GOA Site Report

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

Trial Code:	GONU004161
Year:	2016
Location:	'Allawah', Tullamore
Collaborators:	Neville Jones

Keywords

GONU004, wheat nutrition, nitrogen rates, fallow nitrogen, Tullamore

Take home messages

Increasing rates of N at this site increased yields and grain quality.

In a very wet season delaying N (until Z30) limited the yield potential, but increased grain quality.

Early and mid-fallow applications of nitrogen reduced yields in some treatments when compared to the sowing treatment, and had no influence over grain quality (compared to a sowing timing).

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.

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[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

Project main aims:

- Determine effect of very early N application at the start of the fallow (would it facilitate movement of N deeper into the profile as moisture moved deeper).
- Determine if likely deeper N movement into the soil profile offered improvement in crop yield or protein.
- Measurable N recovery rates and movement.
- Impact of N movement on higher and lower biomass 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 - Gregoryᶲ and Lancerᶲ	Seeding rate	55 kg/ha
Sowing date	18/5/2016	Harvest Date	28/11/2016
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
Soil test results (at sowing)	Colwell P ~ 39 ppm,	Nitrogen	0-30cm ~ 81 kg/ha,

This trial included the following treatments:

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

Table 2. Treatment application timings

Fallow	6/1/2016
Mid Fallow	14/3/2016
Sowing	18/05/2016
Topdressing	18/8/2016 (Z30)

Results were analysed using ANOVA and results compared using 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:

Month	Rainfall (mm)
Nov-15	92
Dec-15	47
Jan-16	110
Feb-16	0
Mar-16	19
Apr-16	50
May-16	59
Jun-16	160
Jul-16	50
Aug-16	56
Sep-16	144
Oct-16	31
Nov-16	54

Rainfall comments:

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

Results

Results from soil cores confirmed site low N status and an increase is soil N in treatments where fertiliser was applied. High levels of N were detected in the mid fallow application treatments. Early fallow N treatment tended to have more mineralised nitrogen in the 30-60 cm layer than either the mid-fallow or the UTC. For example 100 kg N/ha applied in early fallow tested approximately 39 ppm compared to less than 21 ppm in the UTC. There was little or no difference in soil N between the treatments below 60 cm (Figure 1).

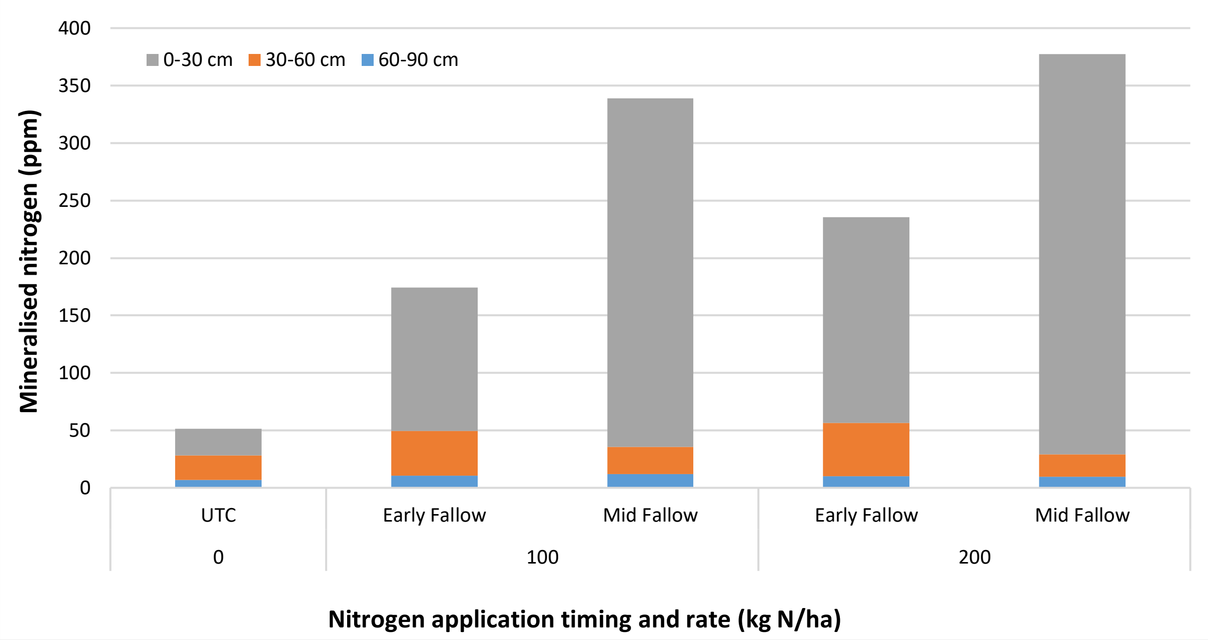

Figure 1. Mineralised soil nitrogen (nitrates plus ammonium)

Yield: Yields from the trial showed strong response to nitrogen. Yield response to N application averaged 2.1 (compared to no applied N) with response 5.0 t/ha for the higher N rate (Figure **2**).

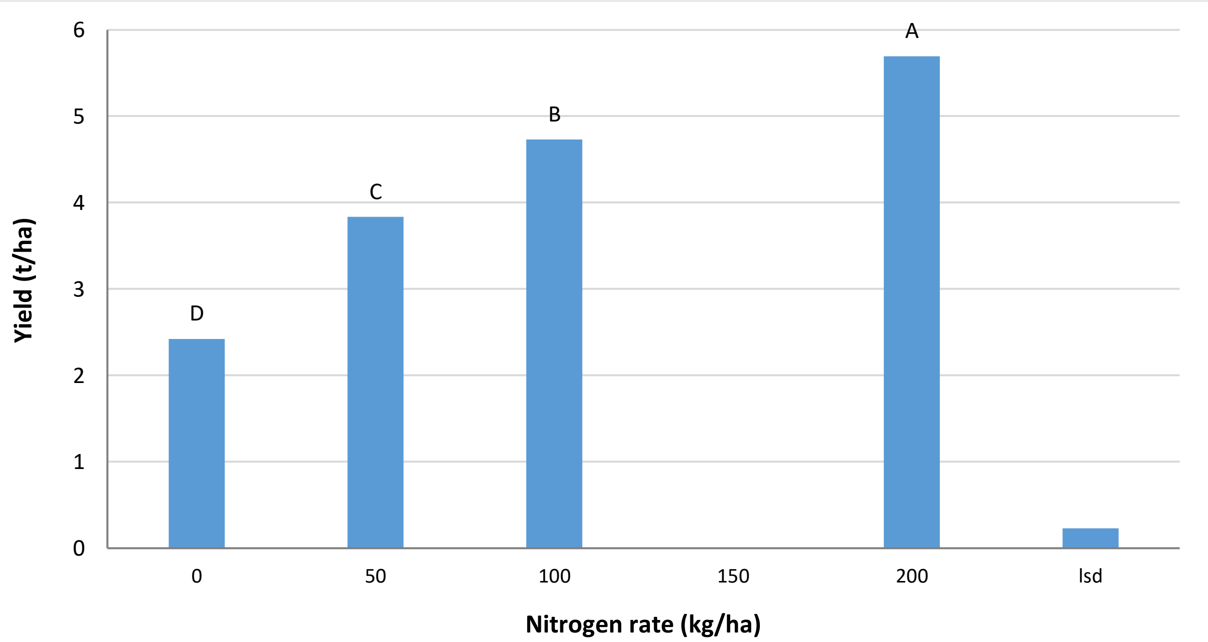

Figure 2. Yields (t/ha) (averaged for application timing and variety)

Yield, variety response: Higher biomass line Gregory⍉ had significantly higher yields than lower biomass (Lancer⍉). Overall, Gregory⍉ out yielded Lancer⍉ by close to 300 kg/ha.

Yield, timing of N application response: N applied at sowing performed better than either of the fallow treatments. It out yielded early fallow treatment by close to 500 kg/ha (Figure 3). Top dressing N was also higher yielding than early fallow application. Timing of nitrogen application, when assessed in isolation from rate and variety, found fallow application yielded less than other treatments by an average of about 300 kg/ha.

Yield, interaction between variety, nitrogen rate and timing: There was an interaction between N rate and timing, but little interaction between variety and timing, or variety and rate. Both varieties responded similarly to N rate and timing.

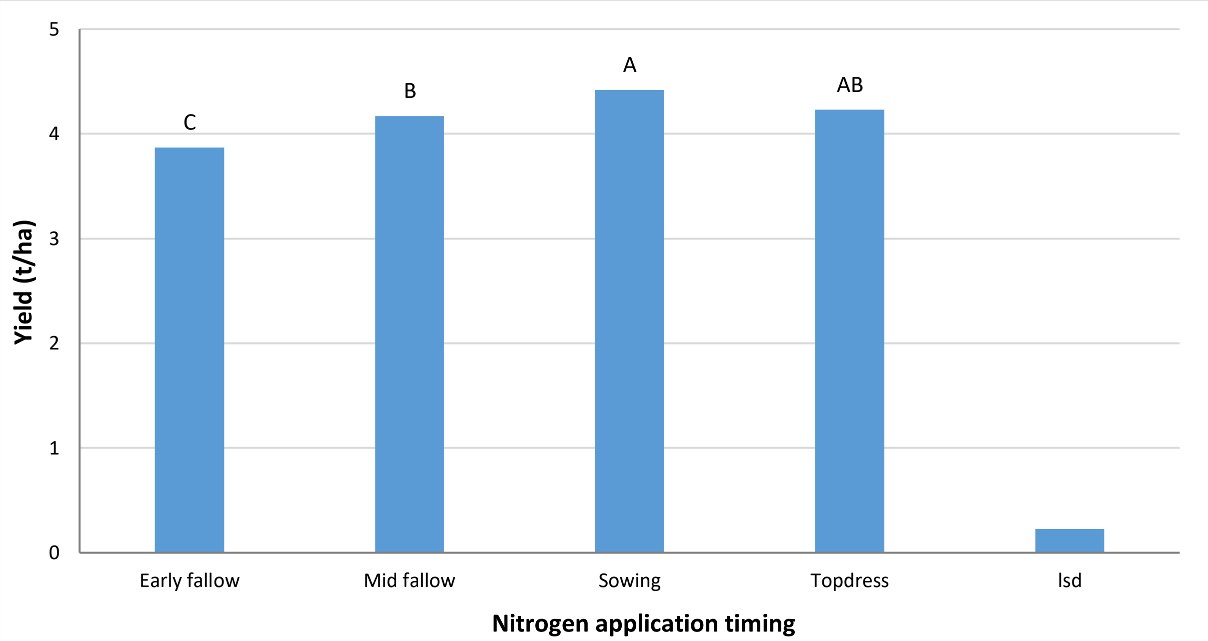

Figure 3. Yields (t/ha) (averaged for rate and variety)

Grain quality - Protein; There was variety difference in both protein and screenings, with high biomass line having higher screenings and lower protein. There was no influence of timing on screenings, however, topdressing treatment had higher protein than other application timings. Protein increased, and screenings decreased with increasing rates of applied N (**Error! Reference source not found.**).

Table 2. Grain protein and screenings (%) for the different rates of nitrogen (kg/ha). Values with the same letter are not significantly different.

Variety	Protein	Screenings
Gregory⦹	9.8 B	4.8 A
Lancer⦹	10.6 A	3.0 B
L.S.D	0.3	0.4
Timing	**Protein**	**Screenings**
Early Fallow	9.9 B	4.0 A
Mid Fallow	9.6 B	4.1 A
Sowing	9.8 B	3.8 A
Top-dress	11.5 A	3.7 A
L.S.D	0.4	0.5
N rate	**Protein**	**Screenings**
0	9.0 C	5.2 A
50	9.3 C	4.2 B
100	10.2 B	3.3 C
200	12.2 A	2.8 C
L.S.D	0.4	0.5

Discussion

Soil nitrogen: Soil nitrogen measured at planting indicated that N had not moved far from where it had been applied in the fallow treatments. For example, very high N levels were measured in fallow treatments (sampled over the drill line, through the fertiliser band) indicated that a large portion of applied N fertiliser remained in or close to the original band. However there was less detected N in early fallow treatment suggesting either more lateral movement and/or losses. Low N levels below 60 cm also indicated limited vertical movement and hence low likely leaching losses during the fallow. The low N status of the 0 N treatment was subsequently reflected in low yield.

N application in the fallow did allow some N to move deeper into the profile, however, this did not have any beneficial influence on yield or grain quality (see below). It is likely that the extremely wet conditions in 2016 maximised utilisation of nitrogen regardless of where it was available in the profile.

Yields: There was no advantage to applying nitrogen in the fallow. Lower yields were recorded for some of the fallow treatments compared to application at sowing (for example 50 kg N/ha mid fallow and 100 kg N/ha early fallow). Lower nitrogen utilisation efficiency for fallow applied nitrogen might be explained by N losses through denitrification. It is unlikely there was any losses due to leaching prior to planting. It is feasible that 500 mm of in-crop rain may have pushed some N beyond the root zone. It is also feasible that some N may have been lost to denitrification prior to sowing (post sowing losses may have also occurred, however, sowing applications would be subjected to the same loss pathways).

Yields increased with increasing N rates, and tended to be higher at sowing timing. Grain quality tended to reflect yield results i.e. higher yields tended to have higher protein. Protein increased as the rate of applied nitrogen increased. Screenings decreased as N rate increased. This may be attributed to the wet season and relatively cool finish (excessive heat during grain fill is a key driver of screenings). N timing also had some effect on quality, with topdressing treatment having higher protein level (in line with other research[2]), though slightly lower yields than the sowing treatment.

Results from this experiment highlight inconsistent results from fallow application of N, making it difficult to recommend it as an alternative to sowing or in-crop application. Other research is being undertaken by GOA assessing various fallow application options to better understand nitrogen efficiencies, i.e broadcasting and broadcasting with incorporation.

Economics

All N treatments resulted in a positive net return (deducting cost of fertiliser). However, there was a large variation in returns, from just above break even to over to $800/ha. As neither yields or grain quality collapsed at the very high nitrogen rates net returns may not have been maximised. For fertiliser applications at sowing or earlier profits were driven mainly by yield. Income for N topdressing was also significantly driven by quality (Figure 4).

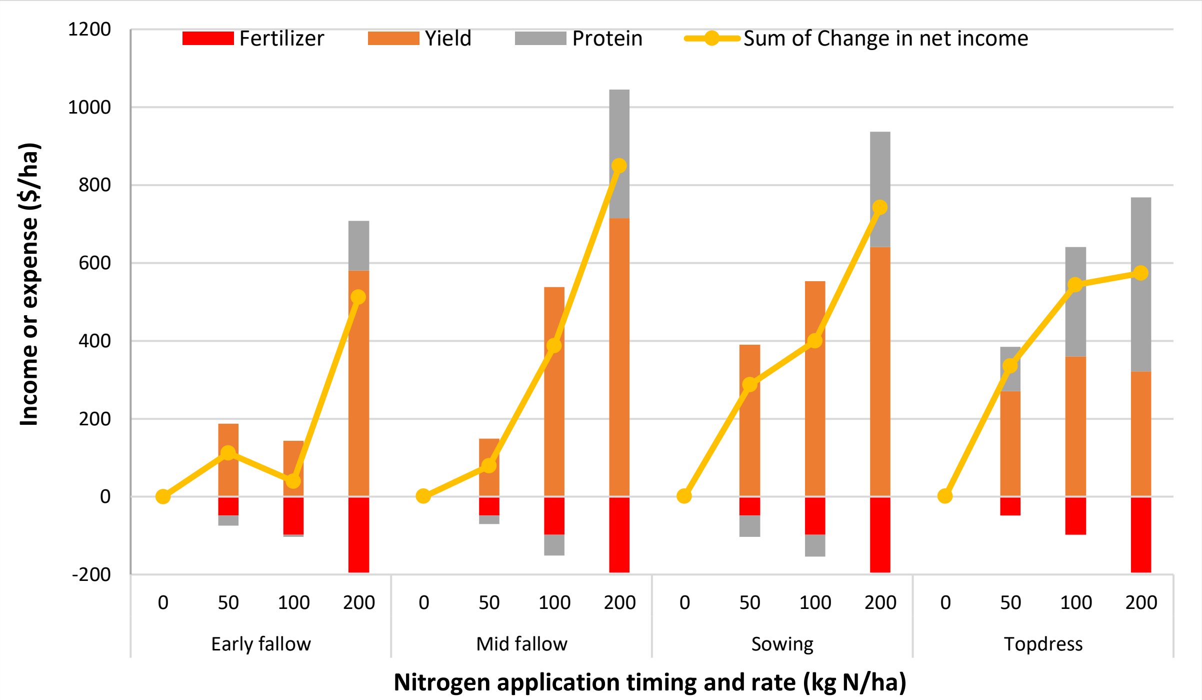

Figure 4. Net profit attributed to yield and protein and fertiliser costs ($/ha) for different nitrogen application timings and rates for Gregory.

Conclusion

Increasing rates of N at this site increased yields and grain quality.

In a very wet season delaying N (until Z30) limited the yield potential, but increased grain quality.

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Acknowledgements

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Appendix

Variety	N Timing	N rate (kg/ha)	YIELD (t/ha)		Screenings (%)		Protein (%)	
Gregory	Early Fall	0	2.73	LMNO	5.8	ABCDE	8.867	IJK
Gregory	Early Fall	50	3.8467	GHIJKL	5.2	ABCDEFG	9.333	GHIJK
Gregory	Early Fall	100	3.5833	HIJKLM	4.4333	ABCDEFGHI	9.133	HIJK
Gregory	Early Fall	200	6.1833	AB	2.8667	FGHI	11.333	CDEFG
Gregory	Mid Fallow	0	2.28	NO	6.7667	AB	8.1	JK
Gregory	Mid Fallow	50	3.1667	JKLMNO	6.2333	ABCD	7.833	K
Gregory	Mid Fallow	100	5.4867	ABCDE	3.9333	BCDEFGHI	9.467	GHIJK
Gregory	Mid Fallow	200	6.5367	A	3.5333	DEFGHI	11.633	BCDEF
Gregory	Sowing	0	2.0633	O	7.1	A	7.8	K
Gregory	Sowing	50	4.3867	DEFGHIJ	5.4	ABCDEF	8	K
Gregory	Sowing	100	5.3567	ABCDE	3.6333	DEFGHI	8.667	IJK
Gregory	Sowing	200	5.8767	ABC	2.7333	FGHI	11.9	BCDE
Gregory	Topdress	0	2.89	KLMNO	6.6	ABC	9.033	HIJK
Gregory	Topdress	50	4.5	DEFGHI	4.5333	ABCDEFGH	10.533	CDEFGHI
Gregory	Topdress	100	5.0367	BCDEFG	3.2	EFGHI	12.067	BCD
Gregory	Topdress	200	4.8033	CDEFGH	4.0333	BCDEFGHI	13.567	AB
Lancer	Early Fall	0	2.3833	MNO	3.7667	CDEFGHI	9.9	EFGHIJK
Lancer	Early Fall	50	3.5067	IJKLMN	2.8333	FGHI	10.4	DEFGHI
Lancer	Early Fall	100	3.3767	IJKLMN	3.1667	EFGHI	9.567	FGHIJK
Lancer	Early Fall	200	5.3433	ABCDE	3.5333	DEFGHI	11.033	CDEFGH
Lancer	Mid Fallow	0	2.5067	MNO	4.1667	BCDEFGHI	9.567	FGHIJK
Lancer	Mid Fallow	50	2.8467	KLMNO	3.9667	BCDEFGHI	8.6	IJK
Lancer	Mid Fallow	100	4.87	CDEFG	2.6333	FGHI	10.267	DEFGHI
Lancer	Mid Fallow	200	5.65	ABCD	1.6333	I	11.367	CDEFG
Lancer	Sowing	0	2.5967	LMNO	4	BCDEFGHI	9.8	EFGHIJK
Lancer	Sowing	50	4.06	FGHIJK	2.9	FGHI	9.167	HIJK
Lancer	Sowing	100	4.99	BCDEFG	2.6333	FGHI	10.167	DEFGHIJ
Lancer	Sowing	200	6.0133	ABC	1.6667	HI	12.667	ABC
Lancer	Topdress	0	1.95	O	3.7667	CDEFGHI	8.967	HIJK
Lancer	Topdress	50	4.3533	EFGHIJ	2.6667	FGHI	10.667	CDEFGHI
Lancer	Topdress	100	5.1333	BCDEF	2.4333	GHI	12.633	ABC
Lancer	Topdress	200	5.16	BCDEF	2.4	GHI	14.467	A
		LSD	1.2783		2.8833		2.1534	