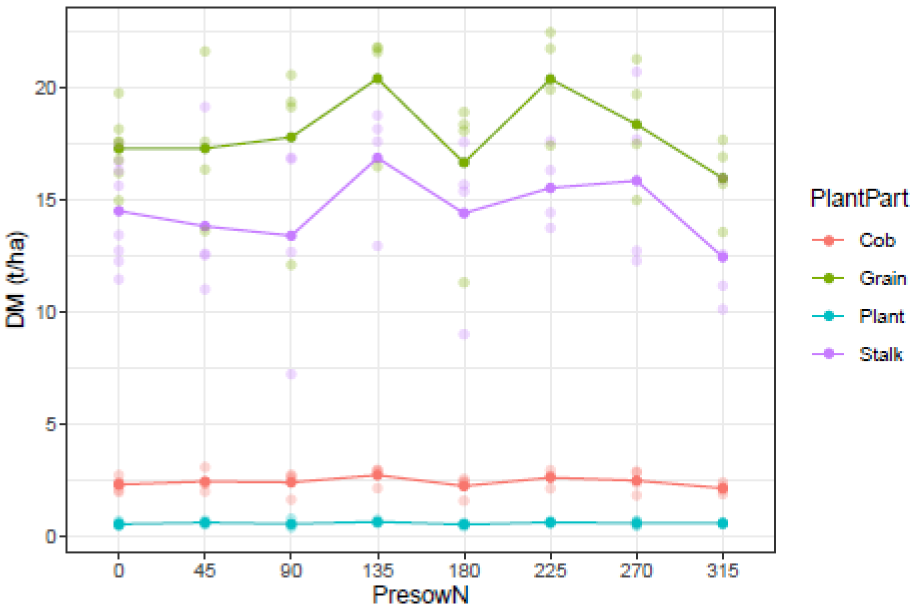

Figure 1: Dry matter accumulation (t/ha) in maize at crop maturity, 7 May 2020.
Note: Plant = DM content of the crop canopy at V6

N content of the crop at harvest indicated that between approximately 415 and 530kg N/ha had been removed depending on applied N treatment, although none of the differences in N content were significant (Figure 2). Approximately 165kg N/ha was provided by mineralisation in the soil in crops where no pre-drilled urea was applied, with 33kg N/ha available in the soil at sowing. At highest level of applied N fertiliser (522kg N/ha) more N fertiliser was applied than was recovered in the crop.

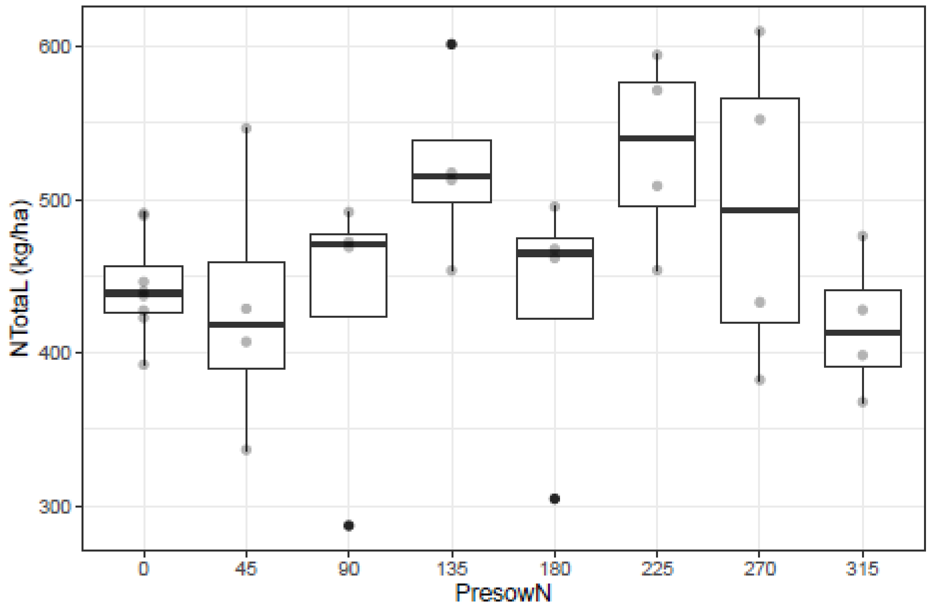

Figure 2: Total Nitrogen content (stalk, cob husk and grain - kg N/ha) in maize at harvest, 31 May 2020.

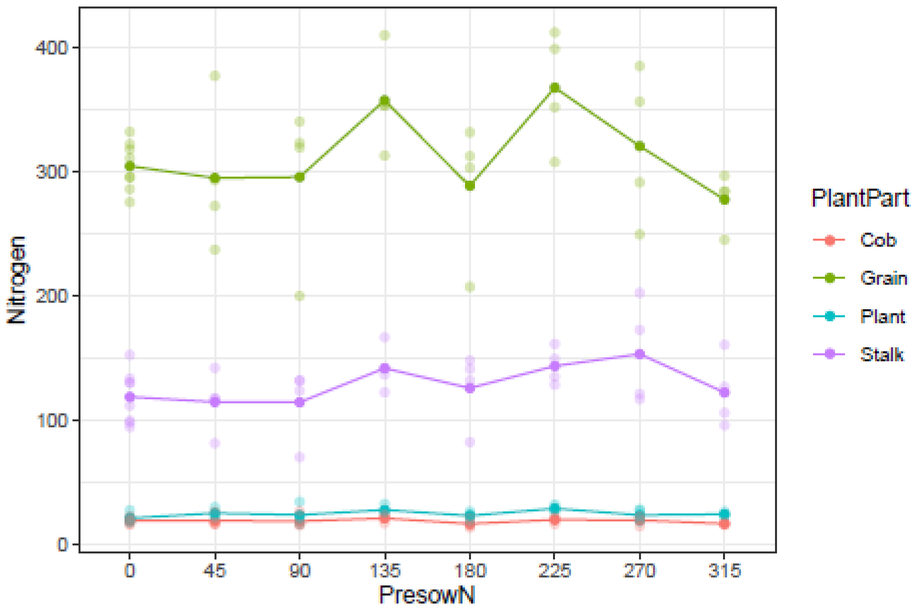

Figure 3: Nitrogen content of component plant parts stalk, cob husk and grain (kg N/ha) in maize at harvest, 31 May 2020. (Plant N = N content of the plant at V6)

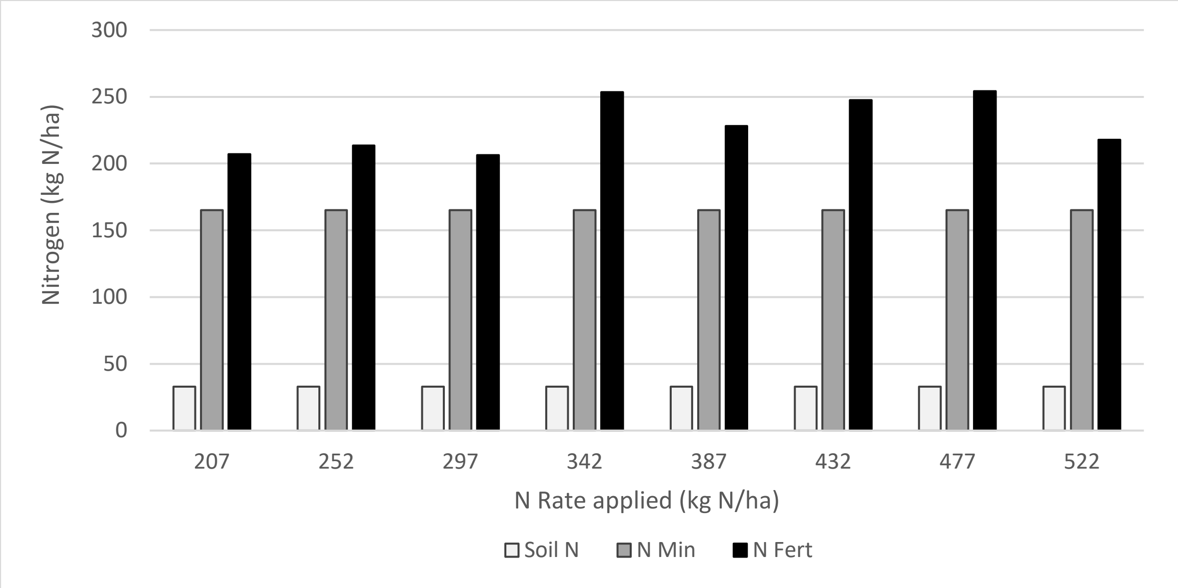

Figure 5: Assumed contribution of N fertiliser to total crop N offtake at harvest (if mineralisation was assumed to be the same in all treatments and that preferential N uptake of soil N rather than bag N was the case).

Note without specific N isotope studies it cannot be accurately calculated what proportion of N uptake by the plant came from the soil and what came from the fertiliser applied).

Table 2: Influence of N rate on leaf %N at V6 (6 leaf collar), R2 (blister stage) and R4 (dough stage).

Total N Applied		**Leaf N (%)**	
kg N/ha	**V6**	**R2**	**R4**
207	4.10	2.27	1.99
387	4.75	2.41	1.96
522	4.53	2.34	1.89

Table 3: Gross income ($/ha) based on grain yield and income after urea costs ($/ha)

Treatment				**Seed Yield and Quality**		
	Pre-drill kg N/ha	**Post drill* kg N/ha**	**Total kg N/ha**	**Gross income $/ha**	**Pre-drill urea costs $/ha $1.20kg N**	**Income after Pre-drill urea costs $/ha**
1	0	207	**207**	5255	0	5255
2	45	207	**252**	5452	54	**5398**
3	90	207	**297**	5313	108	5205
4	135	207	**342**	5516	162	5354
5	180 (Farm)	207	**387**	5403	216	5187
6	225	207	**432**	5255	259	4996
7	270	207	**477**	5377	313	5064
8	315	207	**522**	5319	367	4952
	Mean					

Assumptions: Grain Maize valued at $290/t, Urea fertiliser at $560/t ($1.20kg N)

Other variable costs based on seed, fertilisers and crop protection were $1159/ha (not shown in Table 3).

Table 4: Original ARM analysis of grain yield (t/ha @ 14% moisture) test weight (kg/hL) and harvest index (HI %), 31 May 2020 presented in the provisional results.

Treatment				**Seed Yield and Quality**					
	Pre-drill kg N/ha	**Post drill* kg N/ha**	**Total kg N/ha**	**Yield t/ha**		**Test Wt kg/hL**		**H.I %**	
1	0	207	**207**	18.12	-	81.0	-	49.8	-
2	45	207	**252**	18.80	-	81.0	-	50.3	-
3	90	207	**297**	18.32	-	81.3	-	46.7	-
4	135	207	**342**	19.02	-	81.2	-	45.8	-
5	180 (Farm)	207	**387**	18.63	-	81.3	-	44.9	-
6	225	207	**432**	18.12	-	81.6	-	46.2	-
7	270	207	**477**	18.54	-	80.8	-	47.1	-
8	315	207	**522**	18.34	-	81.2	-	52.3	-
	LSD			NS		NS		NS	
	Mean			18.49		81.1		47.8	
	P Val			0.991		0.926		0.296	
	CV			8.82		1.01		8.99	

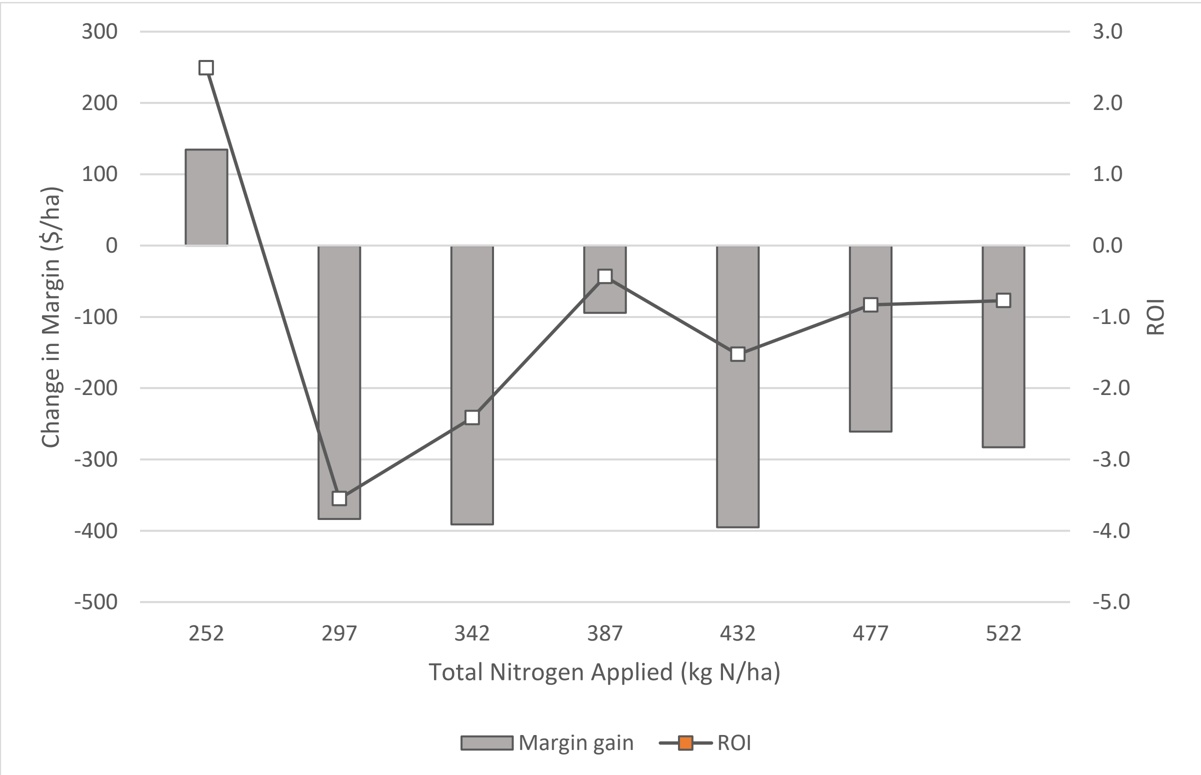

Figure 6. Influence of nitrogen rate on margin over input cost compared to control (207 kg N/ha) ($/ha – value of increased grain production minus cost of inputs) and return on investment (RIO). Based on SAGI predicted yield.

Input costs based on price of $1.20/kg N, Income based on grain value of $290/t.

Trial 2. Nitrogen Use Efficiency Trial – influence of N rate

Protocol Objective:
To evaluate nitrogen use efficiency in grain maize under different rates and of applied N fertiliser applied at sowing and at V6 as urea (46% N).

Kerang, Victoria

Sown: 29 October 2019
Harvested: 22 April 2020
Soil Type: Neutral self-mulching grey clay
Previous crop: Grass dominant pasture (3 years)

Hybrid: Pioneer Hybrid 1756
FAR code: ICC M19-01-2
Irrigation Type: Border check surface irrigation

Key Points:

- *The highest grain yield (machine harvested) achieved was 16.36 t/ha with the applied N rate of 240 kg N/ha in a crop producing 30.63 t/ha dry matter at 50.45% harvest index.*
- *N applications above 240kg N/ha were uneconomic in the trial.*
- *The nil control treatment yielded 10.89 t/ha in a crop producing 26t/ha dry matter at 51% harvest index.*
- *Available Soil N prior to sowing and watering up was 34 kg N/ha (0-60cm). The nil control N offtake at harvest was 241 kg N/ha, suggesting in-crop mineralisation resulted in 207 kg N/ha of the N taken up.*
- *At the highest level of N (560kg N/ha) there was no advantage to applying 80 Kg N/ha of the dose very late at tasselling.*

Mineralisation at the trial site may have been higher than usual due to a long history of pasture and little mineralisation of the soil organic matter over the last few dry years and no irrigation. There was a statistically significant yield response as a more N was applied, which peaked at 240 kg N/ha. N applied at 560 kg N/ha resulted in a yield decrease, while not statistically different to the highest yields, was similar to the low rates (80 and 160 kg N/ha) (Table 1).

Table 1: SAGI analysis for grain yield (t/ha), test weight (kg/hl), harvest index (%) and harvest dry matter (t/ha).

		Yield (t/ha)			Test weight kg/hL		Harvest index (%)		Total DM (t/ha)		
Pre-sow N		PV		SE	PV	SE	PV	SE	PV		SE
1	0	10.89	d	+/- 0.47	82.35	+/- 0.87	51.14	+/- 1.13	26.13	b	+/- 1.59
2	80	12.78	c	+/- 0.47	82.04	+/- 1.16	51.76	+/- 1.13	27.06	b	+/- 1.58
3	160	13.80	bc	+/- 0.47	82.53	+/- 1.19	50.11	+/- 1.13	34.40	a	+/- 1.59
4	240	16.36	a	+/- 0.50	82.44	+/- 1.17	50.45	+/- 1.17	30.63	ab	+/- 1.63
5	320	16.32	a	+/- 0.48	82.09	+/- 1.17	53.49	+/- 1.13	35.08	a	+/- 1.59
6	400	15.48	ab	+/- 0.47	82.5	+/- 1.18	52.48	+/- 1.13	34.26	a	+/- 1.58
7	480	15.56	a	+/- 0.47	81.88	+/- 1.19	50.41	+/- 1.14	33.63	ab	+/- 1.57
8	560	15.62	a	+/- 0.48	82.5	+/- 1.17	49.51	+/- 1.12	32.11	ab	+/- 1.57
Mean		14.6			82.3		51.2		31.7		
P val		0			0.231		0.156		0.002		

LSD	1	0.6	2.8	4.2
CV	14.4	0.5	4.9	13.9

PV= Predicted value, SE= Standard error

Treatment 7 was modified following discussion at the field walk as a result 80 kg N/ha (46% N urea) was applied at tasselling to 480kgN/ha, so both treatment 7 & 8 represent 560kg N/ha.

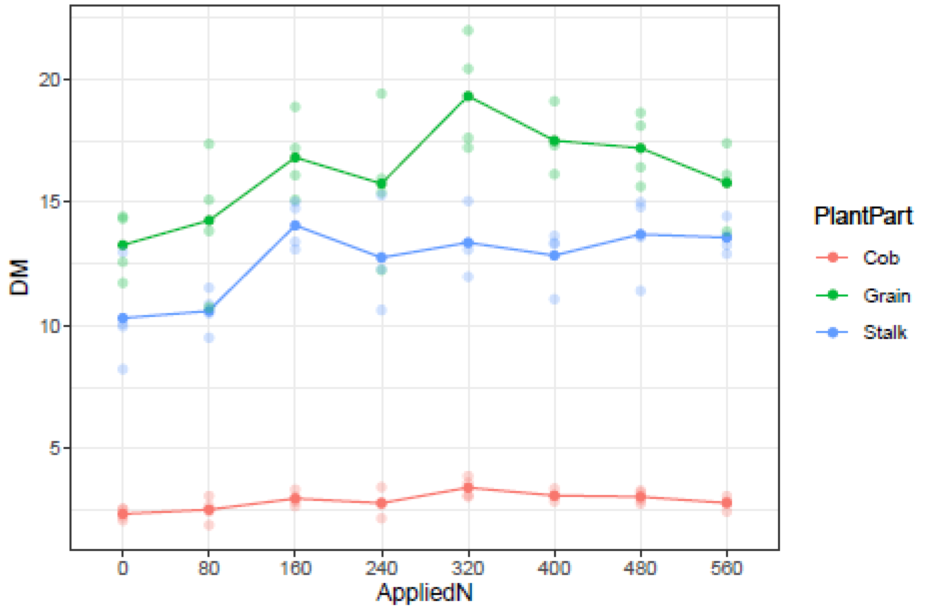

Figure 1: Total dry matter content (kg/ha) in maize at maturity, 23 March 2020.

** This treatment was modified following discussion at the field walk as a result 80 kg N/ha late applied N (46% N urea) was applied at tasselling.*

Nitrogen content Figures followed by different letters are considered to be statistically different (p=0.05)

^ Nitrogen content of stover (stalks, leaves and cob husk) and grain calculated from dry matter at harvest.

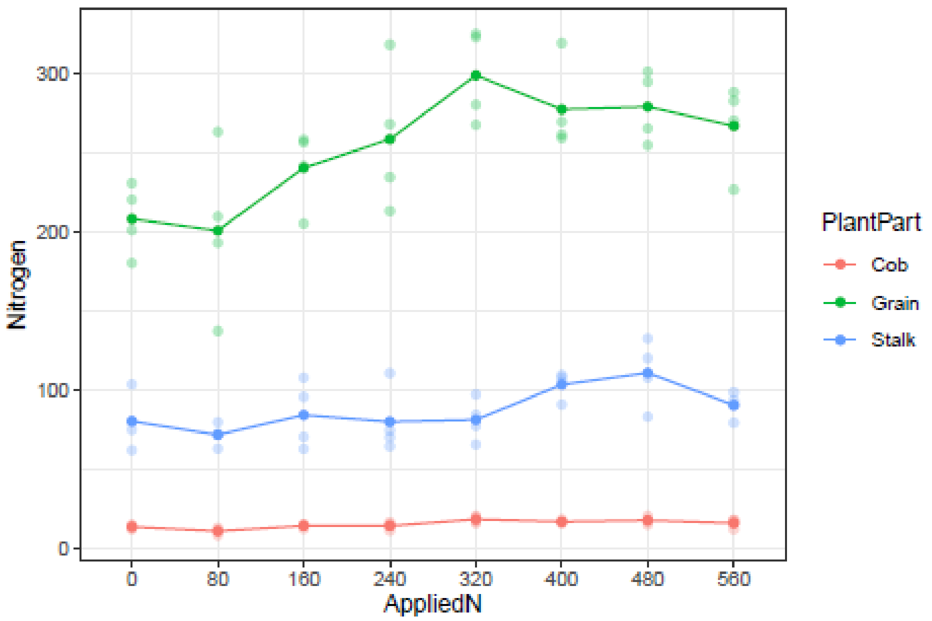

Figure 2. Total crop N (kg N/ha) offtake at harvest in the stover (stalks, leaves, husk) and grain (mean of 2 replicates).

The GRDC Optimising Irrigated Grains Project is a collaborative project including the following project partners:

Treatment 7 was modified following discussion at the field walk as a result 80 kg N/ha (46% N urea) was applied at tasselling to 480kgN/ha, so both treatment 7 & 8 represent 560kg N/ha.
N content has been calculated using DM weights from the sample cuts taken at the bottom of plots to avoid any drag of N by irrigation.

There were differences in N content between the different plant parts and a slight interaction of the combined effect of plant part and Nitrogen indicating that more N went into the grain as applied fertiliser N increased (Figure 2).

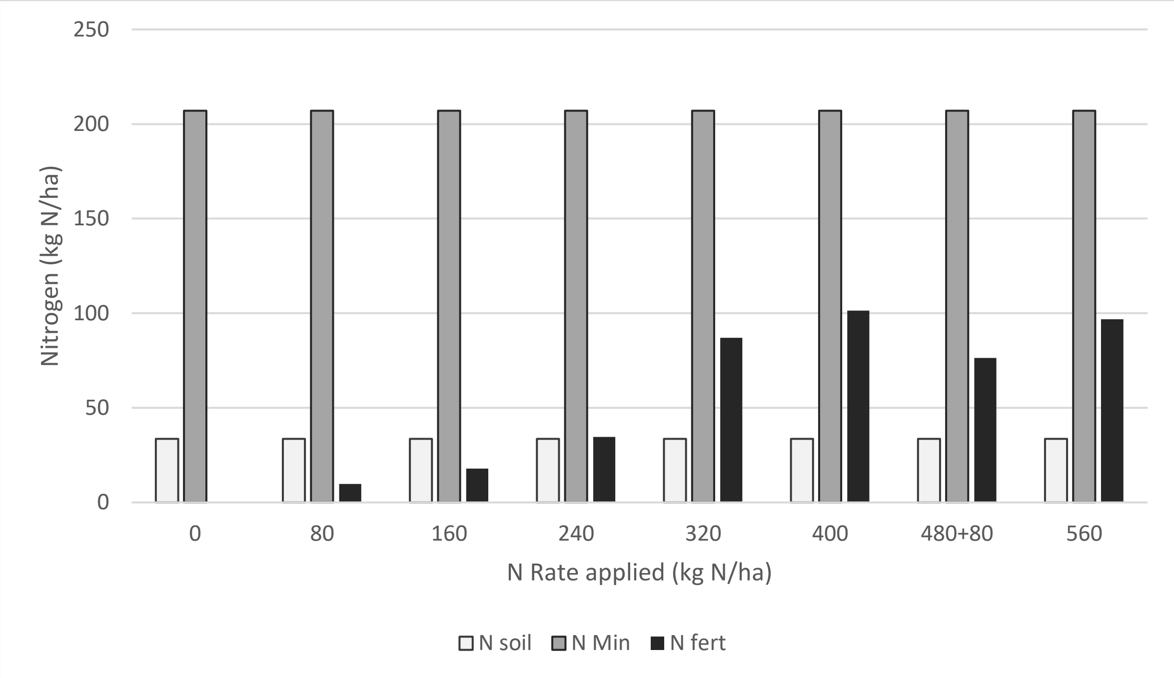

Figure 2: Assumed contribution of N fertiliser to total crop N offtake at harvest (if mineralisation was assumed to be the same in all treatments and that preferential N uptake of soil N rather than bag N was the case).
Note without specific N isotope studies it cannot be accurately calculated what proportion of N uptake by the plant came from the soil or the fertiliser applied).

This trial suggests that mineralisation can contribute a considerable amount when sowing into a pasture paddock. Soil N prior to sowing and watering up was 34 kg N/ha and total N in the untreated crop was 241 kg N/ha at harvest, leaving a balance of 207 kg N potentially supplied by mineralisation. The highest yielding treatment had an N content of 353 kg N/ha at harvest which was achieved by applying 240 kg N/ha N fertiliser. This is 51 kg N/ha higher offtake than in the untreated suggesting minimal contribution to the total crop N from fertiliser applied. The highest amount of N taken up by the crop at harvest was 408 kg N/ha in the '480 + 80 kg N/ha' treatment which was statistically similar to the '400' and '560" treatments. However, none of these higher N contents were associated with significantly higher yields than that achieved with 240kg N/ha.

Yield plateaued after 240 kg N/ha rate. Assuming (with the provisos already stated) the mineralisation rate was approximately 207 kg N/ha, only 70 kg N/ha of the applied fertiliser ended up in the plant, this would represent a very poor nitrogen use efficiency of 29%.

Table 2: Influence of N rate on leaf %N.

N Rate (kg N/ha)	Leaf N (%)	
	Tasselling (VT)	VT + 21 days
Nil (Control)	1.50	1.35
320	2.65	2.15
560	2.50	2.30

Most maize growers would be applying at least 300 kg N/ha to their crops, and do not consider the amount of mineralisation to be a substantial contributor to the N budget. Another comment made at the field days was that applying more N didn't necessarily result in more yield, but high rates are maintained to ensure the crop has too much rather than not enough N. If this surplus N fertiliser is available to the next crop then this might still be an economic approach, however if it is lost from the system as leaching or nitrous oxide emissions then these high N input strategies would be uneconomic. In this trial the margin advantage of 240kg N/ha over 560kg N/ha was almost $500/ha. Both the Peechelba and Kerang trials suggest that mineralisation can contribute a considerable amount of N to the systems and should be considered in the N budget. However, all paddocks will differ in the amount of organic matter available for mineralisation – e.g. a continuously summer cropped paddock is likely to have a lower potential for mineralisation than a long-term clover-based pasture. In both trials in this case optimum N levels of applied fertiliser applied did not exceed 200 - 250kg N/ha.

Table 3: Original analysis of grain yield (t/ha @ 14% moisture), dry matter (t/ha @ 0% moisture), test weight (kg/hL) and harvest index (H.I.%), 21 April 2020 presented in the provisional results.

Treatment				Seed Yield and Quality							
				Yield		DM		Test Wt		H.I	
	Pre-drill	Post	Total kg N/ha	t/ha		t/ha		kg/hL		%	
1	0	0	Nil (Control)	10.91	a	22.02	a	82.4	-	43	ab
2	40	40	80	12.61	b	23.95	a	82.0	-	45	abc
3	80	80	160	14.00	b	29.07	b	82.6	-	42	a
4	120	120	240	16.43	c	28.92	b	82.3	-	49	c
5	160	160	320	16.16	c	30.97	b	82.4	-	45	ab
6	200	200	400	15.78	c	29.50	b	82.5	-	46	bc
7	200	200	480+80*	15.38	bc	29.95	b	81.9	-	45	ab
8	280	280	560	15.37	bc	30.05	b	82.4	-	44	ab
	LSD			1.60		2.94		NS		0.31	
	Mean			14.58		28.06		82.3		45	
	P Val			<0.001		<0.001		0.361		0.040	
	CV			7.4		7.1		0.5		6.0	

Notes: Treatment 7 was modified following discussion at the field walk, as a result 80 kg N/ha (46% N urea) was applied at tasselling to 480kgN/ha, so both treatment 7 & 8 represent 560kg N/ha.
Yield Figures followed by different letters are considered to be statistically different (p=0.05)

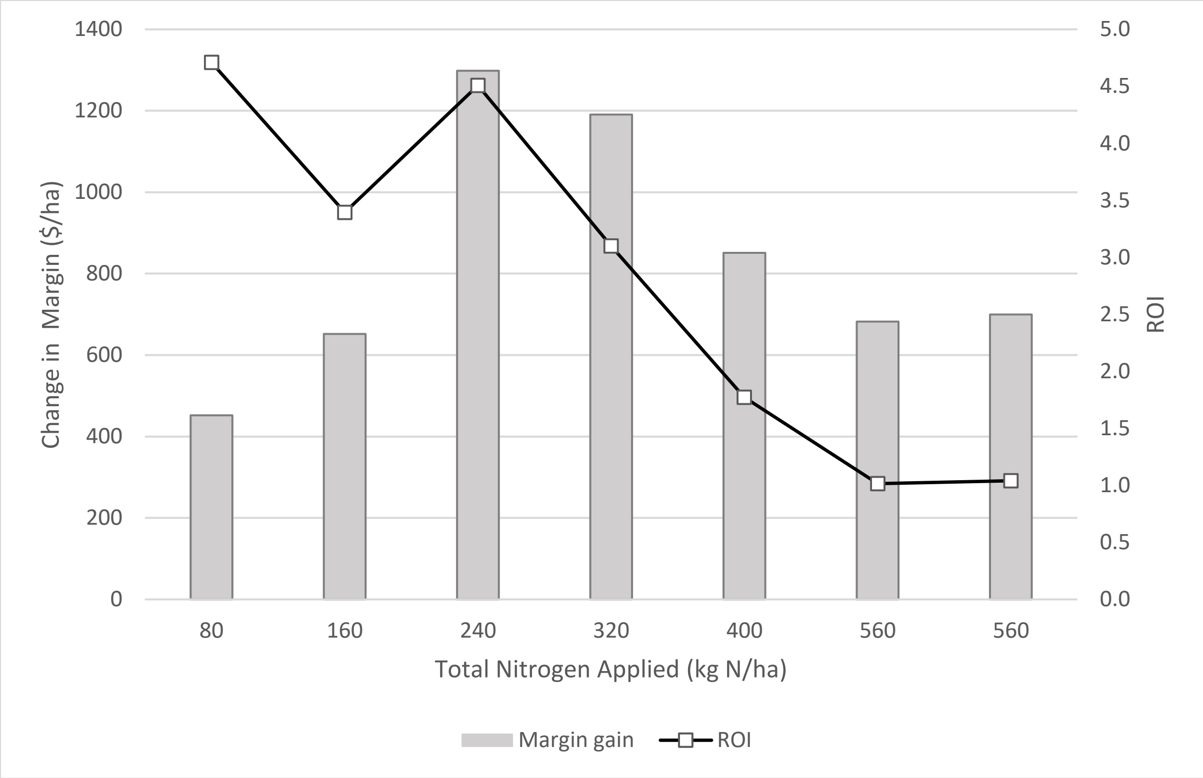

Figure 3. Influence of nitrogen rate on margin over input cost compared to control (0 N) ($/ha – value of increased grain production minus cost of inputs) and return on investment (RIO). Based on SAGI predicted yield.

Input costs based on price of $1.20/kg N, Income based on grain value of $290/t.

Trial 3. Nitrogen Use Efficiency Trial – N Timing

Protocol Objective:
To evaluate the influence of different rates and timings of 46 %N prilled urea applied N prior to later applications of liquid N applied as fertigation applied in grain maize.

Peechelba East, Victoria

Sown: 13 November 2019
Harvested: 31 May 2020
Soil Type: Red loam over clay
Previous crop: Oaten hay
Hybrid: Pioneer Hybrid 1756
FAR code: FAR IRR M19-02-1
Irrigation Type: Overhead pivot

Key Messages:

- *With an average grain yield of 18.28t/ha there were no significant differences in header grain yield from varying nitrogen rate or timing of prilled urea (46%N).*
- *Where no nitrogen was applied early in the season a significant decrease in nitrogen content was observed in the stalk of the plants at harvest, but there no influence on grain N content.*
- *Test weight was significantly reduced when only 207kg N/ha was applied to the crop, there was no significant benefit in test weight when the highest rate of nitrogen was applied.*

Table 1. SAGI analysed grain yield (t/ha @ 14% moisture) of solid urea application rates (0, 90 & 180) at three different application timings.

	Solid Urea N Application Rate (total N applied)					
Prilled Urea N	**0kg/ha N**		**90kg/ha N**		**180kg/ha N**	
	(207)		**(297)**		**(397)**	
Timing	**Yield t/ha**		**Yield t/ha**		**Yield t/ha**	
Pre-Drill	18.26	-	18.65	-	19.05	-
V4	16.99	-	19.54	-	17.71	-
V6	17.91	-	18.20	-	17.49	-
LSD N Application Timing p = 0.05		NS		**P val**	0.691	
LSD N Application Rate p=0.05		NS		**P val**	0.185	
LSD N Timing. x N Rate. P=0.05		NS		**P val**	0.416	

PV= Predicted value, SE= Standard error

** Post sowing nitrogen (207 N) was applied via fertigation with applications on V4 (46N), V8 (60N), pre-tasselling (101 N) on 10 Dec, 26 Dec, 14 Jan and Jan 15*
Available soil N assessed prior to sowing 33 kg N/ha (0-60cm)

Grain Yield

With an average grain yield of 18.28t/ha no significant differences (Table 1) were observed from varying nitrogen rate or the timing of the initial nitrogen applications (pre-drill, V4 or V6) nor was there an interaction between the two variables of rate and timing. A small increase in test weight (less than 1.0kg/hL) was evident when 297kg/ha N or more was applied to the crop (Table 2).

Table 2. SAGI analysis for grain yield (t/ha), test weight (kg/hl) and harvest index (%).

N Timing	N Rate	Yield		Test Weight		Harvest Index	
		PV	SE	PV	SE	PV	SE
4 leaf	0	16.99	+/- 0.75	80.65	+/- 0.29	50.31	+/- 1.18
4 leaf	90	19.54	+/- 0.75	81.50	+/- 0.29	52.14	+/- 1.19
4 leaf	180	17.71	+/- 0.86	81.82	+/- 0.29	50.07	+/- 1.19
6 leaf	0	17.91	+/- 0.75	81.32	+/- 0.29	48.81	+/- 1.18
6 leaf	90	18.20	+/- 0.75	81.67	+/- 0.29	50.2	+/- 1.19
6 leaf	180	17.49	+/- 0.75	81.44	+/- 0.29	51.32	+/- 1.18
Pre-sow	0	18.26	+/- 0.75	80.67	+/- 0.29	51.32	+/- 1.19
Pre-sow	90	18.65	+/- 0.86	81.03	+/- 0.29	48.71	+/- 1.19
Pre-sow	180	19.05	+/- 0.75	81.54	+/- 0.29	50.61	+/- 1.19
Mean		**18.3**		**81.3**		**50.4**	
Timing P val		0.691		0.299		0.765	
Rate P val		0.185		0.019		0.721	
Interaction P val		0.416		0.417		0.2	
LSD		2.3		0.8		3.4	
CV		8.2		0.7		4.8	

PV= Predicted value, SE= Standard error

Dry Matter and nitrogen content of plant components at harvest

Significant differences in nitrogen content of the stalks (including leaves) were observed at harvest, with a significantly less N removed in the stalks where the crop received only 207kg N/ha applied as fertigation (Figure 1). However, there was no difference in the N offtake in the grain.

Although not significant, there was a trend in total dry matter data suggesting that delaying applying nitrogen from pre-drill to V6 increased total dry matter by 3.72 t/ha (Figure 2). Total nitrogen content of all components showed a similar trend. Delaying application of N until V6 increased total N by 38 kg/ha (Figure 3).

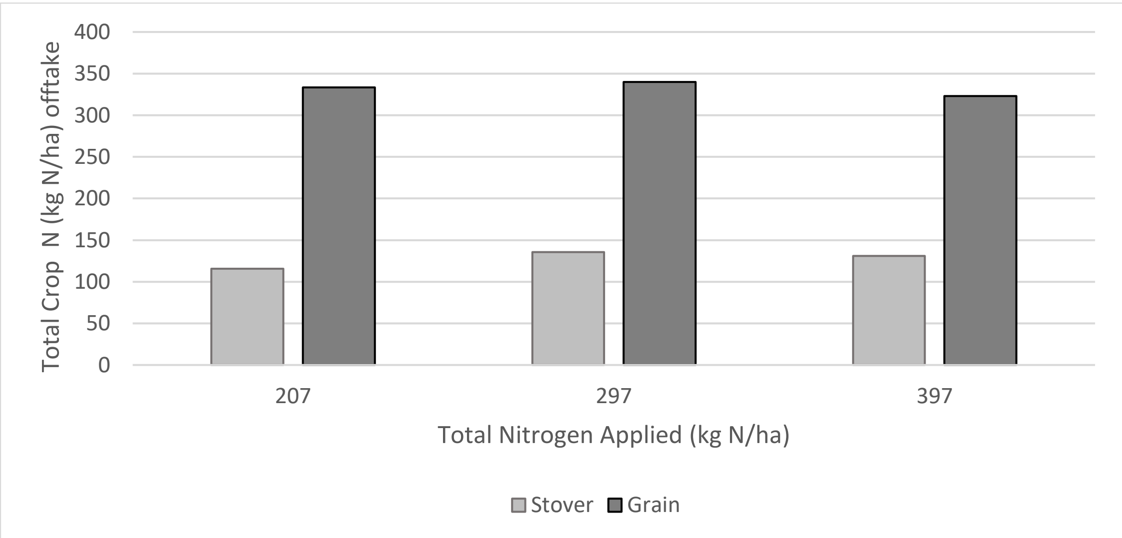

Figure 1. Nitrogen content (kg/ha) in the stover and grain at harvest with three rates of applied Nitrogen applied (mean of three timings of solid urea fertiliser N application)

Post sowing nitrogen (207 N) was applied via fertigation with applications on V4 (46N), V8 (60N), pre-tasselling (101 N) on 10 Dec, 26 Dec, 14 Jan and Jan 15

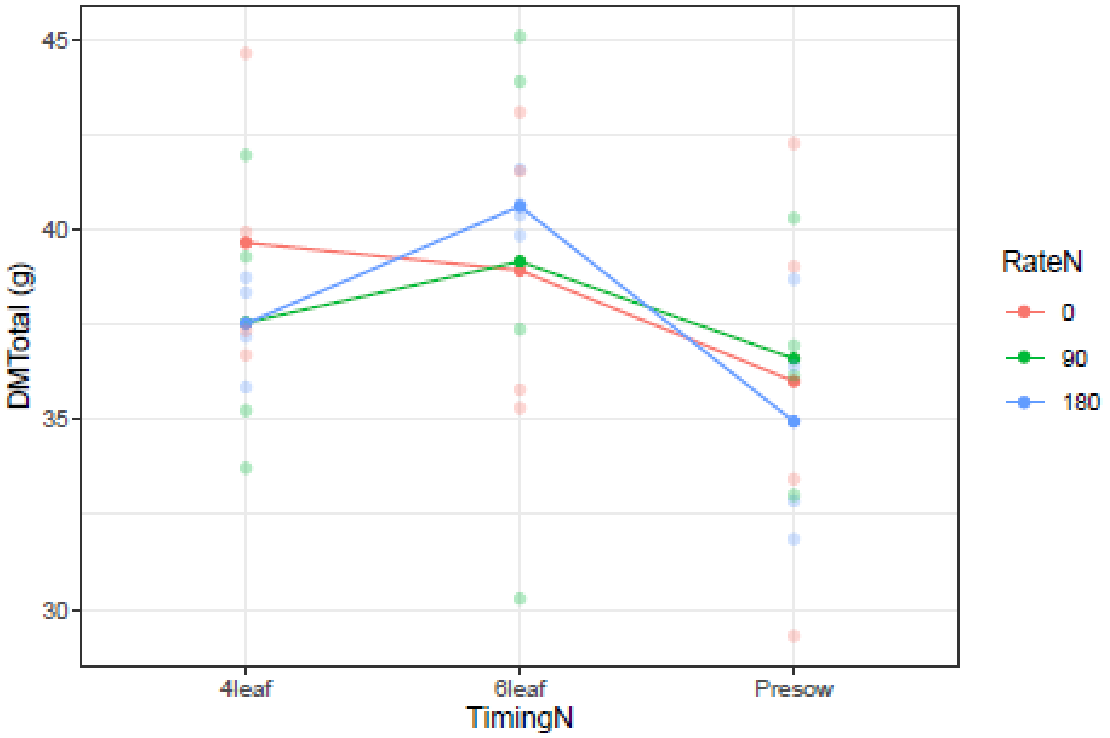

Figure 2. Total dry Matter accumulation at harvest (t/ha) in the stalk, husk and grain when varying the solid nitrogen application timing (0, 90 & 180kg N/ha).
Additional post sowing nitrogen (207 N) was applied via fertigation with applications at V4 (46N), V8 (60N), pre-tasselling (101 N) on 10 Dec, 26 Dec, 14 Jan and Jan 15. Total N applied was therefore 207, 297 and 387kg N/ha

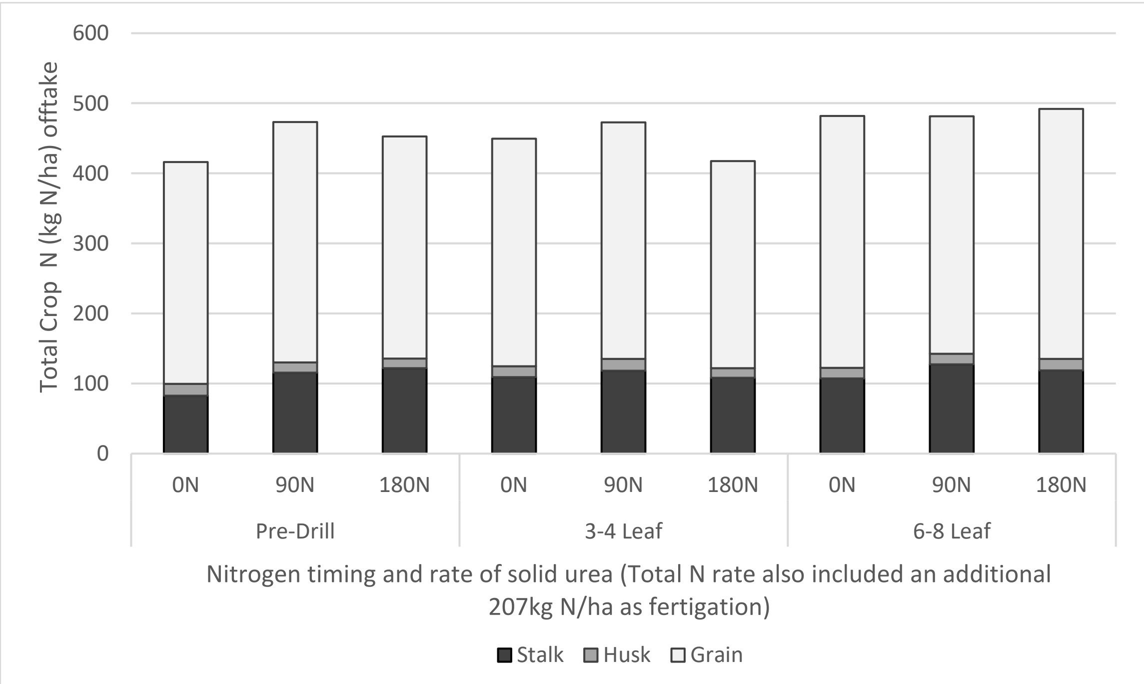

Figure 3. Nitrogen content in the stalk, husk and grain at harvest when varying the first nitrogen application timing.
Additional post sowing nitrogen (207 N) was applied via fertigation with applications at V4 (46N), V8 (60N), pre-tasselling (101 N) on 10 Dec, 26 Dec, 14 Jan and Jan 15.

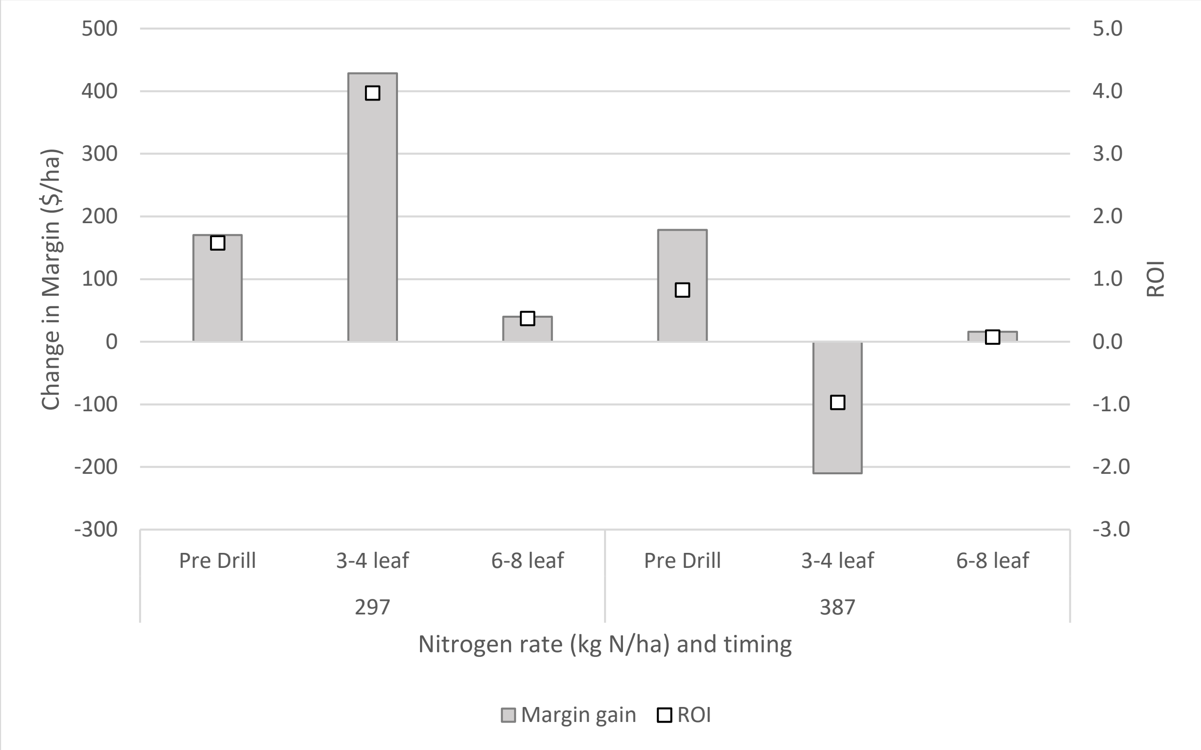

Figure 3. Influence of nitrogen rate and timing on margin over input cost compared to controls (No pre-drill N – fertigation 207N only) ($/ha – value of increased grain production minus cost of inputs) and return on investment (RIO). Based on SAGI predicted yield.
Input costs based on price of $1.20/kg N, Income based on grain value of $290/t.

Trial 4. Nitrogen Use Efficiency – Product and Timing

Irrigated Cropping Council
Promoting irrigated agriculture

Protocol Objective:
To evaluate the influence of different rates and timings of 46 %N prilled urea applied N prior to later applications of liquid N applied as fertigation applied in grain maize.

Kerang, Victoria

Sown: 29 October 2019
Harvested: 22 April 2020
Soil Type: Neutral self-mulching grey clay
Previous crop: Grass dominant pasture (3 years)
Hybrid: Pioneer Hybrid 1756
FAR code: ICC M19-02-2
Irrigation Type: Border check irrigation

Treatment list:

	Applied N rate and timings (kg N/ha)			
Trt.	**Timing (1st N dose)**	**Timing 2nd N dose)**	**Timing 3rd N dose**	**Timing 4th N dose**
	Seedbed	**V2 (2-3 leaf)**	**V4 (3-4 leaf)**	**V6 (6 leaf)**
1	---	---	---	---
2	300			
3	200			100
4	100	100	100	
5	100	---	100	100
6	100	66	66	66
7	200 (slow release Entec)	---	---	100
8	200 (slow release Entec2)	---	---	100

Key Points:

- *Although increasing the frequency of N applications appeared to slightly increase grain yield (machine harvested) compared to all "up front" in seedbed yield differences were not statistically significant.*
- *As a general comment, timing of N application did not affect the grain yield, whether it be all up front or split over 4 timings up to V6.*
- *The nil applied N treatment yielded 9.49t/ha.*
- *However N content of the grain at harvest was greater where split applications involving later timings were compared to all the nitrogen applied at sowing indicating greater N fertiliser efficiency*
- *However, unless there is a premium for the maize protein in the grain resulting from later N timings the difference may be of little value to the grower.*
- *Soil N prior to sowing and watering up was 25 kg N/ha (0-60cm). The nil treatment contained a total of 147 kg N/ha at harvest, suggesting in-crop mineralisation resulted in 122 kg N/ha released to the crop.*

Table 2. SAGI analysed grain yield (t/ha @ 14% moisture), test weight (kg/hl), harvest index (%) and harvest dry matter (t/ha) in response to Nitrogen timing and Product.

	Yield			Test Weight			Harvest Index		Total DM		
Treatment	**PV**		**SE**	**PV**		**SE**	**PV**	**SE**	**PV**		**SE**
1	9.49	b	+/- 0.97	82.4	b	+/- 0.13	52.02	+/- 1.08	23.45	b	+/- 1.74
2	15.02	a	+/- 0.98	82.6	ab	+/- 0.13	55.61	+/- 1.09	33.88	a	+/- 1.74
3	15.21	a	+/- 0.96	82.9	ab	+/- 0.13	54.18	+/- 1.09	35.78	a	+/- 1.74
4	15.45	a	+/- 1.03	82.7	ab	+/- 0.13	54.14	+/- 1.08	34.46	a	+/- 1.73
5	16.60	a	+/- 0.96	82.7	ab	+/- 0.13	53.18	+/- 1.08	38.7	a	+/- 1.74
6	15.80	a	+/- 0.96	82.8	ab	+/- 0.13	54.17	+/- 1.08	36.69	a	+/- 1.74
7	16.81	a	+/- 0.96	82.7	ab	+/- 0.13	52.87	+/- 1.09	35.22	a	+/- 1.74
8	15.29	a	+/- 0.96	83.1	a	+/- 0.13	53.79	+/- 1.09	34	a	+/- 1.74
Mean	**15**			**82.7**			**53.7**		**34**		
P val	0.001			0.027			0.392		0.001		
LSD	1.8			0.3			2.9		5.1		
CV	19.3			0.4			4.1		15.8		

There was a statistically significant yield response to N over the nil control. The highest yielding treatment at 16.81 t/ha was pre-drilling 200 kg N/ha as a 50/50 mix of urea and a new formulation of Entec (Entec 2) treated urea, although this was not statistically different to the other split timing N treatments (Table 2). There was no difference in total harvest dry matter as result of either product or N timing, although all treatments gave significantly higher DM than the zero N control (Figure 1). N offtake in the crop at harvest suggested split timings resulted in more N being removed in the grain compared to where all N was applied upfront (Table 3 & Figure 2).

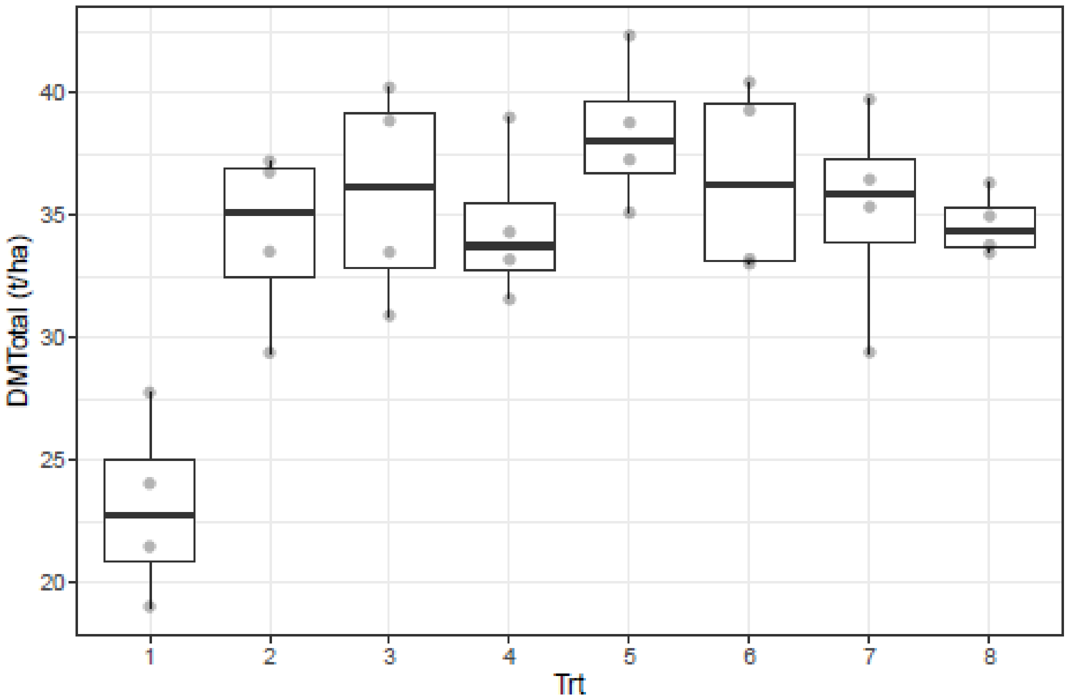

Figure 1. Total dry matter (t/ha) content at harvest in the stover (stalks, leaves, husk) and grain
PV= Predicted value

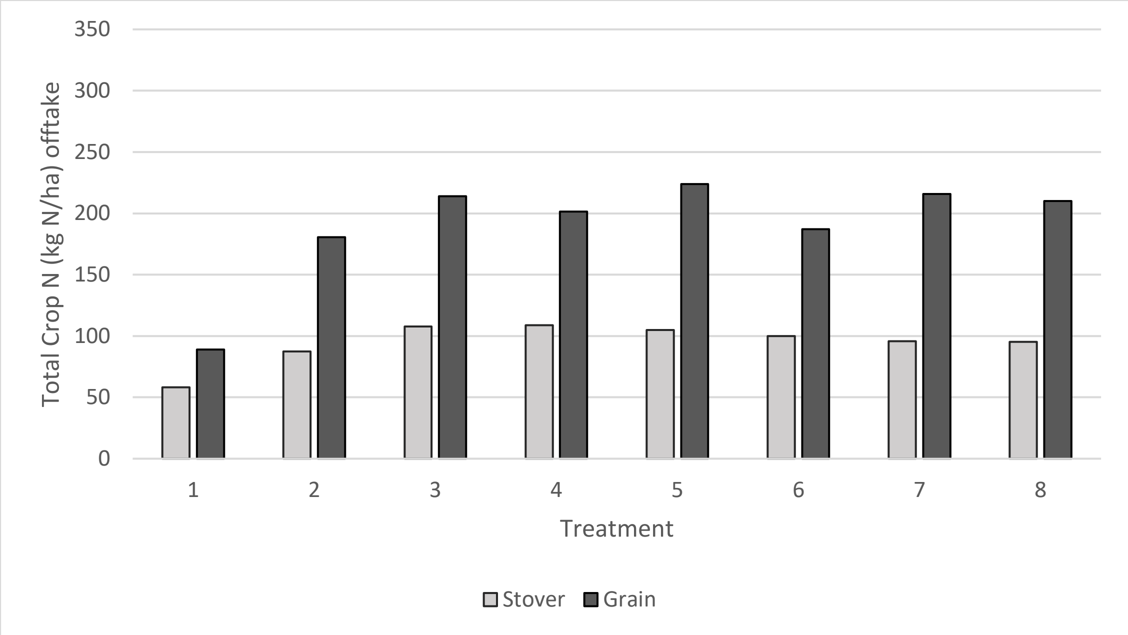

Figure 2. Total crop N (kg N/ha) offtake at harvest in the stover (stalks, leaves, husk) and grain

Table 3: Nitrogen content^ (kg N/ha) in maize at maturity, 23 March 2020.

Treatment	Applied N (kg N/ha)	Stover		Grain		Total N	
		Kg N/ha		Kg N/ha		Kg N/ha	
1	*Nil (Zero Control)*	58.2	a	89.0	a	147.2	a
2	*300 at sowing (s)*	87.5	b	180.7	b	268.2	c
3	*200 (s) + 100 V6*	107.8	c	214.1	bc	321.8	cd
4	*100 (s) + 100 V2 + 100 V4*	108.9	c	201.4	bc	310.2	cd
5	*100 (s) + 100 V4 + 100 V6*	104.9	b	224.0	c	328.9	d
6	*100 (s) + 66 V2 + 66 V4 + 66 V6*	99.9	b	187.2	bc	287.1	bc
7	*200 (50/50 urea/Entec) (s) + 100 V6*	95.8	b	215.9	bc	311.7	cd
8	*200 (50/50 urea/Entec2) (s) + 100*	95.2	b	210.1	bc	305.3	bcd
LSD		19.62		37.55		41.41	
Mean		94.8		190.3		285.0	
P Val		<0.001		<0.001		<0.001	
CV		14.1		13.4		9.9	

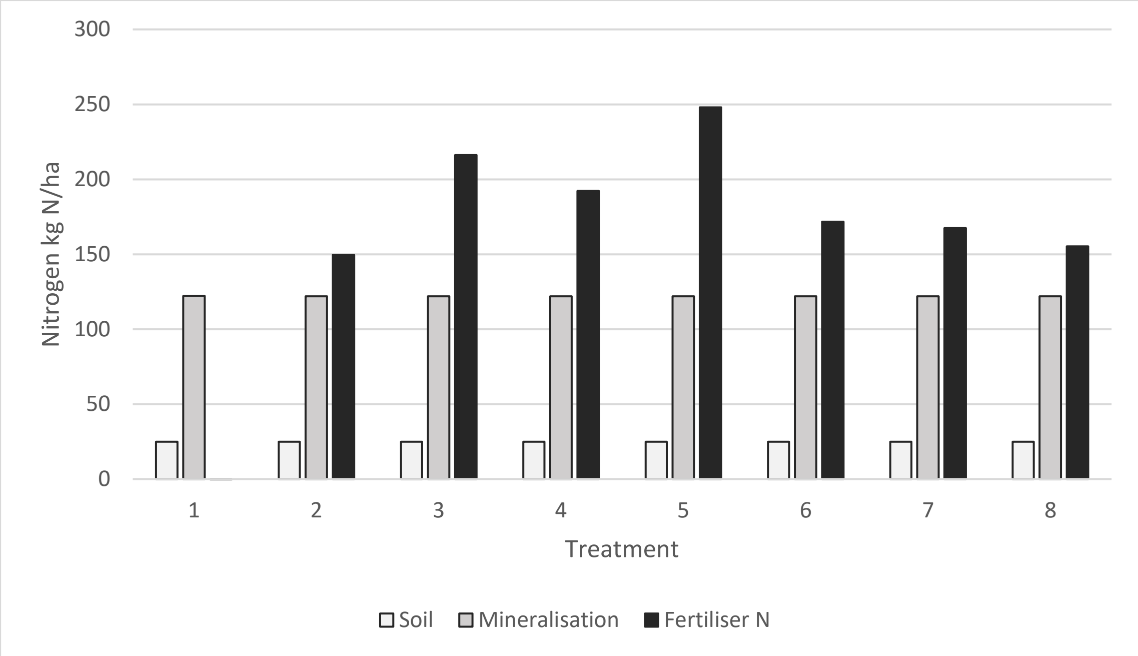

Figure 3: Assumed contribution of N fertiliser to total crop N offtake at harvest (if mineralisation was assumed to be the same in all treatments and that preferential N uptake of soil N rather than bag N was the case).

Note without specific N isotope studies it cannot be accurately calculated what proportion of N uptake by the plant came from the soil or the fertiliser applied).

This trial suggested that mineralisation contributed a considerable amount of N to the final crop and should be considered in the N budget. However, all paddocks will differ in the amount of organic matter available for mineralisation – e.g. a continuously summer cropped paddock is likely to have a lower potential for mineralisation than a long-term clover-based pasture.

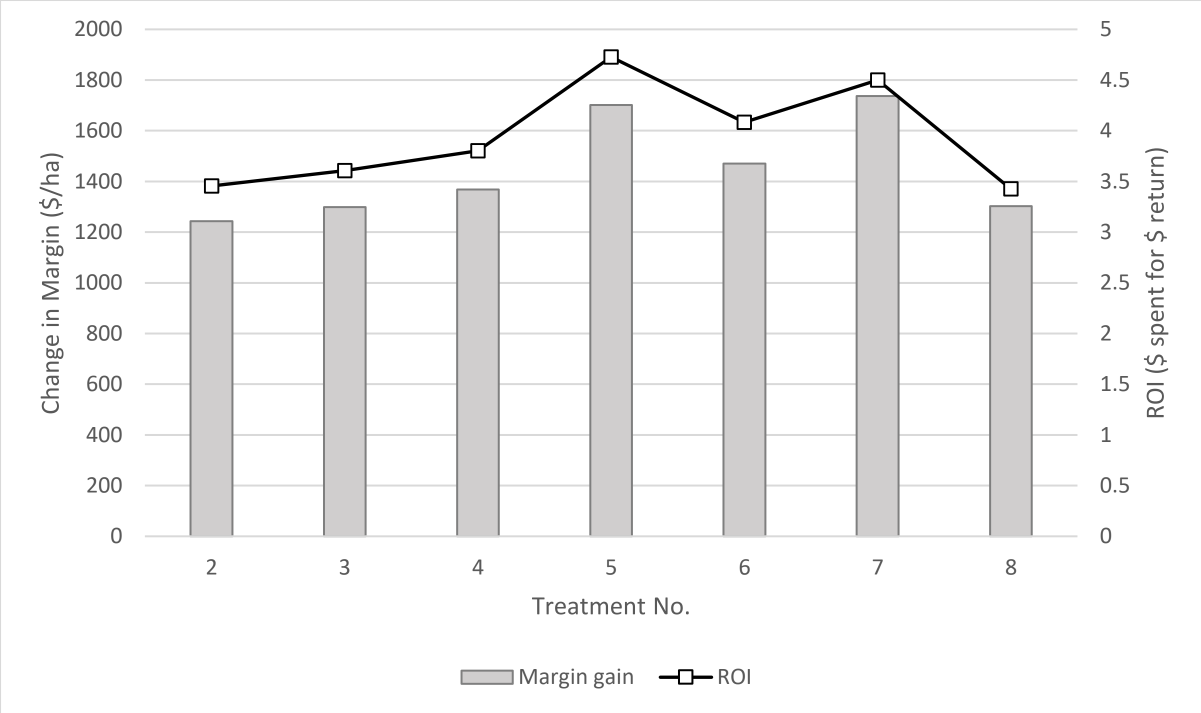

Figure 3. Influence of nitrogen application on margin over input cost compared to controls ($/ha – value of increased grain production minus cost of inputs) and return on investment (ROI). Based on SAGI predicted yield.

Input costs based on price of $1.20/kg N (Urea), $1.46/kg N (Entec), $1.40/kg N (Entec2), Income based on grain value of $290/t.

Trial 5. Nitrogen Use Efficiency – Plant population x nitrogen interaction trial

Protocol Objective
To evaluate the influence of plant population on nitrogen use efficiency (NUE), dry matter production, grain yield and harvest index in grain maize.

Peechelba East, Victoria

Sown: 13 November 2019
Harvested: 31 May 2020
Soil Type: Red loam over clay
Previous Crop: Oaten hay
Hybrid: Pioneer Hybrid 1756
FAR code: FAR IRR M19-03
Irrigation Type: Overhead pivot

Key Messages:

- *The average grain yield (header harvest) of the trial was 17.12t/ha with no indication that increased nitrogen rate (from the use of pre-drill urea) significantly increased yield when 207kg N/ha was subsequently applied in crop as fertigation.*
- *The lowest plant population 79,287 plants/ha resulted in the lowest yields with no grain yield difference between 91,864 and 103,620 plants/ha. 91,864 plants/ha was the most profitable.*
- *Normalised differential vegetative index (NDVI) assessments indicated that ground cover was significantly lower in the lowest plant population across all assessment timings up to V8.*
- *The most efficient recovery of nitrogen applied was recorded with plant populations of approximately 92,000 plants/ha with N applied by fertigation totalling 207 kg N/ha.*

Table 1. SAGI analysis for grain yield (t/ha), test weight (kg/hl), harvest index (%) and harvest dry matter (t/ha).

Treatment		Yield		Test Weight		Harvest Index		Total DM	
Population	**N Rate***	**PV**	**SE**	**PV**	**SE**	**PV**	**SE**	**PV**	**SE**
79,287	0	15.87	+/- 0.62	80.94	+/- 0.38	0.53	+/- 0.02	34.92	+/- 2.47
79,287	90	16.45	+/- 0.62	81.18	+/- 0.38	0.51	+/- 0.02	37.57	+/- 2.42
79,287	180	16.93	+/- 0.62	81.05	+/- 0.38	0.52	+/- 0.02	34.38	+/- 2.51
91,864	0	17.24	+/- 0.62	81.15	+/- 0.38	0.53	+/- 0.02	34.51	+/- 2.46
91,864	90	18.57	+/- 0.62	80.84	+/- 0.38	0.56	+/- 0.02	29.16	+/- 2.52
91,864	180	16.87	+/- 0.70	80.76	+/- 0.38	0.52	+/- 0.02	36.27	+/- 2.46
103,620	0	17.03	+/- 0.62	80.99	+/- 0.38	0.54	+/- 0.02	31.11	+/- 2.41
103,620	90	17.33	+/- 0.62	81.21	+/- 0.38	0.55	+/- 0.02	30.48	+/- 2.46
103,620	180	17.77	+/- 0.62	80.89	+/- 0.38	0.56	+/- 0.02	31.16	+/- 2.42
Mean		**17.1**		**81**		**0.5**		**33.3**	
Population P val		0.032		0.851		0.233		0.051	
N rate P val		0.25		0.829		0.995		0.811	
Interaction P val		0.36		0.928		0.056		0.351	
LSD		1.579		1.033		0.036		6.72	
CV		7.602		0.864		6.691		15.106	

PV= Predicted value, SE= Standard error

** Levels of pre-sow N only showed in table 1. Post sowing nitrogen (207 N) was applied via fertigation with applications at V4 (46N), V8 (60N), pre-tasselling (101 N) on 10 Dec, 26 Dec, 14 Jan and 15 Jan across ALL treatments. Therefore, total N rates in this trial were 207, 297 and 387 kg N/ha.*
Available soil N assessed prior to sowing 33 kg N/ha (0-60cm)

Grain Yield

The trial gave an average of 17.12 t/ha. There was no interaction between plant population and the rate of nitrogen applied indicating that the effects of lower plant population were the same irrespective of the level of pre-drill (sow) urea. Varying plant population did result in significant differences in grain yield when plant populations were reduced to 79,287 plants/ha, with a significant reduction of 0.96 - 1.14t/ha in comparison to the higher plant populations of 91,864 and 103,620 plants/ha (Table 1). There was no yield difference between 91,864 and 103,620 plants/m^2.

NDVI

Significant differences were observed throughout the season in crop reflectance (crop reflectance measured as NDVI with the Greenseeker) indicating less crop ground cover (reduced NDVI) with the lowest plant population plots (79,287plants/ha) in comparison to the higher plant population plots (Figure 1).

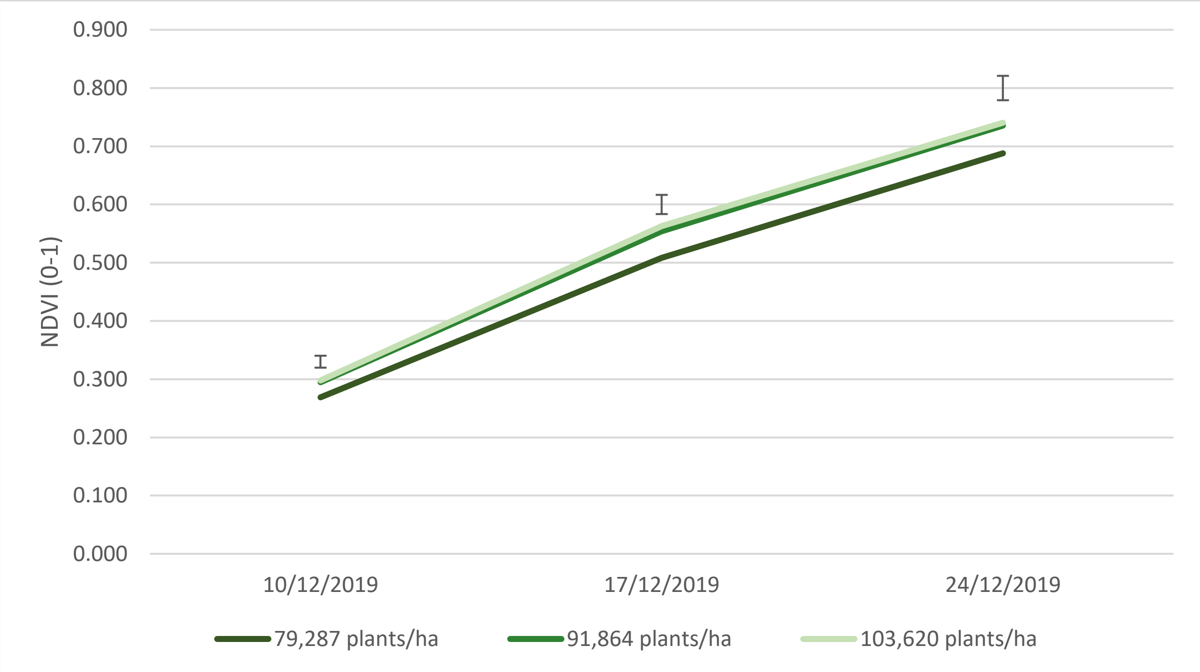

Figure 1. Influence of plant population on Normalised Difference Vegetation Index at V4 on 10 December (p=0.025), V6 on 17 December (p=0.014) and V8 on 24 December (p=0.041).
Error bars are a measure of LSD.

Dry Matter at Harvest

There was no difference in dry matter offtake at harvest as a result of plant population with some evidence of more vegetative growth with the lowest plant population registered as more dry matter as stover (leaves stalk and cob husk) rather than grain (Table 2).

Table 2. Dry Matter (t/ha at 0% moisture) accumulation at harvest in the different plant components.

	Dry Matter (mean of 3 Pre-drill N rates)		
	Stalk	**Cob husk**	**Grain**
Plants/ha	**t/ha**	**t/ha**	**t/ha**
79,287	14.27 a	2.51 -	14.09 b
91,864	12.85 ab	2.47 -	15.11 a
103,620	11.93 b	2.35 -	14.96 a
Mean	13.02	2.40	14.72
LSD	1.68	NS	0.81
P Val	0.038	0.374	0.042

Table 3. Original ARM analysis of grain yield (t/ha @ 14% moisture) of three pre-drill nitrogen application rates at three different plant populations presented in the provisional results.

	Total Applied Nitrogen Rate (additional pre-drill N at sowing in brackets)			
Total N kg N/ha **Pre drill N (..)**	**207kg/ha N** **(0)**	**297kg/ha N** **(90)**	**387kg/ha N** **(180)**	**Mean N rate**
Actual Plants/ha	**Yield t/ha**	**Yield t/ha**	**Yield t/ha**	**Yield t/ha**
79,287	15.89 -	16.37 -	16.88 -	16.38 b
91,864	17.21 -	18.66 -	16.84 -	17.57 a
103,620	17.18 -	17.37 -	17.63 -	17.40 a
	16.76	**17.47**	**17.12**	
LSD N Plant Pop p = 0.05		0.94	**P val**	0.042
LSD N Application Rate p=0.05		NS	**P val**	0.423
LSD Plant pop. x N Rate. P=0.05		NS	**P val**	0.266

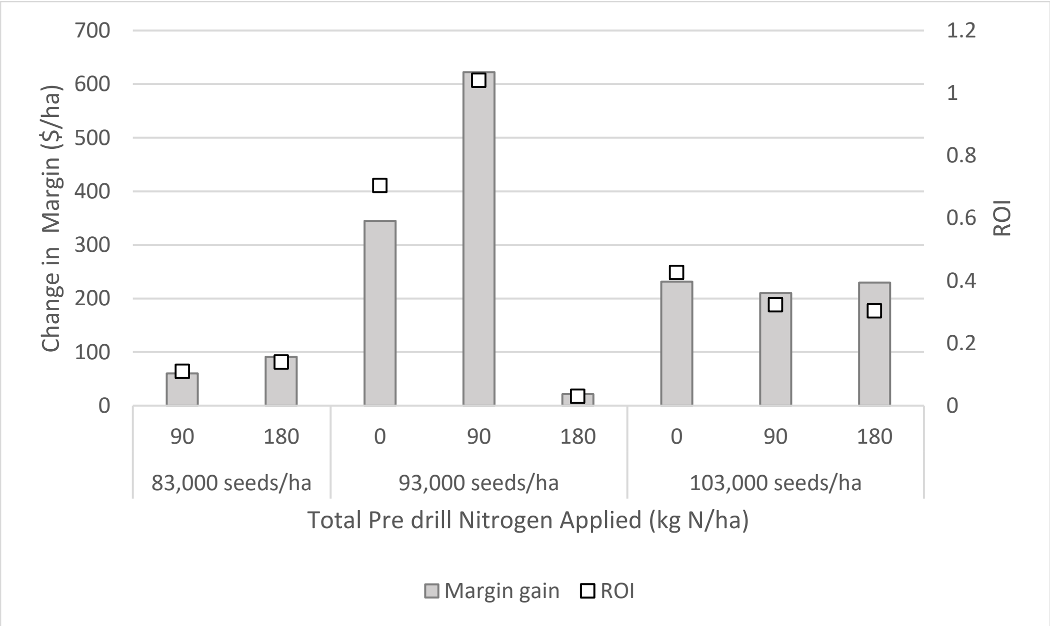

Figure 3. Influence of Pre-drill nitrogen rate on margin over input cost compared to treatment 1 – 83,000 seeds/ha with zero pre drill N ($/ha – value of increased grain production minus cost of inputs) and return on investment (ROI). Based on SAGI predicted yield. Yield differences in N rates were not significant. *Input costs based on price of $1.20/kg N, Seed @ $380/72,000 seeds, Income based on grain value of $290/t.*

Trial 6. Nitrogen Use Efficiency – Plant population x row spacing x nitrogen interaction trial

Protocol Objective:
To evaluate the influence of plant population, row spacing and nitrogen rate on nitrogen use efficiency (NUE), dry matter production, grain yield and harvest index in grain maize.

Kerang, Victoria

Sown: 29 October 2019
Harvested: 22 April 2020
Soil Type: Neutral self-mulching grey clay
Previous crop: Grass dominant pasture (3 years)
Hybrid: Pioneer Hybrid 1756
FAR code: ICC M19-03
Irrigation Type: Border check irrigation

Key Messages:

- *In a variable trial there were no significant differences in grain yield (machine harvested) due to row spacing 500mm v 750mm (20" v 30"), plant population (85,000 v 120,000 pl/ha) or N rate 300 v 450 kg N/ha).*
- *Overall grain yield average in the trial was 16.47 t/ha.*
- *Although no yield differences were recorded it was noted that narrower row spacing produced more overall harvest biomass, particularly at the lower plant population.*
- *Since there were no difference in grain yield associated with narrow row spacing and lower plant population, harvest index was reduced.*
- *Crop canopies at harvest contained more nitrogen than was applied as fertiliser indicating that at 300 kg N/ha applied as much as 235 kg N/ha was supplied from the soil.*
- *Increasing N fertiliser applied from 300 to 450 kg N/ha did not result in any greater N offtake in the crop at harvest, indicating that N was either left in the soil or lost.*

Table 1. Grain yield (t/ha @ 14% moisture) in response to row width (500mm (20inch) v 750mm (30inch) , plant population and N rate

Row Spacing	Population '000 pl/ha	Applied kg N/ha	
Spacing mm		Sowing	V6
500	85	150	150
500	85	225	225
500	120	150	150
500	120	225	225
750	85	150	150
750	85	225	225
750	120	150	150
750	120	225	225

There was some variability in the yield data due to patchy establishment of the trial, resulting in a high co-efficient of variation (cv %), and so the results should be viewed with caution (Table 2).

Table 2. SAGI analysis for grain yield (t/ha), test weight (kg/hl), harvest index (%) and harvest dry matter (t/ha).

Treatment			Yield		Test Weight		Harvest Index		Total DM	
Row Spacing	**Pop ***	**N Rate**	**PV**	**SE**	**PV**	**SE**	**PV**	**SE**	**PV**	**SE**
20	85	300	16.48	+/- 1.21	82.27	+/- 0.19	0.58	+/- 0.02	42.03	+/- 2.13
20	85	450	19.40	+/- 1.21	82.28	+/- 0.19	0.62	+/- 0.02	44.16	+/- 2.11
20	120	300	15.03	+/- 1.21	82.22	+/- 0.19	0.59	+/- 0.02	37.16	+/- 2.11
20	120	450	14.71	+/- 1.21	82.3	+/- 0.19	0.58	+/- 0.02	37.74	+/- 2.1
30	85	300	17.09	+/- 1.21	83.3	+/- 0.19	0.66	+/- 0.02	31.63	+/- 2.07
30	85	450	16.05	+/- 1.21	83.93	+/- 0.19	0.65	+/- 0.02	32.81	+/- 2.14
30	120	300	16.62	+/- 1.21	83.3	+/- 0.19	0.64	+/- 0.02	32.97	+/- 2.08
30	120	450	14.66	+/- 1.21	83.23	+/- 0.19	0.6	+/- 0.02	33.73	+/- 2.13
Mean			16.3		82.9		0.6		36.5	
Interaction P val			0.511		0.151		0.943		0.826	
LSD			3.478		0.519		0.068		5.238	
CV			16.049		0.844		8.306		15.89	

PV= Predicted value, SE= Standard error

** Plant population 85 = 85,000 seeds/ha*

While there was no difference in yield, there was more dry matter produced at the narrower row spacing at the lower plant population, but this was not the case with the wider row spacing (Table 1 & Figure 1). The higher dry matter at narrower row spacing did not result in higher grain yields therefore harvest indices were higher in the wider row spacing (Table 1), again particularly at lower plant populations.

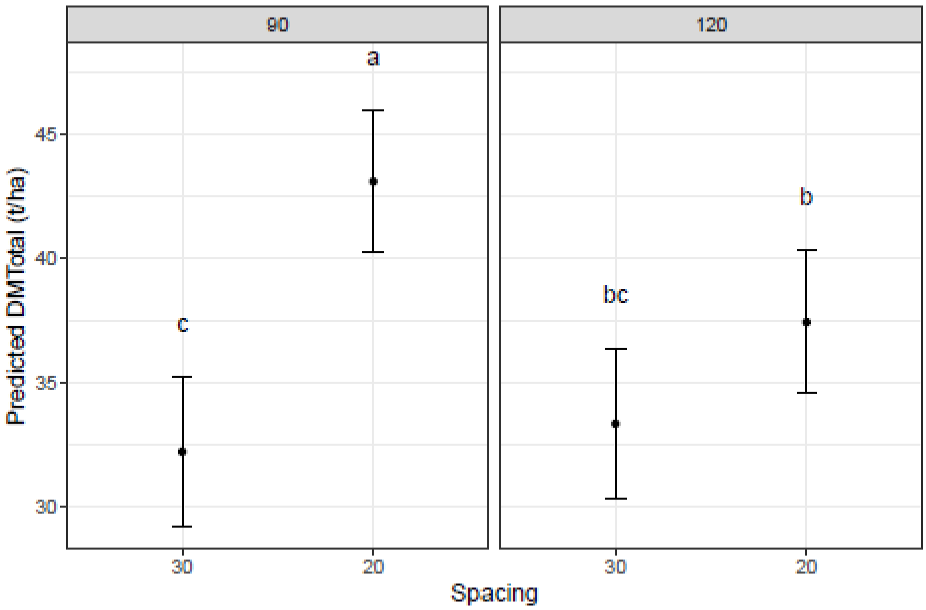

Figure 1. Effect of row spacing 30inch (750mm) and 20inch (500mm) row spacing and plant population on predicted dry matter values at harvest. Population *120 = 120,000 plants/ha*

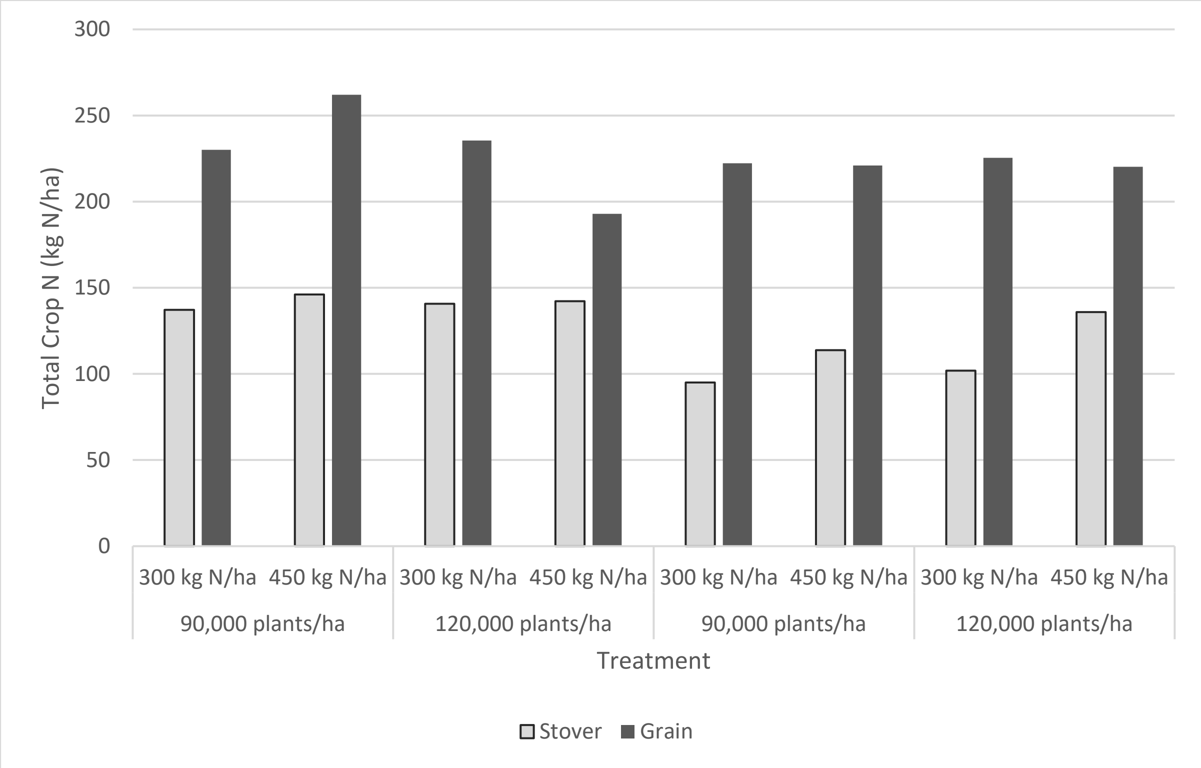

Figure 2. Total crop N (kg N/ha) offtake at harvest in the stover (stalks, leaves, husk) and grain (mean of 2 replicates).

Nitrogen offtake in the crop tended to be generally higher in the narrower row spacing, presumably as a result of greater dry matter accumulation. Maximum N in the crop at harvest was 535 kg N/ha (narrow row spacing, 120,000 pl/ha and 300kg N /ha applied as fertiliser) (Figure 2).

This trial suggests that the narrower row spacing allowed greater crop biomass production, but that this failed to translate into yield. Further investigation is required to improve the harvest index of narrow 20-inch row spacing crops.

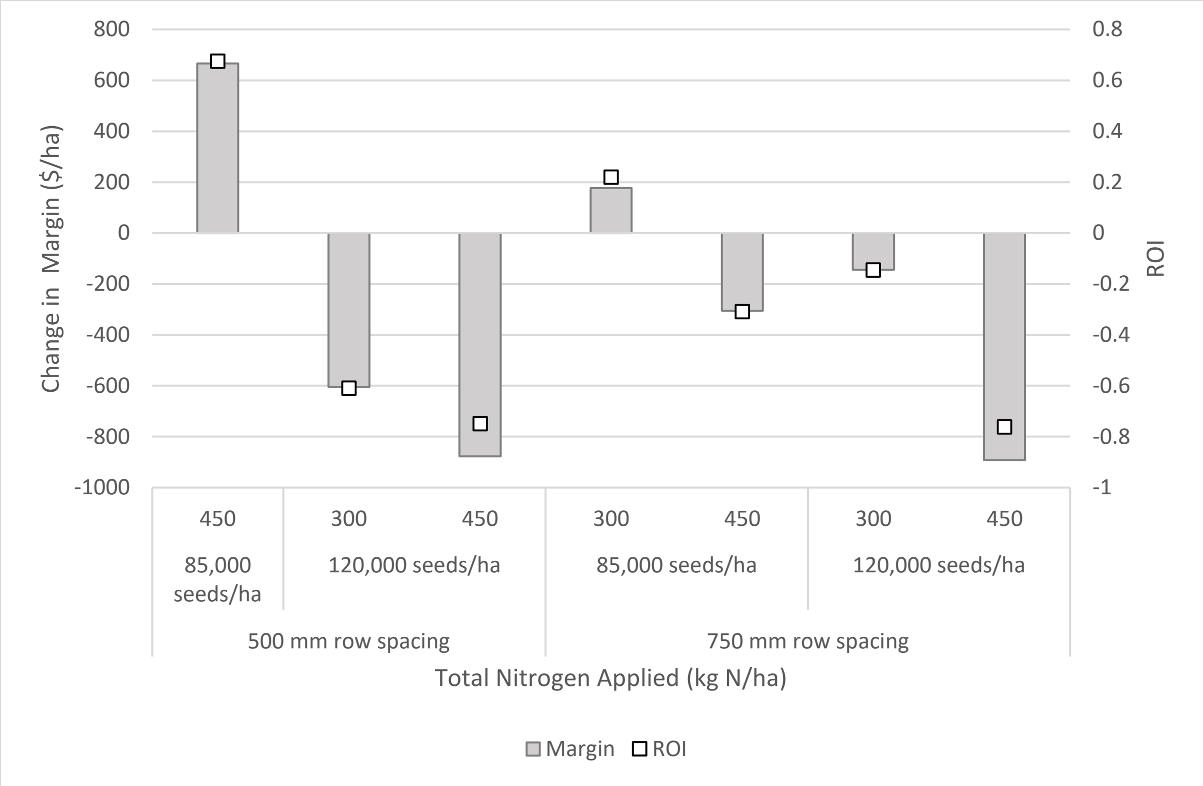

Figure 2. Influence of nitrogen rate on margin over input cost compared to treatment 1 – 85,000 seeds/ha at 300N applied ($/ha – value of increased grain production minus cost of inputs) and return on investment (ROI). Based on SAGI predicted yield.

Input costs based on price of $1.20/kg N, Seed @ $380/72,000 seeds, Income based on grain value of $290/t. No allowance has been made for difference in machinery costs for different row spacing.

Protocol 10. Crop establishment – row spacing x plant population interaction

Trial 1. Row spacing x plant population interaction

Protocol Objective:
To identify the optimum plant populations for the grain maize Pioneer Hybrid 1756 at 500 and 750mm row spacing for grain yield.

Boort, Victoria

Sown: 7 November 2019
Harvested: 16 April 2020
Soil Type: Heavy grey clay
Previous crop: Fallow
Hybrid: Pioneer Hybrid 1756
FAR code: FAR IRR M19-05
Irrigation Type: Subsurface drip irrigation

Key Messages:

- *Decreasing row spacing from 750mm (approx. 30 inch) to 500mm (approx. 20inch) significantly increased grain yield with a 3.21 t/ha yield increase (trials hand harvested).*
- *There were no significant effects of plant population in the trial when 90,000, 105,000 and 120,000 plants/ha were compared.*
- *Variable wind damage resulted in hand harvest quadrats being used as the basis of yield this invariably increases overall yields compared to machine harvest.*
- *There was no interaction between plant population and row spacing evident within the trial.*
- *At 500mm row spacings there was a significant increase in dry matter production and nitrogen uptake in the canopy compared to the 750mm row spacing when recorded at harvest.*
- *A Strong linear relationship between dry matter production and nitrogen content was present throughout the growing season observed at V6 (R^2=0.867) and at harvest (R^2 = 0.824).*

Table 1. SAGI analysis for grain yield (t/ha), test weight (kg/hl), harvest index (%) and harvest dry matter (t/ha).

Treatment		Yield*		Test Weight		HI		Harvest DM	
Row Spacing	**Population**	**PV**	**SE**	**PV**	**SE**	**PV**	**SE**	**PV**	**SE**
500	105,000	22.36	+/- 1.37	74.36	+/- 0.3	0.58	+/- 0.01	37.59	+/- 2.68
500	120,000	21.78	+/- 1.35	74.08	+/- 0.3	0.57	+/- 0.01	35.91	+/- 2.64
500	90,000	23.25	+/- 1.36	73.59	+/- 0.3	0.55	+/- 0.01	41.62	+/- 2.67
750	105,000	19.74	+/- 1.36	74.13	+/- 0.3	0.56	+/- 0.01	32.95	+/- 2.67
750	120,000	19.36	+/- 1.35	74.17	+/- 0.3	0.56	+/- 0.01	30.53	+/- 2.64
750	90,000	17.88	+/- 1.36	73.85	+/- 0.3	0.59	+/- 0.01	28.06	+/- 2.65
Mean		**20.7**		**74**		**56.8**		**34.4**	
Spacing P val		0.009		0.831		0.784		0.023	
Population P val		0.923		0.065		0.818		0.629	
Interaction P val		0.533		0.486		0.065		0.171	
LSD		4.1		0.7		0.04		7.6	

CV	14.5	0.8	5.467	19.5

PV= Predicted value, SE= Standard error

**Trial wind damaged at emergence. Yields taken from hand harvest quadrats as opposed to machine harvest based 2x 2m row opposite one another. Hand harvested quadrates in trials invariably increases yields in comparison to yields obtained by a maize harvester.*

Grain Yield

There was no significant interaction between row spacing and plant population on yield, but significant yield differences were recorded as a result of row spacing. On average (across the three different plant populations) decreasing row spacing by 250mm from 750mm resulted in a yield increase of 3.47t/ha.

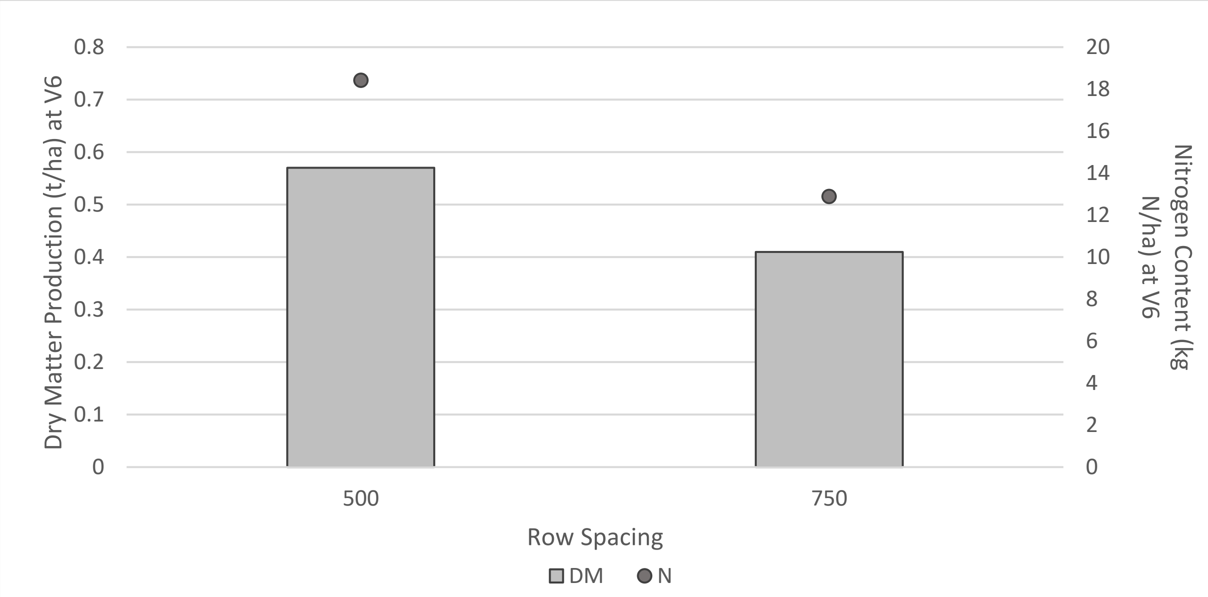

Figure 1. Dry Matter Production (t/ha) and Nitrogen content at growth stage V6 on 16 December 2019.

Dry Matter Production (assessed V6 & harvest)

At the V6 stage significant differences in dry matter accumulation were recorded between the two row spacings, with the narrow 500mm row spacing producing 28% more dry matter than the 750mm row spacing (Figure 1). Nitrogen uptake mirrored the dry matter accumulation with the 500mm row spacing crop containing 30% more nitrogen than the wide spaced crop as a result. At both assessment timings there was strong relationship (R^2 0.87 & 0.84 respectively) between dry matter content and N content recorded in the crop canopies (Figure 2 & 3).

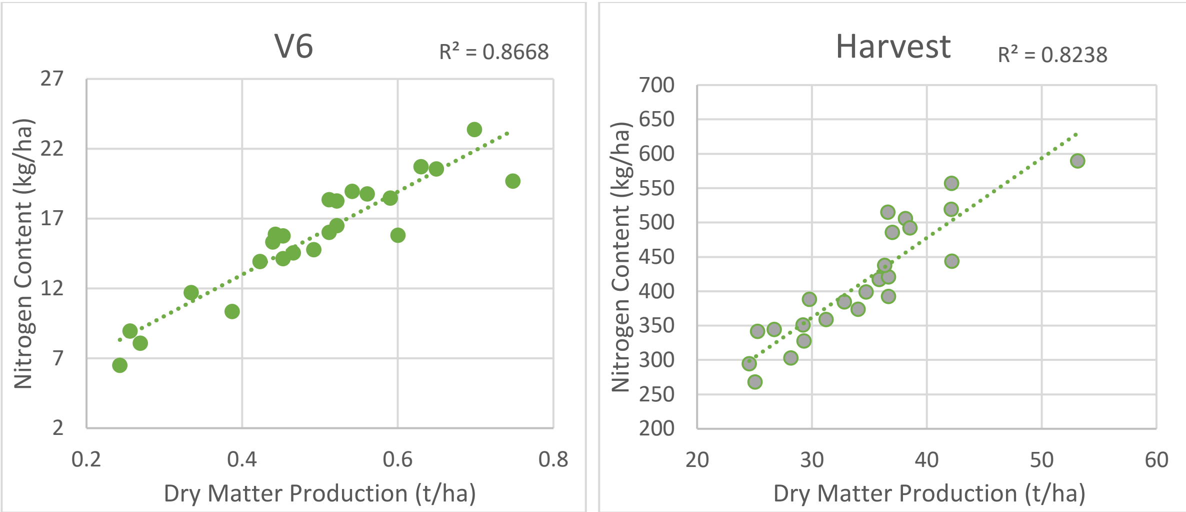

Figure 2 & 3. Coefficient of determination of dry matter production (t/ha) and nitrogen content (kg/ha) at V6 on 16 December 2019 (Figure 2) and at harvest (Figure 3).

Harvest Dry Matter and Nitrogen Content

At harvest there was significantly more total accumulated dry matter in the narrow row spacing compared to the wider 750mm row spacing (Table 1), although differences in stover dry matter were not significant (data not shown).

The relationship between dry matter production and nitrogen was also apparent at the individual plant component level (Figure 5) with an increased up take of N present in the crop with narrow row spacing. On average across the three plant populations narrow row resulted in crop canopies with a content of approximately 475 kg N/ha.

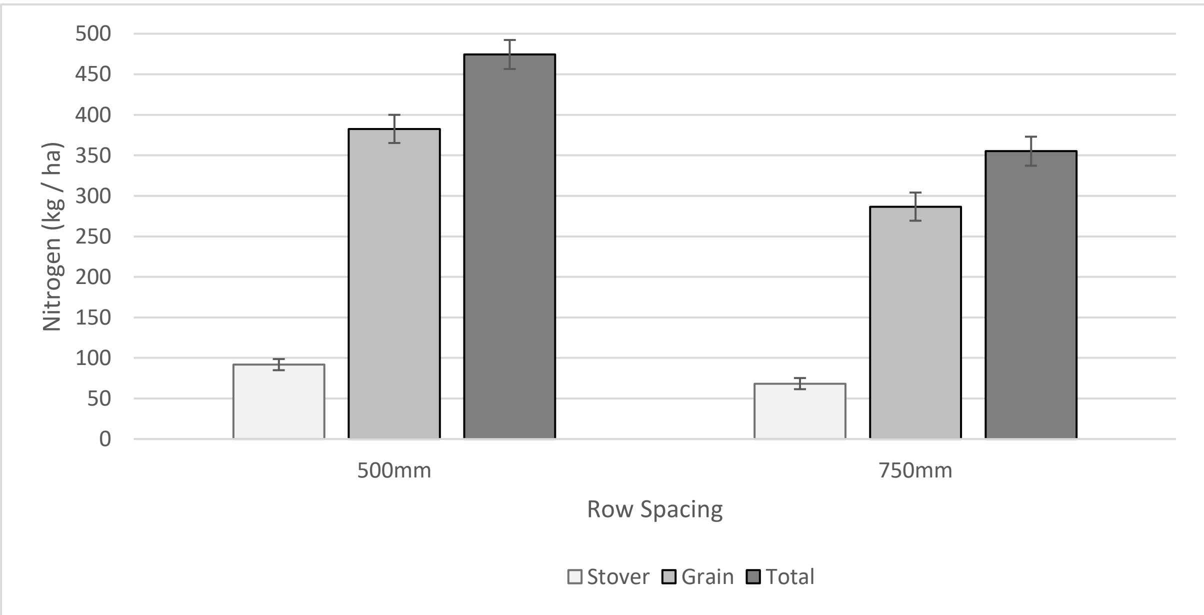

Figure 5. Nitrogen (kg/ha) content of stover and grain at harvest comparing two row spacings (mean of three plant populations). Error bars are a measure of LSD.

Protocol 11. Potassium Use Efficiency

Trial 1. Influence of additional Potassium on grain yield (Yenda)

Protocol Objective:
To assess the influence of additional Potassium fertiliser (Potassium Sulphate) used in crop on grain yield, tissue and grain concentration on soil with adequate K indices.

Yenda, NSW

Sown: 1 October 2019
Harvested: 31 March 2020
Soil Type: Slightly acidic Red Brown Earth
Previous crop: Cotton (summer 2018/19 followed by winter fallow)

Hybrid: Pioneer Hybrid 1756
FAR code:
Irrigation Type: Beds in bays

Key Messages:

- *The Yenda site had a Potassium (K) soil level (0-10cm) that exceeded 500 ppm (Colwell K) at sowing and showed no yield response to additional K applied post sowing in crop.*
- *Application of K as potassium sulphate at V4 and or V8 saw no change in leaf tissue levels when compared to the control (no added K) when tissues were assessed at V8 or tasselling.*
- *Harvest results showed no response to added potassium, indicating that the soil was able to supply the required potassium to the crop.*
- *There was no evidence of luxury uptake of K in tissue and grain samples (assessed in untreated and 80 kg /ha K).*

Table 1. SAGI analysis for grain yield (t/ha @ 14% moisture) and test weight (kg/hl).

Treatment K Rate (kg K/ha) applied V4	Yield t/ha		Test weight	
0 (nil control)	19.17	+/- 0.768	83.55	+/- 0.331
20	18.33	+/- 0.765	83.90	+/- 0.331
40	18.73	+/- 0.768	83.38	+/- 0.331
40+40 (applied V4 & V6)	19.61	+/- 0.77	83.70	+/- 0.331
80	19.21	+/- 0.773	83.47	+/- 0.331
Mean	**19**		**83.6**	
P val	0.81		0.818	
LSD	2.145		0.997	
CV	8.048		0.739	

Yields taken from hand harvest quadrats as opposed to machine harvest based 2x 2m row opposite one another. Hand harvested quadrats tend to give higher yields than machine yields.

There were no statistically significant differences in grain yield as a result of any potassium application in this trial (Table 1) and no indication that K applications led to luxury uptake in the leaf tissue (Table 2), since potassium application had no effect on potassium concentration in either the leaf or grain.

Table 2. Influence of potassium application of leaf and grain K content (%) at V10 and VT- Tasselling (Youngest emerging leaf assessed at V10 & highest leaf at V14)

Treatment (kg K/ha)	Leaf %K		Grain % K
	V10	VT	
Nil (Control)	2.50	1.80	0.41
80	2.55	1.75	0.42

Trial 2. Influence of additional Potassium on grain yield (Kerang)

Protocol Objective:
To assess the influence of additional Potassium fertiliser (Potassium Sulphate) used in crop on grain yield, tissue and grain concentration on soil with adequate K indices.

Kerang, Victoria

Sown: 29 October 2019
Harvested: 22 April 2020
Soil Type: Neutral self-mulching grey clay
Previous crop: Grass dominant pasture (3 years)
Hybrid: Pioneer Hybrid 1756
FAR Code:
Irrigation Type: Border check irrigation

Key Messages:

- *The Kerang site had a Potassium (K) soil level (0-10cm) that exceeded 600 ppm (Colwell K) at sowing and showed no yield response to additional K applied in crop.*
- *As was the case at Yenda the application of K as potassium sulphate at V4 or V8 saw no change in leaf tissue levels when compared to the control (no added K) assessed at V10 or tasselling.*
- *Harvest results showed no response to added potassium, indicating that the soil was able to supply the required potassium to the crop.*
- *There was no evidence of luxury uptake of K in tissue and grain samples (assessed in untreated, 40 (tissue only) and 80 kg /ha K).*

Table 1. SAGI analysis for grain yield (t/ha) and test weight (kg/hl) with variable K input at V6 and V6 & V10. .

Treatment K Rate (kg K/ha) applied V6	Yield (t/ha)		Test weight kg/hL	
0	16.27	+/- 0.842	82.79	+/- 0.125
20	16.16	+/- 0.842	82.53	+/- 0.121
40	16.49	+/- 0.842	82.75	+/- 0.125
40 + 40 (applied V6 & V10)	14.57	+/- 0.845	82.99	+/- 0.125
80	16.02	+/- 0.846	82.70	+/- 0.128
Mean	15.9		82.8	
P val	0.485		0.287	
LSD	2.279		0.388	
CV	10.542		0.387	

Yields taken from hand harvest quadrats as opposed to machine harvest based 2x 2m row opposite one another. Hand harvested quadrats tend to give higher yields than machine yields

There was no significant difference in grain yield as a result of any potassium application. There was some variability in the yield data due to variable plant populations in the plots.

Table 2. Influence of potassium application of leaf and grain K content (%).

Treatment (kg K/ha)	Leaf %K		Grain %K
	V10	VT	
Nil (Control)	2.4	1.4	0.48
40	2.5	1.5	
80	2.1	1.4	0.47

Potassium application had no effect on potassium concentration in either the leaf or grain.

Protocol 7. Disease management for irrigated crops

Trial 1. Products, rates and timing interaction trial

Protocol Objective:
To examine the influence of fungicide timing and rate for the prevention of disease and green leaf retention in grain maize

Hopefield, NSW

Sown: 2 December 2019
Harvested: 27 May 2020
Soil Type: Red loam over clay
Previous crop: Wheaten Hay
Hybrid: Pioneer Hybrid 1756
FAR code: FAR IRR M19-04
Irrigation Type: Overhead pivot

Key Messages:

- *There were no significant yield effects of fungicide application at either V8 (8 leaf) or VT.*
- *No disease was observed in the trial and there was little evidence to suggest that fungicides improved green leaf retention when assessed at V14, V15 and V16.*

Grain Yields

Table 1. SAGI analysis for grain yield (t/ha) and test weight (kg/hl).

Treatment		Yield		Test Weight	
Timing	**Product**	**Predicted value**	**Standard error**	**Predicted value**	**Standard error**
V8	Propiconazole	18.22	+/- 0.67	76.31	+/- 0.59
V8	Prothioconazole	19.29	+/- 0.68	77.8	+/- 0.59
V8	Prothio+Pyraclostrobin	19.11	+/- 0.67	76.74	+/- 0.59
V8	Pyraclostrobin	18.55	+/- 0.67	77.5	+/- 0.59
V8	UTC	18.6	+/- 0.68	76.1	+/- 0.59
VT	Propiconazole	18.33	+/- 0.67	76.84	+/- 0.58
VT	Prothioconazole	18.41	+/- 0.66	77.71	+/- 0.59
VT	Prothio+Pyraclostrobin	19.11	+/- 0.68	77.36	+/- 0.59
VT	Pyraclostrobin	18.95	+/- 0.67	76.62	+/- 0.59
VT	UTC	19.71	+/- 0.68	77.23	+/- 0.59
Mean		**18.8**		**81**	
Timing P val		0.656		0.851	
Product P val		0.698		0.829	
Interaction P val		0.717		0.928	
LSD		1.99		1.033	
CV		7.4		0.864	

Yields taken from hand harvest quadrats as opposed to machine harvest based 2x 2m row opposite one another.
Hand harvested quadrats tend to give higher yields than machine yields
** The use of fungicides in this trial does not constitute a recommendation and have been used for experimental purposes*

Disease and Green Leaf Retention

No disease was recorded in the trial. There were few significant differences recorded in green leaf retention as a result of fungicide application. The use of the both DMI triazoles and QoI (strobilurins) was ineffective when assessed between the middle of February and the end of March (Table 2 – 4).

Table 2. Green Leaf Retention (% GLR) assessed on 17 February 2020 at R3.

	Green Leaf Retention					
	V14		**V15**		**V16**	
Treatment mL/ha	**% GLR**		**% GLR**		**% GLR**	
Timing - V8						
Untreated	96.2	-	97.2	-	97.9	-
DMI – Prothioconazole (Proline) (100g/ha)	95.4	-	96.9	-	97.9	-
DMI – Propiconazole (Tilt) (125g/ha)	95.9	-	97.1	-	98.3	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	95.8	-	97.3	-	98.5	-
DMI/QoI – Prothioconazole + Pyraclostrobin	96.2	-	97.3	-	98.3	-
Timing – VT						
Untreated	96.1	-	97.2	-	98.2	-
DMI – Prothioconazole (Proline) (100g/ha)	95.9	-	97.4	-	98.2	-
DMI – Propiconazole (Tilt) (125g/ha)	96.4	-	97.0	-	98.4	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	96.3	-	97.1	-	98.1	-
DMI/QoI – Prothioconazole + Pyraclostrobin	95.6	-	97.2	-	98.0	-
Mean	95.97		97.14		98.17	
LSD (Fung x Timing)	NS		NS		NS	
P Val (Fung x Timing)	0.538		0.771		0.502	

Table 3. Green Leaf Retention (% GLR) assessed on 9 March 2020 at R4.

	Green Leaf Retention					
	V14		**V15**		**V16**	
Treatment mL/ha	**% GLR**		**% GLR**		**% GLR**	
Timing - V8						
Untreated	96.3	-	97.5	ab	98.2	-
DMI – Prothioconazole (Proline) (100g/ha)	96.3	-	97.3	abc	98.1	-
DMI – Propiconazole (Tilt) (125g/ha)	96.6	-	97.4	abc	97.9	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	96.1	-	97.2	abc	98.0	-
DMI/QoI – Prothioconazole + Pyraclostrobin	95.8	-	97.0	bc	97.9	-
Timing – VT						
Untreated	96.0	-	96.9	c	97.6	-
DMI – Prothioconazole (Proline) (100g/ha)	96.7	-	97.7	a	98.2	-
DMI – Propiconazole (Tilt) (125g/ha)	96.5	-	97.4	abc	98.4	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	96.5	-	97.5	ab	98.1	-
DMI/QoI – Prothioconazole + Pyraclostrobin	96.5	-	97.4	ab	98.3	-
Mean	**96.3**		**97.3**		**98.1**	
LSD (Fung x Timing)	NS		0.50		NS	
P Val (Fung x Timing)	0.424		0.029		0.075	

Table 4. Green Leaf Retention (% GLR) assessed on 30 March 2020 at R5/6.

	Green Leaf Retention					
	V14		V15		V16	
Treatment mL/ha	**% GLR**		**% GLR**		**% GLR**	
Timing - V8						
Untreated	88.5	-	93.6	-	93.4	-
DMI – Prothioconazole (Proline) (100g/ha)	88.0	-	94.0	-	92.3	-
DMI – Propiconazole (Tilt) (125g/ha)	88.9	-	93.5	-	93.1	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	88.4	-	93.5	-	92.5	-
DMI/QoI – Prothioconazole + Pyraclostrobin	87.0	-	94.1	-	93.4	-
Timing – V14						
Untreated	88.6	-	93.9	-	92.8	-
DMI – Prothioconazole (Proline) (100g/ha)	86.7	-	94.0	-	93.7	-
DMI – Propiconazole (Tilt) (125g/ha)	90.0	-	94.2	-	93.6	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	88.6	-	94.0	-	92.5	-
DMI/QoI – Prothioconazole + Pyraclostrobin	86.6	-	94.5	-	92.8	-
Mean	**88.1**		**93.9**		**93.0**	
LSD (Fung x Timing)	NS		NS		NS	
P Val (Fung x Timing)	0.771		0.873		0.308	

Trial 2. Products, rates and timing interaction trial

Protocol Objective:

To examine the influence of fungicide timing and rate for the prevention of disease and green leaf retention in grain maize

Kerang, Victoria

Sown: 29 October 2019

Harvested: 22 April 2020

Soil Type: Neutral self-mulching grey clay

Previous crop: Grass dominant pasture

Hybrid: Pioneer Hybrid 1756

FAR code: ICC M19-04-2

Irrigation Type: Border check irrigation

Key Messages:

- *There was a significant interaction between fungicide product and the timing of application with propiconazole being more effective than prothioconazole at the later VT timing and visa versa at V8, however there is no evidence that this is a real effect.*
- *Application of three different fungicide active ingredients (four products) at either V8 (8 leaf) or VT tasselling produced no yield response at the Kerang site.*
- *Application of a fungicide at either 8 leaf or tasselling did not result in an extended period of green leaf retention during grain fill.*
- *No disease was evident in the trial for the duration of the season.*

Table 1. SAGI analysis for grain yield (t/ha @ 14% moisture) in response to fungicide and timing of application.

Treatment		Yield			Test Weight	
Timing	**Product**	**Predicted value**		**Standard error**	**Predicted value**	**Standard error**
V8	Propiconazole	15.99	ab	+/- 0.6	82.53	+/- 0.23
V8	Prothioconazole	16.46	ab	+/- 0.59	82.52	+/- 0.23
V8	Prothio+Pyraclostrobin	16.51	ab	+/- 0.59	82.52	+/- 0.23
V8	Pyraclostrobin	16.84	ab	+/- 0.6	82.62	+/- 0.23
V8	UTC	15.87	ab	+/- 0.6	82.27	+/- 0.23
VT	Propiconazole	17.20	a	+/- 0.6	82.60	+/- 0.23
VT	Prothioconazole	15.02	b	+/- 0.6	82.65	+/- 0.23
VT	Prothio+Pyraclostrobin	15.85	ab	+/- 0.66	82.70	+/- 0.23
VT	Pyraclo	16.88	ab	+/- 0.6	82.65	+/- 0.23
VT	UTC	16.54	ab	+/- 0.61	82.35	+/- 0.23
Mean		16.3			82.5	
Interaction P val		0.018			0.751	
LSD		1.2			0.7	
CV		8.5			0.5	

Important note: that the use of fungicides in this research trial was purely for experimental purposes. The use of active ingredients does not in any way constitute a recommendation or suggestion that the fungicide necessarily has a recommendation for that crop.

There was no statistically significant yield response as a result of any fungicide product or timing of application (Table 1). The trial was assessed for any effects or leaf damage 21 after fungicide application. No damage or leaf discolouration was noted from either fungicide timing on the leaves that received the fungicide.

Green leaf retention was assessed at 21, 44 and 64 days after tasselling (VT). To assess the greenness of the plants, the following assessment scoring was used:

Table 2: Green leaf retention assessment (based on 1-10 scores)

Score	Plant description/appearance	Score	Plant description/appearance
10	All green	5	Partial green leaves above cob
9	Yellowing lowest leaves	4	Little green remaining, stem green below cob
8	Yellow lower leaves	3	Leaves dry, stems green to cob
7	Green leaves below cob	2	Leaves dry, stems green above cob
6	Partial green leaves to cob	1	Dry

Table 3a. Influence of fungicide product and timing on leaf greenness, 21 days after tasselling (VT).

Fungicide	V8 Application	VT Application	
Nil (Control)	9.75	9.50	
Prothioconazole	9.50	9.25	
Propiconazole	9.50	9.75	
Pyraclostrobin	9.50	9.25	
Prothioconazole + Pyraclostrobin	9.50	9.75	
LSD Fungicide = 0.05	NS	P Val	0.875
LSD Application Timing p=0.05	NS	P Val	0.826
LSD Fung. x Timing. P=0.05	NS	P Val	0.875
CV %	7.4		

Table 3b. Influence of fungicide product and timing on leaf greenness, 44 days after tasselling (VT).

Fungicide	V8 Application	VT Application	
Nil (Control)	8.75	8.00	
Prothioconazole	8.25	8.00	
Propiconazole	8.25	8.25	
Pyraclostrobin	8.00	7.25	
Prothioconazole + Pyraclostrobin	8.75	8.25	
LSD Fungicide = 0.05	NS	P Val	0.692
LSD Application Timing p=0.05	NS	P Val	0.274
LSD Fung. x Timing. P=0.05	NS	P Val	0.970
CV %	15.6		

Table 3c. Influence of fungicide product and timing on leaf greenness, 64 days after tasselling (VT).

Fungicide	V8 Application	VT Application	
Nil (Control)	2.25	2.50	
Prothioconazole	2.25	2.00	
Propiconazole	2.50	2.25	
Pyraclostrobin	2.50	2.25	
Prothioconazole + Pyraclostrobin	2.00	2.25	
LSD Fungicide = 0.05	NS	P Val	0.921
LSD Application Timing p=0.05	NS	P Val	0.847
LSD Fung. x Timing. P=0.05	NS	P Val	0.921
CV %	>20		

Trial 3. Products, rates and timing interaction trial

Protocol Objective:
To examine the influence of fungicide timing and rate for the prevention of disease and green leaf retention in grain maize

Yenda, NSW

Sown: 1 October 2019
Harvested: 31 March 2020
Soil Type: Slightly acidic Red Brown Earth
Hybrid: Pioneer Hybrid 1756
FAR code: ICC M19-04-3
Irrigation Type: Beds in bays

Key Messages:

- *Application of three different fungicide active ingredients (four products) at either V8 (8 leaf) or VT tasselling produced no yield response at the Yenda site.*
- *Application of a fungicide at either 8 leaf or tasselling did not result in an extended period of green leaf retention during grain fill.*
- *No disease was evident in the trial for the duration of the season.*

Table 1. SAGI analysis for grain yield (t/ha @ 14% moisture) and test weight (kg/hl) in response to fungicide and timing of application.

Treatment		Yield		Test Weight	
Timing	**Product**	**Predicted value**	**Standard error**	**Predicted value**	**Standard error**
V8	Propicon	20.05	+/- 0.68	83.02	+/- 0.28
V8	Prothio	20.38	+/- 0.68	83.32	+/- 0.28
V8	Prothio+Pyraclo	20.76	+/- 0.68	83.05	+/- 0.28
V8	Pyraclo	19.73	+/- 0.68	82.65	+/- 0.28
V8	UTC	19.32	+/- 0.68	83.25	+/- 0.28
VT	Propicon	19.59	+/- 0.68	82.67	+/- 0.28
VT	Prothio	19.97	+/- 0.68	83.17	+/- 0.28
VT	Prothio+Pyraclo	19.69	+/- 0.68	82.77	+/- 0.28
VT	Pyraclo	19.29	+/- 0.68	82.92	+/- 0.28
VT	UTC	19.30	+/- 0.68	82.55	+/- 0.28
Mean		19.8		82.9	
Interaction P val		0.841		0.295	
LSD		1.7		0.8	
CV		6.6		0.7	

Important note: the use of fungicides in this research trial was purely for experimental purposes. The use of active ingredients does not in any way constitute a recommendation or suggestion that the fungicide necessarily has a recommendation for that crop.

There was no statistically significant yield response as a result of any fungicide product or timing of application (Table 1).

The trial was assessed for any effects or leaf damage 21 days after the 8 leaf (V8) application and 23 days after the tasselling (VT) application. No damage or leaf discolouration was noted from either fungicide timing.

Green leaf retention was assessed at 23, 50 and 65 days after VT. To assess the greenness of the plants, the following scoring was used:

Table 2: Green leaf retention assessment (based on a 0 – 10 scale).

Score	Plant description/appearance	Score	Plant description/appearance
10	All green	5	Partial green leaves above cob
9	Yellowing lowest leaves	4	Little green remaining, stem green below cob
8	Yellow lower leaves	3	Leaves dry, stems green to cob
7	Green leaves below cob	2	Leaves dry, stems green above cob
6	Partial green leaves to cob	1	Dry

Table 3a. Influence of fungicide product and timing on leaf greenness, 23 days after tasselling (VT).

Fungicide	V8 Application	VT Application	
Nil (Control)	10.00	10.00	
Prothioconazole	10.00	9.75	
Propiconazole	9.75	9.75	
Pyraclostrobin	10.00	10.00	
Prothioconazole + Pyraclostrobin	9.75	10.00	
LSD Fungicide = 0.05	NS	P Val	**0.291**
LSD Application Timing p=0.05	NS	P Val	1.00
LSD Fung. x Timing. P=0.05	NS	P Val	0.457
CV %	2.6		

Table 3b. Influence of fungicide product and timing on leaf greenness, 50 days after tasselling (VT).

Fungicide	V8 Application	VT Application	
Nil (Control)	7.25	8.75	
Prothioconazole	8.25	8.00	
Propiconazole	8.25	8.00	
Pyraclostrobin	8.25	7.50	
Prothioconazole + Pyraclostrobin	7.00	7.75	
LSD Fungicide = 0.05	NS	P Val	**0.373**
LSD Application Timing p=0.05	NS	P Val	0.456
LSD Fung. x Timing. P=0.05	NS	P Val	0.079
CV %	10.6		

Table 3c. Influence of fungicide product and timing on leaf greenness, 65 days after tasselling (VT).

Fungicide	V8 Application	VT Application	
Nil (Control)	5.75	6.25	
Prothioconazole	5.50	5.50	
Propiconazole	6.50	5.50	
Pyraclostrobin	5.75	6.25	
Prothioconazole + Pyraclostrobin	5.75	6.25	
LSD Fungicide = 0.05	NS	P Val	**0.381**

LSD Application Timing p=0.05	NS	P Val	0.606
LSD Fung. x Timing. P=0.05	NS	P Val	0.083
CV %	10.3		

The fungicide application timing and products appear to have little influence on retaining green leaf during grain fill.

APPENDICES

Meteorological Data

Peechelba East, Victoria

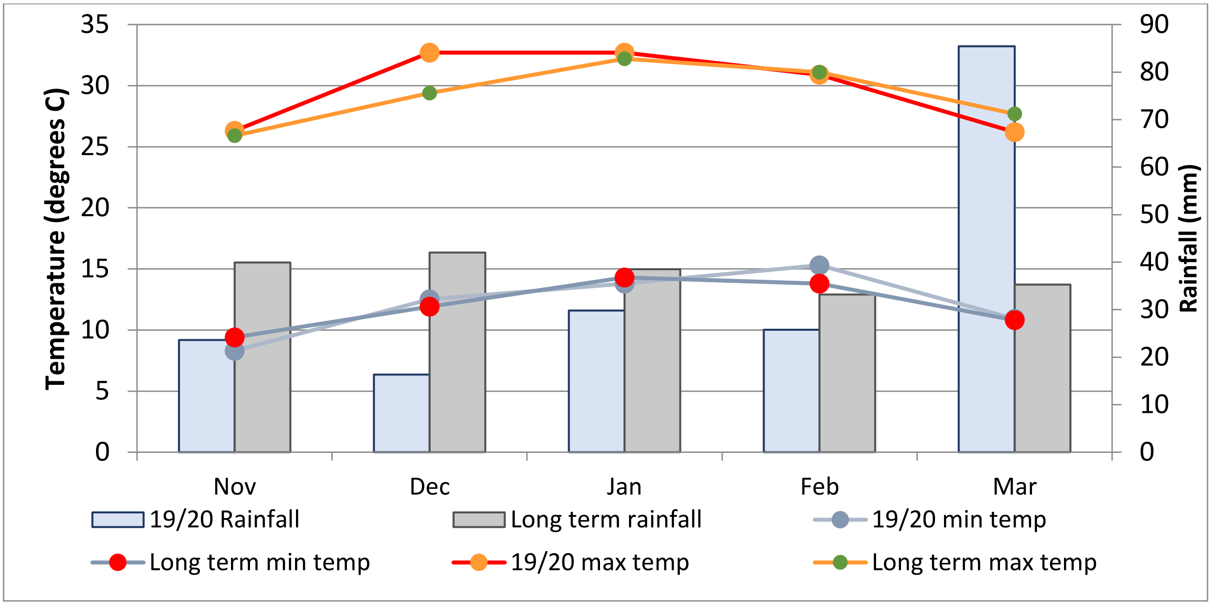

Figure 1. 2019/2020 growing season rainfall and long-term rainfall (1930-2020) (recorded at Peechelba East), 2019/2020 min and max temperatures and long-term min and max temperatures recorded at Wangaratta (1987-2020) for the growing season (November-March).

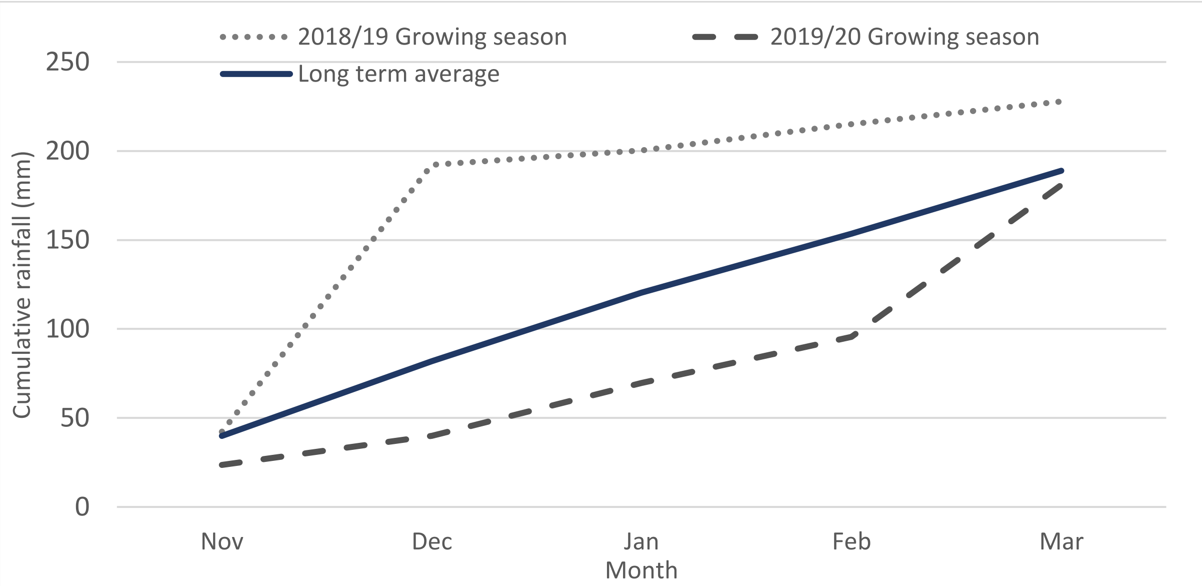

Figure 2. Cumulative growing season rainfall for 2018/2019, 2019/2020 and the long-term average for the growing season (November-March).

Hopefield, NSW

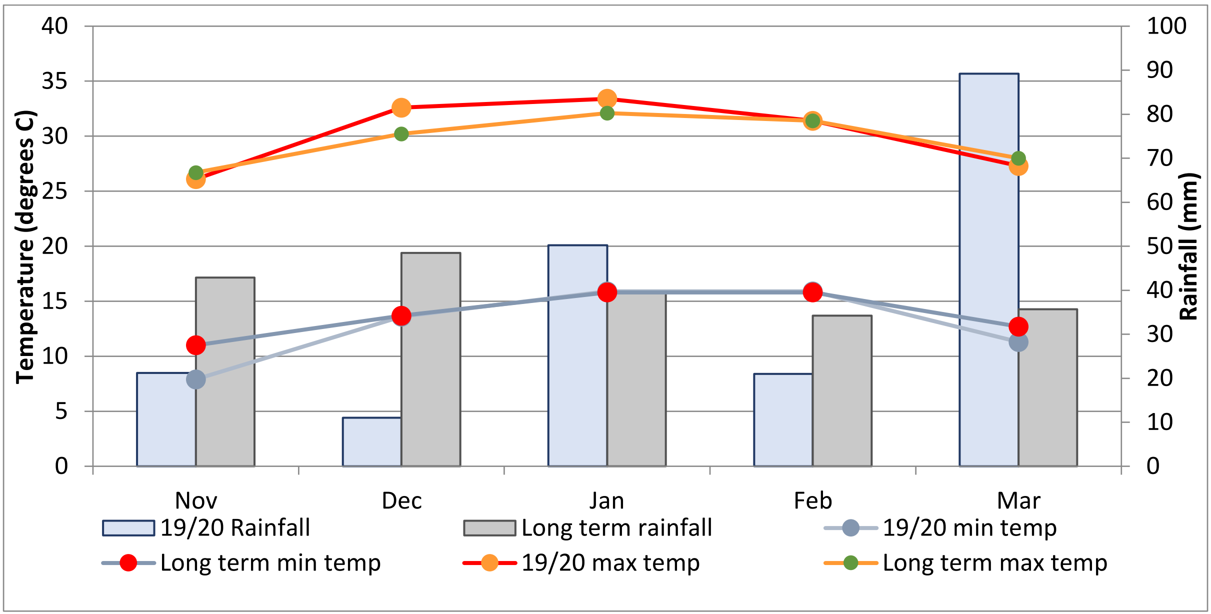

Figure 3. 2019/2020 growing season rainfall and long-term rainfall (1929-2020) (recorded at Hopefield, NSW), 2019/2020 min and max temperatures and long-term min and max temperatures recorded at Corowa, NSW (1890-2020) for the growing season (November-March).

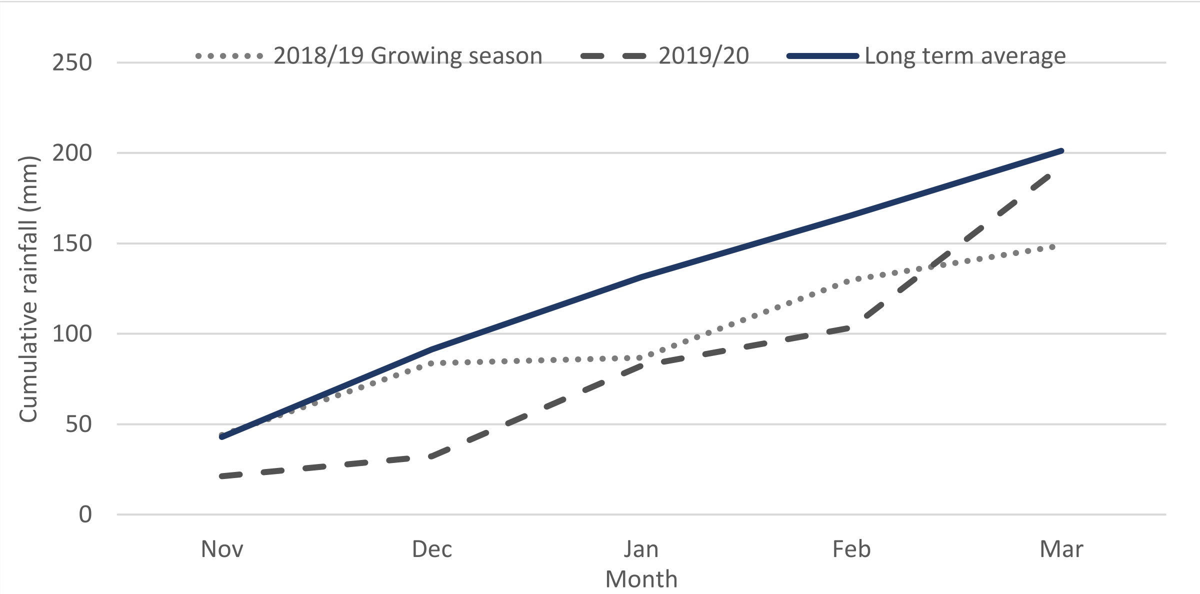

Figure 4. Cumulative growing season rainfall for 2018/2019, 2019/2020 and the long-term average for the growing season (November-March).

Boort, Victoria

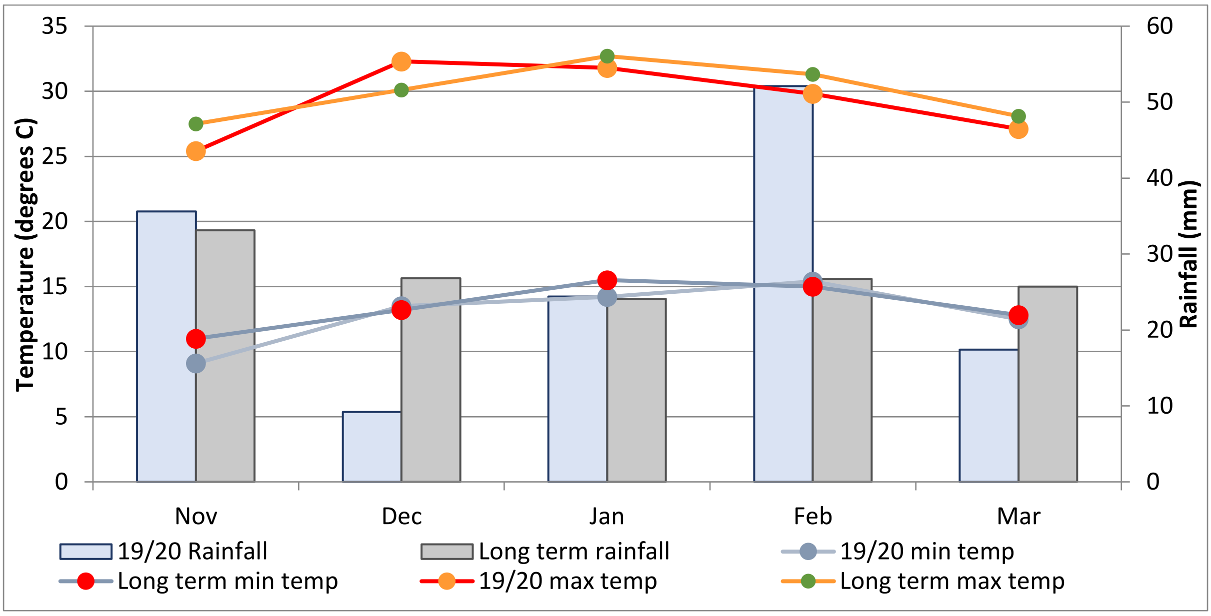

Figure 5. 2019/2020 growing season rainfall and long-term rainfall (1881-2020) (recorded at Boort, VIC), 2019/2020 min and max temperatures and long-term min and max temperatures recorded at Charlton (2004-2020) for the growing season (November-March).

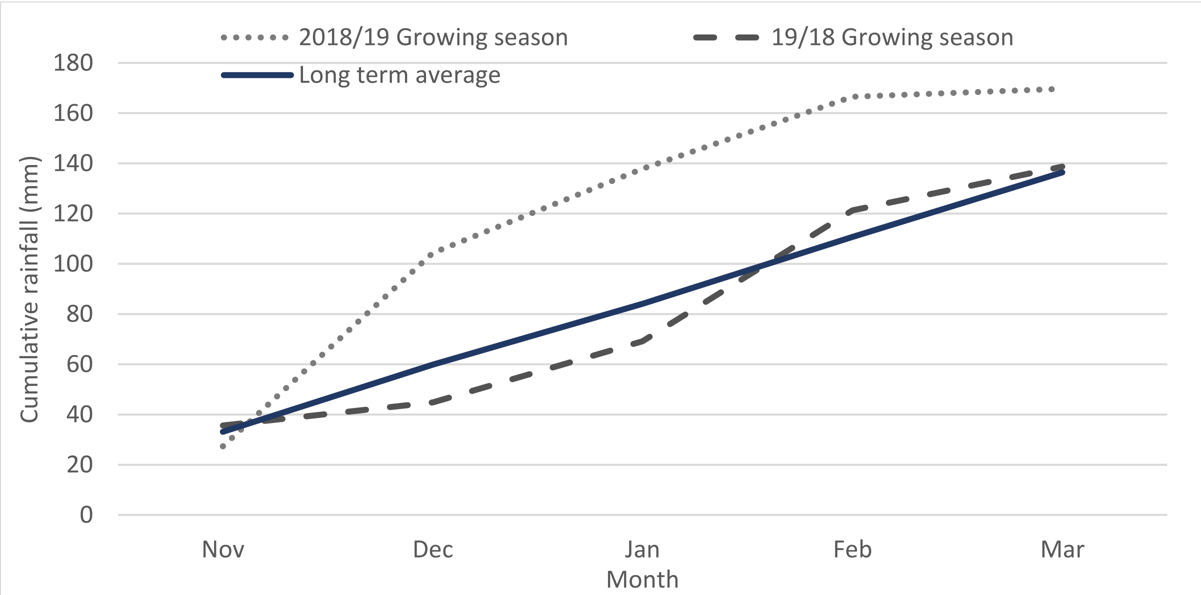

Figure 6. Cumulative growing season rainfall for 2018/2019, 2019/2020 and the long-term average for the growing season (November-March).

Kerang, Victoria

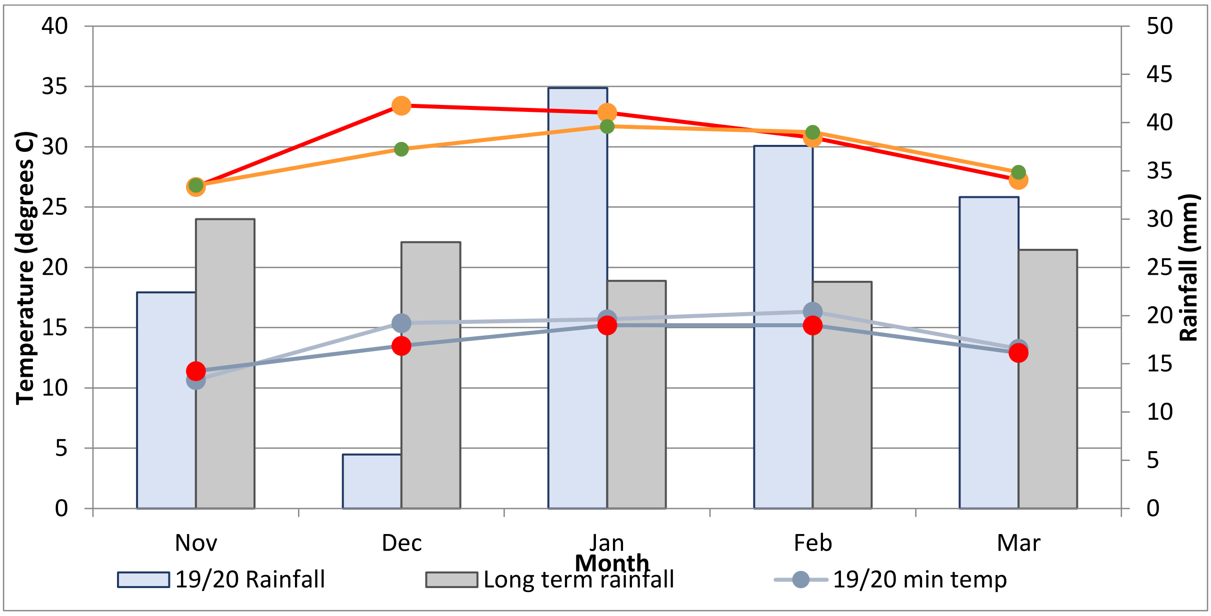

Figure 7. 2019/2020 growing season rainfall and long-term rainfall (1881-2020) (recorded at Kerang, VIC), 2019/2020 min and max temperatures and long-term min and max temperatures recorded at Kerang (1910-2020) for the growing season (November-March).

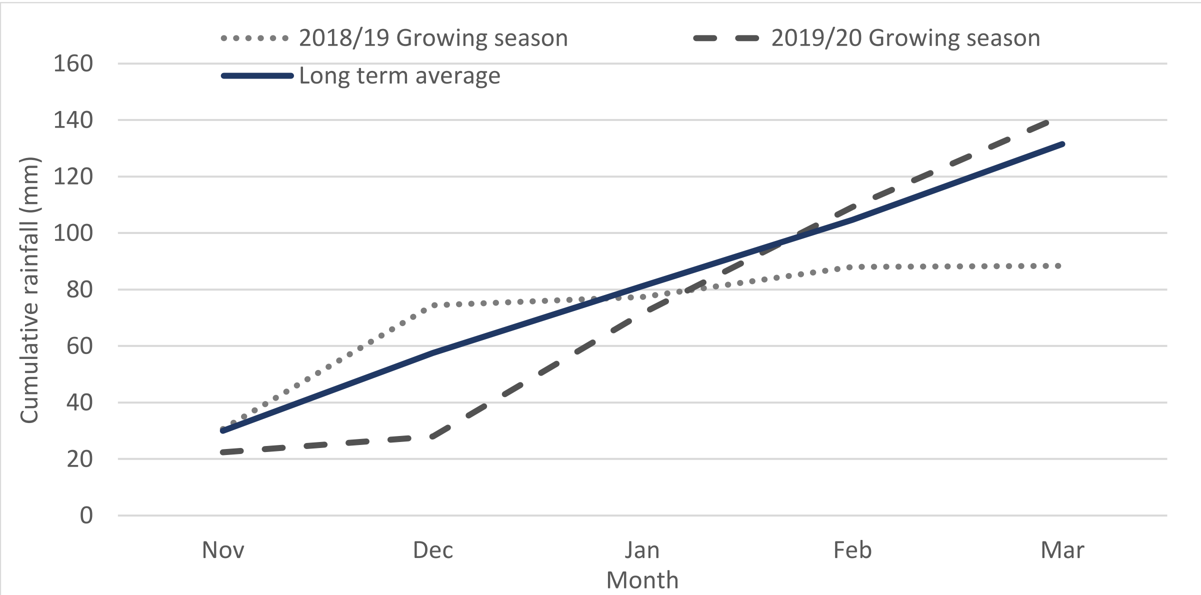

Figure 8. Cumulative growing season rainfall for 2018/2019, 2019/2020 and the long-term average for the growing season (November-March).

Yenda, NSW

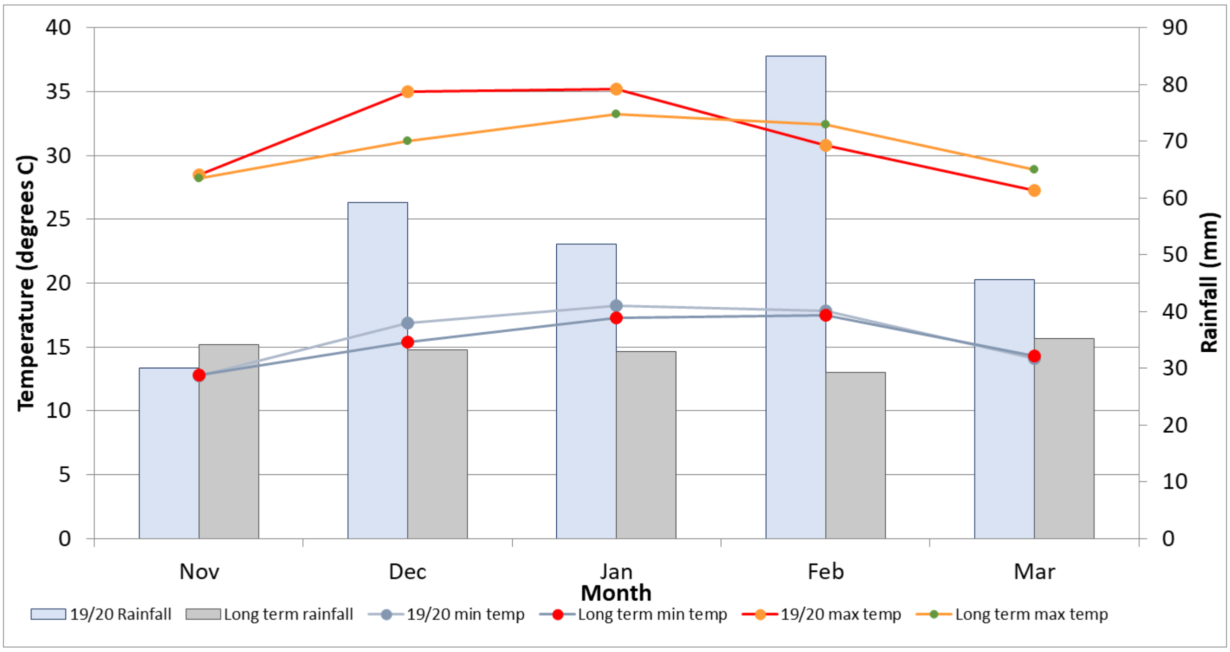

Figure 9. 2019/2020 growing season rainfall and long-term rainfall (1925-2020) (recorded at Yenda, NSW), 2019/2020 min and max temperatures and long-term min and max temperatures recorded at Griffith (1958-2020) for the growing season (November-March).

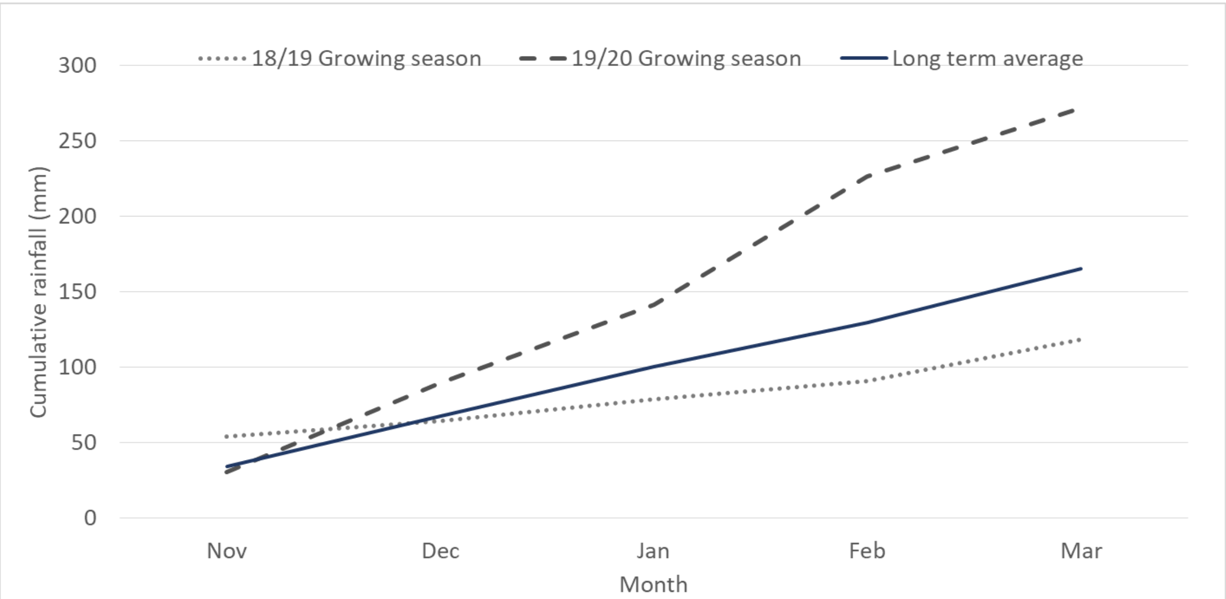

Figure 10. Cumulative growing season rainfall for 2018/2019, 2019/2020 and the long-term average for the growing season (November-March).

Site Details

Peechelba East, Victoria

Paddock and Irrigation records

GPS Location	-36.169247, 146.271604	Irrigation Type	Overhead pivot
Sown	13-Nov-19	Frequency and Rate	Daily 7 or 14mm
Hybrid	Pioneer 1756	First Applied	15-Nov-19
Harvested	31-May-20	Last Application	25-Mar-20
Soil Type	Red loam over clay	Total Water applied	6.08 ML/ha
Previous Crop	Oaten hay		

Crop Nutrition

Date	Product	Rate	Placement	Crop Stage
11-Nov-19	Urea	400 kg/ha	Spread	Pre-Plant
11-Nov-19	Gypsum	2.2 t/ha	Spread	Pre-Plant
11-Nov-19	Potash	300 kg/ha	Spread	Pre-Plant
13-Nov-19	1% Zinc	250 kg/ha	With Seed	Pre-Plant
13-Nov-19	Cotton Starter	30 L/ha	With Seed	Pre-Plant
10-Dec-19	Urea	100 kg/ha	Fertigation	V6
26-Dec-19	Urea	130 kg/ha	Fertigation	V10
26-Dec-19	Molybdenum Mix	250 ml/ha	Fertigation	V10
11-Jan-20	SL Tec TE8	4 L/ha	Foliar Spray	V14
14-Jan-20	Urea	110 kg/ha	Fertigation	V16
15-Jan-20	Urea	110 kg/ha	Fertigation	V16

Crop Protection

Date	Product	Rate	Placement	Crop Stage
14-Nov-19	Dual Gold	2 L/ha	Foliar Spray	Post sow - Pre-Emergence
14-Nov-19	Atrazine	2.5 L/ha	Foliar Spray	Post sow – Pre-Emergence
14-Nov-19	Lorsban	0.8 L/ha	Foliar Spray	Post sow – Pre-Emergence
14-Nov-19	Glyphosate	2 L/ha	Foliar Spray	Post sow - Pre Emergence
11-Jan-20	Abamectin	1 L/ha	Foliar Spray	V14
11-Jan-20	Trojan		Foliar Spray	V14
13-Jan-20	Gemstar	500 ml/ha	Foliar Spray	V15

Hopefield, NSW

Paddock and Irrigation

GPS Location	-35.944516, 146.478170	Irrigation Type	Overhead pivot
Sown	2-Dec-19	Frequency and Rate	Daily -10mm
Hybrid	Pioneer 1756	First Applied	2-Dec-19
Harvested	27-May-20	Last Application	28-Mar-20
Soil Type	Red loam over clay	Total Water applied	6.88 ML/ha
Previous Crop	Wheaten Hay		

Crop Nutrition

Date	Product	Rate	Placement	Crop Stage
15-Nov-19	Gypsum	2.5 t/ha	Broadcast	Pre-Sow
2-Dec-19	MAP	230 kg/ha	Beneath seed	Pre-Plant
2-Dec-19	Urea	200 kg/ha	Beneath seed	Pre-Plant
2-Dec-19	Corn Popup	30 L/ha	With seed	Planting
2-Dec-19	UAN	230 L/ha	Surface Spray	Planting
5-Jan-20	Urea	600 kg/ha	Broadcast	6 Leaf

Crop Protection

Date	Product	Rate	Placement	Crop Stage
25-Nov-19	Sakura	118 g/ha	Surface Spray	Pre-Plant
25-Nov-19	Atrazine	2.5 kg/ha	Surface Spray	Pre-Plant
25-Nov-19	Dual	1.85 L/ha	Surface Spray	Pre-Plant
25-Nov-19	Lorsban	0.8 L/ha	Surface Spray	Pre-Plant
25-Feb-20	Abermectin	1 L/ha	Aerial Foliar Spray	Tasselling

Kerang, Victoria

Paddock and Irrigation

GPS Location	-35.706588 143.812190	Irrigation Type	Border check
Sown	30-Oct-2019	Frequency and Rate	7 days 0.7Ml/ha
Hybrid	Pioneer 1756	First Applied	4-Nov-2019
Harvested	21-April-20	Last Application	26-Feb-20
Soil Type	SM grey clay	Total Water applied	9.8 ML/ha
Previous Crop	Grass pasture		

Crop Nutrition

Date	Product	Rate	Placement	Crop Stage
16-Oct-19	Superfect	650 kg/ha	Spread	Pre-Plant
16-Oct-19	Gypsum	2.5 t/ha	Spread	Pre-Plant
30-Oct-19	Urea	325 kg/ha	Pre-drilled	Pre-Plant
17-Dec-19	Urea	325 kg/ha	Spread	V8

Crop Protection

Date	Product	Rate	Placement	Crop Stage
19-Nov-19	Atrazine	1.1 kg/ha	Foliar Spray	V2
7-Dec-19	Starane	0.6 l/ha	Foliar Spray	V6
14-Feb-20	Astound Duo	0.4 l/ha	Foliar Spray	Post silking

Yenda, NSW

Paddock and Irrigation

GPS Location	-34.323874, 146.316022	Irrigation Type	Beds in bays
Sown	1-Oct-19	Frequency and Rate	7 days, 0.6 ML/ha
Hybrid	Pioneer 1756	First Applied	1-Oct-19
Harvested	1-April-20	Last Application	18-Feb-20
Soil Type	Red Brown Earth	Total Water applied	9.1 ML/ha
Previous Crop	Cotton 2018/19, winter fallow		

Crop Nutrition

Date	Product	Rate	Placement	Crop Stage
15-Sept-19	GranulocZ	350 kg/ha	Drilled	Pre-Plant
15-Sept-19	Urea	325 kg/ha	Drilled	Pre-Plant
23-Nov-19	Urea	115 kg/ha	Water run	V4
6-Dec-19	Urea	115 kg/ha	Water run	V6
16-Dec-19	Urea	115 kg/ha	Water run	V8

Crop Protection

Date	Product	Rate	Placement	Crop Stage
2-Nov-19	Atrazine	2.0 L/ha	Foliar Spray	V3

Soil Test Reports

Peechelba East, Victoria (0 – 30cm)

Analyte	Units	Result	Optimal Range	Status
pH (H_2O)	(pH)	6.599	6 - 7	Slightly Acidic
pH ($CaCl_2$)	(pH)	5.716	5.4 - 6.5	Slightly Acidic
EC*	dS/m	0.067	0 - 0.15	Satisfactory
Lime requirement	t/ha			
ESI	units	0.011	value >0.05	Low
Total Carbon*	%	1		
Total Nitrogen	%	0.113		
Carbon: Nitrogen Ratio	(ratio)	8.92		
Organic Matter	%	1.5	3.25 - 5.2	Very Low
M3 PSR	(ratio)	0.17	0.06 - 0.23	Satisfactory
Mehlich Phosphorus	ppm	123.45	40 - 90	Very High
Potassium	ppm	114.85	195 - 320	Low
Sulphur	ppm	11.77	12 - 45	Low
Calcium	ppm	713.31	1300 - 2200	Low
Magnesium	ppm	196.71	165 - 330	Satisfactory
Sodium	ppm	88.13	16 - 63	Very High
Chloride	ppm	16.7	0 - 200	Satisfactory
Zinc	ppm	7.07	1.6 - 8	Satisfactory
Copper	ppm	2.02	2.5 - 10	Low
Boron	ppm	0.52	1.7 - 4	Very Low
Manganese	ppm	164.11	18 - 70	Very High
Iron	ppm	92.41	30 - 200	Satisfactory
CECe	meq/100g	7.1		
Calcium	meq/100g	3.6 (50.7%CEC)	6.5 - 11.0	Low
Potassium	meq/100g	0.3 (4.2%CEC)	0.5 - 0.8	Low
Magnesium	meq/100g	1.6 (22.5%CEC)	1.4 - 2.7	Satisfactory
Sodium	meq/100g	0.4 (5.6%CEC)	0.1 - 0.3	High
Base Saturation	%	83	80 - 87	Satisfactory
Exchangeable Acidity	meq/100g	1.2 (17.0%CEC)	13 - 20 %CEC	Satisfactory
Aluminium Saturation	%			
Ca:Mg Ratio	(ratio)	2.25	3 - 5	Low
K:Mg Ratio	(ratio)	0.187	0.3 - 0.5	Low

Kerang & Yenda

Site		Yenda Fungicide	Yenda KUE	Kerang KUE	Kerang R SpxPop	Kerang NUE	Kerang Fungicide
Depth	cm	0-10	0-10	0-10	0-10	0-10	0-10
Colour		DKBR	DKBR	DKGR	DKGR	DKGR	DKGR
Gravel	%	0	0	0	0	0	0
Texture		3.0	3.0	2.5	2.5	2.5	2.5
Ammomiun N	mg/kg	6	5	4	4	3	4
Nitrate N	mg/kg	44	49	2	1	4	1
Phosphorus Colwell	mg/kg	42	46	98	108	78	82
Potassium Colwell	mg/kg	634	577	675	725	813	705
Sulfur	mg/kg	38.6	49.9	21.8	19.4	16.1	10.4
Organic Carbon	%	1.10	.98	1.19	1.66	1.38	1.20
Conductivity	dS/m	0.230	.252	0.284	0.192	0.220	0.228
pH ($CaCl_2$)		6.2	5.8	6.9	7.0	7.5	7.5
pH (water)		6.7	6.5	7.8	7.9	8.3	8.4
DTPA Copper	mg/kg	2.23	2.17	1.93	1.85	1.89	1.83
DTPA Iron	mg/kg	77.10	83.30	31.30	30.50	26.80	29.90
DTPA Manganese	mg/kg	23.70	26.33	17.01	15.41	11.32	9.36
DTPA Zinc	mg/kg	1.76	1.79	1.20	1.42	0.93	1.13
Exch Aluminium	meq/100g	0.050	0.050	0.060	0.060	0.060	0.050
Exch Calcium	meq/100g	14.80	11.13	16.62	16.79	15.75	17.75
Exch Magnesium	meq/100g	9.21	7.21	8.87	8.08	8.28	8.83
Exch Potassium	meq/100g	2.03	1.47	2.10	2.06	2.21	2.04
Exch Sodium	meq/100g	0.71	0.65	1.43	1.11	1.41	1.31
Nitrate 0-30 cm	mg/kg	28	32	3	2	3	2
Ammonium 0-30 cm	mg/kg	6	7	4	5	5	4
Nitrate 30-60 cm	mg/kg	21	19	1	1	1	1
Ammonium 30-60 cm	mg/kg	6	6	3	4	3	3
Nitrate 60-90 cm	mg/kg	13	32	1	1	1	1
Ammonium 60-90 cm	mg/kg	6	6	4	3	3	3

Site Photos

Boort, Victoria – 19 December 2019

Yenda, NSW - 23 November 2019

Kerang, Victoria – 23 December 2019

Hopefield, NSW – 24 January 2020

Peechelba East, Victoria -17 December 2019

Field Applied Research Australia
Phone: 03 5265 1290
Post: Shed 2/63 Holder Rd, Bannockburn VIC 3331
Website: www.faraustralia.com.au **ABN:** 33159209480