Nitrogen Management: do barley varieties respond differently to Nitrogen?

Claire Browne[1] and Linda Walters[1]

[1] Birchip Cropping Group, Box 85 Birchip, VIC 3483, claire@bcg.org.au

Abstract
In the Victorian Wimmera and Mallee many different barley varieties are grown in an attempt to meet malting markets. The use of in-crop nitrogen (N) is always at the forefront of grower's minds to ensure that malt specifications are met and that there is at least a 2:1 return on the investment of N. An experiment was set up in 2013 at Nhill in the West Wimmera of Victoria, on a low N site, to determine if new and existing barley varieties respond differently to varied N rates applied at sowing and in-crop. Barley varieties have different growth habits, which potentially impacts the way they respond to N. New Varieties are always being released and there is very little understanding about how these varieties should be managed.

In the trial, highest yielding varieties were Commander, La Trobe and Hindmarsh. Despite the varying rates of N applied, in a year with a wetter than average growing season rainfall, all barley varieties had a similar yield response to N. The greatest profitability in 2013 was achieved with 120kg N/ha applied to barley at Nhill. Even though barley varieties differ in their growth habit, none of the varieties responded differently to each other in terms of yield, test weight, screenings and retention.

Key words
Barley varieties, nitrogen response, interaction, nitrogen, management, barley agronomy

Introduction
This trial was conducted in 2013 as part of the state tri-funded GRDC barley agronomy project, determining whether new and current barley varieties respond differently to nitrogen (N). A variety that is more 'nitrogen' efficient than another, can achieve a greater yield on the same N supply (assuming everything else is equal). Varieties differ in their sensitivity to management practices consequently not all barley varieties can be treated as equal and in some circumstances should be managed differently.

Hindmarsh and La Trobe both have a semi-dwarf gene which causes an erect leaf habit and slower early growth.. Nitrogen responsive varieties such as Hindmarsh benefit from earlier applications of N. (Porker. K, 2014). This paper investigates whether barley varieties respond differently to N applications and whether growers should be implementing N management packages tailored to each variety to ensure they reach their full potential.

Methods
The trial was established at Nhill in the western Wimmera region of Victoria on a Wimmera grey, cracking clay. Rainfall distribution is Mediterranean and the site received 339mm (decile 8) of growing season rainfall. The pre-sowing mineral N status of the trial site was very low at 28kg N/ha to 100cm (nitrate and ammonium nitrogen) after being sown to oaten hay the previous year. The trial was sown on 23 April 2013 at a target plant density of 130 plants/m^2. Varieties sown included Hindmarsh, Skipper, Westminster, Scope CL, La Trobe, GrangeR, Commander and Flinders. All N treatments were applied as urea (46% N) and broadcast using a hand held garden spreader prior to planting and incorporated into the soil by the seeder (Table 1). Though the site received 15mm of rainfall two days prior to sowing, topsoil conditions were marginal for emergence and despite moisture at depth, emergence did not occur until late May. The 120 and 240kg N/ha treatments received a second application of N at early tillering (GS15/21 on 11 July) (Table 1). All treatments received sufficient rainfall after each application to ensure N was washed into the soil. Waterlogging occurred during July and early August (all urea was applied before the water logging occurred), during which time accessibility to the site was limited. However, there was no known impact on plant growth or end yield across the waterlogged site. Measurements included emergence counts (GS23), NDVI (Normalised Difference Vegetative Index) at GS65 and GS85, head counts, yield and grain quality. Partial' gross income (yield t/ha x grain price – N cost) was determined after classifying individual plots as Malt or Feed, based

on quality parameters. Cash prices used were from Nhill GrainCorp; CO1 $211/t, HIND $206/t, F1 $285/t, F2 $172/t (taken on 27 November 2013) to establish returns. Prices were Plots were harvested with a Wintersteiger plot harvester and protein was measured using a Foss Infratec NIR whole grain analyser. Yields were corrected to 11.5% moisture. All other quality parameters (retention, test weight and screenings) were measured with standard procedures.

Table 1. Amount of nitrogen per treatments applied prior to sowing and at early tillering (GS15/21)

Treatment	Applied N (kg/ha)		Total N (kg N/ha)	Total Urea (kg/ha)
	Sowing (23/4/13)	Early tillering (11/7/13)		
A	0	0	0	0
B	30	0	30	65
C	60	0	60	130
D	90	30	120	260
E	120	120	240	522

Results

The low initial soil N status combined with above average growing season rainfall, meant the crop was responsive to N. The trial emerged on 29 May following rainfall on 23 May. Four weeks after sowing, plants in the high N plots (120 and 240kg N/ha), were at growth stage GS11-12, whereas plants in the low N plots were not as developed (GS05). Plant counts were also conducted at the mid tillering stage, showing that the low N plots had tillered less than the higher N plots, but there were no significant differences in plant numbers.

Was there a difference between nitrogen rates?

When applying higher rates of N, there were differences in yield, protein, test weight, retention and NDVI, but no differences in head counts and screenings (<7%). Assessments at GS65 showed NDVI increased as applied N increased. This was due to a greater amount of 'canopy greenness' and biomass production with increasing N rates. A similar trend was noted at GS85, but NDVI values were much lower as the crop was senescing (at grain filling stage).
As expected, applying a greater amount of N resulted in a higher yield (Table 2). The highest mean yield of 4.8t/ha was achieved at the highest rate of 240kg N/ha.

Table 2. Grain yield and quality with applied urea rates.

Total Nitrogen applied (kg N/ha)	Grain yield (t/ha)	Grain protein (%)	Test Weight (kg/hL)	NDVI GS65
0	1.7	10.8	60	0.44
30	2.4	9.9	61	0.58
60	3.2	9.7	64	0.69
90	4.1	10.6	67	0.79
240	4.8	12.8	69	0.85
lsd (P<0.05)	0.2	0.3	2	0.03

Figure 1 shows the relationship between yield and partial gross margin with increasing N rate. While the highest yield occurred at the 240kg N/ha rate, the greatest yield response was seen at the 120kg N/ha rate (as response starts to ease when applying a higher rate). Consequently, partial gross income was greatest also when applying 120kg N/ha. This indicates, that aside from the highest yield being achieved at the 240kg N/ha rate, it was more profitable to apply 120kg N/ha (highest partial gross margin) as there was not sufficient yield benefit to warrant adding extra N.

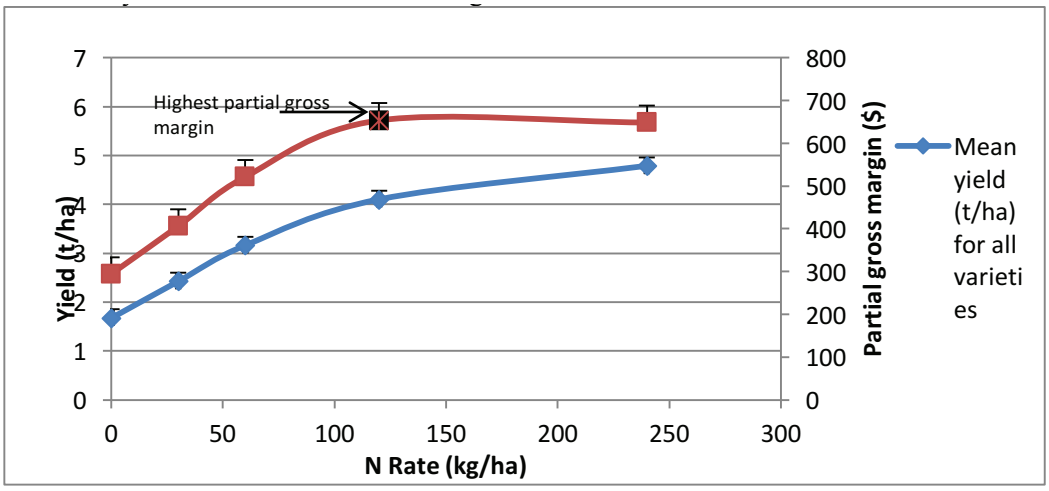

Figure: 1 Relationship between Yield (t/ha) and partial gross margin ($) when applying N
(Significant difference, Rate (Yield) P<.001 LSD=0.18 CV%11.2, Rate (partial gross margin) P<0.001 LSD=39.7 CV%15.9)

Did varieties respond differently?
Despite there being a positive response to applied N, no variety responded significantly differently from another in terms of yield, test weight, screenings and retention. For example, when applying 60kg N/ha to Hindmarsh, the response in yield was similar for all varieties at that rate. There were significant interactions in protein content between varieties and N rate. Among the malting varieties, GrangeR at 60kg N/ha had higher protein (9.4%) than Commander (8.2%), which inheritantly has a lower protein, similar to Gairdner (Table 3). Economic comparisons between varieties showed the partial gross margin of each variety increased with higher rates of N (Table 3). The most profitable rate of N across most varieties was achieved at the 120kg N/ha rate (260kg/ha urea).

Table 3. Summary of varieties x N rate for yield and grain quality, 'partial' gross margin and return on investment ($). Bolded values indicate the highest gross margin value. Note: the cost of N was the only cost incurred in this partial gross margin.

Variety	N Rate (kg N/ha)	Yield (t/ha)	Protein (%)	Test weight (kg/hL)	Income ($/ha)	Cost of Urea ($/ha)	Partial gross margin ($/ha)
Hindmarsh (Food)	0	2.0	10.3	60.9	342	0	348
	30	2.5	9.5	64.6	474	34	444
	60	3.4	9.5	65.5	658	68	591
	120	**4.6**	**10.7**	**69.1**	**952**	**136**	**818**
	240	5.1	13	69.8	1015	271	745
Skipper (Feed)	0	1.8	10.7	59.3	322	0	323
	30	2.5	9.8	60.8	438	34	403
	60	3.3	9.9	64.6	595	68	525
	120	**4.1**	**10.6**	**65.9**	**767**	**136**	**630**
	240	4.7	13	66.5	871	271	597
Westminster (Feed)	0	1.5	10.2	65.2	272	0	272
	30	1.9	11	58.2	341	34	306
	60	2.5	10.7	60.4	439	68	371
	120	3.2	11.5	62.9	572	136	435
	240	**4.3**	**12.6**	**69.3**	**796**	**271**	**523**
Scope CL (Malt)	0	1.6	11.3	58.1	288	0	288
	30	2.6	10.3	58.5	460	34	426
	60	3.0	10	61.6	553	68	481
	120	**3.9**	**10.6**	**64.6**	**743**	**136**	**607**
	240	4.5	12.6	64.9	841	271	569
La Trobe (Feed)*	0	1.9	10.1	58.8	331	0	331
	30	2.7	9	63.2	490	34	453
	60	3.6	9.1	67.1	666	68	597
	120	4.4	9.6	68.7	819	136	680
	240	**5.7**	**12.1**	**69.6**	**1047**	**271**	**774**

GrangeR (Malt)	0	1.5	11.1	58.2	266	0	265
	30	2.4	9.8	56.6	437	34	403
	60	3.2	9.4	61.4	559	68	489
	120	4.0	11	65.6	738	136	600
	240	**4.6**	**13.7**	**68.3**	**906**	**271**	**639**
Commander (Malt)	0	1.7	10.3	56.9	306	0	305
	30	2.8	8.8	61	509	34	475
	60	3.8	8.2	66.1	774	68	704
	120	**4.7**	**9.4**	**68.5**	**985**	**136**	**849**
	240	5.1	12	69.8	1078	271	805
Flinders (Feed)	0	1.2	12.1	58.9	222	0	223
	30	2.1	11.3	61.1	375	34	340
	60	2.7	10.8	63.0	486	68	417
	120	**4.1**	**11.5**	**68.6**	**753**	**136**	**615**
	240	4.4	13.4	69.9	816	271	542
Lsd (P<0.05)		0.2	0.42	2.32			
Variety							
Nitrogen		0.2	0.3	1.8			
Variety x Nitrogen		NS	0.9	NS			

Note: **Prices for malt, were based on Commander price only, as no prices for GrangeR and Scope CL were available at the time. All feed varieties listed are undergoing malt accreditation.
*At the time of writing this article La Trobe was a feed variety, it has since been classified as Malt.

Conclusion

In 2013, all varieties had a similar yield response to the application of different N rates. High N input costs can be potentially risky, particularly in the event of a dry finish to the season. Fortunately, due to the exceptional amount of growing season rainfall experienced at Nhill, this was not the case and yields were greatest when applying high N rates. Corresponding to this, higher N rates were also the most profitable, with the best rate of N to apply being 120kg N/ha to achieve the highest gross margin. Each variety (except Commander), achieved adequate N to achieve Malt at the lower rates of N (0, 30 and 60kg N/ha rates). When the highest rate of N (240kg N/ha) was applied, the maximum protein level for Malt (12%) was exceeded when the yield potential was met. In a high rainfall and high yielding area, Commander, La Trobe and Hindmarsh achieved the greatest yields and were the most profitable. The choice between growing Hindmarsh and La Trobe or Commander, largely comes down to the price differential between Malt and Food/Feed barley. With this in mind, select a barley variety that is best suited to your farm (in terms of soil type, rotational history, rainfall, environment and market availability). Given the variability in seasons, gaining a better understanding of soil N prior to sowing, the amount of N required to achieve maximum yield potential and timing of N applications, will contribute to better crop management and increased yields and profit.

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References

Fettell. N et al, (2010), NSW Government Industry and Investment, Barley growth and development

Government of Western Australia Department of Agriculture and Food, Barley nutrition, 2007, http://www.agric.wa.gov.au/PC_92013.html, accessed 10 January 2013.

Ruffing. B J et al, (1980) Communication in soil science and plant analysis, Nitrogen management for malting barley, Volume 11, Issue 9.

Porker, K. & Wheeler, R. (2014) Getting the best from barley; agronomy and management, GRDC Update Papers. https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/Getting-the-best-from-barley-agronomy-and-management (accessed10 June 2015).