GOA Site Report

Improving nitrogen fertiliser efficiency by manipulating its positional availability through early summer fallow applications

Trial Code: GONU004161

Year: 2016

Location: 'Quandong Park', Collie

Collaborators: Freeth family

Keywords

GONU004, wheat nutrition, nitrogen rates, fallow nitrogen

Take home messages

No yield or quality benefit (or penalty) from N application in a dry fallow followed by a wet winter

N is possibly less mobile in the soil that conventional wisdom may have us think.

Big yield response to N (up to 200 kg/ha N) in an above average rainfall year.

Background

In recent years, anecdotal reports suggest lower than expected grain protein and yields, despite application of adequate nitrogen to winter crops grown in the GOA region. Seasons with a relatively dry finish are commonly suggested as a major reason for poorer yields and poorer responses to applied N. Other views include, N depletion in the sub-soil, possibly largely because of under-fertilising crops and the gradual move away from lucerne and legume-grass pastures in the crop rotation. Poor responses to N may also be exacerbated by late in-crop application, where there is insufficient rainfall and/or time for N to move deeper into the profile.

It is also felt that while sufficient N was applied to crops, it may only be generally available higher in the soil profile. As crops matures applied N may not be readily available because of dry top soil and because plants are mainly only extracting moisture from deeper in the soil profile where N available may be poor.

It is also possible that nitrogen is lost from the system. Research conducted in South Australia[1] noted that under favourable climatic conditions N losses from volatilisation alone can be as high as 1% per day (not including losses from denitrification or leaching). However, it might also be expected that any residual N in the soil should be available for the subsequent crop, possibly lower in the profile.

The trial was designed to assess effect of different N application timing on yield and grain quality, including fallow application, and its movement through the soil profile.

[1]http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Nitrogen-decision-Guidelines-and-rules-of-thumb#sthash.w5RNgxB7.dpuf

Aims

Main aims include:

- Determine if N application during the summer fallow results in deeper N being available at sowing.
- Assess if fallow application of N offers any improvement in crop yield or protein.
- Determine N recovery rates from various N application timing and rate.
- Assess any impact of N rate and application timing on higher and lower biomass wheat varieties.

Methods

A full factorial randomized completed block design, with 3 replications was used. Small plots were used approximately 2 by 10 m in size.

Table 1. Trial site details

Trial Establishment Date	Summer 2015/16		
Crop and Variety	Wheat - Gregory⁽ᴰ⁾ and Lancer⁽ᴰ⁾	Seeding rate	55 kg/ha
Sowing date	19/5/2016	Harvest Date	30/11/2016
Seedling equipment	Double Boot Tyne	Row Spacing	27.5 cm
Crop Nutrition (kg/ha)	100 Triphos	Soil type	Red Kandosol, sandy clay loam
Previous Crop	Canola	Pre-Sowing stubble management	Direct drilled (windrows burnt)
Soil test results (at sowing)	Colwell P ~ 25 ppm, Sulphur ~ 8 ppm	Nitrogen	0-30cm ~ 19 kg/ha,

Treatments were

- **Variety**: high and low biomass, Gregory⁽ᴰ⁾ and Lancer⁽ᴰ⁾
- **Nitrogen rates**: 0, 50, 100 and 200 kg/ha
- **Nitrogen timing:** Early Fallow, Mid Fallow, Sowing and Topdressing (at Z30)

Table 2. Treatments

Fallow	18/12/15
Mid Fallow	16/03/16
Sowing	19/05/16
Topdressing	18/08/16 (Z30)

Results were analysed using ANOVA and results compared with the LSD method at a 95% confidence interval. Any references to differences between treatments should be assumed to be statistically different unless otherwise stated.

Rainfall 2016[2]:

Month	Rainfall (mm)
Nov-15	71
Dec-15	24
Jan-16	76
Feb-16	3
Mar-16	1
Apr-16	41
May-16	62
Jun-16	186
Jul-16	54
Aug-16	34
Sep-16	165
Oct-16	47
Nov-16	15

Rainfall comments:

- 270 mm fallow rainfall (1 Nov 15 – 18 May 16)
- 509 mm in-crop rainfall (19 May 16 – 28 Nov 16)

Soil cores to 90 cm were collected at sowing from the 'Early Fallow' and 'Mid Fallow' treatments at sowing) where 0, 100 and 200 kg N/ha was applied. These cores were split into 3 depths (0-30, 30-60 and 60-90 cm from soil surface) and tested for Nitrate Nitrogen and Ammonium Nitrogen. Soil cores were collected from directly over the drill line.

Results

Soil cores confirmed the site was low in N and showed an increase in N in treatments where fertiliser N was applied. Approximately double the amount of N was detected in the mid-fallow N application compared to early fallow. Similar levels of N were detected regardless of whether 100 or 200 kg/ha was applied.

Early fallow treatment tended to have more nitrates in the 30-60 cm depth layer than either the mid fallow or the UTC. There were negligible differences in soil N between treatments below 60 cm (Figure 1).

[2] APSIM weather station number = 051051, station name = GILGANDRA (BERIDA)

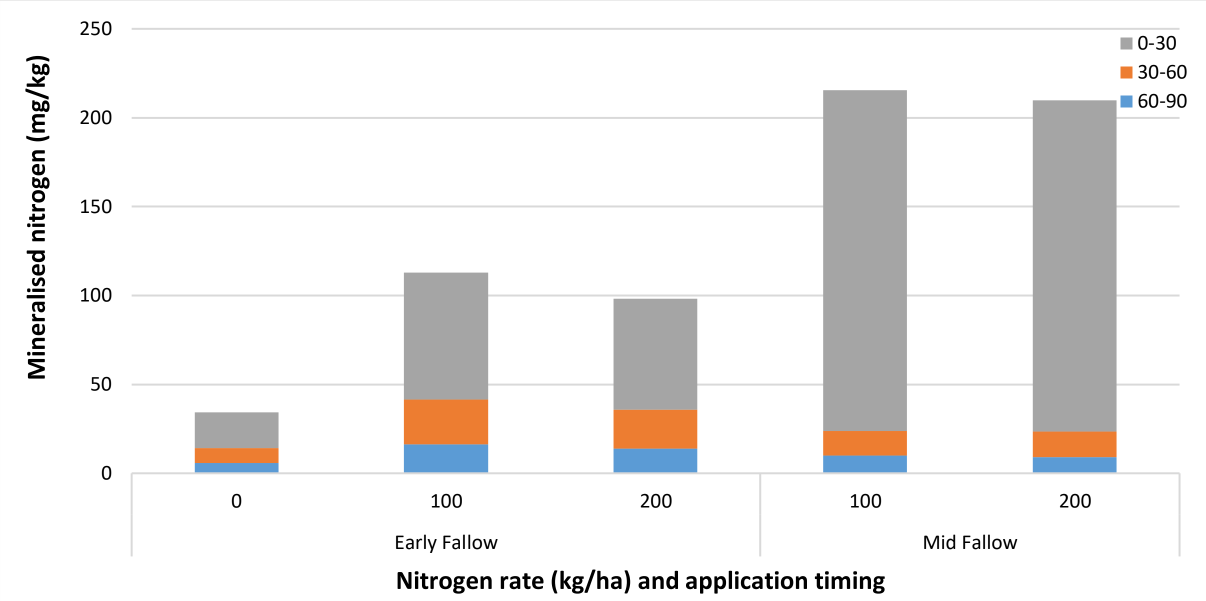

Figure 1. Mineralised soil nitrogen (Nitrates plus ammonium) (ppm)

Yield, N response: Yields showed clear response to nitrogen. Application of N regardless of rate or timing increased yields from an average of 1.4 (no applied N) to 4.5 t/ha (200 kg N/ha),

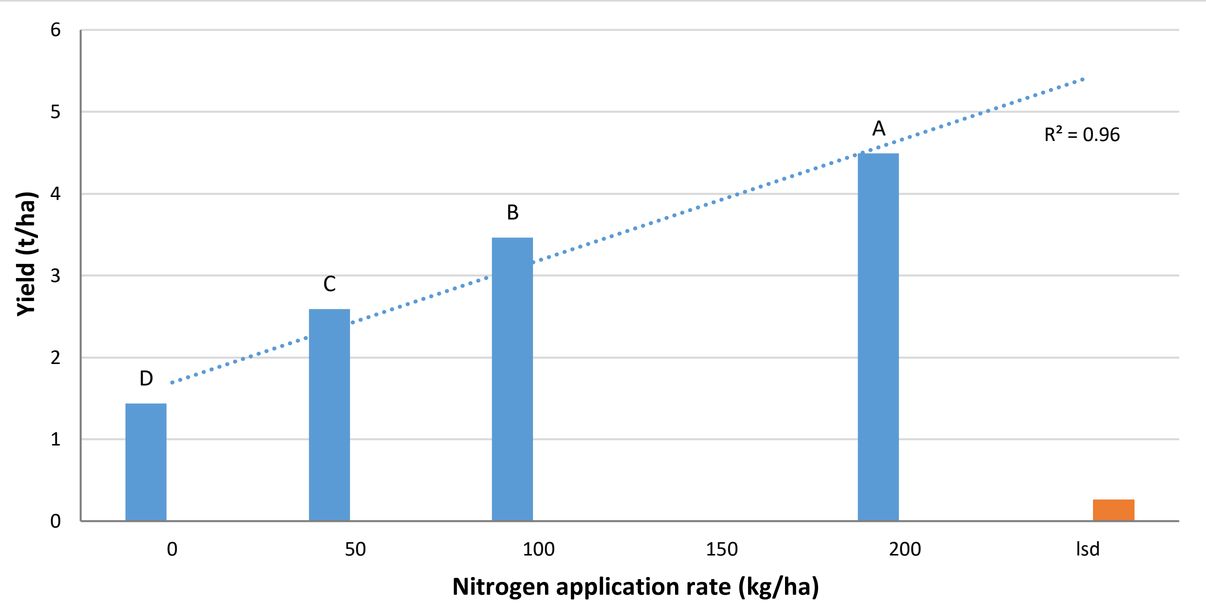

Figure 2.

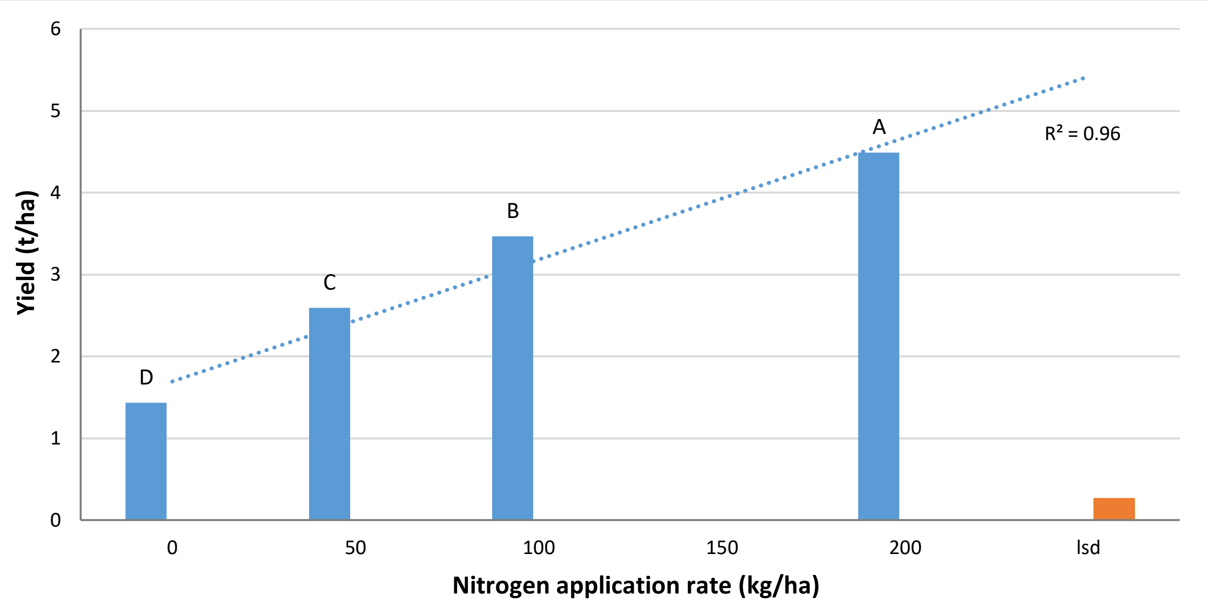

Figure 2. Yields (t/ha) (averaged for application timing and variety) for different nitrogen rates (kg/ha). Treatments with the same letter are not significantly different.

Yield, variety response: There were no differences in yield N responses between the two varieties, i.e. both varieties responded similarly to the various nitrogen rate and timings.

Yield, timing of N application response: N applied at sowing and topdressing (averaged for variety and rate) outperformed both fallow treatments by close to 1.0 t/ha and 0.5 t/ha respectively (Figure 3).

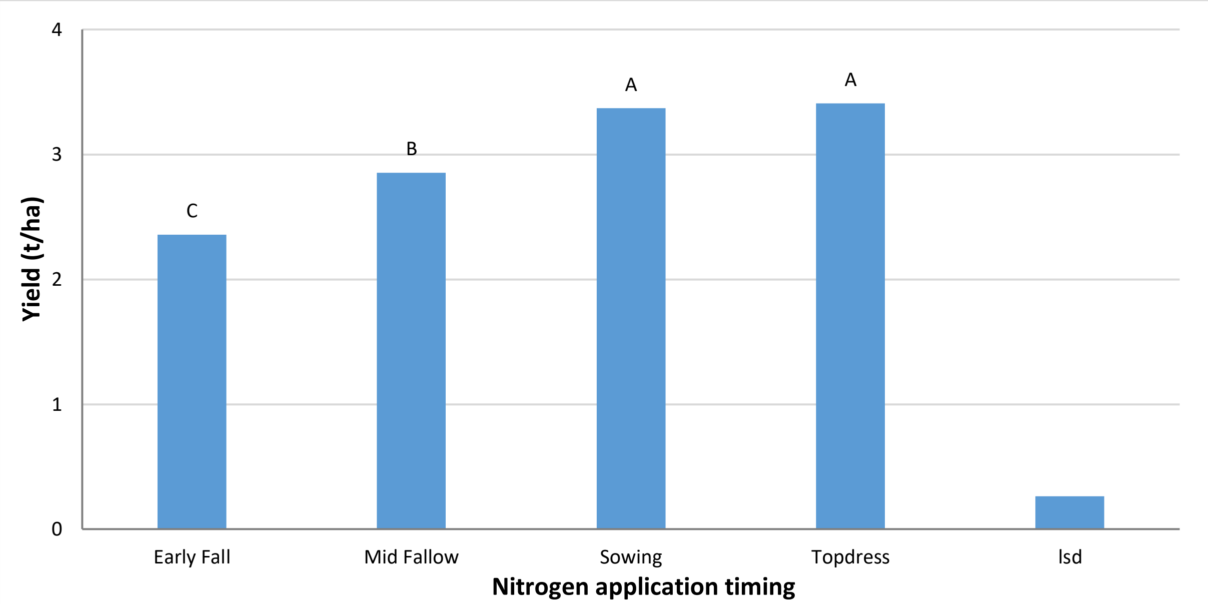

Figure 3. Yields (t/ha) (averaged for N rate and variety) for different N application timings (kg/ha). Treatments with the same letter are not significantly different.

Yield. Interaction between variety, nitrogen rate and timing: there was a significant interaction between N rate and N timing. Higher yields were achieved where higher N rates were applied at sowing and in-crop. There was no variety response, and there was very little variation between variety and N timing, or variety and rate

Grain quality Protein; There was a variety difference in both protein and screenings, with the high biomass line having higher screenings and lower protein. Protein levels increased with increasing nitrogen rates and latter application timings. Screenings tended to decrease as N rate increased (Table).

Table 3. Grain protein and screenings (%) for different rates of Nitrogen (kg/ha). Values with the same letter are not significantly different.

Variety	Protein	Screenings
Gregory⦷	9.2 A	2.6 A
Lancer⦷	10.3 B	1.6 B
L.S.D	0.3	0.2
Timing	**Protein**	**Screenings**
Early Fallow	9.2 C	2.2 A
Mid Fallow	9.3 C	2.2 A
Sowing	9.7 B	1.9 B
Topdress	10.9 A	2.1 AB
L.S.D	0.4	0.3
N rate	**Protein**	**Screenings**
0	8.7 C	2.5 A
50	8.8 C	2.3 AB
100	9.9 B	2.0 B
200	11.7 A	1.7 C
L.S.D	0.4	0.3

Discussion

Soil nitrogen: Soil testing at planting detected some movement of applied nitrogen deeper into the soil profile, with small increases in nitrate in the 30-60 cm layer, particularly for early fallow N timing treatment. It is unlikely that leaching occurred, as changes in N in the 60 - 90 cm segment were negligible, fallow rainfall was not excessive, and the soil profile was observed to be dry at bottom of soil cores while sampling just prior to sowing.

There was a significant anomaly in soil test results with levels of nitrogen detected at 100 and 200 kg/N ha treatments, at both fallow treatments. While it might be expected that where twice as much nitrogen was applied much higher N levels might be measured in the subsequent testing (given that it was 'fallow'). However, detected soil N was similar regardless of rate. Similarly, one might expect that where the same rates of N were applied, regardless of timing, similar levels of N might be detected. However, roughly twice as much mineralised N was detected in the later fallow application than the earlier application.

It is possible that because soil testing was conducted directly over the nitrogen 'band' that either application (longer) or rate (higher) allowed for more lateral N movement, which may not have been detected in sampling. Or it is possible nitrogen was lost to denitrification, a consequence of warm soil temperatures, moist conditions (such as occurred in January 2016) and high concentrations of nitrogen. These could have been ideal conditions for accelerated denitrification. Also possible is that some N became 'tied up' in organic fractions, and was subsequently unavailable for the crop. Testing for this supposition was not undertaken. Lower yields achieved from 'fallow' N application , compared to later applications would tend to support these theories.

Yields: the site was highly N responsive, with a strong linear yield response.

While N response was significant from fallow application it was much lower than when N was applied either at sowing or as a topdressing. Poorer N recovery is possibly explained by denitrification. Soil conditions did not indicate leaching prior to sowing. Another possibility is N tie up in organic fraction.

Post planting N application was subjected to similar in-crop conditions as at sowing application (therefore likely reason for similar yields). N loss pathways, as previously postulated, may have been quite different for fallow applications (i.e. it is feasible that the 500 mm of in crop rain may have pushed some N beyond the root zone). Post sowing losses may have also occurred, and this may have contributed to slightly lower yields of sowing treatment compared to topdressing. Conditions at sowing were extremely wet, and remained wet for the majority of winter, so much so that surrounding paddock did not get planted.

Yields increased with increasing rates of N, and tended to be higher at topdressing timing. Grain quality tended to reflect yield results i.e. higher yields tended to have higher protein. Protein increased as rate of N increased. However, screenings decreased as N rate increased, possibly attributed to the wet season and relatively cool finish (excessive heat during grain fill is a key driver of screenings). Timing also had some effect on quality, with topdressing N having higher protein, which is line with other research[3].

Results suggest that fallow N application is less efficient that in-crop applications, regardless of rate. While small amounts of N moved deeper into the subsoil, this had no influence on yields or grain quality (in a very wet season). It may also be significant that applying nitrogen in fallow and in a band (causing a high concentration), possibly increasing exposure to denitrification. Other work is being undertaken by GOA assessing different application techniques to test whether improvements can be made to efficiency of fallow N applications.

Conclusions

Increasing rates of N increased yields and grain quality.

In a very wet season delaying N (until Z30) maximised yield and grain quality.

Early and mid-fallow N application reduced efficiency of nitrogen utilisation resulting in lower yield and generally lower quality than applying at sowing or in-crop.

Acknowledgements

Research undertaken as part of this project is made possible by significant contributions of growers through both trial cooperation and support of GRDC. The authors would like to thank them for their continued support. Special thanks to the Freeth family for hosting this trial.

DISCLAIMER — TECHNICAL

[3] https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Nitrogen-decision-Guidelines-and-rules-of-thumb

Appendix

Variety	N Timing	N rate (kg/ha)	YIELD (t/ha)		Screenings (%)		Protein (%)	
Gregory	Early Fall	0	1.4	OP	2.6	ABCDEFG	8.3	KLM
Gregory	Early Fall	50	2.4	KLM	2.6	ABCDEFG	7.8	M
Gregory	Early Fall	100	2.7	IJKLM	2.6	BCDEFGH	8.9	IJKL
Gregory	Early Fall	200	3.0	FGHIJK	2.9	ABCDE	9.2	GHIJK
Gregory	Mid Fallow	0	1.4	OP	3.0	ABC	8.1	LM
Gregory	Mid Fallow	50	2.0	MNO	3.3	A	8.3	KLM
Gregory	Mid Fallow	100	3.6	DEF	2.7	ABCDEF	8.5	JKLM
Gregory	Mid Fallow	200	4.1	CDE	2.1	FGHIJKL	10.4	EF
Gregory	Sowing	0	1.4	OP	3.3	AB	8.3	KLM
Gregory	Sowing	50	2.5	JKLM	2.5	CDEFGHI	8.1	LM
Gregory	Sowing	100	4.2	CD	2.2	EFGHIJK	9.0	HIJKL
Gregory	Sowing	200	5.5	A	1.6	JKLMNO	11.9	BCD
Gregory	Topdress	0	1.7	NOP	2.9	ABCD	8.4	KLM
Gregory	Topdress	50	3.5	EFGH	3.0	ABC	9.0	GHIJKL
Gregory	Topdress	100	4.1	CDE	2.4	CDEFGHI	11.1	DE
Gregory	Topdress	200	5.2	AB	2.0	FGHIJKLM	12.6	B
Lancer	Early Fall	0	1.2	P	2.2	DEFGHIJ	9.2	GHIJK
Lancer	Early Fall	50	2.5	JKLM	1.5	KLMNO	9.5	FGHIJ
Lancer	Early Fall	100	2.4	KLM	2.0	FGHIJKLMN	10.0	FG
Lancer	Early Fall	200	3.2	FGHI	1.3	MNO	10.4	EF
Lancer	Mid Fallow	0	1.3	P	1.9	HIJKLMN	8.8	IJKL
Lancer	Mid Fallow	50	2.1	LMN	2.0	GHIJKLMN	8.8	IJKL
Lancer	Mid Fallow	100	3.1	FGHIJ	1.5	KLMNO	9.9	FGH
Lancer	Mid Fallow	200	5.2	AB	1.3	MNO	11.4	CD
Lancer	Sowing	0	1.5	NOP	1.9	IJKLMN	8.8	JKLM
Lancer	Sowing	50	2.9	GHIJK	1.6	JKLMNO	8.9	IJKL
Lancer	Sowing	100	4.0	CDE	1.4	LMNO	9.5	FGHIJ
Lancer	Sowing	200	5.0	AB	1.1	O	12.8	B
Lancer	Topdress	0	1.6	NOP	1.8	IJKLMNO	9.8	FGHI
Lancer	Topdress	50	2.8	HIJKL	1.5	KLMNO	9.8	FGHI
Lancer	Topdress	100	3.6	DEFG	1.3	NO	12.2	BC
Lancer	Topdress	200	4.6	BC	1.5	JKLMNO	14.6	A
lsd			0.8		0.7		1.0	