Barley agronomy – maximising yield potential and quality

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Take home messages:

- In the 2012 season, barley variety and nitrogen rate had a greater impact on yield and grain quality than plant population
- There was no significant increase in grain yield from increasing the N rate beyond a 5t/ha yield potential in this season. Any additional applications did not increase the yield enough to justify the cost of the fertiliser.
- All varieties displayed significant positive responses to the increasing rates of N
- The 62 kg N/ha rate (for 5t/ha crop) gave us the maximum grain yield return.
- Optimum plant populations for grain yield were 200plants/m2. In 2012 although increasing plant densities tended to reduce grain quality but they still made malting quality.

Background

As part of a continued GRDC funded project, 'Southern Barley Agronomy', SFS is investigating the effect of specific agronomic management practices on new and existing varieties'.

Understanding varietal differences, in terms of their performance components, is key to successful barley agronomy. This report aims to investigate how to maximise optimal performance through understanding responses to different agronomic practices.

Aim

Different nitrogen rates and plant populations that will be examined across different varieties to see what is best management to maximise yield without compromising end market objectives.

The intention is to observe how such treatments affect yield and grain quality at low, medium and high levels.

Method

Treatment variables were variety, plant population and nitrogen rates.

Five varieties were selected to reflect different market options aswell as yield and quality potentials. These were Grange and Westminster (new varieties awaiting malt accreditation), Hindmarsh (feed), Commander and Gairdner (malt).

Three plant populations with target establishment 100, 200 and 300pl/m2 were sown. Typical plant population for barley 180plants/m2, equivalent to the middle sowing rate.

The final treatment variable was the rate of nitrogen applied, with three rates calculated based on yield potential (see Table 1 below). This was done by taking account of the nitrogen in the soil profile down to 50cm and what was present in the crop. This value of available nitrogen was then subtracted off what N was required per tonne of yield (using industry standards) to give us the amount required to be top dress fertilised. These calculations do not take account of any N that may become available from the mineralisable pool within the soil and thus is just a guide. Future N budgeting will aim to measure this potential mineralisable N.

Table 1. N requirements based on yield potential using N budget technique. Crop N is based on an average plant sward of approx. 1000 shoots plant pop on 25th August 2012, GS25-30.

		Deep N available					
Target yield potential (t/ha)	**N requirement (target x 30N/t)**	**NO3-N (kg/ha)**	**NH4-N (kg/ha)**	**Total Deep N (kg/ha)**	**Crop N (kg/ha)**	**Adjusted N required**	**Actual applied, Urea kg/ha**
3	90					2.2	0
5	150	51.7	6.1	57.8	30	62.2	135
7	210					122.2	266

For a target yield of 3, 5 and 7t/ha the amount of urea required at growth stage 31 was calculated to be 0, 135 and 266 kg/ha, respectively.

Results & Discussion

In the 2012 season, barley variety and nitrogen rate had a greater impact on yield and grain quality than plant population

Table 1 below illustrates the grain yield and protein response of 5 different varieties to management for 3 different target yields (N rates).

There was a trend for an increase in yield from targeting a 3t/ha yield to a 5t/ha, however this was only significant for Hindmarsh which increased performance by 1t/ha. The suggestion is that as N increased, although there was an initial increase in yield, it tapered off the greater the N rate became. This suggests that in this trial N was not limiting and that N supply exceeded the rate required for maximum yield.

N wasn't the limiting factor that set the yield ceiling. Due to the drier than average spring in 2012 it was more likely that plant available water was the limiting factor. In a water-limiting situation such as a dry finish to a season, yields will plateau earlier and proteins will be high.

Table 1. Varietal performance (yield & protein) at different rates of N applied at GS31.

Variety	Target yield potential (t/ha)	N rate (kg N/ha) - Top Dressed	Yield (t/ha)	Protein (%)	Grade
Westminster	3	0	6.87	9.25	Malt
	5	62	7.16	11.02	Malt
	7	122	7.01	12.46	Feed
Commander	3	0	7.12	9.48	Malt
	5	62	7.21	11.03	Malt
	7	122	7.36	12.19	Feed
Gairdner	3	0	6.81	9.03	Malt
	5	62	7.07	11.27	Malt
	7	122	6.78	12.63	Feed
Hindmarsh	3	0	6.40	10.14	Feed
	5	62	7.40	11.68	Feed
	7	122	7.38	12.79	Feed
Grange	3	0	7.51	9.25	Malt
	5	63	7.66	10.48	Malt
	7	122	7.57	12.50	Feed
		LSD (P=<0.05)			
		Variety	0.43	0.26	
		N-rate	0.14	0.22	
		Var x N	0.32	0.50	
		CV %	6.50	5.60	

It can be seen from observing the LSD figures in Table 1 that nitrogen certainly affected grain protein more than variety. All varieties displayed significant positive responses to the increasing rates of N (graph 1), with Hindmarsh displaying significantly higher protein values than the other four varieties.
Nil N rates produced significantly lower protein than an N rate for 5t/ha, however this rate still achieved malt grade. The N rate for 7t/ha pushed protein above 12%, thus meaning it was unsuitable for malting. It is suspected that because there was no dilution effect from a higher quantity of grain this is why we saw grain protein increase with N rates. Nitrogen supply exceeded the rate required for maximum yield.

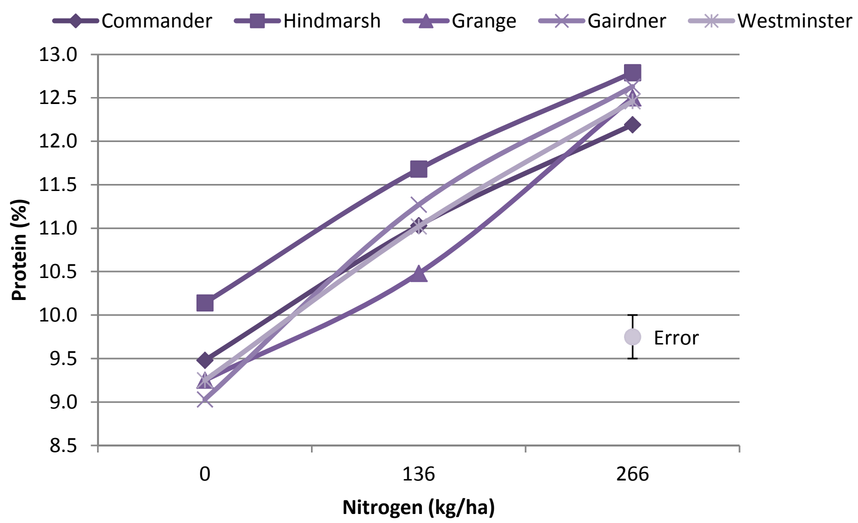

Figure 1. Protein response in the grain to increasing nitrogen rates.

Table 2 shows the results of grain yield and quality observations, based on N rates alone.
Increasing the nitrogen rate from nil to the N rate for a 5t/ha crop significantly increased the yield by over a third of a tonne. However, when the N rate was increased further for a yield potential of a 7t/ha crop, in this trial in this season that did not significantly increase yield. It did, however significantly increase the protein content above the maximum limit of 12%. This would have meant a downgrade at receival, for some varieties, into the Feed bin.

Table 2 Nitrogen rates – a comparison of costs and gross margin based on mean grain yield and quality.

Target yield potential (t/ha)	N rate (kg N/ha) - Top Dressed	Cost of N ($/ha)	Yield (t/ha)	Protein (%)	Grade	Gross Income (S/ha)	Partial gross margin ($/ha)
3	0	0	6.94	9.43	Malt	1943	1943
5	62	82.17	7.30	11.09	Malt	2044	1961
7	122	159.13	7.22	12.52	Feed	1949	1790
		LSD (P=<0.05)	0.14	0.22			
		CV %	6.50	5.60			

Grain prices were taken on 1.1.13 from SQP, Geelong Port Malt 1 $280/t, Feed 1 $270/t
Fertiliser N price based on urea cost of $600/t August 2012

The table also allows us to assess the economics of varying N rates based on target yield potential.
The optimum N rate for grain yield in this trial was the N required for a 5t/ha crop (62kgN/ha). This gave the maximum financial return of $1961.

This optimum N rate is dependent on the price of grain relative to the price of fertiliser – the breakeven ratio. The break even ratio used in Table 2 is calculated by dividing the cost of the nutrient by the crop value. Based on a u price of $600/tonne and a malt grain price of $280/tonne the break even ratio in this trial was 4.64:1. That means 4.64kg of grain is required to pay for 1kg of N fertiliser.

At N rates below this optimum, increasing the N rate by 1kg/ha will increase grain yield by more than 4.64kg/ha so it is economically worth applying more N. At N rates above the optimum, increasing the N rate by 1kg/ha will result in an increase in grain yield of less than 4.64kg/ha, thus making it unviable.

In this case the added cost of fertiliser per ha exceeds the added value of grain per ha so it is not economic to apply more N. This is what happened in this trial (Table 2) when the N rate was increased from a 5t/ha to a 7t/ha target yield. The grain production required to cover the cost of this increase in N rate is 0.2784t/ha and this did not happen, thus making it uneconomic to apply more N.

In fact there would have been an additional penalty of a reduced price/tonne of grain in applying more N. The extra N in this trial raised the protein significantly such that the grain would have been binned as feed rather than malt. The implication on returns would have been a $10/t price penalty compared to that of malt – which would have been achieved if the extra N wasn't applied. This compounds the loss from the unviable application of extra N.

When considering the influence of plant population on performance, mean yield increased significantly across all varieties in the trial when a target of 200 and 300 plants/m^2 was aimed for compared to 100plants. However 300pl/m^2 was not significantly better in terms of increasing yield than 200pl/m^2.

Table 3 Mean grain yield and quality for varying plant populations

Plant population plants/m2	Yield (t/ha)	Protein %	Test Weight kg/hl	Retention %	Screenings %	Grade
100	6.98	11.28	67.53	92.1	2.1	Malt
200	7.18	10.98	67.61	89.1	2.8	Malt
300	7.29	10.78	67.13	86.7	3.3	Malt
LSD (P=<0.05)	0.16	0.24	0.35	1.4	0.5	

When observing protein there is a different story happening. A lower plant population yields lower but achieves a higher protein. In this trial it appears that sowing at a higher plant population sacrifices protein for yield but we could still make malt grade in this trial

Commercial application – what does this mean to the grower?

Planning for target yields based on knowing the starting soil nitrogen reserves and how much this source can contribute to performance will help make more informed decisions on how to maximise barley yields without compromising quality.

Knowing what the optimum N rate is in a given season as fertiliser and grain prices fluctuate will enable the grower to better understand whether changes in N management are likely to be economically worthwhile. Considering grade specifications to ensure such management doesn't result in end market penalties is also important.

In 2012, considering the breakeven ratio (value of grain relative to the price of fertiliser), increasing nitrogen levels up to a point leads to significant increases in yield. However, after this, additional applications do not increase the yield enough to justify the cost of the fertiliser.

In addition, managing nitrogen for different yields had a greater impact on grain quality than quantity. This was a greater effect than that of varietal choice. This trial also showed that optimum plant population for grain yield was 200plants/m2. In 2012 although increasing plant densities tended to reduce grain quality there was no receival penalty. This was likely due to the dry finish to the season.

Acknowledgements
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