GOA Site Report

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

Trial Code: GONU00415-2

Season/years: Summer 2014/15

Location: 'Wandeen', Narromine

Collaborators: Toby Wippel

Keywords

GONU004, wheat nutrition, nitrogen rates, fallow nitrogen, nitrogen, positional availability, Narromine

Take home messages

Applying nitrogen in the fallow did not provide anticipated grain quality (or yield) benefits compared to at sowing, but neither did it result in penalties.

Nitrogen movement deeper into the soil profile maybe slower than expected.

Yield response to fertiliser nitrogen, plateaued between 100 and 200 kg N/ha.

It is difficult to improve grain quality when inherent soil fertility is low.

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 – EGA Gregory⌽ and Lancer⌽	Seeding rate	55 kg/ha
Sowing date	6/5/2015	Harvest Date	17/11/2015
Seedling equipment	Double Boot Tyne	Row Spacing	27.5 cm
Crop Nutrition (kg/ha)	100 Triphos	Soil type	Sandy Clay Loam
Previous Crop	Wheat	Pre-Sowing stubble management	Direct Drilled
Soil test results (at sowing)	Colwell P ~ 14 ppm, Sulphur ~ 8 ppm	Nitrogen (UTC)	0-10cm ~16 kg/ha 10-90cm ~ 12 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.

Table 2. Treatments timings

Fallow	24/12/14
Mid Fallow	7/05/15
Sowing	21/07/15 (Z30)
Topdressing	50% at fallow timing and 50% at topdressing

Rainfall 2015:

Month	Rainfall (mm)[1]
Nov 14	8.1
Dec 14	83.9
Jan 15	80.6
Feb 15	7.9
Mar 15	6.7
Apr 15	84.0
May 15	46.9
Jun 15	57.0
Jul 15	53.5
Aug 15	31.1
Sep 15	5.2
Oct 15	40.0
Nov 15	83.3

Rainfall comments:

- Significant rain (>30 mm) fell within a week of Fallow N timing (December)
- Significant rain (>35 mm) fell within two weeks of Sowing timing (May)
- Significant rain (>50 mm) fell within 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)

The trial has been analysed as a factorial ANOVA and compared by using an LSD method with 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' treatment (and from 50 kg split treatment where 25kg/ha N was applied in the fallow). Cores were split into 4 depths (0-10, 10-30, 30-60 and 60-90 cm from soil surface) and tested for nitrogen (nitrate and ammonium). The results are illustrated below. The largest response was in the top 10cm layer, differences were still apparent at the 11-30cm layer but little difference was observed at the next two testing segments.

[1] Data from SILO: Mumblepeg (Station number 051005)

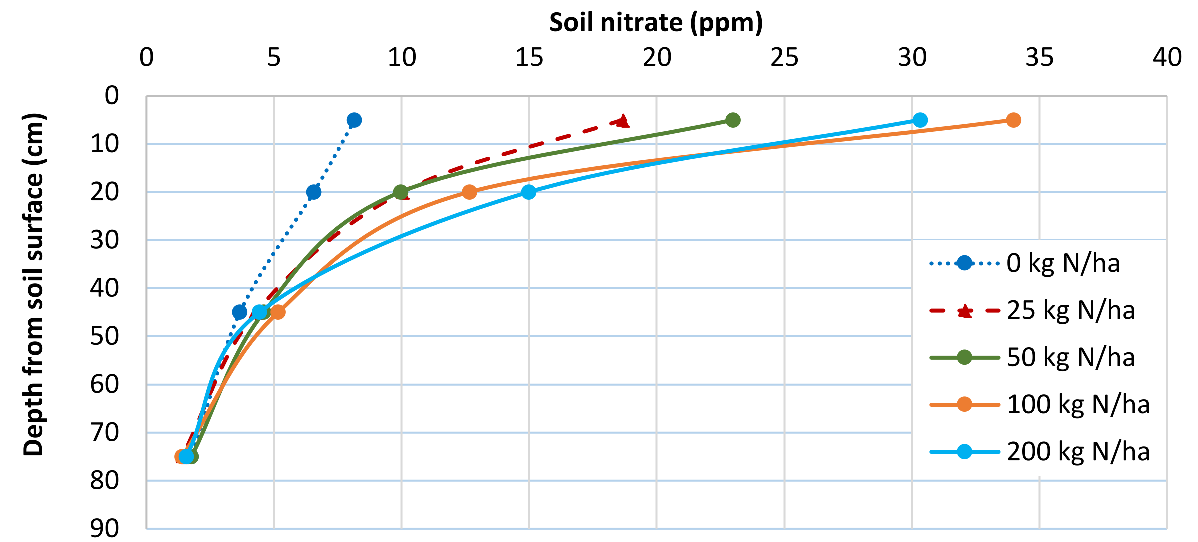

Figure 1. Soil nitrate (ppm) at planting for different rates of nitrogen applied during fallow for four soil profile segments (cm from soil surface).

Crop vegetation was measured throughout the growing season using a 'GreenSeeker' NDVI. At 140 days after sowing (DAS) all N added treatments had more vegetation than 0 N. Effect of N rate and timing showed little difference (i.e. 100 kg/ha N at all timings had a similar vegetation index) with the exception of 200 kg/ha N at fallow, which had lower vegetation index than treatments with the same N rate at other timings (Figure 2). This effect was also observed at 90 and 120 DAS.

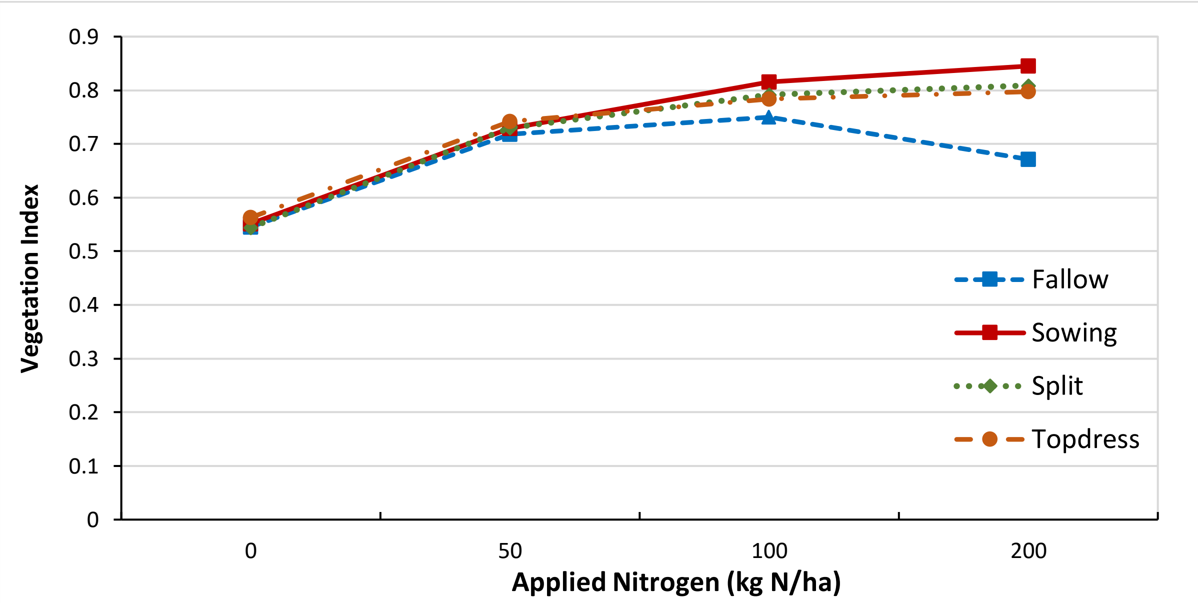

Figure 2. Crop vegetation at 140 DAS for four nitrogen application rates and four timings

Yields

Variety; there was a significant impact of variety with Gregory out yielding Lancer by close to 180 kg/ha.

Nitrogen rate: Grain yields showed a positive yield 1.2 t/ha response to increasing nitrogen rates as illustrated in **Figure 3**. All rates of applied N were higher than the zero rate, but the 200 kg/ha rate was no different to the 100 kg/ha rate or the 50 kg/ha rate.

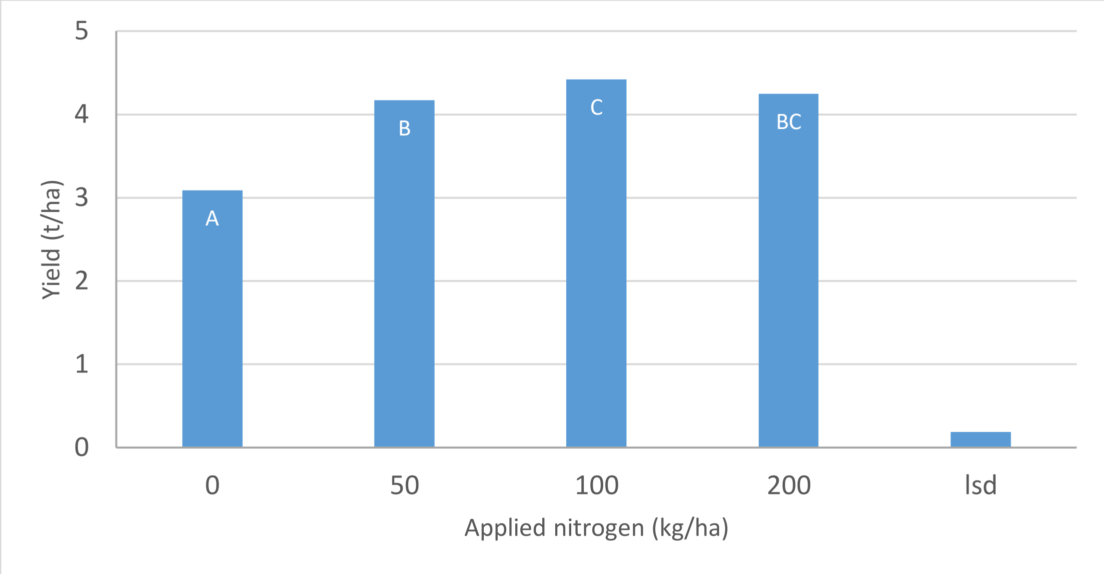

Figure 3. Yield in response to increasing N rate (Treatments with the same letter are not significantly different.)

Timing of N application: There was an interaction of N rate and timing. At either the 50 or the 100 kg/ha rate there was no difference in yields in response to the timing, at the 200 kg/ha rate both the fallow and sowing applications were significantly less than the top-dressed or split application at that same rate.

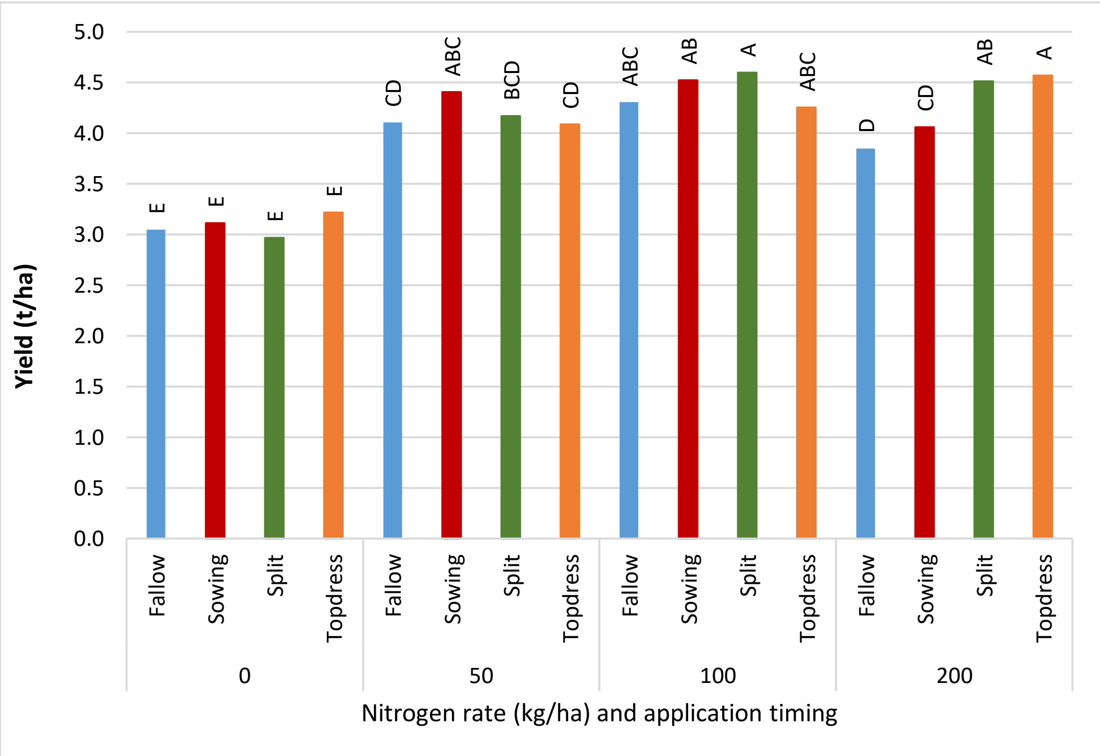

Figure 4. Yields in response to different rates and timing of nitrogen applications (Treatments with the same letter are not significantly different)

Protein and screenings

Increasing N rate increased protein at each N rate as well as increasing screenings but only at the highest rate of 200 N, with a similar response for both varieties.

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

Applied N	Protein		Screenings	
200	12.6	A	3.82	A
100	11.9	B	2.30	B
50	10.6	C	1.97	B
0	9.2	D	2.19	B

Discussion

Soil nitrogen: Soil nitrogen levels measured at planting, in response to applied N measured at planting suggests that potential recovery rates from fallow application decreased with increasing N rate and were modest to poor when more than 50 kg/ha N was applied. N calculations summarised in **Table 3** below show that soil nitrate levels, could account for as low as 27% of what was applied. Considering that there was already inherent soil nitrate and there should be contributions from mineralisation as well, this recovery is alarming. At this time there is little explanation other than the potential for some losses through denitrification with quite wet conditions and warm soils following the fallow applications. Yield performance at the highest rates of N applied in the fallow could support the possibility of some of the applied N having been lost from the system.

Table 3. Nitrogen levels in the profile (0-90 cm depth) and the proportion of applied N available (as NO_3) 108 days after application

Applied N (kg/ha)	0	25	50	100	200
Calculated N* (kg/ha)	50.2	74.6	82.6	105.3	104.8
Proportion of N	n/a	98%	65%	55%	27%

* N calculated using assumed bulk densities

The soil testing did indicate that some N had moved down the profile from the depth of application generally increasing with N rate. However the depth of movement and the proportion of the applied N is not particularly high.

Yields: There was a positive yield response to increasing N rate demonstrating the trial site to N responsive. At the more moderate levels of N applied there was no significant impact of N timings but at the highest rates of N there appears to be some disadvantage with the fallow applications. As discussed above some N may have been lost from the system through denitrification which is supported in the soil tests values and decrease in yield where 200 kg N/ha was applied in the fallow. The depressed yields from the sowing application may not be as easily explained.

Protein: Protein had a positive response to increasing N rates lifting from 9.2% for 0N to 12.6% for 200N. This would be sufficient to lift receival grades and the price/ton received. There was however little impact of timing on protein which was a little unexpected with a common belief that delays in N lead to increased protein response and decreased potential for yield responses.Results tend to suggest that under these growing conditions N application at sowing was at least as good as topdressing for maximising protein with the response similar for different application timings.

Screenings: There were only minor treatment effects on screenings, which overall were low. Interestingly at the higher rates screenings were not elevated, somewhat contrary to the experiences of some growers.

Conclusion

There was a positive yield response to applied nitrogen, with the most benefit coming from the first 50 kg/ha applied. On the other hand both protein and screenings tended to respond even to the higher rates, though the economic benefit is likely to be minimal unless there is a sizeable protein premium.

There tended to be a plateau in yield response to N between 100 and 200 kg N/ha for the fallow and sowing timings, though, there was no observed 'haying off' that might have been expected with such a tight finish to the season.

Some caution should be taken when applying N in fallows at higher N rates, as potential for losses can be considerable, particularly, if conditions are hot and wet, and especially where very high (most likely non-commercial) rates are applied (i.e. 200 and or more kg N/ha). Further work may be warranted to determine if the method of application (banding or broadcast) has any influence on volatilization or denitrification.

Overall the greatest response in these trial was to rate as opposed to timing or variety. There was little useful impact of N timing and the two varieties tested showed similar responses albeit variety characteristics and their performance tended to remain consistent under the range of options tested

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