

# Getting N management right to meet malting specifications for barley

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## Abstract

The ability to achieve malt, when a suitable variety has been selected, can result in significant financial advantages. Nitrogen (N) management of malting barley can be a large determinant of the capacity to achieve both higher yields and grain quality that meets malting specifications. In 2011 three trials were conducted across the northern grains region of NSW to determine the effect of N rates and timing on grain yield and malting specification of two main malt varieties -Gairdner and Commander. Yield responses to applied N were variable. In 2011 only 1 out of 3 sites showed a significant yield response to applied N. At all sites Gairdner had higher protein concentrations, higher screenings and lower retentions compared to Commander, with differences being exacerbated at higher levels of N nutrition. As levels of N nutrition increased, Commander had greater stability in terms of grain quality. Delaying of N application resulted in similar improvements in grain quality over N application at sowing. The results suggested that Gairdner would be more suited to paddocks with low soil residual N, whereas Commander will be more likely to achieve malt specifications from paddocks with higher residual soil N.

## Key Words

Barley, Commander, Gairdner, Grain protein concentration, retention, test weight

## Introduction

The ability to achieve malt, when a suitable variety has been selected, can result in significant financial advantages. Nitrogen (N) management of malting barley can be a large determinant of the capacity to achieve both higher grain yields and grain quality that meets malting specifications. To meet the malt specifications growers should target proteins of 10.5 – 12% to achieve maximum yield. As the rate of N supply is increased, yield will generally increase to a maximum level, whereas protein may continue to increase with further N application (Weston *et al.* 1993). Drier or wetter than expected seasonal conditions can significantly change yield potential mid season, which consequently changes N requirements to meet target protein contents. Therefore, the flexibility of delaying N application to in-crop timings can be a risk management strategy for growers to adapt to changing seasonal conditions. When considering in-crop N applications it is critical to know what soil N levels are available at the start of the season. Many paddocks may have high starting soil N levels well in excess of what is required to achieve realistic target yields and maintaining proteins suitable for the production of malting barley. Previous studies have demonstrated large variations in genotype responses to different levels of N nutrition (Emebiri *et al.* 2003). Gairdner barley when it was first released was recognised as a low protein achiever, particularly under favourable grain-filling conditions but had issues with small grain size for malting (Emebiri and Moody 2004). Many of the recently released malting lines, most notably Commander in the northern grains region of Australia, have shown improved capacity to meet malting specifications with low protein and suitable grain size (Emebiri *et al.* 2007). Three trials were conducted across the northern grains region of New South Wales to investigate the interaction between N application rates and timings on the capacity of the two main malt barley varieties, Gairdner and Commander, to meet the malt specifications.

## Methods

There were three N sites, located near Breeza (150°42'61"E, 31°1'8"S), Bithramere (150°83'68"E, 31°1'5"S) and Moree (150°05'58"E, 29°2'4"S) selected throughout the northern grains region of New South Wales. The soil types at Breeza, Bithramere and Moree was a Black Vertosol, Red Chromosol and Grey Vertosol, respectively (Isbell 1996). Basic soil nutrition for each site is presented in Table 1. Sowing occurred on the 29 June, 10 June and 19 May 2011 for Breeza, Bithramere and Moree, respectively, with all sites receiving 60 kg/ha of Granulock Starter Z (11 % N; 21.8 % P; 4 % S; 2 % Zn).

**Table 1. Mineral N (kg/ha) in the 0 – 120 cm depth interval and soil pH (CaCl<sub>2</sub>), Colwell Phosphorus (mg/kg), Sulfur (KCl 40 – mg/kg) and organic carbon (%) in the 0 – 30 cm depth interval prior to sowing.**

Site	Mineral N (0-120 cm)	Soil pH (0-30 cm)	Colwell P (0-30 cm)	Sulfur (0-30 cm)	Organic Carbon (0-30 cm)
Breeza	109	7.5	24	5.1	0.8
Bithramere	42	5.3	42	14.7	1.1
Moree	41	7.5	6	3.6	0.8

Two malting barley varieties - Commander and Gairdner, , were grown at plant populations of 60 and 120 plants/m<sup>2</sup> at all three trials sites. In each trial 4 rates of N were applied at sowing including 0, 20, 40 and 80 kg N/ha as granular urea (46 % N). Two additional N treatments were applied - 40 kg N/ha applied at growth stage 31 (GS31 - stem elongation) and a split application treatment where 20 kg N/ha was applied at sowing with a further 20 kg N/ha applied at GS31. The in-crop N was applied as 50% diluted liquid UAN, sprayed through streamer bars at 100 L/ha water rate. All trials had 4 replicates of each treatment combination and arranged in a complete randomised block design.

Dry matter cuts were taken at maturity to determine harvest index and yield components. Plots were harvested for grain yield and samples were analysed for grain protein, screenings, test weight and retention.

## Results

Growing season rainfall received was 488, 395 and 426 mm at Bithramere, Breeza and Moree, respectively, with a majority of rainfall coming during September, October and November.

Commander had significantly greater yields than Gairdner at Breeza and Moree (Table 2), while there was no difference between the varieties at Bithramere. Similarly, at Moree and Breeza increasing plant population from 60 to 120 plants/m<sup>2</sup> significantly increased yields by 0.15 and 0.50 t/ha, respectively (data not shown). Bithramere was the only site where a significant yield response to N rates was observed. The application of 20 or 40 kg N/ha resulted in similar grain yields as the control (0 kg N/ha) treatment. Applying 80 kg N/ha or a 20 + 20 split application resulted in similar yields that were greater than the control. The delayed application of 40 kg N/ha achieved the highest yields of 4.1 t/ha.

**Table 2: Grain yields (t/ha) for Commander and Gairdner at Bithramere, Breeza and Moree in 2011**

Location	Commander	Gairdner
Bithramere	3.65	3.71
Breeza**	5.74	4.50
Moree**	3.99	3.55

\*\* represents a significant ( $P<0.05$ ) variety response at trial site

Gairdner had significantly ( $P<0.05$ ) higher protein than Commander at the 40 and 80 kg N/ha, therefore giving a greater protein response to applied N at Bithramere (Table 3). Gairdner had on average 0.8 % more screenings than Commander across all N treatments (Table 3), but all treatments were below 5%, which is the maximum level for malt acceptance. The 80 kg N/ha treatment for Gairdner resulted in significantly ( $P<0.05$ ) higher screenings than all other treatments (Table 3). Retention for Gairdner was 4.5 to 9 % lower than Commander and significantly declined when N rates exceeded 40 kg N/ha compared to the control (Table 3). In comparison, retention for Commander was relative stable with 40 kg N/ha applied at GS31 being the only treatment that significantly reduced retention compared to the control but was still >90% (Table 3). In contrast to other grain quality parameters, the test weight for Gairdner was relatively stable across N treatments, whereas Commander had increasing test weights with increasing N rate (Table 3). The split application, in-crop N and 80 kg N/ha treatments slightly increased test weights for Gairdner compared to the control (Table 3). With each increase in N rate from 0 to 80 kg N/ha there was a significant increase in test weight for Commander (Table 3).

**Table 3. Effect of N rate, either applied at sowing (SB) or growth stage 31 (GS31), on protein, test weight, screenings and retention at Bithramere.**

N Treatment	Protein (%)		Test weight (kg/hL)		Screenings (%)		Retention (%)	
	Comm	Gair	Comm	Gair	Comm	Gair	Comm	Gair
0	11.2	11.0	62.9	64.3	1.1	1.8	96.0	90.7
20	11.7	11.4	63.6	64.3	1.2	2.1	95.4	90.7
40	11.2	11.8	64.5	64.5	1.4	2.1	95.1	89.3
80	12.1	13.4	66.2	65.1	1.5	3.2	94.3	85.6
20 SB:20 GS31	11.5	11.9	64.7	65.3	1.3	2.2	94.6	89.2
0 SB:40 GS31	11.8	12.0	65.3	65.6	1.5	2.4	93.3	88.9
Lsd ( $P = 0.05$ )	0.4		0.6		0.5		1.6	

The Breeza site had very high grain protein results (well in excess of malting requirements) and showed that Gairdner had significantly ( $P < 0.05$ ) greater protein than Commander for all N treatments including the control (table 4). Delaying all N until stem elongation for Gairdner resulted in the highest grain protein. Test weight for Commander was significantly ( $P < 0.05$ ) reduced when N application rate exceeded 20 kg N/ha, whereas, there was a significant increase in test weight with the application of N to Gairdner. Screenings for Gairdner were significantly ( $P < 0.05$ ) greater than Commander for all N treatments, but were exacerbated by higher N rates or delayed N application. Even at the 0 N rate, screenings were in excess of 5 %. Screenings for Commander also increased with increasing N rate, however, in contrast to Gairdner delaying all N until stem elongation did not significantly ( $P < 0.05$ ) increase screenings above the control. Similar to the Bithramere site retention for both Commander and Gairdner significantly ( $P < 0.05$ ) declined as N application increased above 40 kg N/ha. Retention for Commander was on average 24 % greater than Gairdner across all N rates.

**Table 4. Effect of N rate, either applied at sowing (SB) or growth stage 31 (GS31), on protein, test weight, screenings and retention at Breeza.**

N Treatment	Protein (%)		Test weight (kg/hL)		Screenings (%)		Retention (%)	
	Comm	Gair	Comm	Gair	Comm	Gair	Comm	Gair
0	13.7	15.5	64.0	64.4	3.3	6.8	91.2	68.0
20	14.1	15.8	63.6	64.7	3.5	6.6	90.5	68.0
40	13.7	16.4	63.4	64.6	4.1	7.5	89.6	65.6
80	14.6	16.6	63.1	64.8	4.6	7.3	87.5	65.1
20 SB:20 GS31	14.5	16.5	63.6	64.9	4.2	7.9	87.9	65.4
0 SB:40 GS31	14.3	17.0	63.4	64.8	3.3	7.9	88.6	65.3
Lsd ( $P = 0.05$ )	0.5		0.3		0.6		2.1	

Like Breeza grain proteins at Moree for both varieties were well above the requirements for malt specification and Gairdner was approximately 2 % higher than Commander (Table 5). Grain protein significantly increased for both varieties when N rates exceeded 20 kg N/ha. At Moree the delayed or split application of N did not result in a significant increase in protein compared to the upfront option. Test weight for Gairdner (71 kg/hL) was unaffected by N rate, however, delaying N significantly reduced test weight compared to the control treatment. In contrast, test weight for Commander slightly increased at the 20 and 40 kg N/ha rates compared to the control. Screenings were very low at Moree and weren't significantly influenced by N rates. Similarly, retention for Commander was also unaffected by N application. Gairdner had comparable retentions to Commander at Moree, however, there were significant declines with each increase in N rate.

**Table 3. Effect of N rate, either applied at sowing (SB) or growth stage 31 (GS31), on protein, test weight, screenings and retention at Moree.**

N Treatment	Protein (%)		Test weight (kg/hL)		Screenings (%)		Retention (%)	
	Comm	Gair	Comm	Gair	Comm	Gair	Comm	Gair
0	14.2	16.3	69.2	71.0	1.2	1.1	96.8	96.4
20	14.4	16.6	70.1	70.8	1.1	0.9	96.9	95.7
40	15.1	16.8	69.8	70.6	1.1	1.2	96.8	95.2
80	15.7	17.6	69.5	70.5	1.2	1.1	96.7	94.8
20 SB:20 GS31	15.0	17.1	69.8	70.1	1.4	1.3	96.5	95.1
0 SB:40 GS31	14.8	16.5	69.5	70.4	1.2	1.0	96.6	95.9
Lsd ( $P = 0.05$ )	0.4		0.5		-		0.4	

## Discussion

Yield responses to N applications across the 3 sites was minimal with Bithramere being the only site showing a significant yield response to applied N. There were existing high levels of available N (109 kg N/ha) at the Breeza site, which would have limited the expression of any N responses. Although existing available N at Moree was similar to the starting available N at Bithramere there was still a lack of N response. It was postulated that either P (6 mg/kg) or S (3.6 mg/kg) may have been limiting despite fertiliser applications at sowing, which potentially limited the expression of the N response. Despite the limited yield responses observed in the trials the key findings of the study was how N nutrition can influence grain quality parameters and the chances of achieving malt quality grain and the impact that varietal choice can have.

At all 3 sites and for both varieties protein was shown to significantly increase with N rate, particularly N rates beyond 40 kg N/ha. Grain protein concentration has been previously described to linearly increase with increasing N rate with little to no genotype  $\times$  N interaction (Emebiri *et al.* 2004). The same linear relationship does not exist between grain yield and N application, which was also supported by this study. The other consistent finding was that Commander generally achieved lower protein than Gairdner, particularly when protein levels exceeded 12 %. Breeding programs are now targeting and releasing germplasm with inherently lower grain protein concentration (Emebiri *et al.* 2003), which may explain why Commander has achieved lower protein levels in this study compared to Gairdner that was released 8 years prior. Generally, the interaction between N nutrition and test weight was relatively minor with differences within 1-2 kg/hL. However, at Bithramere test weights for Commander increased by 3.4 kg/hL between 0 and 80 kg applied N/ha, which was the difference between meeting the minimum test weight requirement for malt specification. It is unclear why there was an increase in test weight in this instance but it was not repeated in Gairdner or at other sites. Commander generally had a higher retention and lower screenings than Gairdner. Furthermore the retention and screenings for Commander were less responsive to increasing N nutrition compared to retentions for Gairdner, which declined sharply as N application increased. Emebiri and Moody (2004) reported similar findings with Gairdner under higher N nutrition.

## Conclusion

Overall, Gairdner had higher protein, screenings and lower retentions than Commander and these characteristics were more responsive to N treatments. Delaying N application resulted in similar or improved in grain quality over the up front application. Based on these results Commander barley is more likely to achieve malt quality specifications than Gairdner when grown under a higher level of N nutrition. However, it is critical to note that Commander is a variety that is very susceptible to lodging and a high level of N nutrition, especially at sowing, may exacerbate this issue. Commander has also demonstrated an ability to maintain lower grain protein levels compared to the Gairdner, the main malting variety. Based on the results it may be concluded that Gairdner would be more suited to paddocks with low soil residual N, whereas Commander will be more likely to achieve malt specifications from paddocks with higher residual soil N but lodging management must be considered in these situations.

## Acknowledgements

This project is funded by NSW DPI and GRDC under the Northern Barley Agronomy Project (DAN00131). Thanks to Gavin Hombsch, "Hyland" Bithramere, and Hugh Ball, "Oodnadatta" Moree, for providing the trial sites. The technical assistance provided by Stephen Morphett, Jim Perfrement, Patrick Mortell, Alan Bowring, Jan Hoskings, Rod Bambach and Bruce Haigh are gratefully acknowledged.

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