Optimising Irrigated Grains
Maize Agronomy in Focus

2020/21 Provisional 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 **Optimising Irrigated Grains (OIG) – Grain Maize**

Trial Sites **Peechelba East and Kerang, Victoria**

Project Funder **GRDC**

Study Director **Nick Poole**

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

Research Manager **Ben Morris**

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

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Results

Applicable to each of the yield tables are the following:
Yields in the Provisional report were provided by ARM software or genstat and were based on plot yields recorded. Yield data and key measurements such as harvest index, dry matter at harvest and test weights have been sent to SAGI for spatial analysis to assess if there is spatial variation in the trial results. Any differences reported by SAGI affecting the significance of results will be presented as predicted values in the final research results report released in February 2022.
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 are focussed 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 have been focussed 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 at Finley, NSW and Kerang, VIC.

Which Crops?

The crops 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 is based on spring sown barley in Tasmania and winter barley where appropriate on the mainland.

How are the project objectives being achieved?

The objectives of the project now in its second year are underpinned by approximately 65 - 70 field trials conducted annually at five Irrigated Research Centres (IRCs). The principal Research Centres at Kerang and Finley will cover all five autumn sown crops (faba beans, chickpeas, durum, barley and canola) with the addition of maize sown in the spring on commercial farms. Satellite centres have been established in Frances, Griffiths and Tasmania with a smaller number of trials per annum. The soil amelioration research has been established in collaboration with NSW DPI and is based on two large block research trials at Kerang (Grey Clay under surface irrigation) and Finley (Red Duplex under overhead irrigation). Different soil amelioration treatments were established at these research sites in March 2020 and results of the first year experiments (faba beans at Finley and oats at Kerang) were reported in the Provisional Winter Crop report in February 2021.

Grain Maize (Summer Crop Results – Year 2)

This is the second year of grain maize results from the project, and it's been exciting for the project team to compare results with 2019/20 season since both research sites have been located on the same soil types close to where the previous year's research was conducted. At Peechelba East in Victoria the research site was located under the same pivot as 2019/20 but in 2020/21 established on grain maize stubble from the year before to see how grain maize on grain maize stubble would compare to grain maize on oat stubble in the first year. At Kerang the research site was established following a grass dominant pasture, again similar to year 1 results.

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 Kaara Klepper (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 Neale and Daniel Coulthard in providing the research site at Peechelba Colin and Geoff Gitsham at Kerang, and Campbell Dalton at Yenda Hopefield. 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 2021.

Finally, can I place on record my thanks for my own trials team for bringing this research programme through to harvest, in particular Ben Morris, Tom Price and Kat Fuhrmann. I would like to thank Sharon Nielsen from SAGI for all of her input to the analysis of the results.

Nick Poole – Managing Director, FAR Australia

27 August 2021

GRAIN MAIZE RESULTS SUMMARY – YEAR 2 (2020 – 2021)

10 irrigated grain maize trials were established at two locations in northern Victoria. The primary focus of this second year of field research was to look at the influence of higher levels of nitrogen (N) input on harvest dry matter, grain yield, harvest index, nitrogen offtake and profitability. In addition, the research programme also examined the influence of plant population, row spacing and disease management. At the main research sites in Peechelba East and Kerang, irrigation was provided by overhead pivot and surface irrigation (Flood - border check) respectively. Total irrigation quantities applied were as follows, Peechelba East (Pivot 5.1 Mega L/ha applied) and Kerang (Surface irrigation border check 11.6 MegaL/ha). All research was conducted using the Pioneer Hybrid P1756, the same hybrid used in year one of the programme. To ensure soil type consistency between seasons the principal trials were conducted at the same field research sites (different parts of the paddock) as 2019/20. At Peechelba East on a commercial farm (red loam over clay) the research was conducted under the same pivot as 2019/20 (not on the same area under the pivot) with all trials established into grain maize residues from the previous season, compared to grain maize following oaten hay stubble in the first year of research. At Kerang (self-mulching grey clay) in both years maize research has been conducted following grass dominant pasture.

Grain yields and nutrition

Grain maize crops yielding 16 -19t/ha with dry matters of 33 - 35t/ha commonly remove 400kg N/ha from the soil, but in results generated over the last two years these crops do not respond significantly to N fertiliser inputs greater than approximately 250kg N/ha. Of the nitrogen removed by the crop canopy at harvest approximately 30 – 35% of the N is returned to the soil as stover residues, so based on a 400kg N offtake approximately 120 - 140kg N/ha is returned to the soil as harvest residues. Applications of nitrogen in excess of 250kg N/ha with up to 550kg N/ha experimented upon in the project have been largely uneconomic in the season; these applications lost up to $400/ha depending on the price of N fertiliser and the exact rates of N applied. With applications of N fertiliser commonly applied at levels of 300 – 450kg N/ha on farm for irrigated grain maize it has not been possible to illustrate that such high levels of N input are the route to higher grain yields in this crop. Whilst in an irrigated system it is unclear how much of the excess N is available the following season, research conducted indicates that we need to rethink the profitability of such large doses or at a minimum take account of soil mineralisation for nitrogen applications in irrigated summer crops. At both research sites supply of nitrogen from the soil has been responsible for supplementing fertiliser N in the production of large crop canopies and grain yields in excess of 16t/ha. **Whilst we cannot mine our soils without regard to this contribution, the research has illustrated that in-crop mineralisation in the summer months is an extremely significant contributor to the N budget calculations under irrigation.** Whilst over fertilising can be claimed to be beneficial for following crops it is important to recognise that this research has failed to generate any evidence to suggest that grain maize crops can respond (with statistical significance) to more than 250kg N/ha. Clearly, the level of organic carbon in the soil will vary and contribute different amounts of soil N supply through the course of a season, however the key finding has been our inability to generate significant yield responses up to the levels of fertiliser being applied on farm. At Peechelba East in 2021 the research was conducted in a maize-on-maize scenario in order to test whether economic responses could be secured from higher amounts of N compared to 2020 when maize was grown following oaten hay. Overall grain yields were lower yielding at 16 - 17.5t/ha in 2021 and although 17t/ha crops were achieved with N rates above 250kg N/ha, the economics were marginal - in some cases slightly positive (Trial 1) and in other cases negative (Trial 3). In no cases at this site over the last two years were statistically significant yield increases achieved with N rates above 250kg. These results have been generated in commercial situation where 200 – 230kg N/ha has been applied as fertigation with applications from V4, V8 and pre VT (tasselling). In 2020 at this site the highest grain yields recorded (machine harvested plots) were 18 - 19t/ha; these were produced on crop canopies fertilised with approximately 250kg N/ha (50N as pre drill urea and the remaining 200N as fertigation).

N timing has failed to generate significant yield effects but for the second year there has been some evidence to suggest split applications, with an emphasis on later applications (up to tasselling), has been associated with higher grain protein. In addition, if large applications were made at sowing as single doses there was evidence to suggest nitrification inhibitors (eNpower) have a role, but yield increases were not statistically significant.

Plant population and row spacing

Over two years plant population and row spacing have been noted to have significant effects on dry matter production and grain yields. Optimum plant populations at Peechelba East maize on maize were lower than those observed following oaten hay in 2020 when yields were higher (18 - 19t/ha). At yields of 16 - 17t/ha when maize followed maize, an economic optimum of 80,000 plants/ha was established compared to 92,000 plants/ha with the same hybrid P1756. Although there was evidence that higher plant populations respond to higher N input, **the best margins ($/ha) from the Peechelba East site in 2021 were generated with 230kg N/ha (applied as fertigation) applied to 80,000 plants/ha.** At Kerang there was no yield advantage associated with higher plant populations (105 - 107,000 plants/m2) of hybrid P1756 compared to 83 - 84,000 plants/m2. Spatial configuration of the low plant populations is an important consideration from results generated so far, with data suggesting that narrower row spacing combined with lower plant populations may offer higher productivity than the traditional 750mm row spacing. **In 2021 at Kerang the combination of 500mm row spacing and lower plant population generated the highest grain yields on the research site.** At Boort in 2020 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). This will be a major emphasis of the final year of research in 2021/22 as it has been one of the few factors, other than overall N input, to significantly influence maize grain yield. Poorer establishment in that trial resulted in no significant differences due to plant population.

Foliar nutrition

The project with the assistance and support of industry evaluated a number of different foliar applications of both macro and micronutrients in 2021. At Peechelba East these liquid fertilisers (based on calcium nitrate and Natures K) were applied as supplement applications on top of a standard N fertigation strategy (based on 230N) and a higher N input of 420kg N/ha at V5, V7 and up to V9. There were some interesting interactions and significant effects on total dry matter produced but no statistically significant yield responses over the standard N controls. Potassium levels in the newest tissue were shown to be low at this site when assessed at tasselling, but none of the treatments were seen to significantly increase K concentration in the upper leaves relative to the untreated crops. At Kerang an application of Spraygro Complete K (an NPK trace element liquid) applied at silking and 14 days after silking had no impact on yield. Monitoring of tissues at Kerang revealed tissue levels of key elements to be sufficient when assessed at silking, apart from N concentration. In this first year of evaluation the significance of the results generated did not live up to the level of discussion that generated the research programme. Work in this area will continue in 2022.

Rotation Position

To better understand the effect of previous crop the research at Peechelba East took quadrat cuts out of an adjacent crop of P1756 that was grown following a crop of faba beans that was terminated in October. Although results are not statistically comparable using equivalent N input from research conducted with maize on maize, the comparison revealed greater overall DM production and grain yield (18.17t/ha) where maize followed a terminated faba bean crop compared to 16.59t/ha following maize (note yields are expressed at 0% moisture in this case).

Disease Management

Two 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. Other than low levels of common rust *(Puccinia sorghi)* little foliar disease was observed in these trials. This two years of research work examining this aspect of agronomy research will now be discontinued and greater emphasis placed on row spacing, population and nutrition for 2022. In the maize-on-maize scenario at Peechelba East a low frequency of blackened plants was identified in the trials, but the foliar fungicides had no impact on the level of these blackened plants.

RESULTS

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 of applied N fertiliser applied as pre drill urea (46% N) prior to a standard fertigation (230N) with an overhead lateral.

Peechelba East, Victoria

Sown: 4 November 2020
Harvested: 6 May 2021
Soil Type: Red loam over clay
Previous crop: Grain Maize
Hybrid: Pioneer Hybrid 1756
FAR code: FAR IRR M20-01-1
Irrigation Type: Overhead pivot

Key Points:

- *Header grain yields averaged 17t/ha with no yield benefit observed from applying pre-drill urea in the trial when N was applied post sowing as fertigation (230kg N applied).*
- *In a trial with an overall dose of post sowing N of 230 kg N/ha applied via fertigation there was no value to the earlier pre-drill N applications of between 0 – 315kg N/ha.*
- *No significant differences were recorded in dry matter (DM) accumulation at V5 or NDVI at V7.*
- *The N offtake at harvest revealed an average N content of 420kg N/ha with a range of approximately 395-460kg N/ha in the crop.*
- *The N uptake at harvest indicated soil mineralisation provided up to 79kg 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 80.7kg/hL)*
- *Dry matter at harvest showed no differences with an average reading of 35.3t/ha and harvest index mean of 46.9%.*
- *Exactly two thirds of the N removed in the crop was present in the grain with an average of 280kg N/ha in the grain and 140kg N/ha in the stover.*

Table 1: Grain yield (t/ha @ 14% moisture) test weight (kg/hL) and harvest index (H.I. %), 6 May 2021.

Treatment				Grain Yield and Quality					
	Pre-drill kg N/ha	Post plant* kg N/ha	Total kg N/ha	Yield t/ha		Test Wt kg/hL		H.I %	
1.	0	230	230	16.03	-	80.4	-	46.0	-
2.	45	230	275	16.05	-	81.0	-	50.0	-
3.	90	230	320	17.04	-	80.7	-	47.0	-
4.	135	230	365	17.00	-	81.0	-	48.0	-
5.	180	230	410	17.68	-	80.5	-	45.0	-
6.	225	230	455	17.09	-	80.4	-	48.0	-
7.	270	230	500	17.70	-	80.7	-	44.0	-
8.	315	230	545	17.41	-	80.7	-	48.0	-
	LSD			NS		NS		NS	
	Mean			17.00		80.7		46.9	
	P Val			0.478		0.167		0.150	
	CV			7.79		7.79		5.83	

** Post sowing nitrogen (230 N) was applied via fertigation with applications on V4 (46N), V8 (69N), pre-tasselling (115 N) on 20 Nov, 20 Dec and 15 Jan*
Available soil N assessed prior to sowing 111 kg N/ha (0-60cm)
Harvest index based on grain and stover recorded at 0% moisture

There was no significant difference in grain yield as a result of applying predrill N rates of between 0 and 315kg N/ha, however there was a trend suggesting that 90kg N/ha pre drill and a total of 320kg N/ha was higher yielding and gave better margin after urea cost (see Table 5).

Dry matter accumulation at V5 stage averaged 0.42t/ha and showed no significant differences in DM across any rate of nitrogen applied pre-drill (data not shown). At V7 stage there was no difference in NDVI as fertigation application became available to the plant.

Table 2: Dry matter accumulation (t/ha) in maize at crop maturity, 23 April 2021.

Treatment			**Harvest Dry Matter (recorded at 0 % moisture)**			
Nitrogen (kg N/ha)			**Stalks**	**Cobs**	**Grain**	**Total**
	Pre-drill	**Total**	**t/ha**	**t/ha**	**t/ha**	**t/ha**
1.	0	230	17.03 -	2.23 -	16.68 -	35.95 -
2.	45	275	14.99 -	2.29 -	16.88 -	34.15 -
3.	90	320	16.79 -	2.19 -	16.26 -	35.25 -
4.	135	365	15.79 -	2.19 -	16.58 -	34.55 -
5.	180	410	16.54 -	2.03 -	15.19 -	33.78 -
6.	225	455	17.04 -	2.39 -	17.82 -	37.23 -
7.	270	500	17.21 -	2.07 -	15.06 -	34.35 -
8.	315	545	17.03 -	2.37 -	17.91 -	37.33 -
	Mean		16.55	2.22	16.55	35.32
	LSD		NS	NS	NS	NS
	P Val		0.803	0.339	0.235	0.746

Grain yield is higher than machine harvest (Table 1) as data was recorded from quadrat cuts and is expressed at 0% moisture

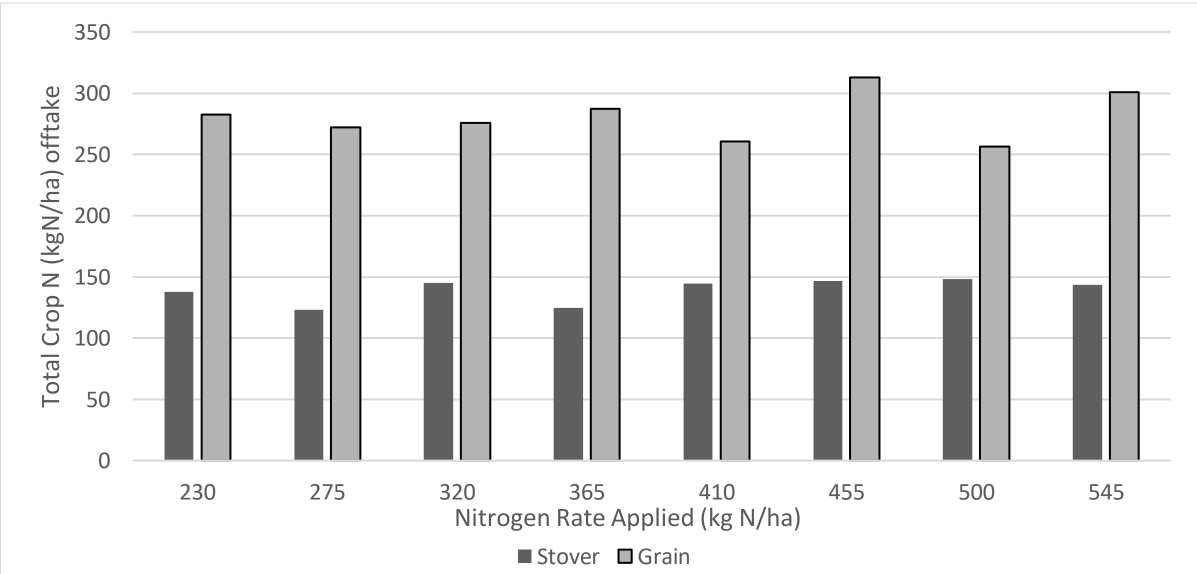


Figure 1. Total crop N (kg N/ha) offtake at harvest in the stover (stalks, leaves, husk) and grain

N uptake into the crop at harvest indicated that between approximately 395 and 460kg N/ha had been removed from soil depending on applied N treatment, although none of the differences in N uptake were significant (table 3). Approximately 79kg N/ha was provided by mineralisation from the soil in crops where no pre-drilled urea was applied, with 111kg N/ha available in the soil at sowing, giving a total of 190kg N/ha available to crop as soil supply. At higher levels of applied N fertiliser (500 & 545kg N/ha) more N fertiliser was applied than was recovered in the crop.

If the mineralisation in the soil was assumed to be the same over the course of the season for all treatments and all plots had equal access to the same available soil N at sowing then efficiency of N recovery in the crop declined from 26.2kg N/t where 230 kg N/ha was applied as fertigation to 42.2kg N/ha where 315kg N/ha was applied as pre drill Urea and 230kg N/ha was applied as fertigation (Table 4).

Table 3: Nitrogen content (kg N/ha) in maize at harvest, 6 May 2021.

Treatment			**Harvest Nitrogen Content***			
Nitrogen (kg N/ha)			**Stalks**	**Cob husk**	**Grain**	**Total**
	Pre drill	**Total**	**N kg/ha**	**N kg/ha**	**N kg/ha**	**N kg/ha**
1.	0	230	124.4 -	13.5 -	282.3 -	420.1 -
2.	45	275	109.4 -	13.7 -	272.3 -	395.3 -
3.	90	320	131.9 -	13.3 -	275.6 -	420.8 -
4.	135	365	111.6 -	13.1 -	287.2 -	411.9 -
5.	180	410	132.4 -	12.4 -	260.4 -	405.2 -
6.	225	455	132.3 -	14.5 -	312.7 -	459.5 -
7.	270	500	135.8 -	12.2 -	256.2 -	404.2 -
8.	315	545	128.7 -	14.6 -	300.8 -	444.1 -
	Mean		125.8	13.4	280.9	420.1
	LSD		NS	NS	NS	NS
	P Val		**0.755**	**0.366**	**0.366**	**0.759**

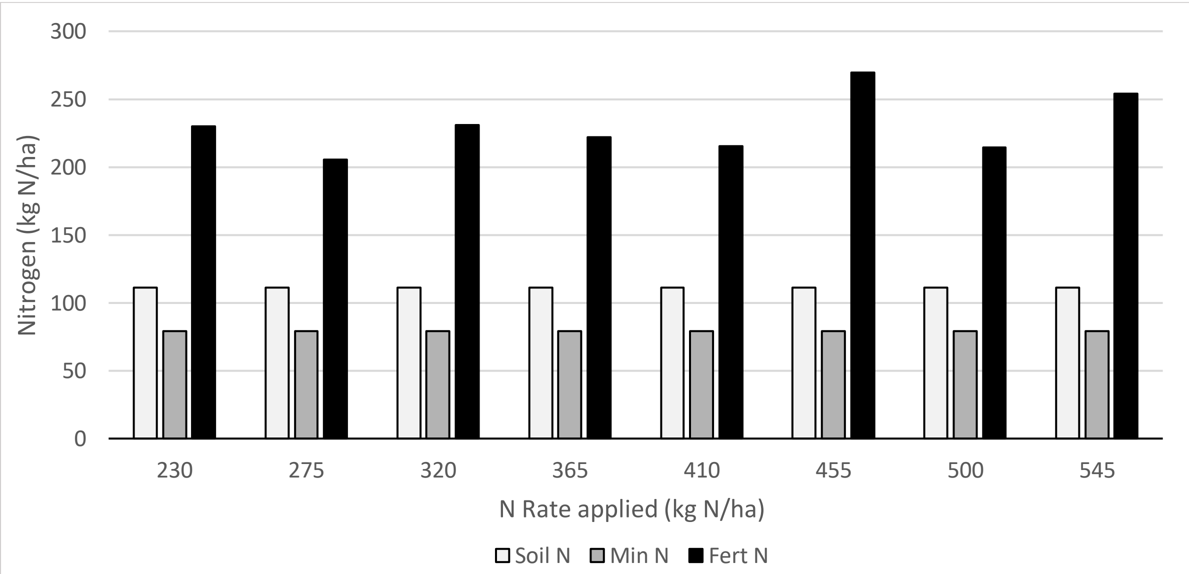


Figure 2: Assumed contribution of N fertiliser to total crop N offtake at harvest (if mineralisation was assumed to be the same in all treatments and that preferential N uptake of soil N rather than bag N was the case). Soil N available at sowing (111kg N/ha), in crop mineralisation N (Min N) (79kg N/ha), Fertiliser N (Fert N) applied as pre drill urea and post sow fertigation.
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 4: Efficiency of N fertiliser application in relation to nitrogen recovered in the whole crop and per tonne of grain produced at harvest, 6 May 2021.

	Pre-drill kg N/ha	Post drill* kg N/ha	Total kg N/ha	Total N offtake in crop kg N/ha	Machine Grain Yield t/ha (14% moisture)	Fertiliser N recovered in crop (% of applied) +	NUE Kg N fert applied/t of grain (++)
1.	0	230	**230**	420.1	16.03	230 (100)	14.4 (26.2)
2.	45	230	**275**	395.3	16.05	205 (75)	17.1 (29.0)
3.	90	230	**320**	420.8	17.04	231 (72)	18.8 (29.9)
4.	135	230	**365**	411.9	17.00	222 (61)	21.5 (32.6)
5.	180	230	**410**	405.2	17.68	215 (52)	23.2 (33.9)
6.	225	230	**455**	459.5	17.09	270 (59)	26.6 (37.7)
7.	270	230	**500**	404.2	17.70	214 (43)	28.2 (39.0)
8.	315	230	**545**	444.1	17.41	254 (47)	31.3 (42.2)

+ Assumptions: Soil nitrogen available at sowing (111kg N/ha) and mineralised through the course of the season (79kg N/ha) was similarly available to all N rate treatments applied

++ Figure in brackets is Kg N/t grain if soil N supply is added to fertiliser applied (total 190kg N/ha of soil mineral N at sowing and mineralised N)

** Post sowing N applied as fertigation (see Table 1)*

If the yields of the treatments were considered without statistical significance the highest margins were generated by N applications of 410kg N/ha, since the small non-significant yield increases associated with N application above 230kg N/ha applied were large enough to pay for the additional fertiliser (Table 5).

Table 5: Gross income ($/ha) based on grain yield and income after urea costs ($/ha)

Treatment						
	Pre-drill kg N/ha	**Post drill* kg N/ha**	**Total kg N/ha**	**Gross income $/ha**	**Pre drill urea cost $/ha $1.74kg N**	**Income after Pre drill urea cost $/ha**
1	0	230	**230**	4809	400	4409
2	45	230	**275**	4815	478	4337
3	90	230	**320**	5112	557	4555
4	135	230	**365**	5100	635	4465
5	180	230	**410**	5304	713	4591
6	225	230	**455**	5127	791	4336
7	270	230	**500**	5310	870	4440
8	315	230	**545**	5223	948	4275

Assumptions: Grain Maize valued at $300/t, Urea fertiliser at $800/t ($1.74kg N)

Trial 2. Nitrogen Use Efficiency – Influence of N Rate

Kerang, Victoria

Sown: 3 November 2020
Harvested: 20 May 2021
Rotation position: Grass dominant pasture.
Previous crop: Grass dominant pasture (3 years)
Soil Type: Neutral self-mulching grey clay

Hybrid: Pioneer Hybrid 1756
FAR code: ICC M20-01-2
Irrigation Type: Border check surface irrigation

Key Messages:

- *The highest machine harvested yield achieved was 16.42 t/ha with the applied N rate of 560 kg N/ha, however this was not statistically different to the yield where 240 kg N/ha was applied.*
- *Yield plateaued beyond the '240 kg N/ha' treatment (16.18t/ha), mirroring the 2019/20 results which produced a similar N applied optimum.*
- *Where no N fertiliser was applied the yield was 9.70 t/ha with a dry matter of 21.8t/ha at harvest compared to 16.18t/ha and 35.79t/ha for the optimum N rate of 240kg N/ha.*
- *The N offtake at harvest revealed an average N content of approximately 188-448kg N/ha in the crop with the 240N treatment giving an offtake of 395kg N/ha with 58% of the N in the grain.*
- *Increasing N rate from 240kg to 560kg N/ha applied did not significantly increase dry matter present at harvest, although there is evidence of additional N content in the dry matter above 240kg N/ha.*
- *Soil N prior to sowing and watering up was 32 kg N/ha (0 – 60cm). One month after sowing and wetting up this figure had risen to 107kg N/ha.*
- *The nil N treatment contained a total N content of 188 kg N/ha at harvest, suggesting in-crop mineralisation through the course of the season resulted in 156 kg N/ha released.*
- *In-crop mineralisation in the 2020/21 season was lower than in 2019/20 (241kg N/ha) but still contributed a significant portion of the crop N budget.*

Table 1: Influence of fertiliser N rate (applied as 50% split between predrill and V6) on grain yield (t/ha @ 14% moisture), dry matter (t/ha), test weight (kg/hl) and harvest index (H.I.), 20 May 2021.

Treatment				Grain Yield, Dry Matter Yield and Quality					
Kg N/ha				**Yield**		**DM**		**Test Wt**	**H.I.**
	Pre-drill	**Post drill**	**Total kg**	**t/ha**		**t/ha**		**kg/hL**	
1.	0	0	**Nil**	9.70	d	21.78	d	82.4	0.38
2.	40	40	**80**	12.89	c	29.27	c	83.3	0.38
3.	80	80	**160**	14.07	b	32.93	bc	82.5	0.37
4.	120	120	**240**	16.18	a	35.79	ab	82.3	0.39
5.	160	160	**320**	15.75	a	34.91	ab	83.1	0.39
6.	200	200	**400**	16.25	a	34.00	ab	81.9	0.42
7.	200	200 (+80)	**480**	16.12	a	37.70	a	82.4	0.37
8.	280	280	**560**	16.42	a	37.09	a	83.7	0.38
	LSD			1.02		3.67		ns	ns
	Mean			14.67		32.93		82.7	0.39
	P Val			<0.001		<0.001		0.153333	0.677

CV	4.7	7.9	1.1	9.2

Figures followed by different letters are considered to be statistically different (p=0.05)
Treatment 7 was the same as treatment 6 with 80 kg N/ha (46% N urea) was applied at tasselling to bring the total to 480kgN/ha.

There was a statistically significant yield response as a more N was applied up to 240 kg N/ha. Yield then plateaued at approximately 16 t/ha.

A similar response was also seen in the total dry matter produced, although the trend is not as clear cut. Highest dry matter was produced by the '480 kg N/ha' treatment, although this was not statistically different to that of the '240 kg N/ha' treatment.

Table 2: Nitrogen content (kg N/ha) in maize at physiological maturity, 14 April 2021.

Treatment				**Stover**		**Grain**		**Total N**	
	Pre-drill	**Post**	**Total kg N/ha**	**Kg N/ha**		**Kg N/ha**		**Kg N/ha**	
1.	0	0	**Nil (Control)**	87.3	e	101.1	e	188.4	f
2.	40	40	**80**	119.1	de	161.5	d	280.5	e
3.	80	80	**160**	142.5	cd	184.0	c	326.5	d
4.	120	120	**240**	164.3	abc	231.1	b	395.4	c
5.	160	160	**320**	162.4	bc	241.7	ab	404.1	bc
6.	200	200	**400**	153.9	cd	238.3	ab	392.3	c
7.	200	200	**480+80***	198.6	a	249.4	a	448.0	a
8.	280	280	**560**	196.6	ab	237.8	ab	434.5	ab
	LSD			**153.1**		**205.6**		**358.7**	
	Mean			34.8		17.0		38.6	
	P Val			<0.001		<0.001		<0.001	
	CV			16.5		6.6		7.3	

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

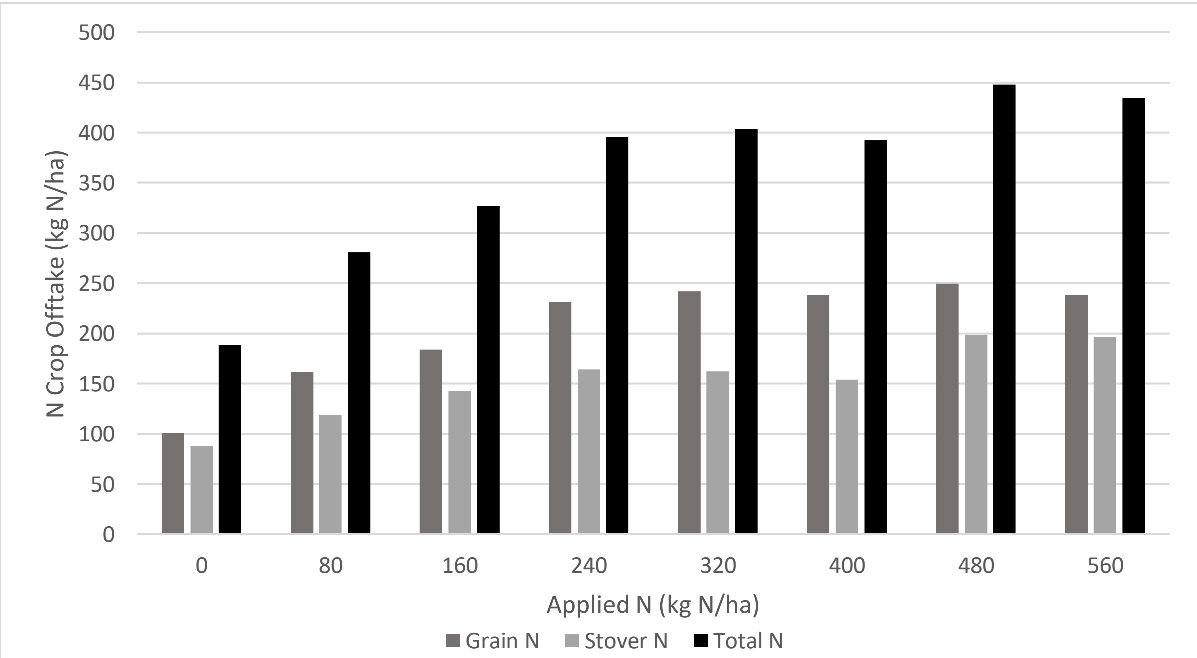


Figure 1. Influence of applied N rate on Crop N offtake; grain, stover and total N (kg N/ha).

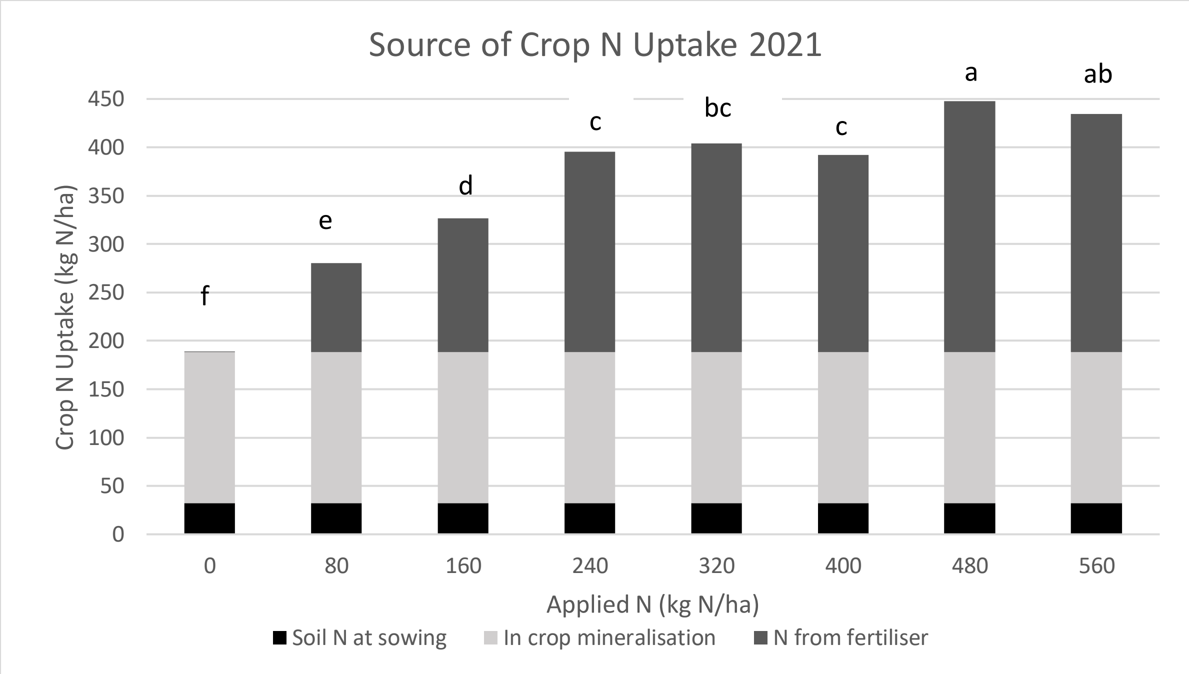


Figure 2: Soil N at sowing, in crop mineralisation and fertiliser contribution to total crop N

Lsd Total N p=0.05 38.62 P val <0.001 cv% 7.3
Lsd fertiliser N p=0.05 38.63 P val <0.001 cv% 15.4
Applied N columns followed by different letters are considered to be statistically different (p=0.05)
The statistical superscripts apply both to the total column as well as the N derived from the fertiliser.

Note: Assumed contribution of N fertiliser to total crop N offtake at harvest (if mineralisation in zero N applied treatment was assumed to be the same in all treatments and that preferential N uptake of soil N rather than bag N was the case). Soil N available at sowing (32kg N/ha), in-crop mineralised N (Min N) (156kg N/ha), Fertiliser N (Fert N) applied as pre drill and post sow urea.

Figure 2 illustrates the contribution of the three sources to crop uptake. Soil N at sowing was 32 kg N/ha, in-crop mineralisation was assumed to be 156 kg N/ha based on the '0 applied N' treatment accumulating 188 kg N/ha and the N derived from the applied fertiliser.

This trial suggests that mineralisation can contribute a considerable amount when sowing into a previous pasture paddock. Limited soil testing was conducted early in the season where samples taken 1 month after sowing in a non-cropped area had accumulated 107 kg N/ha.

The highest amount of N taken up by the crop was 448 kg N/ha by the '480 kg N/ha' treatment.
The highest yielding treatment (560 kg N/ha applied) had an N content of 435 kg N/ha. However, while the yield was not significantly different to the yield of the '240 kg N/ha' treatment, the N uptake was. The '240 kg N/ha' treatment had 207 kg N/ha higher N offtake than the nil control suggesting a considerable proportion of the N applied was taken up by the crop.

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. Comments made at previous crop walks were that applying more N didn't necessarily result in more yield, but high rates are maintained to ensure the crop has too much N rather than not enough. Assuming the '240 kg N/ha' treatment is the appropriate N rate for comparisons between seasons, crop N uptake was higher in

2020/21 (395 vs 310 kg N/ha) for similar yields, with reduced in-crop mineralisation and hence greater uptake of the applied fertiliser.

These two trials suggest that mineralisation can contribute a considerable amount and should be considered in the N budget. However, note that 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.

Yield plateaued after 240-250kg N/ha, which mirrored the responses observed in 2019/20 trials. Assuming the '240 kg N/ha' treatment is the appropriate N rate for comparisons between seasons, crop N uptake was higher in 2020/21 (395 vs 310 kg N/ha) for similar yields, with reduced in-crop mineralisation and hence greater uptake of the applied fertiliser.

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: 4 November 2020
Harvested: 5 May 2021
Soil Type: Red loam over clay
Previous crop: Grain Maize

Hybrid: Pioneer Hybrid 1756
FAR code: FAR MRC M20-02-1
Irrigation Type: Overhead pivot

Key Messages:

- *With an average grain yield of 17.29t/ha there were no significant differences in header grain yield from varying nitrogen rate or timing of prilled urea (46%N) when 230 kg N/ha was applied as fertigation post sowing.*
- *Dry matter was between 30 and 35t/ha at harvest with approximately 50% of this dry matter present as grain and the remaining 50% as stover.*
- *In terms of nitrogen uptake in the crop at harvest 70% of the N on average was in the grain with 30% in the stover (leaves, stalk and cob husk).*
- *There was some evidence that additional N increased grain N content, but this was not associated with yield increases.*
- *The trial results are similar to the same trial run in 2019/20 which following oaten hay had an average yield of 18.2t/ha compared to 17.3t/ha when sown maize on maize.*

Table 1. 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**	
	(230)		**(320)**		**(410)**	
Timing	**Yield t/ha**		**Yield t/ha**		**Yield t/ha**	
Pre-Drill	17.74	-	18.01	-	17.17	-
V4	16.60	-	17.14	-	18.03	-
V6	16.80	-	16.93	-	17.24	-
LSD N Application Timing p = 0.05		NS		**P val**	0.536	
LSD N Application Rate p=0.05		NS		**P val**	0.576	
LSD N Timing. x N Rate. P=0.05		NS		**P val**	0.448	

** Post sowing nitrogen (230 N) was applied via fertigation with applications on V4 (46N), V8 (69N), pre-tasselling (115 N) on 20 Nov, 20 Dec and 15 Jan*
Available soil N assessed prior to sowing 111 kg N/ha (0-60cm) 49 kg N/ha (0-30cm), 62 kg N/ha (30-60cm)
Yield Figures followed by different letters are considered to be statistically different (p=0.05)

Grain Yield

With an average grain yield of 17.29t/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 N rate and timing.

Dry Matter and nitrogen content of plant components at harvest

There was no significant difference in dry matter at harvest with total dry matters in the range of 30 – 35t/ha and on average grain accounting for approximately 50% of the N content (Figure 1). In terms of nitrogen content (Table 2 & Figure 2) there were no significant differences in the stalks and cob husk but there was a significant difference in grain N content (p=0.033). Approximately 70% of the N content of the crop was in the grain at harvest.

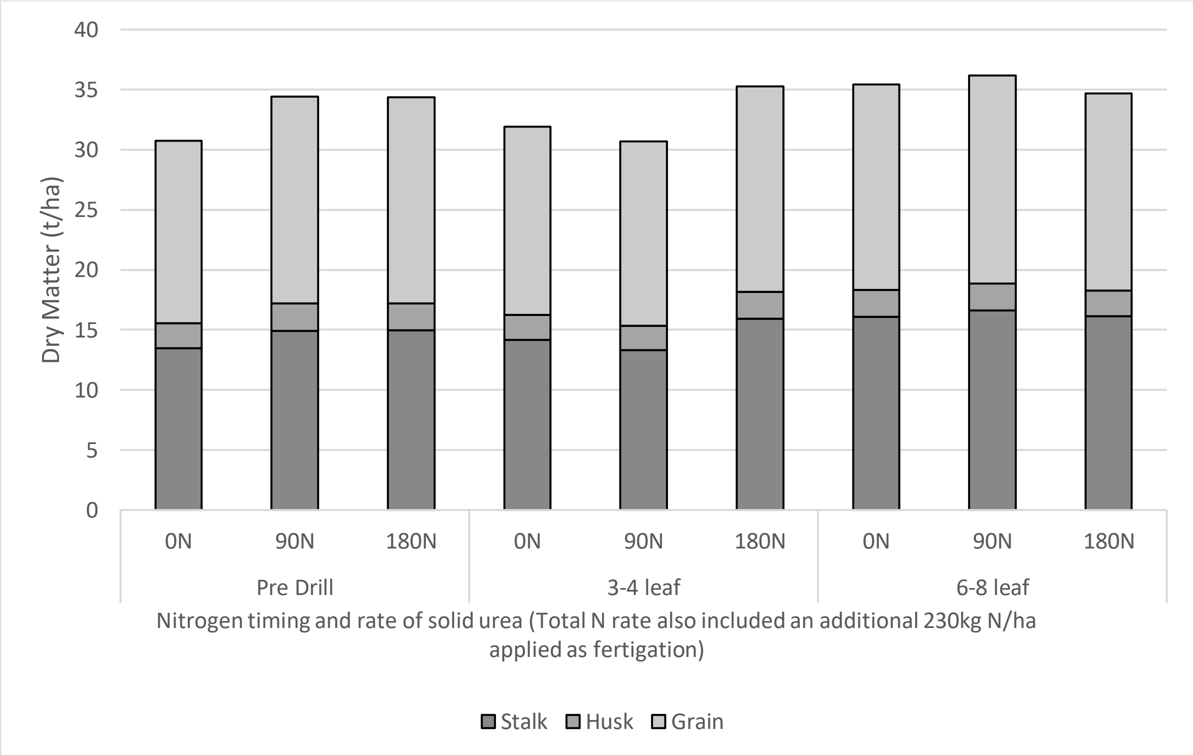


Figure 1. Dry Matter accumulation at harvest in the stalk (p=0.588), husk (p=0.641) and grain (p=0.365) when varying the solid nitrogen application timing and rate.
Additional post sowing nitrogen (230 N) was applied via fertigation with applications on V3 (46N), V7 (69N), pre-tasselling (115N) on 20 Nov, 20 Dec and Jan 15

Table 2: Nitrogen content (kg N/ha) in maize at physiological maturity, 23 April 2021.

Treatment			**Stalk N**	**Cob N**	**Grain N**	
Timing N/ha)	**Rate**	**Total kg N/ha**	**Kg N/ha**	**Kg N/ha**	**Kg N/ha**	
1. Pre drill	0	**230**	105.2	12.8	263.7	c
2.	90	**320**	94.1	14.1	298.8	abc
3.	180	**410**	106.3	14.3	299.8	abc
4. 3-4 Leaf	0	**230**	100.7	14.3	255.0	c
5.	90	**320**	95.8	13.5	269.5	bc
6.	180	**410**	117.0	14.6	335.5	a
7. 6-8 Leaf	0	**230**	103.7	15.0	320.7	ab
8.	90	**320**	134.9	14.2	278.9	bc

9		180	**410**	113.1	13.7	276.0	bc
	Mean			**107.9**	**14.0**	**288.7**	
	LSD			ns	ns	38.6	
	P Val			0.174	0.568	0.033	
	CV			18.1	13.3	12.3	

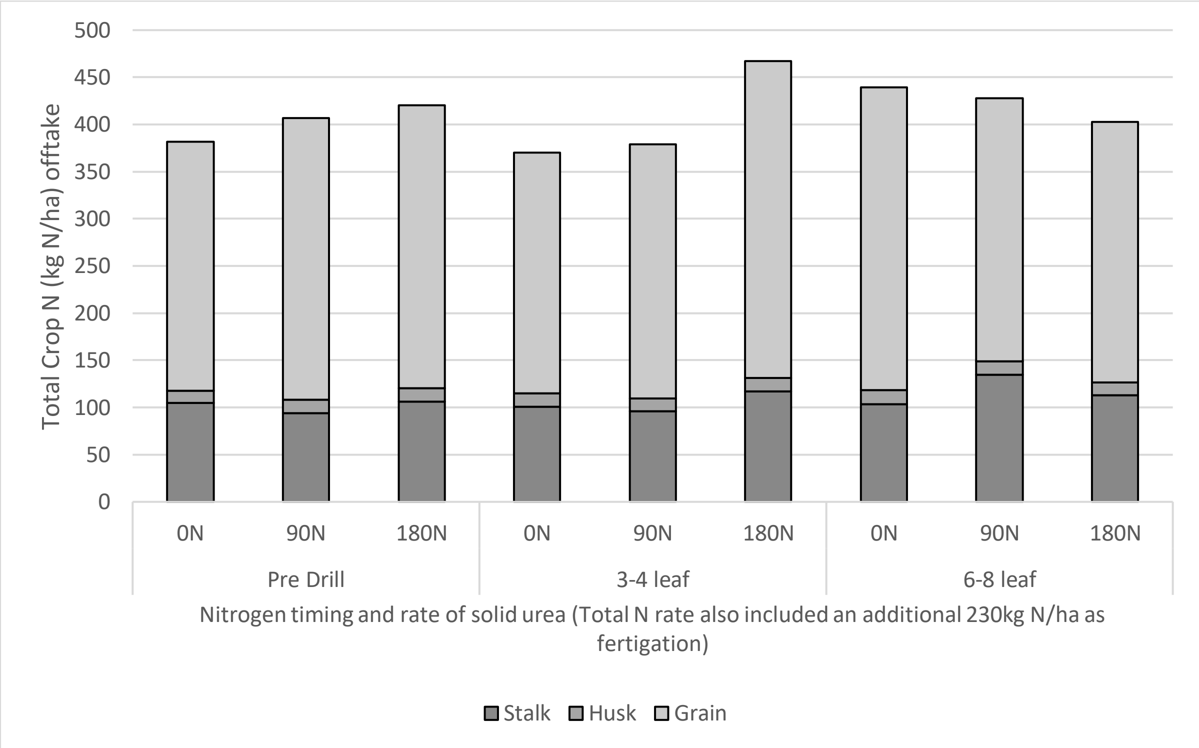


Figure 2. Nitrogen content in the stalk (p=0.174), husk (p=0.568) and grain (p=0.033) at harvest when varying the first nitrogen application timing, total N offtake p=0.088.

Trial 4. Nitrogen Use Efficiency – Product and Timing

Kerang, Victoria

Sown: 3 November 2020
Harvested: 20 May 2021
Rotation position: Grass dominant pasture.
Previous crop: Grass dominant pasture (3 years)
Soil Type: Neutral self-mulching grey clay

Hybrid: Pioneer Hybrid 1756
FAR code: ICC M20-02-2
Irrigation Type: Border check surface irrigation

Key Messages:

- *In all treatments where N fertiliser was applied there were no statistically significant differences in grain yield.*
- *The highest yield achieved was 16.82 t/ha with the total applied N of 300 kg N/ha, applied as 100 kg N/ha at sowing, then 3 subsequent topdressings of 66 kg N/ha up to tasselling, but achieved similar yields to applying 300 kg N /ha at sowing only.*
- *The nil applied N treatment yielded 10.61 t/ha and had a dry matter of 19.58t/ha and a N content of 176kg N/ha at harvest.*
- *Soil available N prior to sowing and watering up was 44 kg N/ha (0-60cm).*
- *The nil N applied treatment contained a total of 176 kg N/ha at harvest, suggesting in-crop mineralisation resulted in 132 kg N/ha being released from the soil during the course of the season.*
- *In this trial as long as at least 100 N (and 200 kg N/ha in total) was applied beginning at sowing, product or timing did not influence yield.*

Treatment list: (kg N/ha) unless overwise stated N was applied as prilled urea (46% N))

		Applied N rate and timings (kg N/ha)			
Trt.	**Timing (1st N dose)**	**Timing 2 N dose)**	**Timing 3 N dose**	**Timing 4 N dose**	**Timing 5 N dose**
	Seedbed (sowing)	**V4 (3-4 leaf)**	**V6 (6 leaf)**	**V8 (8 leaf)**	**VT (tasselling)**
1	---	---	---	---	---
2	300	---	---	---	---
3	300 (eNpower)	---	---	---	---
4	100	66	---	66	66
5	100	100	---	100	---
6	100	66	66	66	---
7	100	---	---	100	---
8	200 (eNpower)	---	---	100	---

Grain Yield

There was no statistically significant yield differences amongst any of the N treatments applied, although all treatments gave a significant yield response over nil N control. The highest yielding treatment at 16.82 t/ha was achieved by applying 300 kg N/ha in four applications from pre-drilled (100N) through to the last application at tasselling VT (66N), however an identical yield was generated by a single application of eNpower (300N) applied prior to sowing. Reducing the rate of applied N to a total of 200 kg N/ha did not significantly reduce yield compared to treatments that received 300 kg N/ha.

Table 1. Grain yield (t/ha @ 14% moisture), test weight (kg/hl), total dry matter (t/ha) and harvest Index (HI) in response to Nitrogen timing and Product.

Treatm	Applied Nitrogen (kg N/ha)	Yield		Test Wt	Total DM		HI
1	*Nil (Zero Control)*	10.61	b	81.9	19.58	c	0.47
2	*300 at sowing (s)*	16.13	a	83.4	34.88	ab	0.40
3	*300 (s) as eNpower^*	16.80	a	82.6	35.82	a	0.41
4	*100 (s) + 66 V4 + 66 V8 + 66VT*	16.82	a	82.6	33.52	ab	0.43
5	*100 (s) + 100 V4 + 100 V8*	15.91	a	82.4	34.11	ab	0.40
6	*100 (s) + 66 V4 + 66 V6 + 66V8*	16.63	a	82.5	33.58	ab	0.43
7	*100 (s) + 100 V6*	15.99	a	83.4	32.86	ab	0.42
8	*200 (s) as eNpower^ + 100 V6*	16.43	a	82.5	32.58	b	0.44
Mean		15.7		82.7	32.1		0.43
LSD		1.17		ns	3.15		ns
P Val		<0.001		0.136	<0.001		0.186
cv%		6.1		0.9	6.8		8.4

Yield figures followed by different letters are considered to be statistically different (p=0.05)
^: eNpower™ 18:20 contains the nitrification inhibiter DMP in IncitecPivot Fertilisers patented DMP-G formulation. DMP works by inhibiting nitrifying bacteria in the soil, slowing down the conversion of ammonium N to nitrate which is more prone to loss.

N product or timing at rates of 200 or 300kg N/ha applied had little influence on total dry matter, with harvest crops ranging from 32 – 36t/ha. There was a significant difference in dry matter between the two eNpower treatments with 200kg N/ha giving lower DM than 300kg N/ha, but this did not translate to yield.

Harvest index was not influenced by any treatment.

Nitrogen content of the crop canopy of N fertilised plots at harvest ranged from 366 – 413kg N/ha with no significant differences recorded but the lower N rate of 200N registering the lowest N content of the fertilised plots. All treatments had significantly greater uptake than the unfertilised treatment, which had a total of 176kg N/ha in the crop at harvest. There was evidence that grain N content was increased in those treatments adopting later split N applications compared to single pre sowing N applications or where overall N applications were increased from 200 to 300kg N/ha applied.

Table 2: Influence of N timing, rate and product on Nitrogen content^ (kg N/ha) in maize at maturity, 23 March2021.

Treatment						
Applied N (kg N/ha)	**Stover**		**Grain**		**Total N**	
	Kg N/ha		**Kg N/ha**		**Kg N/ha**	
1. *Nil (Zero Control)*	66.8	b	109.5	c	176.2	b
2. *300 at sowing (s)*	144.2	a	229.5	b	373.6	a
3. *300 (s) as eNpower^*	165.9	a	243.6	ab	409.4	a
4. *100 (s) + 66 V4 + 66 V8 + 66VT*	149.5	a	263.5	a	413.0	a
5. *100 (s) + 100 V4 + 100 V8*	141.7	a	245.2	ab	386.9	a
6. *100 (s) + 66 V4 + 66 V6 + 66V8*	146.6	a	265.0	a	411.4	a
7. *100 (s) + 100 V6*	144.8	a	221.3	b	366.1	a
8. *200 (s) as eNpower^ + 100 V6*	130.1	a	246.2	ab	376.3	a
LSD Stover N (p=0.05) 36.2	**P Val**	<0.001		**CV**	18.1	
LSD Grain N (p=0.05) 30.74	**P Val**	<0.001		**CV**	9.2	

LSD Total N	(p=0.05)	48.14	P Val	<0.001	CV	9.0

Yield figures followed by different letters are considered to be statistically different (p=0.05)

Crop N uptake (kg N/ha) at maturity

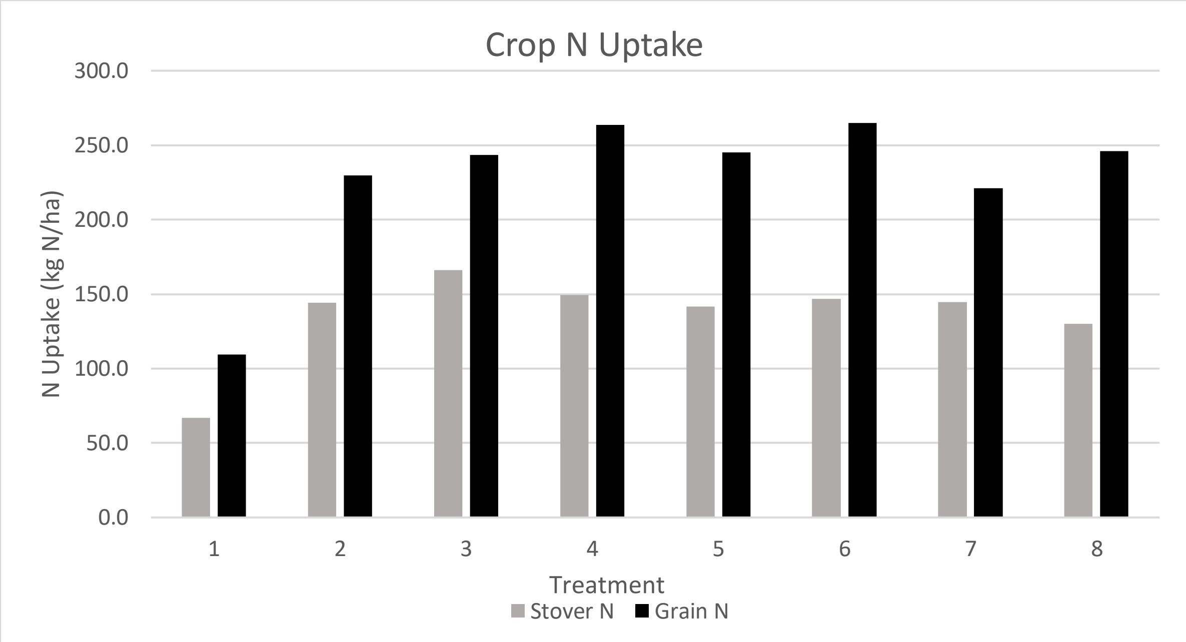


Figure 1. Influence of N timing, rate and product on Nitrogen Uptake (kg N/ha) in the stover and grain at maturity, 23 March 2021.

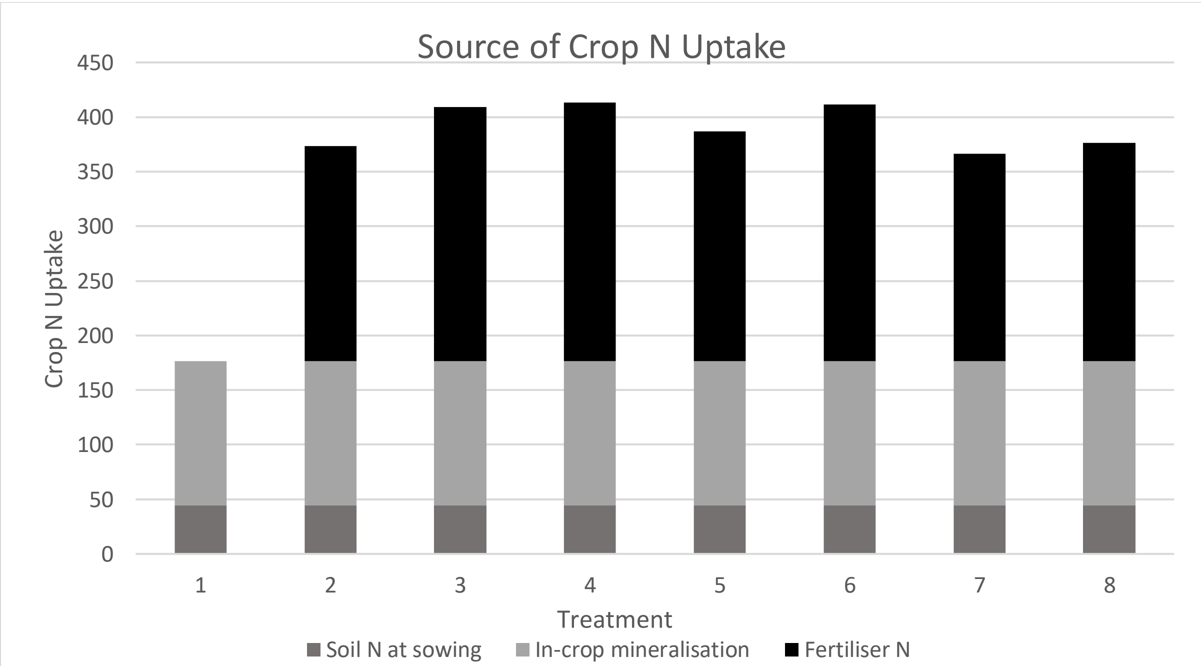


Figure 2: Assumed contribution of N fertiliser to total crop N uptake at harvest *(if mineralisation was assumed to be the same in all treatments and that there was preferential N uptake of soil N rather than bag N). Soil N available at sowing (44kg N/ha), in crop mineralisation (Min N) (kg N/ha), Fertiliser N (Fert N) applied.*

All treatments (where N was applied) were statistically similar meaning it didn't matter when the N was applied or in what proportions, as long as at least 200 kg N/ha was applied in total beginning with an application prior to sowing of at least 100 kg N/ha, yield was not affected.

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: 4 November 2020
Harvested: 6 May 2021
Soil Type: Red loam over clay
Previous crop: Grain Maize
Hybrid: Pioneer Hybrid 1756
FAR code: FAR IRR M20-03-01
Irrigation Type: Overhead pivot

Key Messages:

- *The average grain yield (header harvest) of the trial was 16.33t/ha with an uneconomic trend for higher yields if N rate and seedrate was increased.*
- *Plants populations of 80,000, 93,333 and 102,222 gave no statistical difference in grain yield, grown in a maize-on-maize rotation position.*
- *There was a trend suggesting a response to nitrogen at higher plant populations, but this was not significant. Highest yields were associated with N uptake at harvest of 400 – 450kg N/ha.*
- *Grain maize established on grain maize stubble in 2020/21 was approximately 1 t/ha lower yielding than the trial in the same paddock in 2019/20 when grain maize was established in oaten hay stubble.*
- *Comparing the two seasons there was a significant reduction in yield last season when the population was reduced from approximately 92,000 to 79,287 plants/ha. There was no difference in this experiment with maize grown on maize stubbles.*
- *In terms of profitability using the yields generated, the highest margin was generated with approximately 80,000 plants/ha and 230kg N/ha applied as fertigation.*
- *The additional cost of N ($1.74kg/N and seed required for 17t/ha in this trial exceeded the value of 0.7t/ha grain maize valued at $210/ha, hence lowest N rate and seedrate were most cost effective.*
- *Last season with slightly higher yields it was the 92,000plants/ha with 297kg N/ha was most profitable.*

Table 1. Grain yield (t/ha @ 14% moisture) of three pre-drill nitrogen application rates at three different plant populations.

	Total Applied Nitrogen Rate (additional pre-drill N at sowing in brackets)							
	230kg/ha N		**320kg/ha N (90)**		**410kg/ha N (180)**		**Mean N rate**	
Actual Plants/ha	**Yield t/ha**		**Yield t/ha**		**Yield t/ha**		**Yield t/ha**	
80,000	16.40	-	16.61	-	16.18	-	**16.40**	-
93,333	14.91	-	15.81	-	17.10	-	**15.94**	-
102,222	15.83	-	17.09	-	17.05	-	**16.66**	-
	15.71	**-**	**16.50**	**-**	**16.77**	**-**		
LSD N Plant Pop p=0.05			NS		**P val**		0.370	
LSD N Application Rate p=0.05			NS		**P val**		0.094	

LSD Plant pop. x N Rate. p=0.05	NS	**P val**	0.831

** Post sowing nitrogen (230 N) was applied via fertigation with applications on V4 (46N), V8 (69N), pre-tasselling (115 N) on 20 Nov, 20 Dec and 15 Jan*
Available soil N assessed prior to sowing 111 kg N/ha (0-60cm)
Yield Figures followed by different letters are considered to be statistically different (p=0.05)

Grain Yield

The trial gave an average of 16.33t/ha compared to 17.12t/ha in 2019/20. In this trial where grain maize was grown on grain maize there was no reduction in grain yield when plant population was reduced to 80,000 plants/ha. There was no significant interaction to suggest the different populations responded differently to the application of predrill urea, however there was a trend to suggest higher yields from predrill urea when the established population was higher, that was the case when the lowest population was evaluated.

Dry Matter at Harvest

At harvest there was a significant increase in grain dry matter as N rate was increased when the effect of the three plant populations was averaged (Table 2). A similar trend exhibited in stover residue and total dry matter content was also observed. In contrast total DM did not increase with plant population. Higher plant populations required higher N input to achieve final dry matters achieved at lower plant populations in this maize-on-maize scenario (Figure 1).

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

	Dry Matter (mean of 3 plant populations)			
N Applied	**Stalk**	**Cob husk**	**Grain**	**Total**
(kg/ha)	**t/ha**	**t/ha**	**t/ha**	**t/ha**
230	13.3 -	1.81 -	13.48 b	28.58 -
320	14.83 -	2.08 -	15.23 ab	32.13 -
410	15.16 -	2.16 -	16.31 a	33.63 -
Mean	14.43	2.01	15.00	31.45
LSD	NS	NS	2.08	NS
P Val	0.323	0.079	0.041	0.110

Note: Yield components were taken from quadrat cuts and suggest different results to machine harvest yields recorded in Table 1.

Although not significant, a trend can be seen where higher populations are more responsive to increasing nitrogen rates in terms of dry matter production (Figure 1).

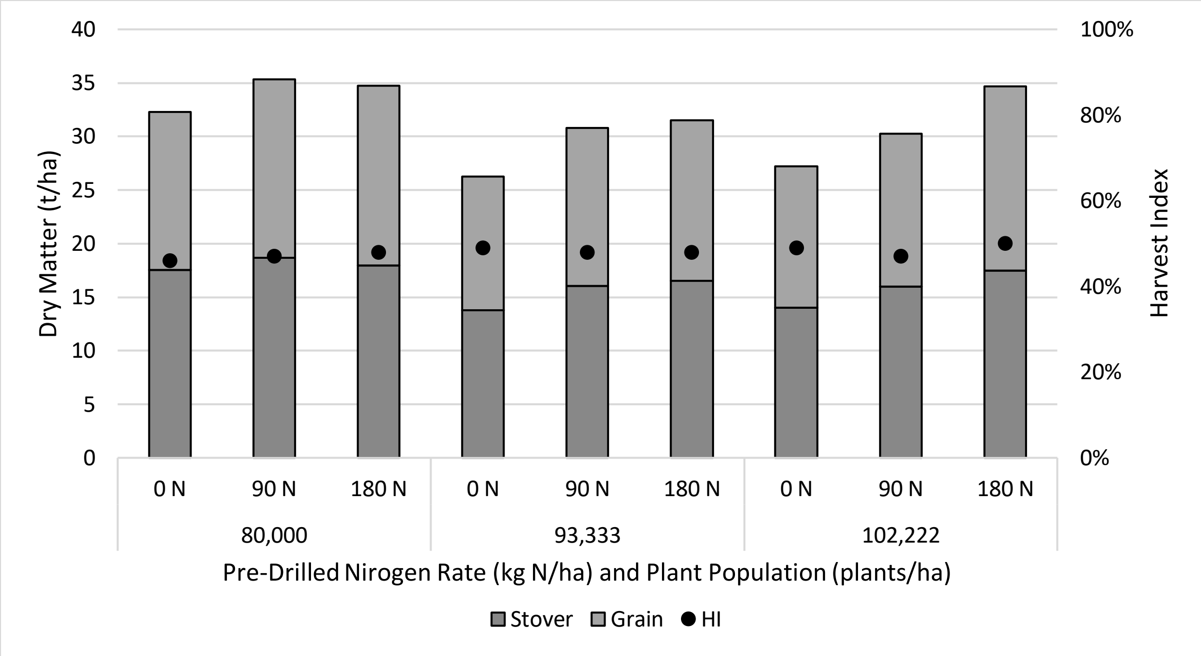


Figure 1. Harvest dry matter components (t/ha) and harvest index (%) at each population (plants/ha) and varying pre-drilled nitrogen rate (kg/ha). *Further 230kg N applied as fertigation throughout growing season was additional to pre dill totals in the graph.*

N uptake in the canopy at harvest indicated a range of 350 – 450kg N/ha in the crop with an average of 68% of the N in the grain at harvest (Figure 2) and a trend that follows the DM trend with higher plant populations having increased content irrespective of plant population.

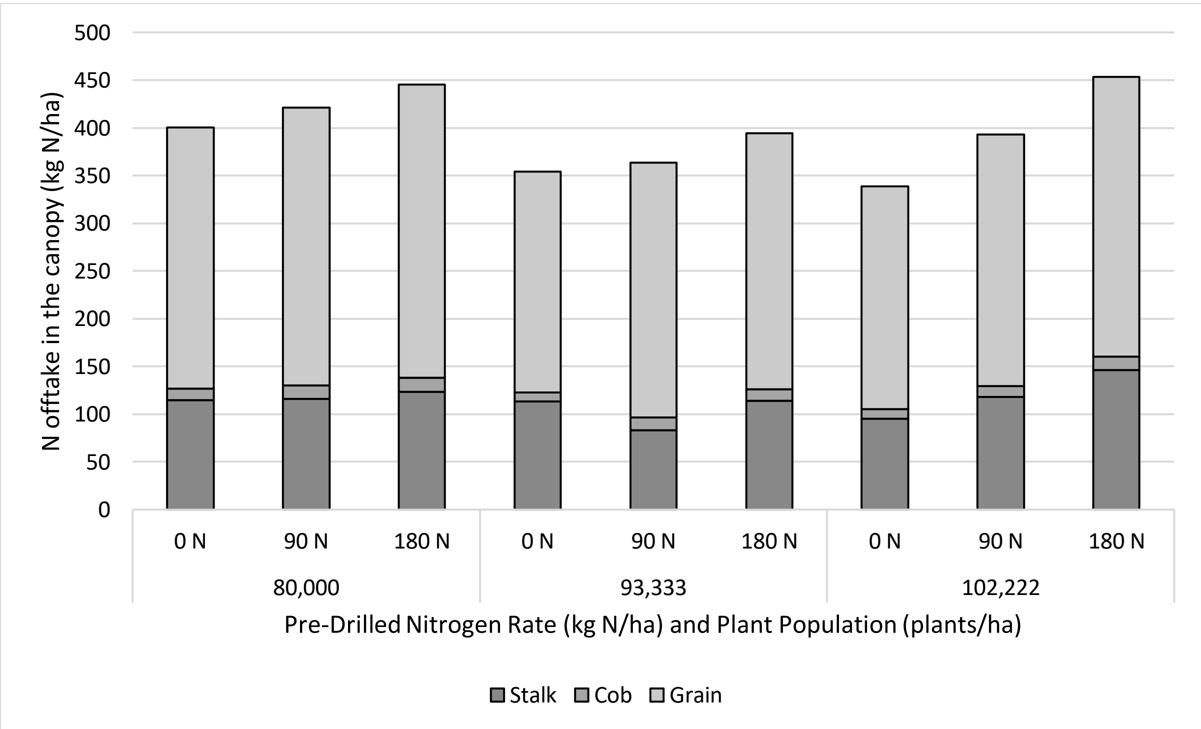


Figure 2. Nitrogen removal (kg N/ha) in each harvest component; stalk, cob, and grain at each population (plants/ha) and varying pre-drilled nitrogen rate (kg/ha). *Further 230kg N applied as fertigation throughout growing season was additional to pre dill totals in the graph.*

The additional cost of N ($1.74kg/N) and seed required for 17t/ha in this trial exceeded the value of 0.7t/ha grain maize valued at $210/ha, hence lowest N rate and seedrate were the most cost effective (Figure 3).

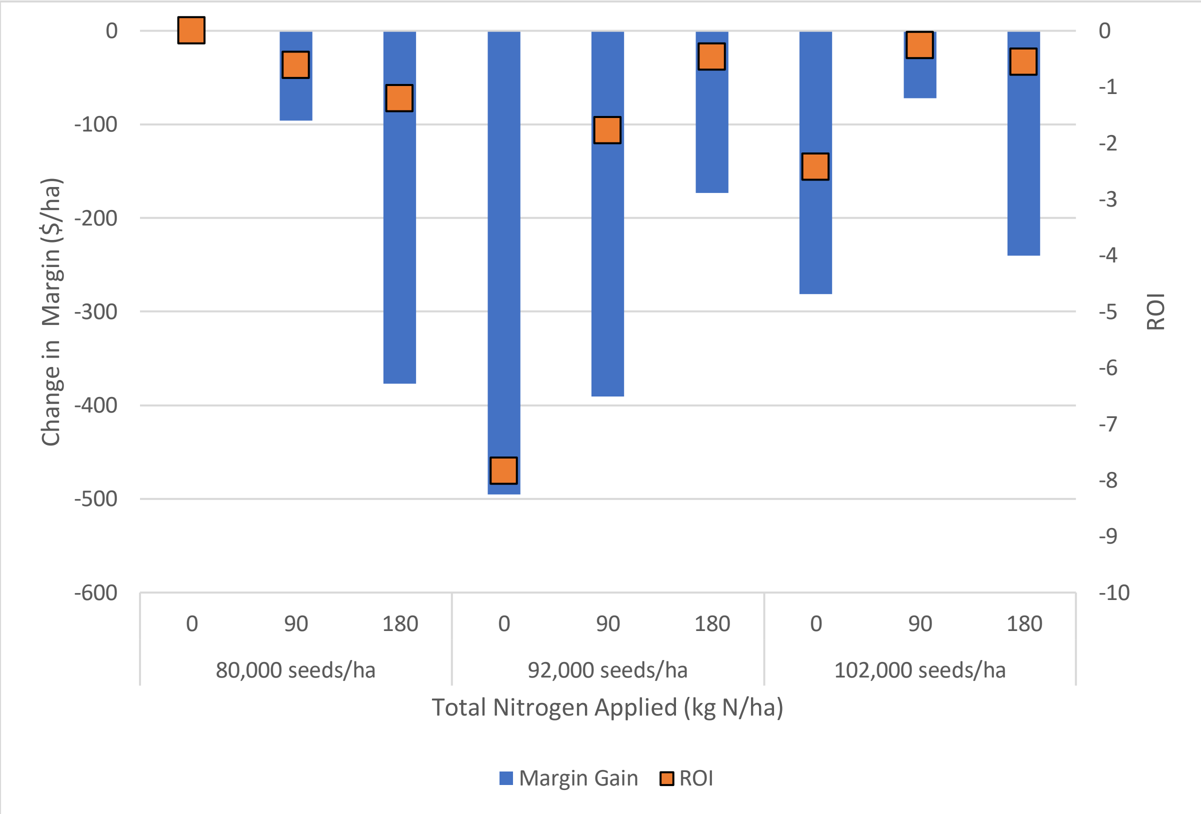


Figure 3. Influence of Pre-drill nitrogen rate on margin over input cost compared to treatment 1 – 80,000 seeds/ha with zero pre drill N and 230kg N/ha applied as fertigation ($/ha – value of increased grain production minus cost of inputs) and return on investment (ROI). Yield differences to N rates applied were not significant. Input costs based on price of $1.74/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

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.

Kerrang, Victoria

Sown: 3 November 2020
Harvested: 20 May 2021
Soil Type: Neutral self-mulching grey clay
Previous crop: Grass dominant pasture (3 years)
Hybrid: Pioneer Hybrid P1756
FAR code: ICC M20-03-2
Irrigation Type: Border check irrigation

Key Messages:

- *Grain yield was significantly higher in the narrower row spacing (500mm) at both high and low plant populations (nominally 85,000 v 106,000 plants/ha) (Caution different harvest methods were engaged for logistical reasons – see note below).*
- *Overall grain yield average in the trial was 16.53 t/ha.*
- *Total crop biomass (dry matter) at maturity was similar across all treatments suggesting narrower row spacing combined with lower plant population significantly improved harvest index and therefore grain yield.*
- *Of the three components (row spacing, plant population and N rate), N rate (either 300 or 450kg N/ha) had minimal influence on the yield and biomass results, since the lower rate of 300 kg N/ha met the N requirement of yield (already established 240N optimum N rate-see Trial 2).*
- *Row spacing and plant population did interact in the analysis of the trial data, making the assessment of the contribution of these factors difficult.*
- *Nitrogen use efficiency (NUE) was greatest with narrow rows, low population and 300N at 16.15kg N applied for each tonne of grain produced and 25.57kg N/t if 188kg N/ha soil supply was added to fertiliser applied (see Trial 2)*

Table 1. Grain yield (t/ha @ 14% moisture) and harvest dry matter in response to row width (mm), plant population (plants/m^2) and N rate (kg N/ha)

Row Spacing (mm)	Plant pop/ha	Applied N kg ha		Yield t/ha		Dry Matter t/ha
500	**85,625**	**150**	**150**	18.57	a	30.25
500	**85,000**	**225**	**225**	18.79	a	35.59
500	**105,000**	**150**	**150**	16.05	bc	33.46
500	**106,250**	**225**	**225**	17.31	ab	32.28
750	**84,333**	**150**	**150**	15.52	c	35.03
750	**83,458**	**225**	**225**	14.87	c	33.35
750	**105,667**	**150**	**150**	15.96	bc	32.38
750	**107,083**	**225**	**225**	15.15	c	32.84
LSD (p=0.05)				1.72		ns
P Val				<0.001		0.111
Cv				7.1		7.2

Yield figures followed by different letters are considered to be statistically different (p=0.05)
Caution: Yields for narrow row trials were hand harvested from plots based on 4m x 2 row quadrats, whilst wide rows were machine harvested.

Analysis of the results are complex because the treatments are presented as a single entity in Table 1, each treatment is made up of three components – plant population, row spacing and N rate. The 2-way ANOVA using the row spacing and population as the factors is presented in Table 2. Treatment means only are presented due to the significant interaction between the two factors.
There was a significant interaction (p=0.009) between row spacing and population where the highest yields were achieved with the lower population at the narrower row spacing at either N application rate, and with the high population at the narrow row spacing at the high N rate.
When the results were analysed using N as the treatment, means for both rates (300 v 450N applied) were identical (16.53 t/ha) and not significant (p=0.993). This result is supported by the results of the other NUE trials on the site which saw no yield response to N rates exceeding 240 kg N/ha.

Table 2: Grain yield (t/ha) in response to row width and population^

Row Spacing	Low Population		High Population
500mm	18.68		16.68
750mm	15.20		15.56
LSD Row spacing p = 0.05	---	P val	<0.001
LSD Plant population p=0.05	---	P val	0.058
LSD row spacing x Pl pop P=0.05		P val	0.009

^ For the point of the analysis, the plant populations of approximately 85,000 plants/ha is described as 'low' and the population of approximately 106,000 plants/ha is described as 'high'.

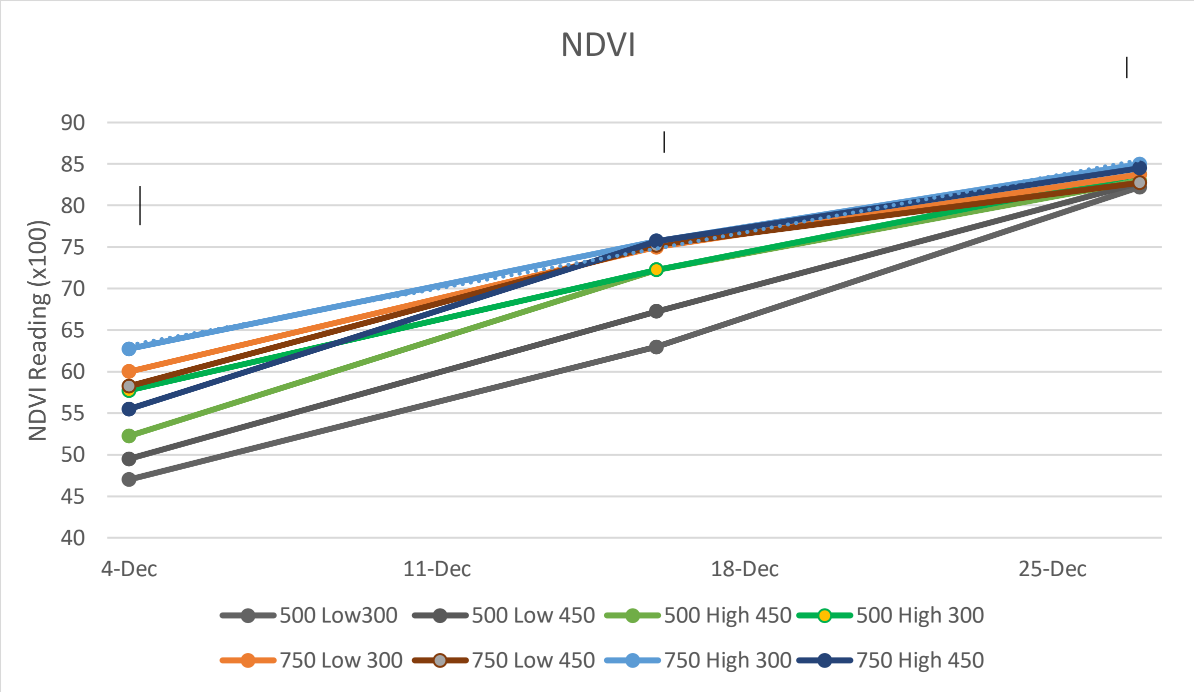
There was a significant interaction between plant population and row spacing on the harvest index. Harvest index was higher at the lower plant populations and highest overall at the low population on narrow (500mm) rows (Table 3).

Table 3: Harvest index % (% harvest dry matter as grain)

Row Spacing	Low Population	High Population
500mm	49.2	41.9
750mm	45.8	40.6
LSD Row spacing p = 0.05	P val	0.002
LSD Plant population p=0.05	P val	0.081
LSD row spacing x Pl pop P=0.05	P val	0.009

Factor means are presented only as there was significant interaction between row spacings and plant populations.

The canopy NDVI measured on 4 December showed lower NDVI scores for the 500mm row spaced low population treatments (Figure 1). These treatment readings were still statistically lower at 27 December, although the numerical difference was only less than 2 by that development stage, compared to a difference of 13 when measured on 4 Dec.



Treatment labels: Row Spacing (500 or 750mm) Population (low or high) and N Rate (300 or 450 kg N/ha applied)

Figure 1: Canopy development 4 – 27 Dec as measured by NDVI (Greenseeker – scale x100)

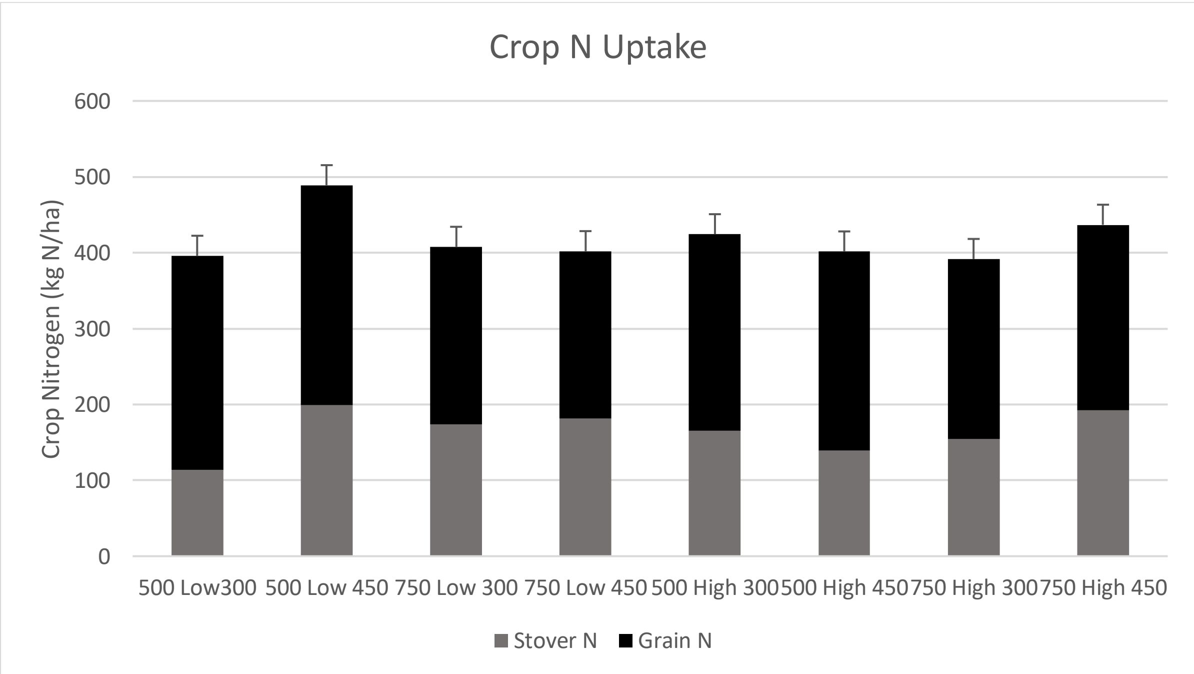


Figure 2. Total crop N (kg N/ha) offtake at harvest in the stover (stalks, leaves, husk) and grain.

Total N Uptake p = <0.001 lsd = 26.53 cv% = 7.1

Bars represent the lsd value of the Total N (stover + grain) crop uptake

Treatment labels: Row Spacing (500 or 750mm) Population (low or high) and N Rate (300 or 450 kg N/ha applied)

Nitrogen offtake in the canopy at harvest did vary between treatments (Figure 2) with maximum N uptake of 488 kg N/ha associated with 500mm row spacing, high population and 450kg N /ha applied, but the yield of this treatment was no different to the 500mm row spacing, low population and 300kg

N /ha which had a final canopy N uptake of 400kg N/ha with evidence that more N went into the stover with 450kg N/ha rather than grain.

This trial suggests that narrow row spacing combined with lower plant population significantly increases grain yield by improving harvest index. In 2019/20 this same configuration of low plant population and narrow row spacing increased harvest dry matter harvest but not yield.

Trial 7. Fungicide 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 grown on grain maize stubbles

Peechelba East, Victoria

Sown: 4 November 2020
Harvested: 6 May 2021
Soil Type: Red loam over clay
Previous crop: Grain Maize

Hybrid: Pioneer Hybrid 1756
FAR code: FAR IRR M20-04-1
Irrigation Type: Overhead pivot

Key Messages:

- *There were no significant yield effects of fungicide application at either V9 (9 leaf) or VT (Tasselling) development stages.*
- *Low levels of disease were observed in the trial but there was little evidence to suggest that fungicides improved green leaf retention when assessed at R4.*
- *Late infection of Common rust (Puccinia sorghi) was detected in upper canopy*

Table 1. Influence of four fungicide products applied at one of two timings on grain yield (t/ha)

Treatment*	Fungicide Application Timing			
	V9 (6 Jan)		VT (Jan 22)	
	Yield t/ha		Yield t/ha	
Untreated	17.86	-	16.49	-
DMI – Prothioconazole (Proline) (100g/ha)	16.68	-	17.94	-
DMI – Propiconazole (Tilt) (125g/ha)	17.42	-	17.09	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	18.41	-	17.79	-
DMI/QoI – Prothioconazole + Pyraclostrobin	17.33	-	16.87	-
Mean	**17.54**	**a**	**17.24**	**b**
LSD Fungicide p= 0.05	ns		P val	**0.532**
LSD Application Timing p=0.05	0.25		P val	**0.031**
LSD Fung. x Timing. P=0.05	ns		P val	**0.363**

Yield Figures followed by different letters are considered to be statistically different (p=0.05)
Yields taken from hand harvest quadrats as opposed to machine harvest based 2x 2m row opposite one another.
** The use of fungicides in this trial does not constitute a recommendation and have been used for experimental purposes only.*

Disease and Green Leaf Retention

Little disease was recorded in the trial other than a late infection of common rust. There were few significant differences recorded in green leaf retention as a result of fungicide application. The use of both DMI triazoles and QoI strobilurins was ineffective at increasing green leaf retention preventing blackened stems or improving test weight or thousand seed weight (Table 2 – 3).

Table 2. Green Leaf Retention (% GLR) assessed on 30 March 2021 at R4 and number of blackened stems assessed on 27 April at R6.

	R4				R6	
	Green Leaf Retention				Black Stems	
	Ear		Ear-1			
Treatment mL/ha	**% GLR**		**% GLR**		**no. per plot**	
Timing - V9						
Untreated	94.8	-	80.8	-	3.3	-
DMI – Prothioconazole (Proline) (100g/ha)	94.9	-	79.0	-	2.3	-
DMI – Propiconazole (Tilt) (125g/ha)	95.3	-	80.8	-	3.3	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	94.5	-	81.9	-	3.3	-
DMI/QoI – Prothioconazole + Pyraclostrobin	94.8	-	81.5	-	3.8	-
Timing – V14						
Untreated	95.5	-	82.2	-	2.8	-
DMI – Prothioconazole (Proline) (100g/ha)	91.3	-	64.0*	-	1.8	-
DMI – Propiconazole (Tilt) (125g/ha)	93.3	-	78.4	-	3.0	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	94.8	-	84.1	-	2.5	-
DMI/QoI – Prothioconazole + Pyraclostrobin	93.1	-	82.4	-	3.0	-
Mean	**94.2**		**79.5**		**2.9**	
LSD (Fung x Timing)	NS		NS		NS	
P Val (Fung x Timing)	0.561		0.296		0.995	

** Very variable readings from replicates*

Table 3. Grain Quality analysis for test weight (kg/hL) and thousand seed weight (TSW) (g) of harvest sample.

	Test Weight		TSW	
Treatment mL/ha	**kg/hL**		**g**	
Timing - V9				
Untreated	78.6	-	340.3	-
DMI – Prothioconazole (Proline) (100g/ha)	79.0	-	344.9	-
DMI – Propiconazole (Tilt) (125g/ha)	78.8	-	347.9	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	78.9	-	344.6	-
DMI/QoI – Prothioconazole + Pyraclostrobin	78.8	-	342.8	-
Timing – V14				
Untreated	78.9	-	346.0	-
DMI – Prothioconazole (Proline) (100g/ha)	79.4	-	339.9	-
DMI – Propiconazole (Tilt) (125g/ha)	79.6	-	345.1	-
QoI – Pyraclostrobin (Cabrio) (200g/ha)	79.4	-	355.0	-
DMI/QoI – Prothioconazole + Pyraclostrobin	79.4	-	356.1	-
Mean	**79.1**		**346.3**	
LSD (Fung x Timing)	NS		NS	
P Val (Fung x Timing)	**0.992**		**0.142**	

Trial 8. Fungicide Products, rates and timing interaction trial

Kerrang, Victoria

Sown: 3 November 2020
Harvested: 20 May 2021
Soil Type: Neutral self-mulching grey clay
Previous crop: Grass dominant pasture (3 years)

Hybrid: Pioneer Hybrid P1756
FAR code: ICC M20-04-2
Irrigation Type: Border check irrigation

Key Messages:

- *Application of different DMI (triazoles) and QoI (strobilurins) fungicides at either 8 leaf (V8) or tasselling (VT) resulted in no yield response over the untreated crop.*
- *There was no observed effects of a fungicide application on green leaf retention post application.*

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

Treatment (g/ha active ingredient)	**Timing**		
Fungicide	**V8 Application**		**VT Application**
Nil (Control)		15.73	
DMI – Prothioconazole (Proline) (100g/ha)	16.14		15.93
DMI – Propiconazole (Tilt) (125g/ha)	15.90		15.95
QoI – Pyraclostrobin (Cabrio) (200g/ha)	15.96		15.16
DMI/QoI – Prothioconazole + Pyraclostrobin	16.06		16.25
LSD Timing p=0.05	**ns**	**P val**	*0.611*
LSD Fungicide p=0.05	ns	**P val**	0.736
LSD Timing x Fungicide P=0.05	ns	**P val**	0.851
CV	6		

Yield figures followed by different letters are considered to be statistically different (p=0.05)

There was no statistically significant yield response as a result of fungicide product or timing of application.

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.

Green leaf retention was assessed at 40, 60 and 75 days after tasselling (VT). To assess the greenness of the plants, the following scoring system was used:

Table 2: Green leaf assessment scoring (1 -10 scale).

Score	Plant description/appearance
10	All green
9	Yellowing lowest leaves
8	Yellow lower leaves
7	Green leaves below cob
6	Partial green leaves to cob

5	Partial green leaves above cob
4	Little green remaining, stem green below cob
3	Leaves dry, stems green to cob
2	Leaves dry, stems green above cob
1	Dry

Table 3a. Influence of fungicide product and timing on leaf greenness, 40 days after tasselling (VT).

Treatment (g/ha active ingredient)		**Timing**	
Fungicide	V8 Application		VT Application
Nil (Control)		9.75	
DMI – Prothioconazole (Proline) (100g/ha)	9.75		9.75
DMI – Propiconazole (Tilt) (125g/ha)	9.75		10.0
QoI – Pyraclostrobin (Cabrio) (200g/ha)	9.75		10.0
DMI/QoI – Prothioconazole + Pyraclostrobin	9.75		9.75
LSD Timing p=0.05	ns	P val	0.486
LSD Fungicide p=0.05	ns	**P val**	0.943
LSD Timing x Fungicide P=0.05	ns	**P val**	0.943
CV	4.6		

Table 3b. Influence of fungicide product and timing on leaf greenness, 60 days after tasselling (VT).

Treatment (g/ha active ingredient)		**Timing**	
Fungicide	V8 Application		VT Application
Nil (Control)		8.00	
DMI – Prothioconazole (Proline) (100g/ha)	7.00		7.50
DMI – Propiconazole (Tilt) (125g/ha)	7.75		8.00
QoI – Pyraclostrobin (Cabrio) (200g/ha)	7.00		7.00
DMI/QoI – Prothioconazole + Pyraclostrobin	7.25		7.00
LSD Timing p=0.05	**ns**	P val	**0.713**
LSD Fungicide p=0.05	ns	**P val**	0.086
LSD Timing x Fungicide P=0.05	ns	**P val**	0.923
CV	11.4		

Table 3c. Influence of fungicide product and timing on leaf greenness, 75 days after tasselling (VT).

Treatment (g/ha active ingredient)		**Timing**	
Fungicide	V8 Application		VT Application
Nil (Control)		3.25	
DMI – Prothioconazole (Proline) (100g/ha)	3.00		2.75
DMI – Propiconazole (Tilt) (125g/ha)	3.00		3.00
QoI – Pyraclostrobin (Cabrio) (200g/ha)	3.75		2.50
DMI/QoI – Prothioconazole + Pyraclostrobin	2.75		3.50
LSD Timing p=0.05	**ns**	P val	**0.501**

LSD Fungicide p=0.05	ns	**P val**	0.852
LSD Timing x Fungicide P=0.05	ns	**P val**	0.103
CV	22.6		

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

Trial 9. Foliar Nutrition Trial

Protocol Objective:

The trial had two similar but related objectives.

- To evaluate the influence of macro and micronutrient rates and timings on dry matter production, grain yield and harvest index in grain maize.
- To evaluate the fluctuations in macro and micronutrient tissue levels that occur both naturally in grain maize and in response to alternative strategies for nutrition.

Peechelba East, Victoria

Sown: 4 November 2020
Harvested: 6 May 2021
Soil Type: Red loam over clay
Previous crop: Grain Maize
Hybrid: Pioneer Hybrid 1756
FAR code: FAR IRR M20-07-1
Irrigation Type: Overhead pivot

Key Messages:

- *With an average grain yield of 16.51t/ha there were no significant differences in header grain yield from varying nitrogen rate or applying liquid potassium products.*
- *Applying Calcium Nitrate Ca $(NO_3)_2$ caused a decrease in yield when it was combined with an additional application of pre drill 90 kg/ha of nitrogen.*
- *There was evidence that additional nutrients significantly interacted (p=0.044) with the overall level of N fertiliser applied with liquid calcium nitrate giving greater benefits with 230N (applied as fertigation than when N was application was increased to 320kg N/ha (predrill urea = fertigation).*

In addition to the nutrition strategies of the host farmer the following nutrients were experimented on using either solid potassium chloride (160kg/ha, 80kg K/ha) and liquid applications of calcium nitrate 13% N and 18.5% Ca (2 x 200l/ha) and Natures K (0.6%N 1.8%P 10.0%K 2.6%S). Liquid fertilisers were applied as a liquid stream at the base of the plant (replicating a Y shaped irrigator dropper).

Treatment List

Table 1. Nutrients applied with different alternative nutrition strategies. The rate of nitrogen includes pre plant N (0 and 90 kg N/ha) and fertigation N (230 kg/ha)*

N Rate	Additional	Rate	Nutrients applied (kg/ha)				
(kg/ha)	Nutrition	(kg or L/ha)	N	P	K	S	Ca
0	Nil	-	230	-	-	-	-
0	KCl	160 kg	230	-	80	-	-
0	CaNO3	400 l	282	-	-	-	74
0	Natures K	600 l	235	11	60	16	-
90	Nil	-	320	-	-	-	-
90	KCl	160 kg	320	-	80	-	-
90	CaNO3	400 l	372	-	-	-	74
90	Natures K	600 l	325	11	60	16	-

** Post sowing nitrogen*

Table 2. Grain yield (t/ha @ 14% moisture) of solid urea application rates (0 & 90) with four different alternative nutrition products.

			Pre drill Urea N Application Rate (total N			
Prilled Urea N			**0kg/ha N**		**90kg/ha N**	
			(230)		**(320)**	
Product	**Rate**	**Timing**	**Yield t/ha**		**Yield t/ha**	
Nil	-	-	16.95 a		16.92 a	
KCl	160 kg/ha	Pre-em	15.93 ab		17.26 a	
$Ca(NO_3)_2$	2 x 200 l/ha	V5, V7	16.82 a		14.81 b	
Natures K	3 x 200 l/ha	V5, V7 & V9	16.25 ab		17.10 a	
Mean			16.49		16.52	
LSD N Application Rate p = 0.05			NS	**P val**		0.901
LSD Alternative Nutrition p=0.05			NS	**P val**		0.267
LSD N Rate x Alt. Nutrition P=0.05			1.70	**P val**		0.044

** Post sowing nitrogen (230 N) was applied via fertigation with applications on V3 (46N), V7 (69N), pre-tasselling (115N) on 20 Nov, 20 Dec and Jan 15*

Available soil N assessed prior to sowing 49 kg N/ha (0-30cm), 62 kg N/ha (30-60cm)

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

Grain Yield

With an average grain yield of 16.51t/ha the only significant difference (Table 2) observed was when calcium nitrate ($CaNO_3$) was applied together with the high rate of nitrogen (320 kg N/ha). This resulted in a reduction in yield compared to other treatments. There was evidence that additional nutrients significantly interacted (p=0.044) with the overall level of N fertiliser applied with liquid calcium nitrate giving greater benefits with 230N (applied as fertigation) than when N was application was increased to 320kg N/ha (pre drill urea = fertigation).

Dry Matter and nitrogen content of plant components at harvest

There was evidence that treatments did have an effect on stover dry matter production (p=0.05) when assessed at harvest, however there was no evidence that grain dry matter (yield) was increased (p=0.11).

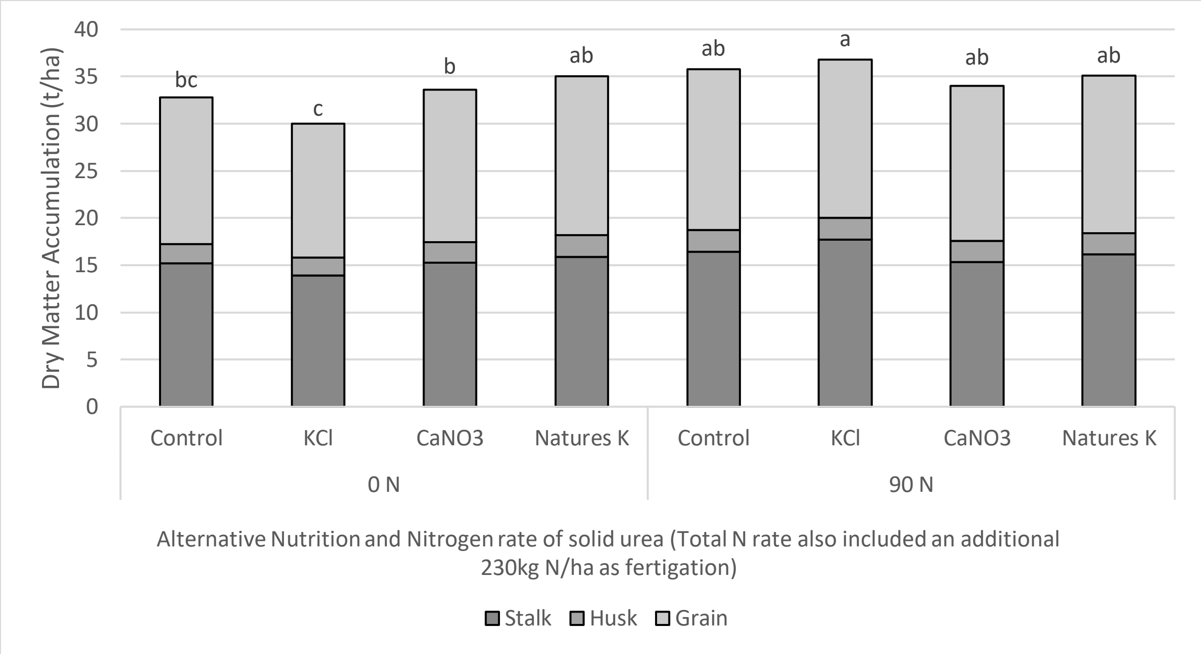


Figure 1. Dry Matter accumulation at harvest in the stalk (p=0.05), husk (p=0.11) and grain (p=0.11), total DM (p=0.018) when varying the nutrition and nitrogen rate. *Note that grain dry matter (yield) is based on quadrat scores and so maybe different to machine headed yields taken from the whole plot area.*

Bars with different letters are regarded as significantly different for total N offtake in the canopy at harvest.

Additional post sowing nitrogen (230 N) was applied via fertigation with applications on V3 (46N), V7 (69N), pre-tasselling (115N) on 20 Nov, 20 Dec and Jan 15

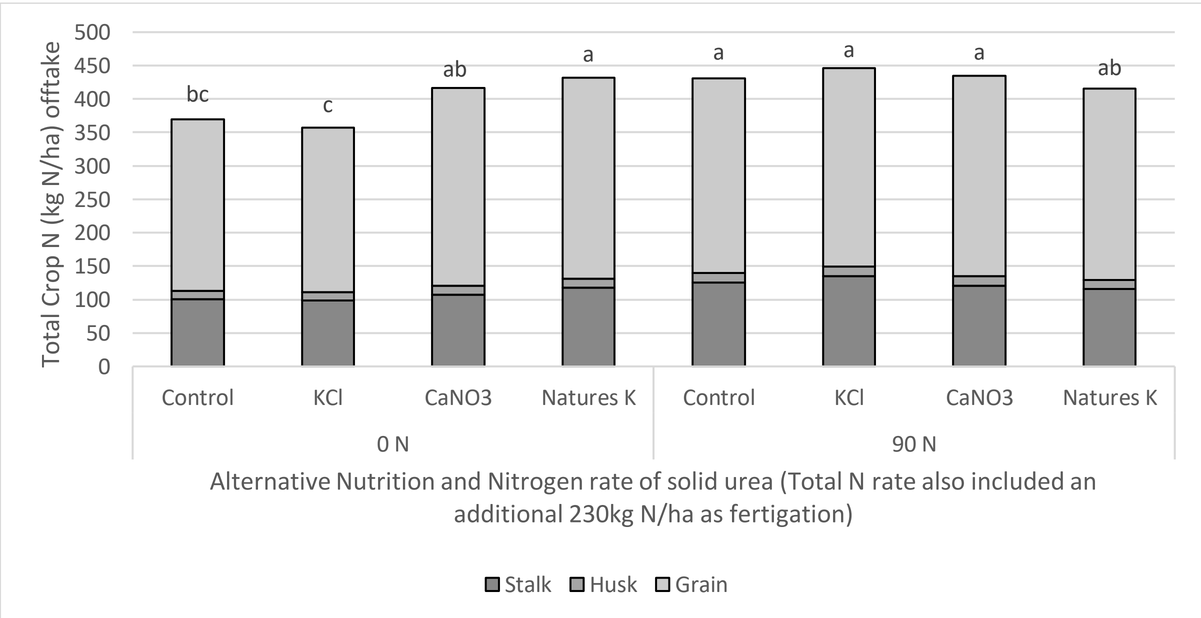


Figure 2. Nitrogen content in the stalk (p=0.185), husk (p=0.590) and grain (p=0.110) at harvest when varying the first nitrogen application timing, total N offtake (p=0.046). *Bars with different letters are regarded as significantly different for total N offtake in the canopy at harvest.*

The trial was sampled at V5, V9 and VT development stages to assess the impact of development stage on tissue levels of key nutrients within the crop. The newest two fully unfolded leaves were combined and sampled at each assessment timing for tissue levels in the tables presented below. Green is regarded as adequate, yellow is high and red is low (source: Agvita laboratory)

Table 3. Tissue test results from the control treatments at the V5 development stage

N Rate	N	P	K	S	Ca	Mg	Zn
(kg/ha)	%	%	%	%	%	%	mg/kg
0	3.87	0.476	3.49	0.288	0.340	0.1955	43.9
90	4.29	0.478	3.18	0.291	0.382	0.1965	58.3

Table 4. Tissue test results from all treatments at the V9 development stage

N Rate		N	P	K	S	Ca	Mg	Zn
(kg/ha)	Product	%	%	%	%	%	%	mg/kg
0	Nil	1.74	0.372	3.39	0.133	0.299	0.225	29.9
0	KCl	2.11	0.394	3.35	0.153	0.318	0.225	31.8
0	CaCO3	2.49	0.438	3.10	0.164	0.349	0.239	37.0
0	Natures K	2.22	0.430	3.11	0.152	0.333	0.231	32.0
90	Nil	2.83	0.469	2.65	0.187	0.325	0.263	38.6
90	KCl	2.19	0.439	3.20	0.181	0.295	0.243	39.7
90	CaCO3	2.76	0.402	2.52	0.184	0.322	0.236	35.7
90	Natures K	2.69	0.410	2.37	0.180	0.376	0.245	36.2

Table 5. Tissue test results from all treatments at the VT (Tasselling) development stage

N Rate		N	P	K	S	Ca	Mg	Zn
(kg/ha)	Product	%	%	%	%	%	%	mg/kg
0	Nil	2.44	0.278	1.41	0.207	0.401	0.171	52.6
0	KCl	2.56	0.279	1.41	0.205	0.415	0.181	54.0
0	CaCO3	2.28	0.268	1.36	0.201	0.424	0.172	50.4
0	Natures K	2.47	0.277	1.45	0.200	0.359	0.168	47.9
90	Nil	2.70	0.285	1.36	0.212	0.431	0.173	57.9
90	KCl	2.52	0.280	1.36	0.218	0.436	0.183	59.8
90	CaCO3	2.77	0.283	1.37	0.221	0.470	0.169	58.4
90	Natures K	2.66	0.278	1.39	0.215	0.423	0.164	56.2

Table 6. Tissue test (%) results from all treatments based on the grain produced

N Rate		N	P	K	S	Ca	Mg	Zn
(kg/ha)	Product	%	%	%	%	%	%	mg/kg
0	Nil	1.58	0.509	0.509	0.115	0.005	0.182	26.2
0	KCl	1.57	0.504	0.493	0.115	0.004	0.186	25.5
0	CaCO3	1.75	0.508	0.501	0.119	0.005	0.192	26.5
0	Natures K	1.66	0.537	0.516	0.115	0.004	0.197	27.1
90	Nil	1.72	0.518	0.507	0.120	0.004	0.195	28.8
90	KCl	1.73	0.555	0.532	0.121	0.005	0.208	30.4
90	CaCO3	1.59	0.481	0.486	0.119	0.004	0.178	26.4
90	Natures K	1.61	0.505	0.491	0.115	0.005	0.181	25.8

Trial 10. Foliar Nutrition Trial

Kerrang, Victoria

Sown: 3 November 2020
Harvested: 20 May 2021
Soil Type: Neutral self-mulching grey clay
Previous crop: Grass dominant pasture (3 years)

Hybrid: Pioneer Hybrid P1756
FAR code: ICC M20-07-2
Irrigation Type: Border check irrigation

Key Messages:

- *Foliar application of a micronutrient mixes failed to provide in any yield improvement over and above the standard nutrition adopted (see appendix).*
- *Tissue testing prior to, and at tasselling, revealed no micro or macro nutrient deficiencies, and no response to the additional nutrient applications.*

Foliar nutrition (based on 3L/ha Spraygro Complete K - NPK 5:10:27 plus trace elements) was applied at different timing in relation to silking, either at silking or 14 days after silking. These foliar nutrition treatments were superimposed two timings of 250kg N/ha, either predrill and V4 (leaf 4) or V4 & V6 (6 leaf).

Table 1. Grain yield (t/ha @ 14% moisture) and test weight (kg/HL) in response to the timing of N application and foliar nutrient application.

Treatment				**Grain Yield, Dry Matter Yield and Quality**		
					Yield	**Test Wt**
	Pre-drill	**4 leaf**	**6 Leaf**	**Foliar Appl'n**	**t/ha**	**kg/hL**
1.	125	125	-	Nil	16.20	84.2
2.	125	125	-	Silking	16.10	83.7
3.	125	125	-	Silk+14	16.23	84.2
4.	0	125	125	Nil	16.52	84.1
5.	0	125	125	Silk	16.66	84.2
6.	0	125	125	Silk +14	16.04	84.2
	LSD Yield	**(p=0.05)**	ns	**P Val**	0.665	cv%
	LSD Test Wt	**(p=0.05)**	ns	**P Val**	0.458	cv%

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

Table 1a: Grain Yield (t/ha @14% moisture)

Nitrogen kg N/ha			**250 kg N/ha Pre-drill + 4 Leaf**		**250 Kg N/ha 4 Leaf + 6 Leaf**
Nil (Control)			16.20		16.52
Foliar Appl'n @ Silking			16.10		16.66
Foliar Appl'n Silking + 14 days			16.23		16.04
LSD N Timing	**p=0.05**	**ns**		P val	**0.529**
LSD Foliar	**p=0.05**	ns		**P val**	0.648
LSD N x Foliar	**P=0.05**	ns		**P val**	0.916
CV		3.7			

There was no statistically significant yield response as a result of the different N timing controls or foliar nutrient application treatments. No treatment had any significant influence on grain test weight.

Table 2a: Summary of the leaf tissue testing (ear leaf), taken at silking, prior to foliar treatment.

Treatment	Total N	P	K	S	Ca	Mg	Fe	Mn	Cu	Zn	B	Mo
	%	%	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Pre-drill + 4 Leaf	2.85	0.27	2.1	0.24	0.52	0.34	104	86	14	33	59	0.18
4 Leaf + 6 Leaf	2.80	0.27	2.1	0.23	0.52	0.33	60	77	12	24	54	0.15
Critical	2.5	0.2	1.6	0.13	0.1	0.08	20	15	2	15	2	0.10
Satisfactory	2.7-3.25	0.22-0.30	2.5-3.5	0.15-0.22	0.12-0.30	0.12-0.25	50-200	20-150	3-10	18-25	3-10	0.20

Table 2b: Summary of the leaf tissue testing (ear leaf), taken at 14 days after silking, post foliar nutrition treatments.

Treatment	Total N	P	K	S	Ca	Mg	Fe	Mn	Cu	Zn	B	Mo
Untreated Control	%	%	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Pre-drill + 4 Leaf (Control)	2.55	0.26	1.80	0.20	0.51	0.34	120.0	83.5	11.0	23.5	44.5	0.25
4 Leaf + 6 Leaf (Control)	2.60	0.27	1.80	0.21	0.53	0.35	140.0	86.5	11.0	26.0	40.5	0.26
Foliar Appl'n 14 days prior												
Pre-drill + 4 Leaf	2.55	0.28	1.85	0.21	0.58	0.38	145.0	96.0	12.0	25.5	47.5	0.29
4 Leaf + 6 Leaf	2.55	0.27	1.80	0.20	0.54	0.35	140.0	86.5	11.5	35.0	38.0	0.28
Critical	2.5	0.2	1.6	0.13	0.21	0.08	20	15	2	15	2	0.10
Satisfactory	2.7-3.25	0.22-0.30	2.5-3.5	0.15-0.22	0.12-0.30	0.12-0.25	50-200	20-150	3-10	18-25	3-10	0.20

Apart from Total N taken 14 days post silking, all nutrients tested were at satisfactory levels in the samples analysed.

The leaf tissue samples taken from plants 14 days after application (the treatment labelled 'Foliar Application 14 days prior') in Table 2b did show a trend to higher levels of the various trace elements, but as the levels were already satisfactory, there was no influence on grain yield.

Rotation Position observations

Peechelba East, Victoria

Sown: 4 November 2020
Harvested: 5 May 2021
Soil Type: Red loam over clay
Previous summer crop: Maize
Hybrid: Pioneer Hybrid 1756
FAR code: 2020 Irrigated Maize Research Site
Irrigation Type: Overhead pivot
Winter Management: Fallow

Key Points:

- The following observations were made on the same farm using similar management, but it was not possible to conclude exactly what factors were responsible for the differences observed (since this has not been statistically compared).
- Grain maize following a terminated faba bean crop planted into the previous maize residues generated higher dry matter offtakes and grain yields than leaving the land fallow over winter and spring.
- Grain maize yielded 21.13 t/ha (14% moisture) following the terminated faba beans and 19.29t/ha following winter fallow *(recorded from hand harvested quadrats which are typically higher yielding than machine harvested plots).*

Table 1. Summary of previous crop rotations for Pivot 1 (Research site) v Pivot 2

Year	Grain Maize following maize (no cover) Pivot 1	Grain Maize following faba bean cover crop Pivot 2
2018	Barley	Barley
2018	Maize Silage	Maize Silage
2019	Oats (hay)	Oats (hay)
2019	Maize Grain	Maize Grain
2020	Winter/early spring fallow (Research site)	Faba beans (terminated in October)
2020	Maize Grain (sown 5 November)	Maize Grain (sown 5 November)

Pivot 2 was sown following a winter cover crop of faba beans sown into grain maize residues in early June 2020 while the research centre was left as a winter fallow in grain maize residues from the previous crop. The faba beans were terminated in October. N levels were matched from specific treatments at the research site to the level of N applied to Pivot 2 (approximately 135kg N as predrill urea and 230N as fertigation. Both pivots received similar irrigation and fertigation schedules (5.1 mega L & 230N as fertigation.

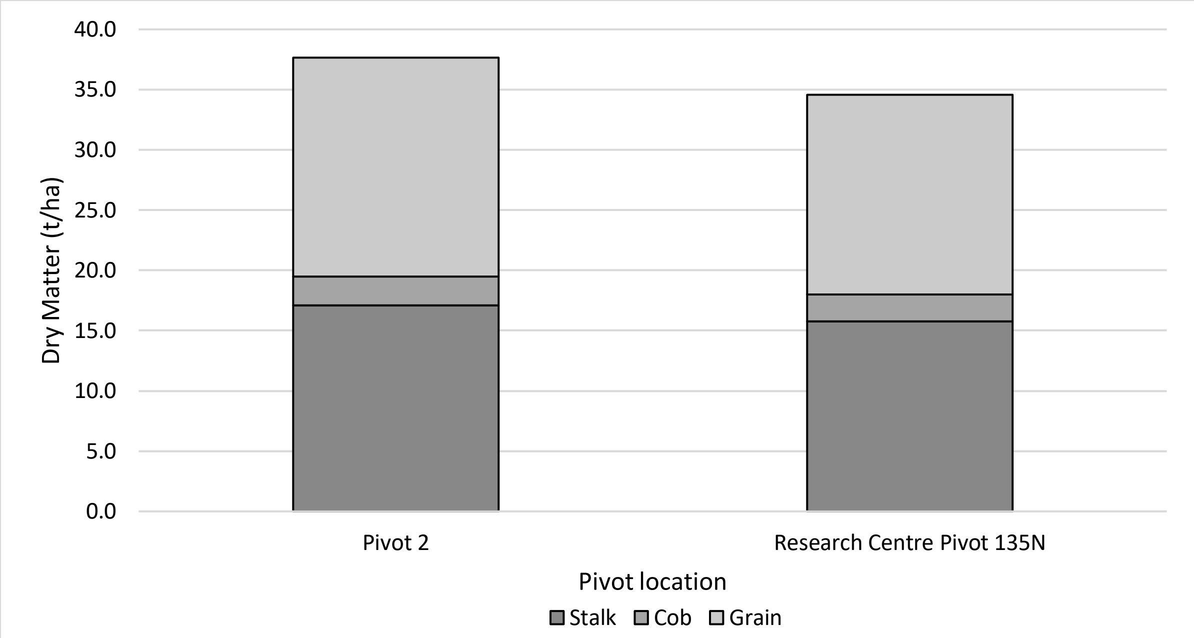


Figure 1. Harvest dry matter components from different paddocks with varying winter crop rotations.

Table 2. Summary of harvest components from the two paddocks with and without winter faba bean cover crop.

Winter	Stalk DM	Cob DM	Grain DM	Harvest Index	Grain Yield (14% moisture) (t/ha)*
Following Faba bean cover	17.11	2.40	18.17	0.48	21.13
Following winter fallow (no cover)	15.79	2.19	16.59	0.48	19.29

* Calculated from 1.5m^2 quadrats (14 plants) cut at harvest time (5 May)

APPENDICES

Meteorological Data

Peechelba East, Victoria

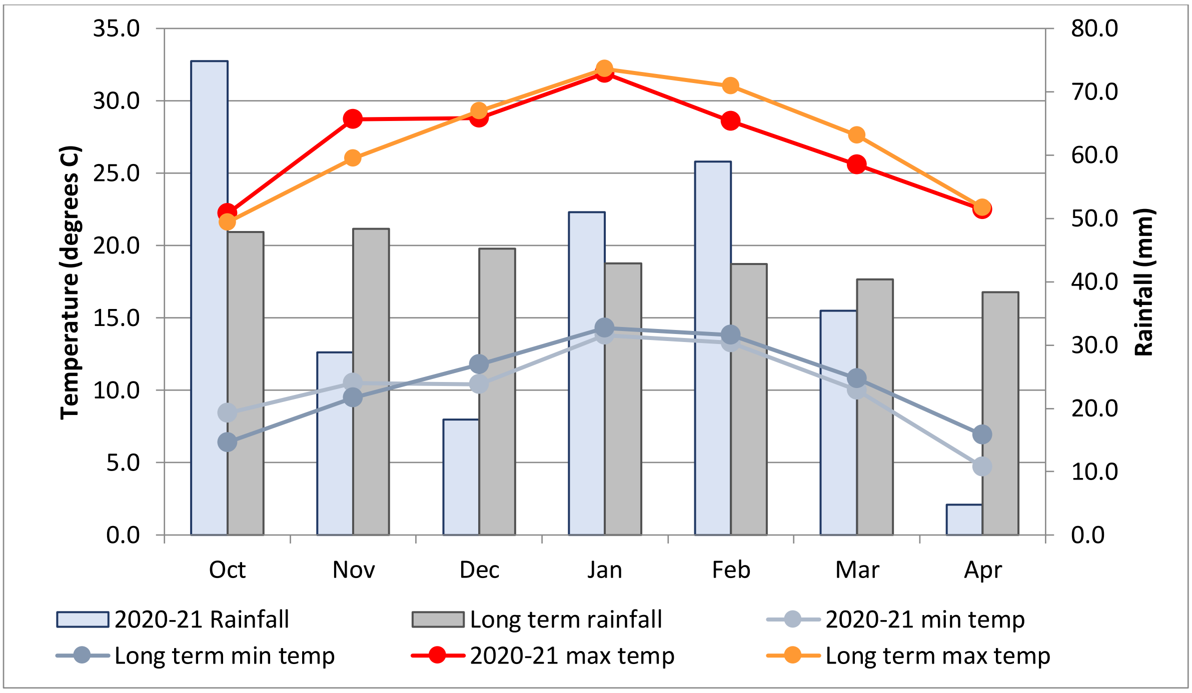


Figure 1. 2020/2021 growing season rainfall and long-term rainfall (1930-2021) (recorded at Peechelba East), 2020/2021 min and max temperatures and long-term min and max temperatures recorded at Wangaratta (1987-2021) for the growing season (October - April).

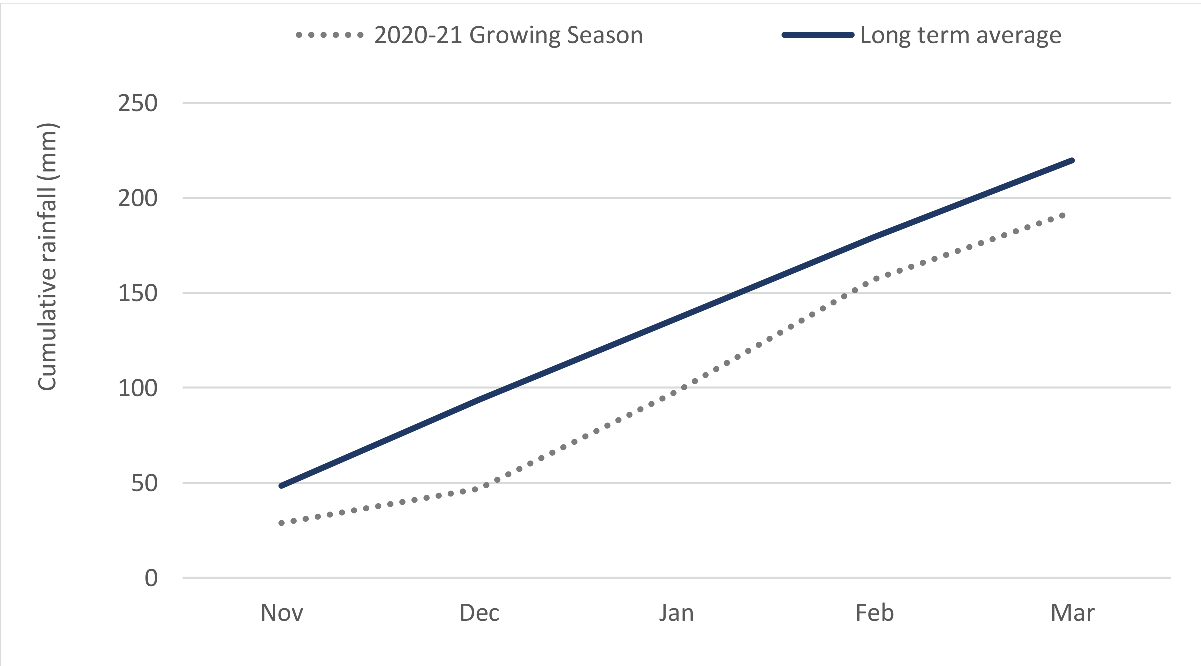


Figure 2. Cumulative growing season rainfall for 2020/21 2020/21 and the long-term average for the growing season (November-March).

Kerang, Victoria

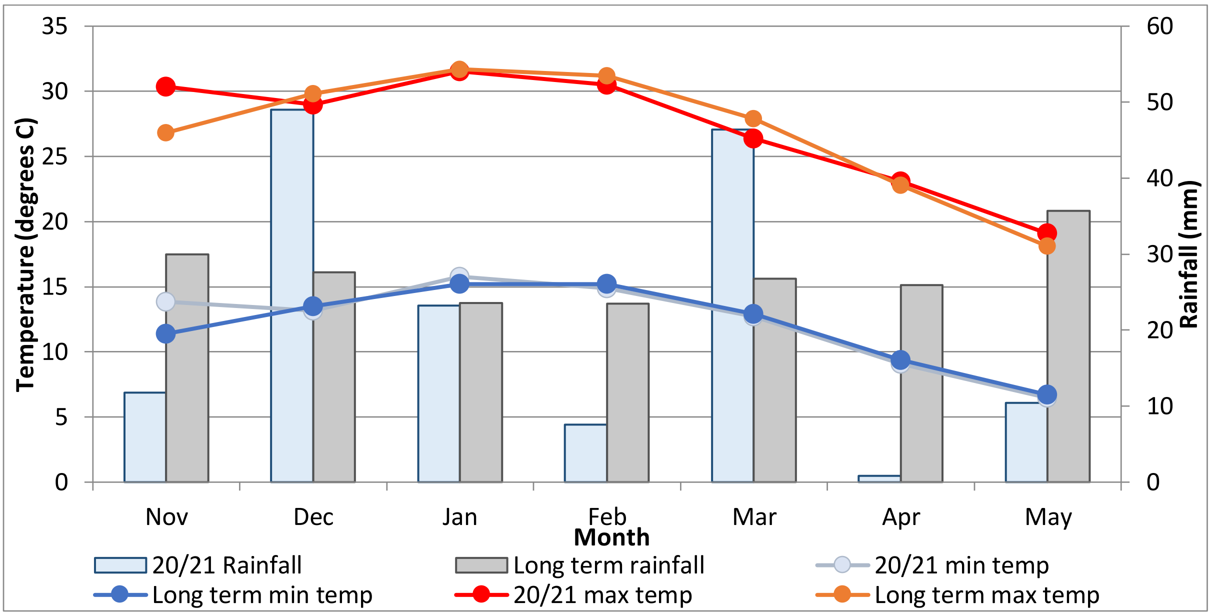


Figure 3. 2020/2021 growing season rainfall and long-term rainfall (1881-2020) (recorded at Kerang, VIC), 2019/2021 min and max temperatures and long-term min and max temperatures recorded at Kerang (1910-2021) for the growing season (November-March).

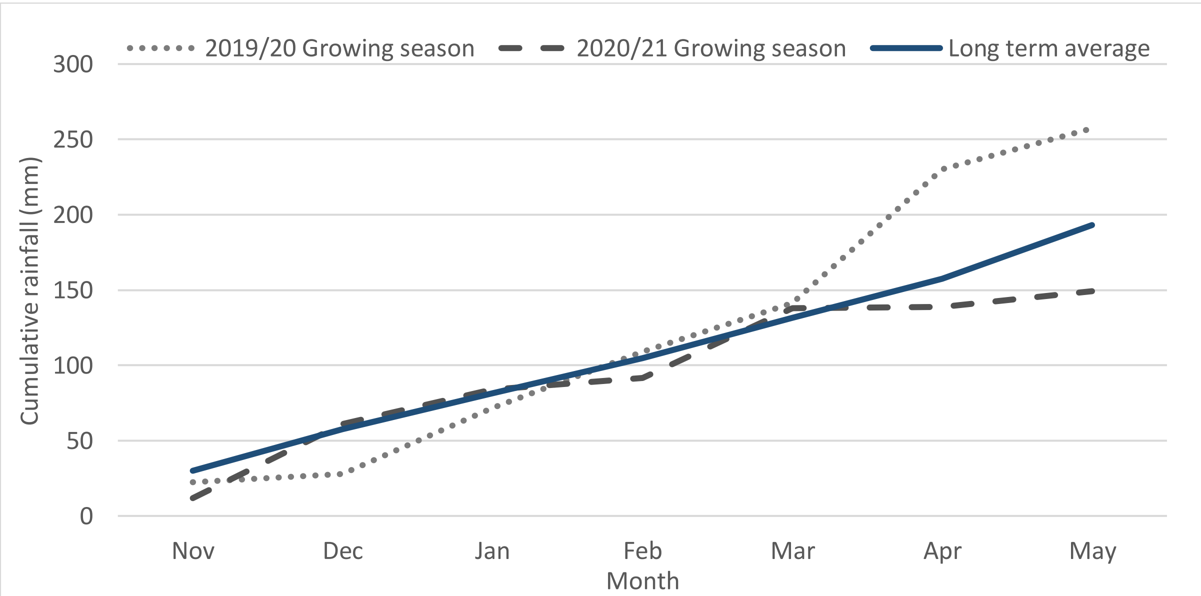


Figure 4. Cumulative growing season rainfall for 2019/2020, 2020/2021 and the long-term average for the growing season (November-March).

Site Details

Peechelba East, Victoria

Paddock and Irrigation records

GPS Location	-36.169247, 146.271604	**Irrigation Type**	Overhead pivot
Sown	4 November 2020	**Frequency and Rate**	Daily 6.35mm
Hybrid	Pioneer 1756	**First Applied**	4-Nov-20
Harvested	5-May-20	**Last Application**	19-Mar-21
Soil Type	Red loam over clay	**Total Water applied**	5.1 ML/ha
Previous Crop	Grain Maize		

Crop Nutrition

Date	Product	Rate	Placement	Crop Stage
31-Oct-20	Urea	300 kg/ha	Spread	Pre Plant
4-Nov-20	DAP	220 Kg/ha	In Furrow	At Plant
4-Nov-20	Worm Juice	10 L/ha	With Seed	Pre Plant
4-Nov-20	Cotton Starter	40 L/ha	With Seed	Pre Plant
20-Nov-20	Urea	100 kg/ha	Fertigation	V4
13-Dec-21	Worm Juice	5 L/ha	Foliar Spray	V7
13-Dec-21	TE8	3 L/ha	Foliar Spray	V7
13-Dec-21	MOP 25	250 ml/ha	Foliar Spray	V7
20-Dec-21	Urea	150 kg/ha	Fertigation	V8
15-Jan-21	Urea	250 kg/ha	Fertigation	V16

Crop Protection

Date	Product	Rate	Placement	Crop Stage
5-Nov-19	Dual Gold	1 L/ha	Foliar Spray	Post sow - Pre Emerg
5-Nov-19	Atrazine	2.5 Kg/ha	Foliar Spray	Post sow - Pre Emerg
5-Nov-19	Lorsban	1 L/ha	Foliar Spray	Post sow - Pre Emerg
3-Nov-20	Glyphosate	2.5 L/ha	Foliar Spray	Post sow - Pre Emerg
9-Jan-21	Altacor	70 g/ha	Foliar Spray	V14
9-Jan-21	Paramite	350 ml/ha	Foliar Spray	V14

Irrigation
3.5 Mega litres was applied between 4/11/20 and 20/1/21. The remaining 1.6 Mega litres was applied after 20/1/21. The water was applied in daily applications of 6.35 mm (1/4”)

Fertigation
All trials received a standard input of nitrogen applied through the irrigation system. Any differences in N levels for this site were achieved with differential amount of prilled solid urea (46%).
Post sowing nitrogen (230 N) was applied via fertigation with applications on V4 (46N), V8 (69N), pre-tasselling (115 N) on 20 Nov, 20 Dec and 15 Jan

Kerang, Victoria

Paddock and Irrigation

GPS Location	-35.706588 143.812190	**Irrigation Type**	Border check
Sown	3-Nov-2020	**Frequency and Rate**	8 days 0.8Ml/ha
Hybrid	Pioneer 1756	**First Applied**	4-Nov-2020
Harvested	20-May-21	**Last Application**	17-March-21
Soil Type	SM grey clay	**Total Water applied**	11.6 ML/ha

Previous Crop	Grass pasture		

Crop Nutrition

Date	Product	Rate	Placement	Crop Stage
26-Oct-20	Superfect	650 kg/ha	Spread	Pre Plant
26-Oct-20	Gypsum	2.0 t/ha	Spread	Pre Plant
3-Nov-20	Urea	325 kg/ha	Pre-drilled	Pre-Plant
27-Dec-20	Urea	325 kg/ha	Spread	V8

Crop Protection

Date	Product	Rate	Placement	Crop Stage
3-Dec-20	Gesaprim	1.2 kg/ha	Foliar Spray	V2

	Date	Mega Litres/ha
Irrigation	4 November	1.6 Ml/ha
	23 November	0.7 Ml/ha
	4 December	0.8 Ml/ha
	16 December	0.8 Ml/ha
	27 December	0.8 Ml/ha
	5 January	0.8 Ml/ha
	12 January	0.8 Ml/ha
	20 January	0.8 Ml/ha
	28 January	0.8 Ml/ha
	8 February	0.7 Ml/ha
	16 February	0.8 Ml/ha
	24 February	0.8 Ml/ha
	5 March	0.7 Ml/ha
	17 March	0.7 Ml/ha
Total Irrigation		**11.6 Ml/ha**

Soil Test Reports – 2021 & 2020

Peechelba East, Victoria (0 – 30cm) – soil tested at sowing 2021 taken 13 October 2020

Nutrient		Result	
pH (water)		**5.80**	
pH (CaCl2)		**4.80**	
Sulphur	MCP	**0.00**	mg/kg
Chloride		**17.00**	mg/kg
Copper	DTPA	**1.10**	mg/kg
Zinc	DTPA	**2.50**	mg/kg
Manganese	DTPA	**54.00**	mg/kg
Iron	DTPA	**42.00**	mg/kg
Phosphorus	Colwell	**82.00**	mg/kg
Available Potassium	Amm-acet	**100.00**	mg/kg
Total Cation Exchange Capacity			
Potassium	Amm-acet	**0.26**	meq/100g

Calcium	Amm-acet	**1.80**	meq/100g
Magnesium	Amm-acet	**0.77**	meq/100g
Sodium	Amm-acet	**0.34**	meq/100g
Aluminium	KCL	**0.17**	meq/100g
CEC		**3.32**	meq/100g
Organic Carbon		**0.68**	%
Sodium % of cations		**10.00**	%
Aluminium saturation		**5.20**	%
EC		**0.08**	dS/m
Ca:Mg Ratio		**2.30**	

Deep Soil N test (2020/21)

Depth	**0-30 cm**	**30-60 cm**	**Total (0 – 60cm)**
mg/kg N	12.60	16.0	
kg/ha N	**49**	**62**	**111**

Peechelba East 2020 Soil Test Results (from same paddock)

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, Victoria 2021

Analyte	Units	Result	Optimal Range	Status
pH (H_2O)	(pH)	7.5	6 - 7	Slightly Alkaline
pH ($CaCl_2$)	(pH)	6.7	5.4 - 6.5	Slightly Acidic
EC*	dS/m	0.221	0 - 0.15	Satisfactory
Total Nitrogen	ppm	16		
Nitrate N 0-30cm	ppm	10		
Nitrate N 30-60cm	ppm	7		
Ammonium N 0-30cm	ppm	5		
Ammoinium N 30-60cm	ppm	3		
Organic Matter	%	1.39	3.25 - 5.2	Very Low
Colwell Phosphorus	ppm	59	40 - 90	Satisfactory
Potassium	ppm	573	195 - 320	High
Sulphur	ppm	46.6	12 - 45	High
Zinc	ppm	1.38	1.6 - 8	Low
Copper	ppm	2.12	2.5 - 10	Low
Boron	ppm	2.39	1.7 - 4	Satisfactory
Manganese	ppm	13.341	18 - 70	Low
Iron	ppm	27.5	30 - 200	Low
CECe	meq/100g	7.1		
Calcium	meq/100g	15.26 (60.7%CEC)	6.5 - 11.0	High
Potassium	meq/100g	1.52 (6.1%CEC)	0.5 - 0.8	High
Magnesium	meq/100g	27.16 (28.5%CEC)	1.4 - 2.7	Satisfactory
Sodium	meq/100g	1.04 (4.3%CEC)	0.1 - 0.3	High
Aluminium	meq/100g	0.13 (0.5%CEC)	<5.0% CEC	Satisfactory
Ca:Mg Ratio	(ratio)	2.16	3 - 5	Low
K:Mg Ratio	(ratio)	0.21	0.3 - 0.5	Low

Site Photos

Kerang Harvest Processing – May 2021

Peechelba East, Victoria – 18 December 2020

Peechelba Field Day, Victoria – 29 January 2021

Kerang Field Day, Victoria -28 January 2021

Kerang harvest, Victoria – May 20 2021

Kerang surface irrigation, Victoria – December 2020