GOA Site Report

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

Trial Code: GONU00415-3

Season/year: Summer 2014/15

Location: 'Belmore', Nyngan

Collaborators: Adrian Taylor

Keywords

GONU004, wheat nutrition, nitrogen rates, fallow nitrogen, Nyngan

Applying nitrogen in the fallow did not result in movement of N deeper into the profile

Applying nitrogen in the fallow did not provide anticipated grain quality or yield benefits, however, neither did it result in penalties when compared to conventional application timings (all timings much the same yield).

Yield gains from N application were significant and profitable.

Background

A long history of possible under-fertilising of crops and a gradual move away from lucerne and legume-grass pasture rotations, coupled with low frequency of pulse crops in otherwise non-legume continuous cropping systems has seen a gradual decline in soil N reserves. As a result, there is a need to apply N to the farming system to meet the shortfall of N to maintain a productive and profitable crops.

However, application of additional N fertiliser is not well adopted in the region for a number of possible reasons. One such reason is that when growers have applied N to crops, often top-dressed, the response is often disappointing to them. Both yield and grain quality responses are seen as inconsistent and marginal in terms of their return on the money invested.

One possible explanation for the poor response is the positional availability of the N applied and the rainfall distribution following applications.

N is generally applied as urea which is top-dressed in crop, rainfall following application is assumed to dissolve the fertiliser and move it into the soil where the crop can take it up in soil water. The hypothesis is that despite the movement of the N into the soil profile the region in which it is incorporated is quite shallow unless further rainfall moves it deeper into the profile. If it is not moved deeper into the soil the surface layers quickly and frequently dry out from evaporation or by plant use rendering any further uptake of N, not possible. The applied N in effect becomes unavailable due to its position in the soil which could be termed positionally unavailable.

Spring rainfall in the GOA region can be infrequent and warmer temperatures leading to more rapid drying of the surface layers, could result in this scenario being more common than more southern region areas. Further to this there is an increasing reliance on storage of rainfall outside of the growing period in the soil profile through fallowing. This means in the absence of rainfall the crop draws on stored water often stored deeper in the soil well away from the region where N fertiliser may be placed.

This trial was designed to assess if applying N at the beginning of the fallow period prior to sowing wheat could avoid this possible, positional unavailability of applied N. By applying it early in the fallow period, subsequent rainfall would theoretically move the applied N deeper into the soil profile prior to peak crop demands. This would allow the crop to uptake applied N throughout the crop cycle but also have N available in the region of the soil where the crop is drawing soil water from when it is needed.

Aims

Project main aims:

- Determine effect of very early N application, at beginning of fallow and how it might facilitate N movement deeper into the profile via moisture moving down the profile.
- Determine if applied N that has been moved deeper into the soil profile offered any improvement in fertiliser efficiency measured as crop yield or protein as opposed to surface applied N.

Methods

The trial used a full factorial randomised completed block design with 3 replications and small plots of approximately 2 by 10 m in size.

Table 1. Trial site details

Trial Establishment Date	Summer 2014/15		
Crop and Variety	Wheat – Gregory and Lancer	Seeding rate	55 kg/ha
Sowing date	8/5/2015	Harvest Date	10/11/2015
Seedling equipment	Double Boot Tyne	Row Spacing	27.5 cm
Crop Nutrition (kg/ha)	100 Triphos	Soil type	Sandy Clay Loam
Previous Crop (and yield)	Wheat	Pre Sowing Stubble Management	Direct Drilled
Soil test results (at sowing)	Colwell P ~ 14 ppm, Sulphur ~ 3.4 ppm pH ~ 7.4	Soil Nitrogen	0-10cm ~16 kg/ha, 10-90cm ~16 kg/ha

Following treatments were included:

- **Wheat varieties**: high and low biomass lines, EGA Gregory⦶ and Lancer⦶ respectively
- **Nitrogen rates**: 0, 50, 100 and 200 kg/ha applied as urea
- **Nitrogen timing:** Fallow, Sowing, Topdressing (at Z30) and Split (fallow/topdressing)
- **Application method:** All urea applications other than the top-dressing treatment were drilled by a tyne planter. The top-dressed application was hand spread in front of forecast rain events.

Rainfall 2015:

Month	Rainfall (mm)[1]
Nov 14	1.2
Dec 14	84.7
Jan 15	79.1
Feb 15	9.5
Mar 15	4.8
Apr 15	49.6
May 15	50.7
Jun 15	70.3
Jul 15	41.2
Aug 15	26.9
Sep 15	8.5
Oct 15	22
Nov 15	88.5

Rainfall comments:

- Significant rain (>40 mm) fell within a week of Fallow timing (December)
- Significant rain (>30 mm) fell within a two weeks of Sowing timing (May)
- Significant rain (>40 mm) fell within a two weeks of Topdressing timing (July)
- 271 mm fallow rainfall (1 Nov 14 – 30 Apr 15)
- 233 mm in-crop rainfall (1 May 15 – 30 Oct 15)

Nitrogen Treatment Application Timings	
Fallow	22/12/2014
Sowing	8/05/2015
Topdressing	9/07/2015 (Z21)
Split	50% at fallow and 50% at topdressing

The trail has been analysed as a factorial ANOVA and results compared by using a LSD method with a 95% confidence interval. Any references to differences between treatments should be assumed to be statistically different unless otherwise stated.

Results

Soil cores to 90 cm were collected at sowing from 'Fallow' application treatments (and from the 50 kg split treatment that had 25 kg N/ha applied in the fallow) prior to sowing (137 days after application). These cores were split into 4 layers (0-10, 10-30, 30-60 and 60-90 cm from the soil surface) and tested for nitrate nitrogen and ammonium nitrogen.

Differences were detected in levels of nitrate N (Figure 1). There was little difference between different N treatments in either the 10 – 30, 30-60 or 60 – 90 cm depths. In the 0 - 10 cm layer 200, 50 and 25 kg/ha N treatments had more Nitrate N than untreated control. 100 kg/ha N had the highest N level. Ammonium levels were very low and not different between treatments.

[1] Data from SILO: Miandetta (Station number 051030)

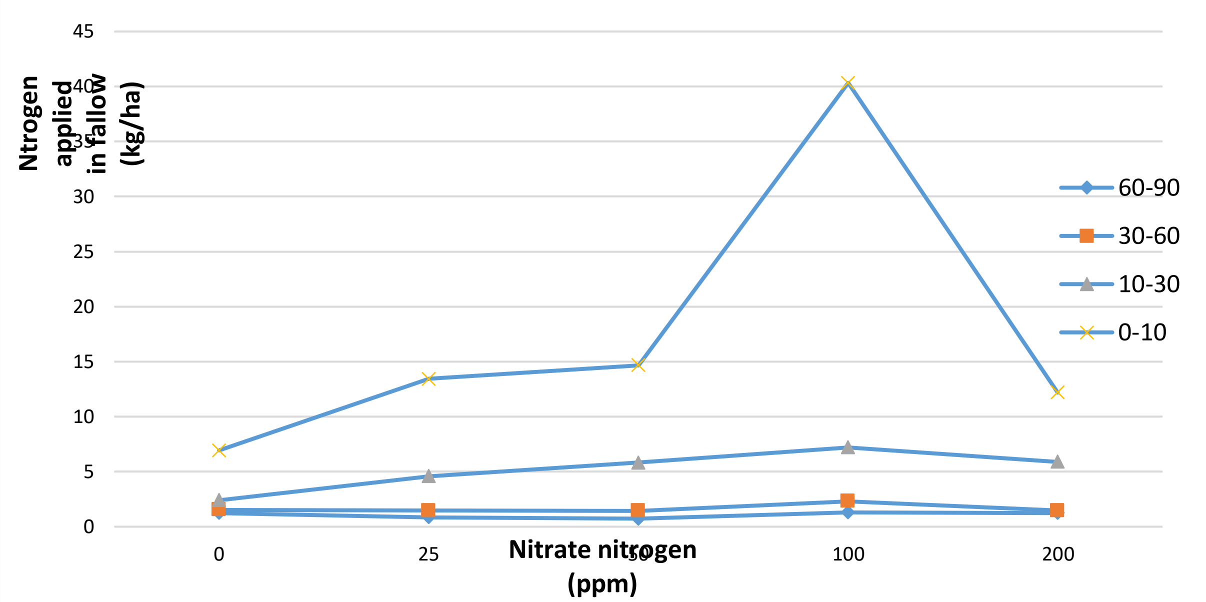

Figure 1. Soil nitrate (ppm) tested at planting for different rates of nitrogen applied during the fallow for 4 soil profile segments (measured in cm from the soil surface).

Crop vegetation index was measured throughout the growing season using a "GreenSeeker" NDVI. At 140 days after sowing (DAS) all N treatments had higher vegetation indices than zero N. Sowing treatment had slightly higher vegetation indices than other timings. 200 kg N/ha fallow treatment had a much lower vegetation Index than other timings where the same rate was applied (

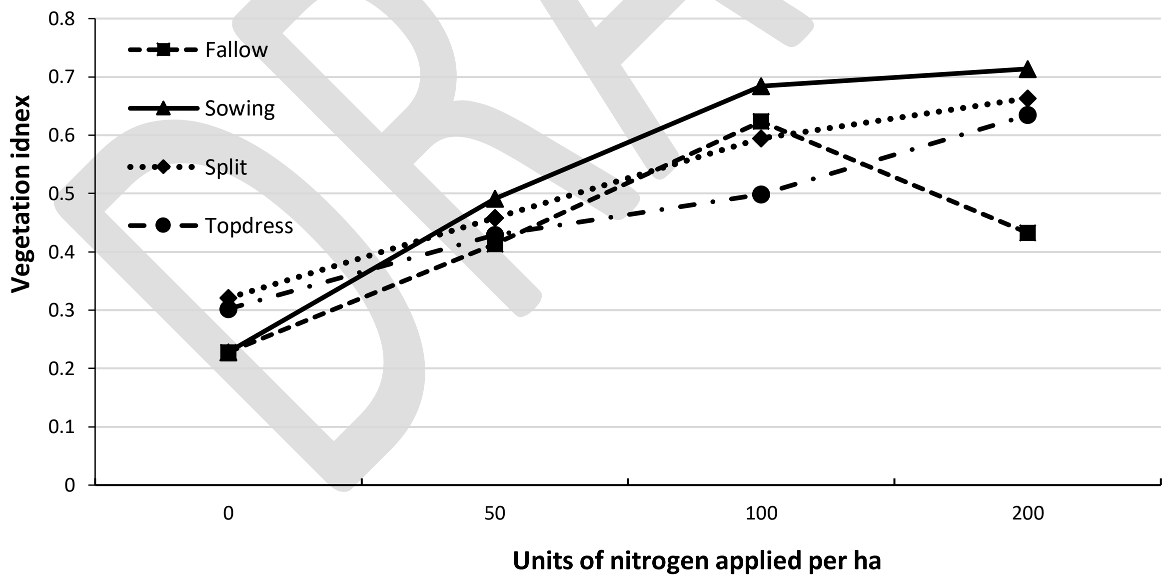

Figure 2).

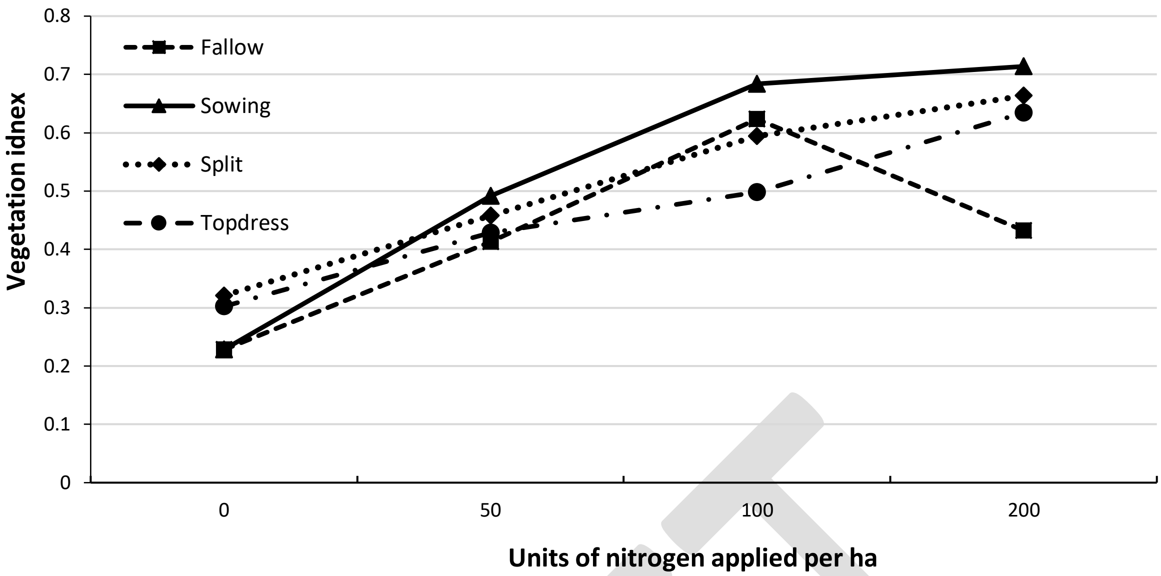

Figure 2. Crop Vegetation at 140 days after sowing for the 4 nitrogen application rates and 4 timings

Yield, N response: The trial showed a significant response to nitrogen. Application of N regardless of rate or timing increased yields from an average of 1.1 to 2.0 t/ha.

Nitrogen rates: Yields increased with increasing applied nitrogen up to 100 kg/ha, after which yield tended to decline (though difference between 100 and 200 kg/ha were not significant), Figure 3.

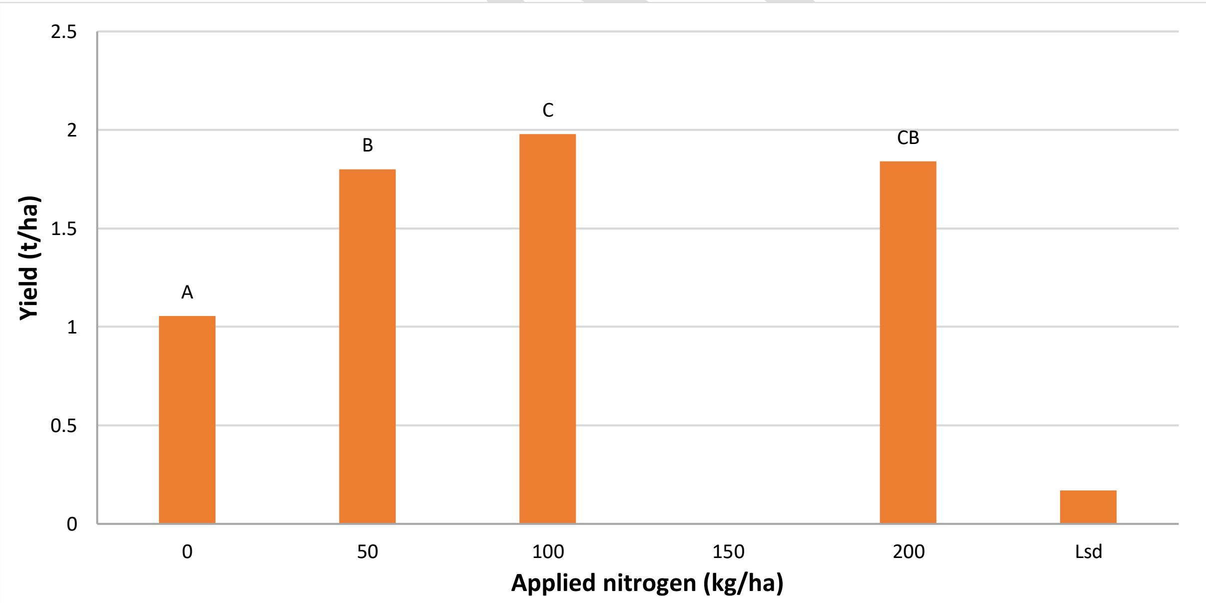

Figure 3. Yields (t/ha) moisture adjusted for the different nitrogen application rates (kg/ha). Treatments with the same letter are not significantly different.

Yield, variety response: There was no difference between yield of high and low biomass varieties, i.e. both varieties responded in a similar manner to the various nitrogen rate and timings.

Yield, timing of N application response: There was generally no significant differences in yields between N application timings.

Yield, interaction between variety, nitrogen rate and timing: There were only weak interactions between N rate and N timing. However 50 kg N/ha applied to Gregory at sowing outperformed the same N rate applied as topdressing by about 0.5 t/ha (regardless of variety).

Grain Quality

Protein and screenings increased with increasing rates of applied nitrogen (Table 2).

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

Nitrogen rate	Protein	Screenings
0	8.1 C	2.9 C
50	8.4 C	2.8 C
100	10.9 B	6.1 B
200	11.9 A	9.1 A
LSD	0.5	1.5
Variety	**Protein**	**Screenings**
Lancer	10.5 A	3.9 B
Gregory	9.2 B	6.6 A
LSD	0.4	1.1
Nitrogen timing	**Protein**	**Screenings**
Sowing	11.0 A	7.7 A
Split	10.0 B	5.3 B
Top-dress	9.5 B	4.5 BC
Fallow	8.9 C	3.2 C
LSD	0.5	1.5

There is little impact of timing on grain quality for the first 50 kg/ha of applied N. As rate of N increased so did both screenings and protein. However, there were exceptions; for example, 200 kg/ha applied in the fallow had low screenings and protein. Gregory tended to have lower protein and higher screenings than Lancer while N application at sowing had both the highest protein and screenings of any of the timings.

Discussion

Soil nitrogen: the soil nitrogen measured at planting following the fallow applications suggests that the potential nitrogen use efficiency using this strategy may be low, particularly where higher rates were applied. However when comparing the subsequent crop performance of fallow applied, compared to other application timings, there was little or no differences in yields (with the exception of 200 kg N/ha fallow applied treatment).

Yields: 50 kg N/ha was adequate to achieve the highest yields (and tended to be relatively more robust if applied either in the fallow or at sowing). That the split and the top-dressed treatments tended to yield lower (than sowing treatment) would indicate that the crop was not able to fully utilise nitrogen added later in the cropping season.

Increasing protein levels proved to be challenging where soils have low fertility. Generally the addition of 100 kg N/ha only improved protein enough to lift one grade, however, this was offset by increased screenings which would have downgraded quality grade (from ASW to AGP1). This tends to follow the general rule of thumb/pattern for nitrogen response where in a highly responsive situation a large yield response may be associated with little change in protein[2].

Application of N in the fallow did not increase yields or grain quality over other timings, neither did it come at a discount. Also high rates of N, applied early in the crop cycle, in a season with a dry finish, did not 'hay off', contrary to some research where yields of some varieties have declined with increasing N rates[3] (more so for Gregory than Lancer).

Conclusion

There was a positive yield response to applied nitrogen, however, a protein response was more difficult to achieve. Fallow application of N did not detrimentally impact grain quality or yield. Caution should be taken when applying high rates of N in summer fallows, as losses can be considerable particularly if conditions are hot and wet.

Acknowledgements

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[2] http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Nitrogen-decision-Guidelines-and-rules-of-thumb#sthash.7wBkwMIc.dpuf

[3] https://www.aggrowagronomy.com.au/wp-content/uploads/2017/11/Merriwagga-VSAP-Report-2015.pdf

Appendix

Variety	N Timing	N rate (kg/ha)	YIELD (t/ha)		Screenings (%)		Protein (%)	
Gregory	Fallow	0	1.0	H	7.4	NOP	2.9	EFG
Gregory	Fallow	50	2.0	ABC	7.4	NOP	3.6	EFG
Gregory	Fallow	100	1.9	ABC	10.7	FGH	9.2	CD
Gregory	Fallow	200	1.9	ABC	7.3	OP	2.4	FG
Gregory	Sowing	0	1.0	H	7.3	OP	2.8	EFG
Gregory	Sowing	50	2.1	A	8.5	JKLMNOP	3.8	EFG
Gregory	Sowing	100	2.0	ABC	11.6	DEF	12.4	BC
Gregory	Sowing	200	1.7	ABCD	14.4	AB	16.9	A
Gregory	Split	0	1.1	FGH	7.1	P	3.0	EFG
Gregory	Split	50	1.6	BCDEF	7.8	MNOP	4.1	EFG
Gregory	Split	100	2.0	ABC	10.0	GHIJ	6.8	DE
Gregory	Split	200	1.8	ABC	12.6	CDE	13.1	ABC
Gregory	Topdress	0	1.1	GH	7.9	LMNOP	2.8	EFG
Gregory	Topdress	50	1.6	CDEF	7.4	NOP	3.4	EFG
Gregory	Topdress	100	1.8	ABC	9.0	JKLM	6.0	DEF
Gregory	Topdress	200	1.8	ABC	11.3	EFG	11.7	BC
Lancer	Fallow	0	1.0	H	8.8	JKLMN	1.8	FG
Lancer	Fallow	50	1.7	ABC	8.7	JKLMNO	1.5	G
Lancer	Fallow	100	2.1	A	11.4	DEFG	2.4	FG
Lancer	Fallow	200	1.8	ABC	9.3	HIJKL	1.8	FG
Lancer	Sowing	0	0.8	H	8.1	KLMNOP	2.4	FG
Lancer	Sowing	50	2.1	A	9.1	IJKLM	2.2	FG
Lancer	Sowing	100	2.1	AB	13.4	BC	5.9	DEFG
Lancer	Sowing	200	1.7	ABC	15.8	A	15.6	AB
Lancer	Split	0	1.2	EFGH	9.3	HIJKL	3.8	EFG
Lancer	Split	50	1.6	CDEFG	9.3	HIJK	2.3	FG
Lancer	Split	100	2.0	ABC	11.0	FG	3.0	EFG
Lancer	Split	200	2.0	ABC	12.8	CD	6.7	DE
Lancer	Topdress	0	1.3	DEFGH	8.9	JKLM	3.6	EFG
Lancer	Topdress	50	1.7	ABCDE	9.1	IJKLM	1.6	G
Lancer	Topdress	100	2.0	ABC	10.5	FGHI	2.9	EFG
Lancer	Topdress	200	2.1	AB	11.9	DEF	4.4	EFG
lsd			0.5		1.5		4.8	