Chasing high yields with high rates of nitrogen - what happened in 2014?

Gina Kreeck[1] and Craig Farlow[2]
[1] *Southern Farming Systems*
[2] *Incitec Pivot Fertilisers*

Key messages

- Application of nitrogen fertiliser significantly increased yield compared to no fertiliser.
- Grain protein results suggest that in 2014 nitrogen was not the limiting factor to yield especially at the higher rates; incremental increases in mean grain protein were recorded with each increase in N, up to 300 kg N/ha.
- Variety choice had a significant effect on final grain yield and protein, however individual variety response to applied N rates were relatively similar.
- There was a strong link between N rate and what was left in the soil after harvest, and the higher rates left a considerable amount.

Introduction

Making decisions around nitrogen often requires an educated guess on what the season is going to do. Split application allows the risk to be managed a little better, and is probably becoming more common in high rainfall zone (HRZ) due to unreliable springs that can sometimes deliver, and sometimes not. Crop nitrogen budgets are influenced by water-limited yield potential, targeted grain protein (and grade), previous paddock history and crop management factors including time of sowing and choice of variety. The trend towards earlier sowing in recent years using longer season wheat varieties, has been driven by greater yield potential and additional grazing opportunities with dual-purpose winter wheat types. Higher yields can be at the expense of grain protein if the nitrogen demands of the crop are not adequately met, especially in continuous cropping systems. Apart from grade discounts on delivery, low protein grain can also be indicative that significant yield potential has not been achieved. Limited research assessing effects of nitrogen rate and timing in the HRZ has examined the interaction with variety choice including winter and milling wheat. This trial aims to investigate variety specific responses to applied N.

Method

The trial was set up with two variables; variety and nitrogen rate. The varieties chosen were Trojan, Derrimut, Beaufort, Revenue and Bolac. The nitrogen rates ranged from 0 rising to 300 kg N/ha in 50-100 kg increments at GS30. All nitrogen treatments were single applications, bar one which had a split of 150 kg N/ha at GS30 and the same rate at GS32. For ease of interpreting N rate responses, the split application was not always included in the data presented in this report. The starting soil nitrogen as nitrate (NO3-) and ammonium (NH44) was measured in 30 cm increments in the top 90 cm, and the results are shown in Figure 1.

The nitrogen was applied by a hand spinner in the form of urea as each variety matured to the appropriate growth stage. Application dates are shown in Table 1.

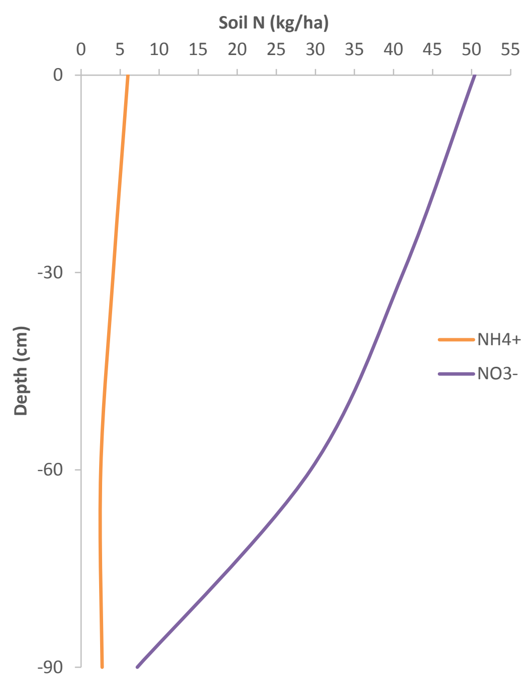

Figure 1. Initial soil nitrogen at Westmere, July 2014.

Table 1. Application dates of nitrogen for milestone growth stages

Variety (grade)	GS30 application	GS32 application (split treatments only)
Trojan (APW)	15 July	14 August
Derrimut (AH)	15 July	14 August
Beaufort (feed)	5 August	14 August
Revenue (feed)	28 August	16 September
Bolac (AH)	5 August	28 August

All weeds, disease and pest insects were controlled as per the district standard. Each occurrence was dealt with in a timely manner and was not thought to have affected the results of the trial.

Discussion

Nitrogen rate

Grain yield at all rates of nitrogen was increased over the control (no nitrogen). Yield was maximised at 100 kg N/ha but this was not statistically different from an application of 50 kg N/ha. Grain protein increased incrementally at all rates of nitrogen. Despite limited rainfall to finish the season, wheat yield followed the 11% protein 'rule of thumb' with yield maximised at 100 kg N/ha but protein continued to increase with further N applications.

Variety

Beaufort and Trojan were statistically the highest yielding varieties and Bolac was significantly lower yielding, which probably contributed to the highest mean protein concentration of that variety. With a 8 May sowing date, not all varieties were sown within their ideal sowing window, the obvious one being Revenue. Bolac, while not sown late was affected by the harsh spring, this appeared to favour the likes of Trojan and Derrimut which otherwise may have been marginally early at this sowing date. Environmental conditions at the time of application may vary greatly, as the varieties reached key growth stages over a spread of six weeks (Table 1). The applications on 5 August and 14 August in particular had very little or no rainfall in the following days. Despite the dry spring and high nitrogen rates applied, screenings were relatively low and did not differ significantly between varieties.

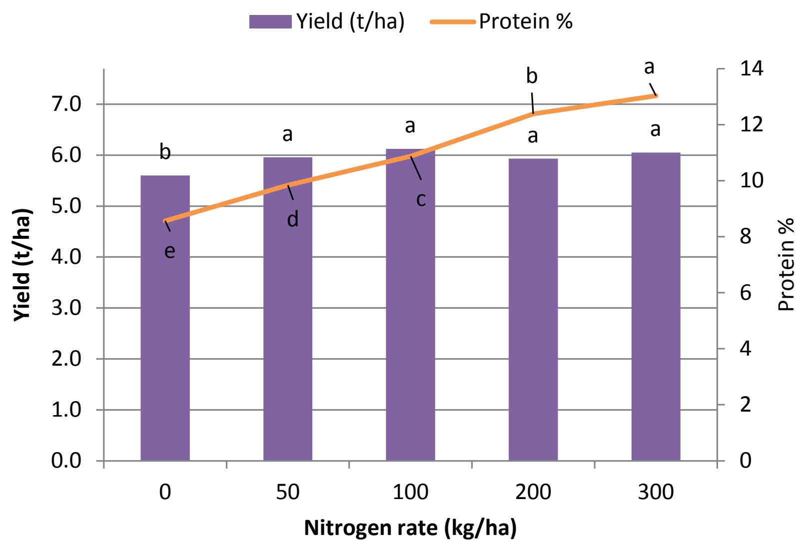

Figure 2. Effect of N rate (kg N/ha) on grain yield and protein averaged across five varieties. Means followed by the same letter do not significantly differ, Yield: p=0.009, LSD (p=0.05) = 0.25, Protein: p<0.001, LSD (p=0.05) = 0.46.

Table 2. Effect of variety on grain yield and quality averaged across all N rates.

Variety	Yield (t/ha)		Test weight (hL/kg)		Protein %		Screenings %		Grade
Trojan	6.12	ab	76.3	a	11.1	b	2.9	a	APW1
Derrimut	5.92	b	74.5	ab	11.3	b	3.0	a	AGP1
Beaufort	6.35	a	72.8	b	11.1	b	3.8	a	FED1
Revenue	5.87	b	73.8	b	10.7	c	3.3	a	FED1
Bolac	5.37	c	75.9	a	11.7	a	3.0	a	AUH2
***p*-value**	**<0.001**		**0.007**		**<0.001**		**NS**		
LSD (*p*=0.05)	**0.345**		**1.78**		**0.34**		**0.7**		

Means followed by the same letter do not significantly differ (p=0.05).

Variety yield response to N rate

As previously mentioned, yield was limited by lack of moisture to a maximum of approximately 6.5 t/ha (Beaufort). With a reasonably large amount of starting soil N (88 kg N/ha), yield trended to increase across all varieties best, to somewhere between 50 and 100 kg/ha of applied N. Figure 3 is a graph outlining the responses.

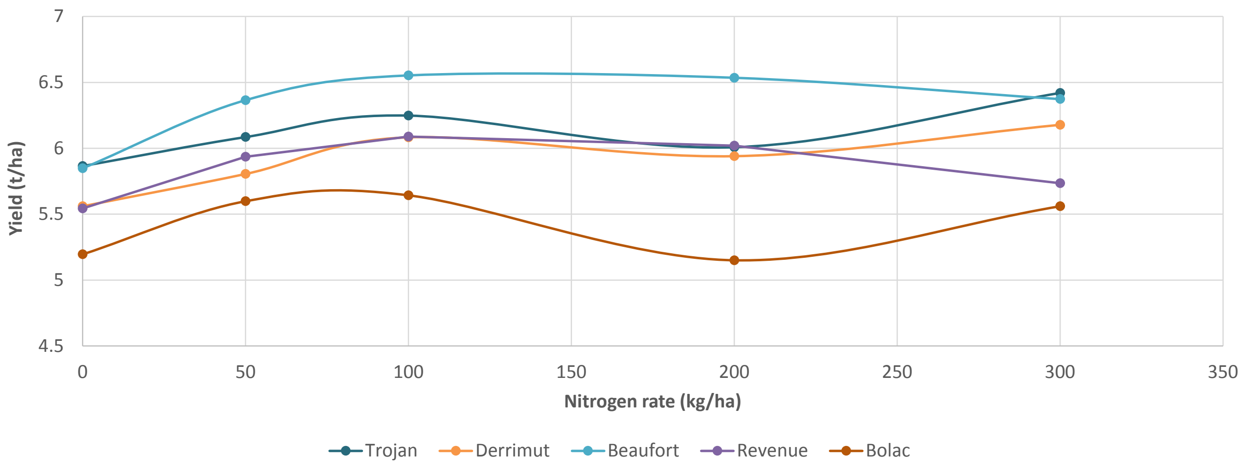

Figure 3. Effect of N rate and variety on yield. *p*<0.001, LSD (*p*=0.05) = 0.63.

Variety grain protein response to N rate

Varietal response was fairly similar overall, with incremental increases in protein with additional nitrogen fertiliser. The red wheat varieties of Beaufort and Revenue had an almost a linear response to N, while all three milling varieties (Bolac, Derrimut and Trojan) flattened off above 200 kg N/ha. Bolac achieved significantly higher grain protein at higher rates of N, associated with significantly lower yield compared to other varieties. Bolac managed to have the protein required in the higher applied rates for H1 classification of 13%. While 200 kg N/ha was required to attain AH quality protein levels in Bolac and Derrimut, extrapolation from Figure 4 indicates somewhere between 100 and 150 kg N/ha would have been sufficient. Trojan is currently a white variety and rate of 100 kg N/ha or more allowed and over allowed the protein required for APW1 of 10.5%. Trojan tended to maintain a test weight of around 76 kg/hL. Both Derrimut and Bolac would have been downgraded to APW1 at the 100 kg N/ha rate and below. All three milling varieties would have only achieved ASW with 50 kg N/ha.

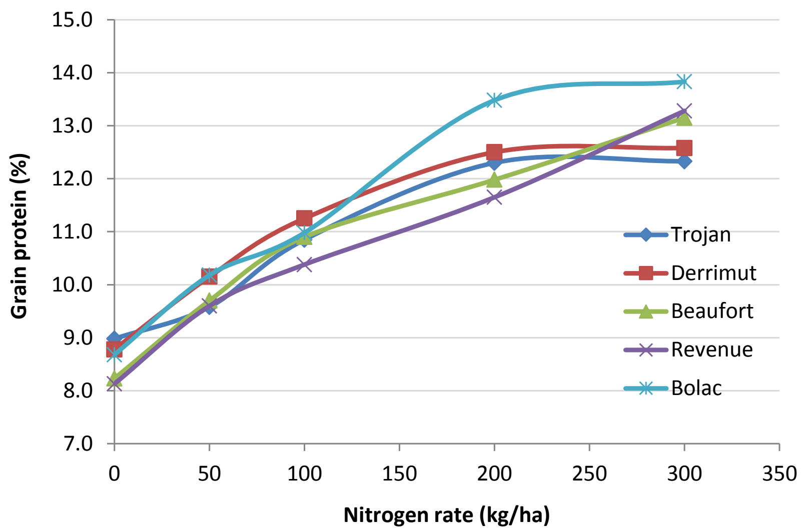

Figure 4. Effect of N rate and variety on grain protein. *p*<0.001, LSD (*p*=0.05) = 0.64. Note. The figures shown take into account the costs associated with a nitrogen application scenario only. They are not true gross margins. Each variety was treated in an identical manner, so it is thought that the figures are relevant.

Financials

Table 3 illustrates the financial positives and negatives in 2014 in response to N rate. In all cases but one, the 50 kg N/ha rate allowed for the greatest gain. Losses were evident for any application of 200 kg N/ha and beyond, for any variety. This means that the cost of urea and application outweighed any financial gains made. Unlike the others, Derrimut recorded a larger gain at 100 kg N/ha, than at the lower rates. Beaufort and Trojan did not show any difference between the 50 and 100 kg N/ha rates, however it would be assumed that a lower input option would be more viable. Beaufort as a whole appeared to be the less risky choice, trending the least losses, even towards the highest rate.

Table 3. Basic financial outcomes for varieties based on N regime costs only (urea price $450/t).

N rate (kg/ha)	Profit/loss when compared to nil nitrogen*				
	Trojan	Derrimut	Beaufort	Revenue	Bolac
0 (no N costs)	$1,754	$1,596	$1,515	$1,436	$1,504
50	+$5	+$9	+$73	+$41	+$56
100	+$5	+$40	+$73	+$31	+$20
200	-$165	-$99	-$30	-$84	-$221
300	-$140	-$128	-$170	-$256	-$200
150+150	-$257	-$198	-$164	-$226	-$346

Recovery of nitrogen in grain and soil

Grain N recovery (GNR) is a synthesised figure to indicate how much nitrogen was removed at harvest, and is calculated in wheat as follows; GNR (kg N/ha) = yield (t/ha) x protein (%) x 1.75. This calculation has shown an incremental response to N rate, in a predictable manner. N recovery with no nitrogen applied was 84 kg N/ha and increased to 138 kg N/ha at the highest N rate (Figure 5). There were no significant varietal differences in grain N recovery in response to increasing N rate.

Mineral soil N recovered post-harvest in late January from profile sampling of Beaufort plots in increments of 0-30 cm, 30-60 cm and 60-80 cm are shown in Figure 6. The majority (approximately 80%) of mineral soil N recovered post-harvest was detected in the top 30 cm. Further mineralisation following Dec/Jan rainfall could have contributed to a total of 44 kg N/ha recovered where no nitrogen was applied. Total soil mineral N recovered at 50, 100, 200 and 300 kg N/ha of applied N over and above the control (0 N) were 3, 29, 52, and 93 kg N/ha respectively. A negligible amount of nitrogen was left in the profile at 50 kg N/ha. Given that the 0 and 50 kg N/ha rates were not significantly different from each other in remaining N in the top 30 cm, thought needs to be given to the idea that some of the N accounted for in soil testing is perhaps not available to be used by the plant. This is supported by the limited grain yield and protein to the 0 kg N/ha treatment that was discussed earlier.

The fact that there is only a small amount of N remaining at depth, suggests that there has been little leaching of N into other areas of the profile that is not accessible. Dry spring conditions would have greatly reduced potential for denitrification losses of N. Fertiliser nitrogen immobilised ('tied-up') in microbial and plant organic forms has not be accounted for and can become available to future crops.

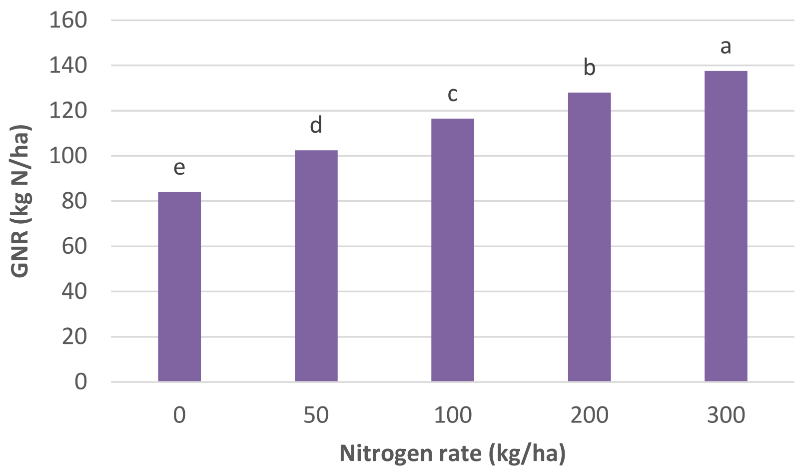

Figure 5. Grain N Recovery at the differing N rates, averaged across all varieties. $p<0.001$, LSD (p=0.05) = 7.6.

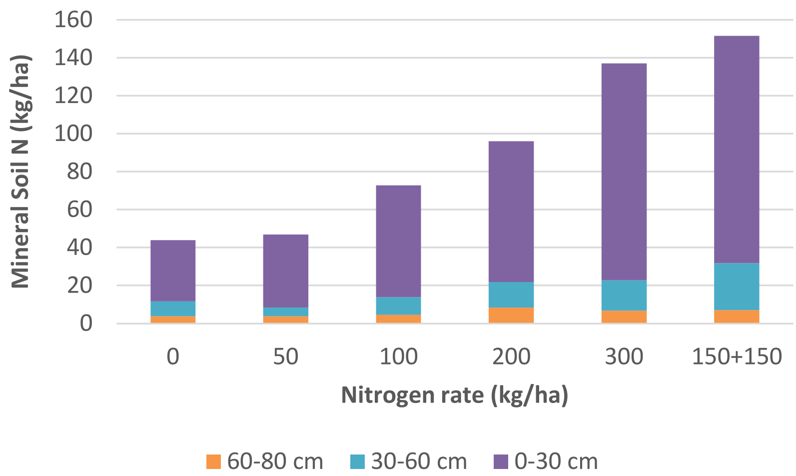

Figure 6. Mineral N at three separate soil segments taken post-harvest on 29 Jan 2015. 0-30 cm: p=0.0032, LSD (p=0.05) = 9.2, 30-60 cm: p =0.0177, LSD (p=0.05) = 2.2, 60-80 cm: p=0.008, LSD (p=0.05) = 0.5. N.B. Soil tests were performed on Beaufort plots only and varietal comments are not able to be made.

Figure 7. The trial early in the season prior to N application, showing varietal differences.

Conclusion

When chasing yield, the higher rates were not beneficial in 2014. In 2013, feed wheats in the HRZ returned high yields (between 8 and 9 t/ha) with 250-300 kg/ha rates of N and a grain protein of around 12%. It would be safe to say that it did not pay off this year, however careful decisions based on the season are required to get the most out of the dollar spent.

In 2014, while variety choice had a significant influence on final yield and grain protein level, a relatively flat yield response up to 50 kg N/ha and incremental grain protein response to increasing N applied was mirrored by all varieties. Variety specific N requirements related mainly to achieving targeted grades and the relative risk: reward from additional fertiliser applied. How these varieties would respond to N management in a higher yield situation with optimal time of sowing should be the focus of future research. SFS and IPL will be looking to develop a nitrogen response curve for both yield and protein for different varieties over many seasons to come.

Interestingly, while rates of 200-300 kg N/ha were clearly excessive given the limited GSR and yield potential, increasing grain protein levels were associated with minimal screenings, indicating the crop did not hay off. This reinforces the value of knowing your starting soil nitrogen levels and, if adequate, delaying topdressing until the reproductive phase. Post-harvest soil N recovery accounted for a significant portion of the nitrogen not recovered in grain. In the absence of fertiliser application, it would be interesting to examine how much nitrogen was recovered in the subsequent crop.

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