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High yielding barley - nitrogen modelling at Kendenup

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Key messages

- Yield and quality response to nitrogen program and seeding rate was difficult to observe due to moisture stress throughout grain-fill.
- Seeding rate had no significant effect on grain yield or quality.
- Nitrogen program significantly affected N uptake and grain protein, but not yield or other quality parameters. Grain protein was very high overall.

Aim

To investigate the effect of seeding rate and nitrogen program (application rate and timing) on grain yield and quality to reduce the yield gap in the high-rainfall zone where there is high yield potential.

Background

The recent release of feed barley varieties that out-yield malting varieties, and the continued risks associated with meeting malt specifications is providing an opportunity for growers to re-assess the value of growing feed-only varieties. In the high-rainfall zones where yield potential exceeds 4t/ha, the new variety RGT Planet, which is also being evaluated for malt, appears to be a winner. A trial established by the Barley Agronomy Project at Kendenup aims to determine the best agronomy package for high-yielding barley in the WA high-rainfall zone. This paper extends certain treatments within this trial. We focus on barley grown without a plant growth regulator (PGR), with an extensive disease management program, using two seeding rates and three nitrogen application rates.

Methods

The main Kendenup trial consisted of 234 experimental plots, but here we focus on 18. These are comprised of six treatments (three nitrogen programs at two seeding rates) replicated three times (Table 1). Barley variety RGT Planet was sown on 7 June, 2018 after a late break. Table 2 shows the rate and application timings of nitrogen (N) across three programs, delivering 120, 180 or 240 kg/ha of N. At sowing, N was applied in compound fertilisers banded and top-dressed. A scheduled top-dressing of Flexi-N five weeks after sowing was missed for reasons outside our control. Instead, urea was top-dressed four weeks after sowing and again nine days later. The final application at Z37 (flag leaf just visible) was also a top-dressing of urea.

The plots analysed here all received the same extensive fungicide program despite disease pressure being low, thus there was no significant difference in yield based on fungicide.

Table 1. Treatments included in this analysis.

Factor	Level	Total rate (kg/ha)
Seeding rate	Low	150
	High	220
Nitrogen program	1	120
	2	180
	3	240

Table 2. Nitrogen applications within three nitrogen programs.

Program	Total rate (kg/ha)	Pass rate (kg/ha)	Timing	
1	120	20	Seeding	7 Jun
		40	Z25-29	7 Aug
		60	Z30	16 Aug
2	180	20	Seeding	7 Jun
		100	Z25-29	7 Aug
		60	Z30	16 Aug
3	240	20	Seeding	7 June
		100	Z25-29	7 Aug
		60	Z30	16 Aug
		60	Z37	12 Sept

Pre-season soil testing showed adequate nitrogen levels in the topsoil, which was also highly acidic (Table 3). In-season at early stem elongation (Z31) and flowering (Z60-69), tissue testing was carried out to determine nitrogen uptake followed by dry matter cuts to measure biomass. Key events are shown in Figure 1 along with rainfall at the site. Plot yields were recorded and the grain was assessed for various quality specifications including protein, screenings and harvest.

Table 3. Pre-seeding soil test results.

Trial 18KA24	$pH_{(CaCl2)}$	Clay fract-ion	Org C (W/B)	Total N	NH_4^+ N	NO_3^- N	K (HCO_3)	P (HCO_3)	PRI	Total P
	pH	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mL/g	mg/kg
0-15 cm	4.4	4	1.23	0.103	7	15	19	55	3.9	180
15-30 cm	5.3	5	0.35	0.023	1	4	24	11	1.3	54
30-45 cm	6.4	36	0.34	0.025	<1	4	140	3	45	39

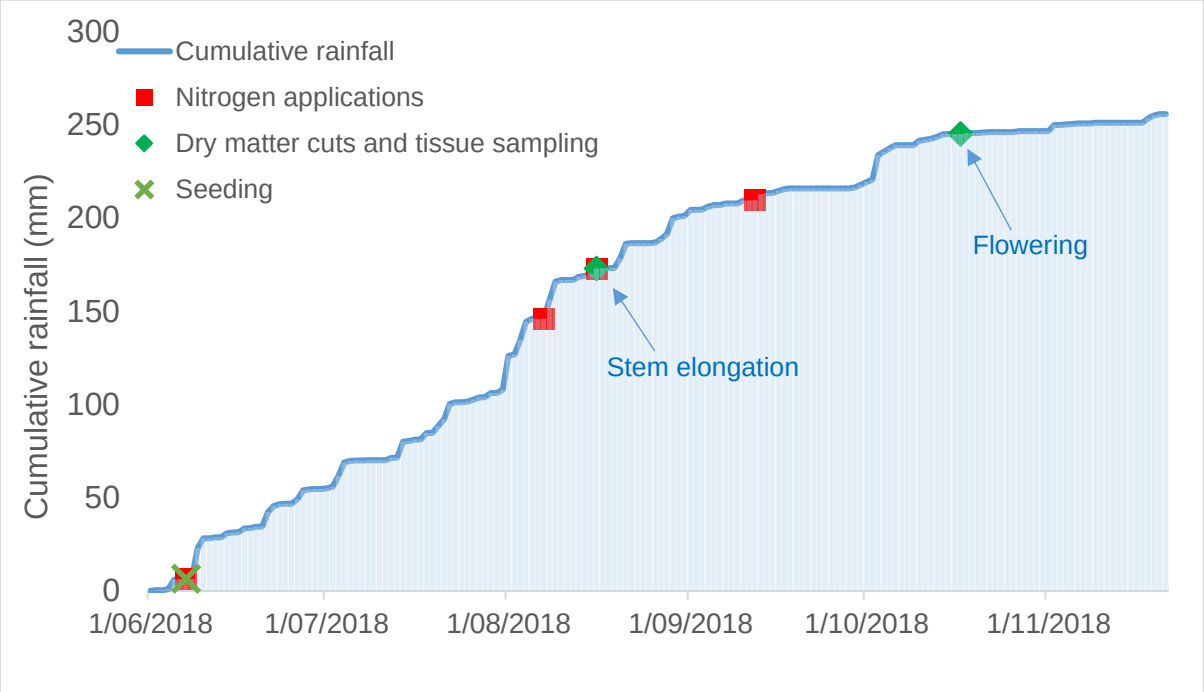

Figure 1. Cumulative rainfall recorded at the Stirlings South DPIRD weather station (PL001) from June to late November.

Results

The 2018 growing season was characterised by a late break (June 5) and crop vigour was low due to cooler temperatures following emergence. The site was moisture stressed throughout September and October during the flowering and grain fill periods which limited the value of the fourth N application at 12 September (Fig. 1). There were very obvious edge effects between plots, in terms of outside rows being greener, taller and maturing faster.

At early stem elongation (Z31), the N programs had delivered either 60 kg/ha or 120 kg/ha of nitrogen to the crop, but according to two-way analysis of variance (ANOVA) there was no significant difference in dry matter at this point in relation to N program (Fig. 2). Dry matter was higher at the high seeding rate 220 kg/ha, though this was not deemed statistically significant compared to seeding at 150 kg/ha (DM 1139 kg/ha, 995 kg/ha respectively).

Later in the season at flowering (Z60-69), the average dry matter per hectare was 10.9 tonnes. There was no significant difference in DM in relation to seeding rate or nitrogen program at this point, however nitrogen program significantly affected the amount of nitrogen measured from leaf tissue tests (N uptake) ($p = 0.04$). The 120 N program showed average N uptake of 163 kg/ha which was significantly less than the 240 N program which had average N uptake of 195 kg/ha (Fig. 3).

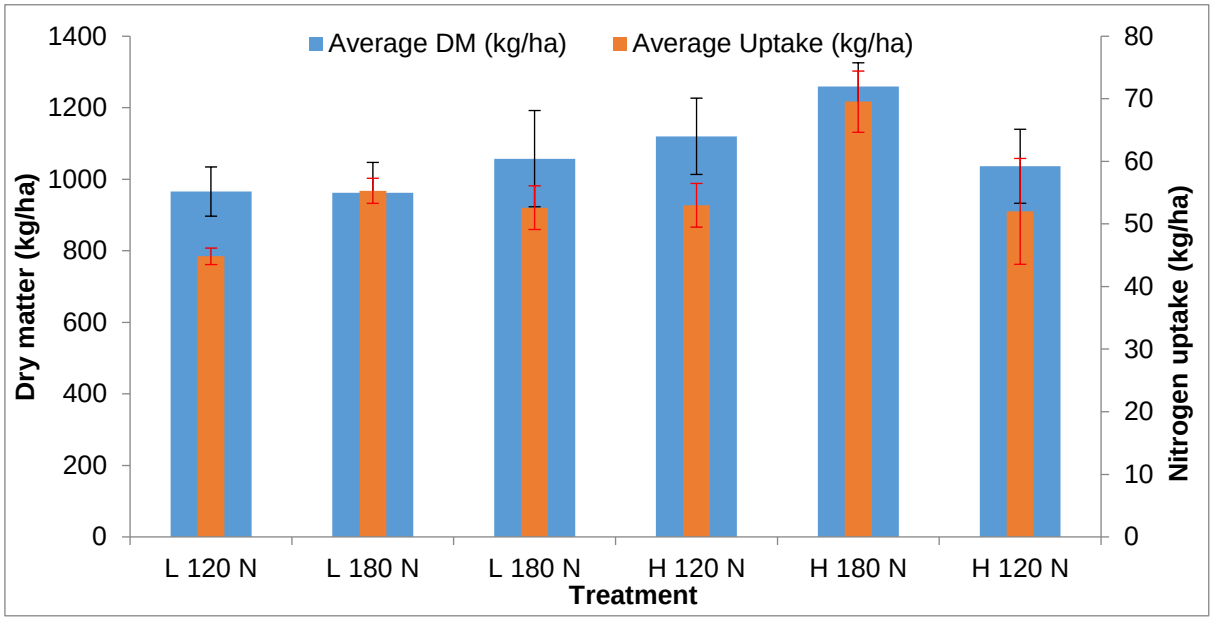

Figure 2. Dry matter production and calculated nitrogen uptake measured at early stem elongation (Z31) under different seeding rate treatments (L = low seeding rate 150 kg/ha, H = high seeding rate 220 kg/ha) and nitrogen programs (NOTE: only 60 kg/ha or 120 kg/ha of N were delivered by this growth stage).

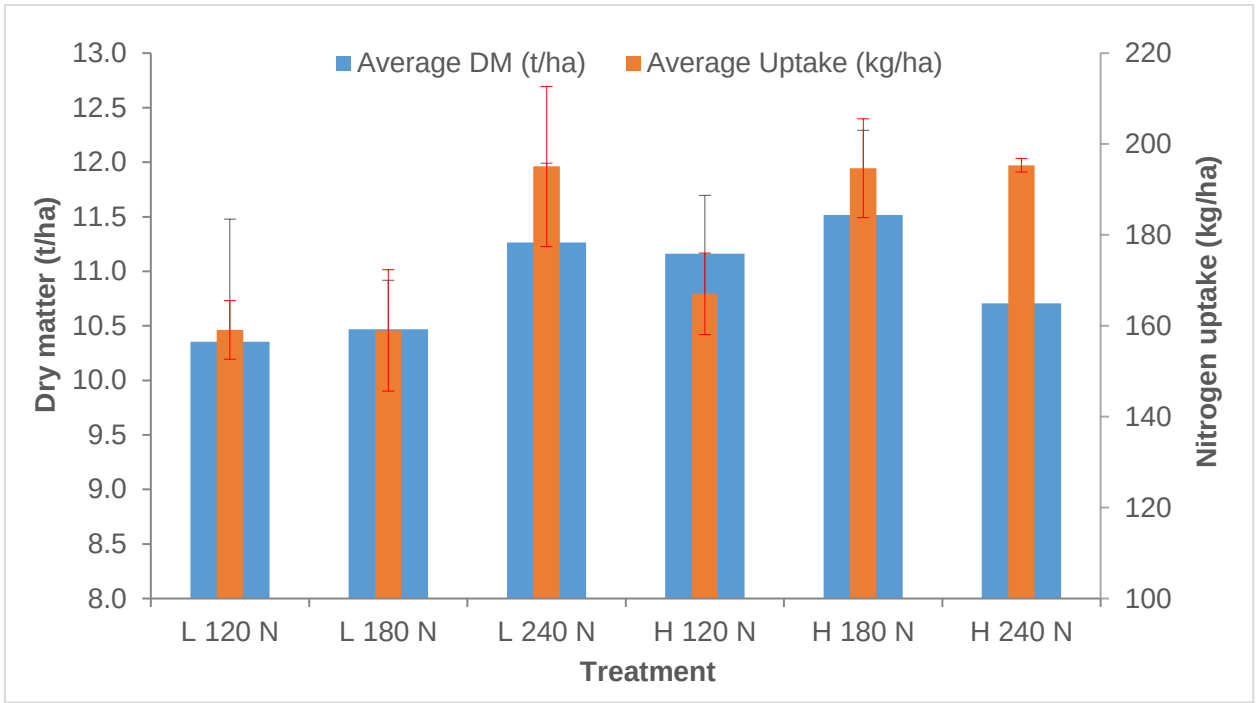

Figure 3. Dry matter production and calculated nitrogen uptake measured at flowering (Z60-69) under different seeding rate treatments (L = low seeding rate 150 kg/ha, H = high seeding rate 220 kg/ha) and nitrogen programs (120, 180 and 240 kg/ha of N).

Overall, the tight finish produced small grains that were very high in protein. The plots analysed here would not have met food/malt specifications due to low hectolitre weight, very high protein and very high screenings. We found no significant difference in yield, average grain weight or hectolitre weight in response to seeding rate or N program (Table

4). Unfortunately, N was not the limiting factor to production in this season but rather rainfall.

Table 4. Table of means and least significant difference (LSD). Letters indicate significant differences.

		Yield		Grain wt		Hectolitre wt		Protein	
		t/ha	LSD	mg, db	LSD	kg/hl	LSD	%	LSD
Seeding rate (kg/ha)	150	2.62	0.37	30.41	3.78	61.38	3.61	15.17	0.88
	220	2.62		27.63		58.80		14.77	
N Program (kg/ha)	120	2.86	0.45	30.74	4.63	61.42	4.42	13.58[a]	1.07
	180	2.43		28.41		60.02		15.25[b]	
	204	2.57		27.90		58.83		16.08[b]	

According to significant differences in N uptake measured at flowering, we expected to see a difference in grain protein at harvest. It followed that N program did significantly affect grain protein when seeding rate and block were accounted for (p=0.001). Plots that received the lowest N (120 N program) had significantly lower protein (13.6%) than the two higher N programs. The higher N programs, 180 N and 240 N were not significantly different in terms of protein (15.3% and 16.1% protein).

Select Your Nitrogen Model

Select Your Nitrogen (SYN) is a decision support tool for managing nitrogen applications based on soil type, crop rotation and yield potential. Parameters were set based on starting soil organic carbon (1.23%, loamy sand), crop rotation (no legumes in previous four years) and potential yield for the area. Despite the trial site having a theoretical yield potential in excess of 4t/ha, we set the yield potential in the model to 2.3t/ha to reflect the 2018 season (using Potential Yield Tool for decile 4, WUE 12). Barley price was set to $250/t. Yield, protein and net return were compared after matching the fertiliser inputs to reflect the Kendenup trial.

The model calculated that:

- The 120 N program would yield 2.3t/ha at 11.9% protein, giving a net return of $484/ha.
- The 180 N program would yield 2.21t/ha at 12.8% protein, giving a net return of $417/ha.
- The 240 N program (adjusted into three applications) would yield 2.23t/ha at 12.7% protein giving a net return of $377/ha.

It is worth noting that the SYN model uses algorithms for older crop varieties. The present high-yielding varieties like La Trobe, Rosalind and RGT Planet have different agronomic characteristics and may respond differently to earlier varieties that SYN was modelled for.

Conclusion

This study aimed to investigate the effect of seeding rate and nitrogen program (application rate and timing) on grain yield and quality to reduce the yield gap in the high-rainfall zone where there is high yield potential. Due to the low-decile season and tight finish, the full effects of nitrogen program and seeding rate on PGR Planet barley performance was difficult to observe. Seeding rate had no significant impact on yield, grain size, hectolitre weight or protein. Plots that received the least nitrogen yielded the highest (2.86 t/ha, though not significant) and had the lowest grain protein, though still higher than desirable (13.56%). This result was consistent with existing knowledge that moisture stress at grain-fill, paired with excessive nitrogen supply produces smaller grains with high protein content.

Acknowledgments

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