Effect of nitrogen fertiliser on grain yield and quality of eight barley cultivars – Condobolin 2016

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Key findings

- Rosalind$^{\Phi}$ (fast maturity) had the highest grain yield at all rates of applied nitrogen.
- Higher lodging at higher nitrogen rates reduced yield response to applied nitrogen in Compass$^{\Phi}$, Commander$^{\Phi}$ and Scope CL$^{\Phi}$.
- High spring rainfall and mild growing conditions resulted in high yields and full use of applied nitrogen.

Introduction

Early season nitrogen (N) applications can increase cereal crop yield, however, excessive applications can affect grain size and decrease N-use efficiency. It can also induce lodging due to increasing plant biomass height. This experiment assessed the yield, quality and lodging susceptibility of eight barley varieties to five N applications.

Site details

Location	Condobolin Agricultural Research and Advisory Station
Soil type	Red–brown chromosol
Soil N at sowing	30 kg/ha (0–10 cm), 39 kg/ha (10–60 cm)
Experimental design	Randomised complete block design, varieties and N treatments randomised within three replicates
Sowing date	18 May 2016
Sowing	Sown using a six-row DBS plot seeder at 30 cm row spacings for 120 plants/m^2 target plant density
Fertiliser	70 kg/ha mono-ammonium phosphate (MAP) was applied at sowing, providing an additional 7 kg/ha of available N
Weed control	Pre-emergent weed control: WipeOut 450® 2 L/ha Post-emergent weed control: Axial® 100EC® 300 mL/ha + Adigor® 500 mL/100 L water
Pest control	Aphids: Primor WG® 150 g/ha
Growing season rainfall (1 April–30 September)	467 mm (long-term average is 192 mm)

Treatments

Nitrogen applied

Nitrogen applied as urea at sowing at 0, 30, 60, 90 and 120 kg N/ha

Varieties

Commander$^{\Phi}$, Compass$^{\Phi}$, Fathom$^{\Phi}$, GrangeR, La Trobe$^{\Phi}$, Rosalind$^{\Phi}$, Scope CL$^{\Phi}$, Spartacus CL$^{\Phi}$

Results

Grain yield

The highest yielding variety across all N treatments was Rosalind$^{\Phi}$, although it was equal to GrangeR at 0 kg N/ha (Table 1). Commander$^{\Phi}$ had the lowest response to applied N, with a yield reduction of 0.26 t/ha recorded between 0 kg N/ha and 120 kg N/ha treatments. Commander$^{\Phi}$ was the only variety that had a reduction in the total number of grains per square metre (Figure 1), with a total reduction of 3.9%, while the most responsive variety, Rosalind$^{\Phi}$, increased total grain numbers by 34.5%.

Table 1. Grain yield (t/ha) of eight barley varieties at five rates of applied N at Condobolin in 2016.

Variety	N applied (kg/ha)				
	0	30	60	90	120
	Total available N (kg/ha)				
	76	106	136	166	196
	Grain yield (t/ha)				
Commander	5.1	5.3	4.7	5.0	4.8
Compass	4.6	5.0	4.9	4.9	5.1
Fathom	5.0	5.9	5.8	6.2	5.8
GrangeR	5.9	6.1	6.3	6.7	7.0
La Trobe	5.6	5.7	6.3	6.2	5.2
Rosalind	5.9	6.4	7.1	7.2	7.6
Scope CL	4.6	5.0	5.4	5.1	5.3
Spartacus CL	5.3	5.7	6.1	6.9	6.8
l.s.d. ($P = 0.05$) N rate = 0.33 t/ha; variety = 0.93 t/ha					

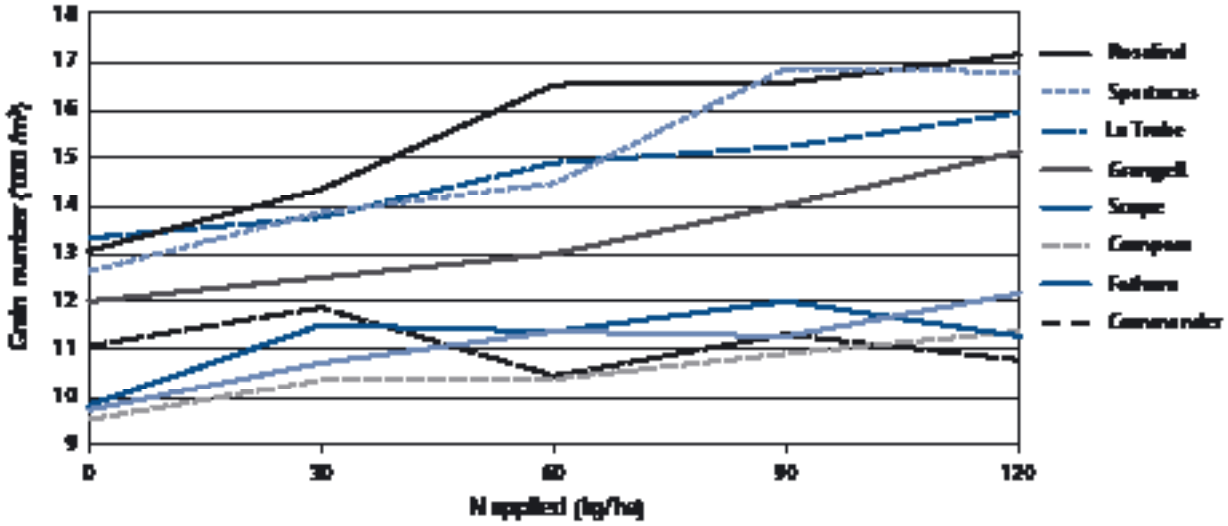

Figure 1. Grain number per square metre response of varieties to increasing rates of applied N in an experiment at Condobolin in 2016; l.s.d. ($P = 0.05$) N rate: 730 grains/m^2; variety: 100 grains/m^2.

There was a significant increase in tillers per square metre with increasing N rates, although increased tillers did not have a strong correlation with yield. Nitrogen treatments did not have a significant effect on grain weight per tiller. The total number of grains per square metre and grain yield had a linear correlation ($R^2 = 0.82$, Figure 2).

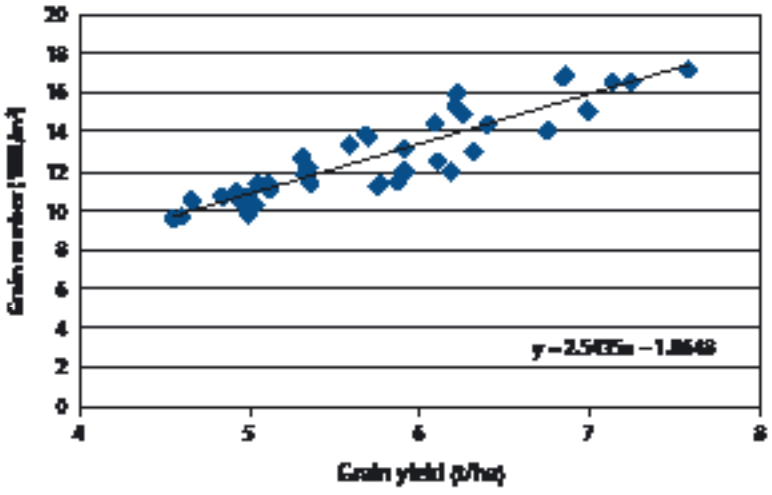

Figure 2. Grain number per square metre vs grain yield in an experiment at Condobolin in 2016; $R^2 = 0.82$.

Grain quality

There were significant differences between varieties for grain protein, screenings (% <2.2 mm), retention (% >2.5 mm), grain weight and hectolitre weight, but no significant interaction between N rate and variety. There were significant differences between N treatments for all quality traits except for hectolitre weight.

Screenings and retention of all treatments were above receival malt. Neither Spartacus CL$^{\Phi}$ nor Fathom$^{\Phi}$ (not a malt variety) reached the maximum acceptable protein concentration of 12% with the 120 kg N/ha treatments (Table 2). The wet and mild spring weather caused lower grain protein concentrations due to high grain yield.

Table 2. Protein (%) and grain weight (g/1000) of eight barley varieties treated with five rates of applied N.

Variety	N applied (kg/ha)									
	0		30		60		90		120	
	Protein (%)	Grain weight (g/1000)	Protein (%)	Grain weight (g/1000)	Protein (%)	Grain weight (g/1000)	Protein (%)	Grain weight (g/1000)	Protein (%)	Grain weight (g/1000)
Commander	8.9	46.2	9.5	44.6	10.5	44.6	10.4	44.3	11.1	44.8
Compass	9.4	47.9	9.8	48.5	10.0	47.7	10.8	45.3	11.2	45.0
Fathom	9.4	50.8	10.5	51.0	10.9	50.6	11.9	51.6	12.2	51.0
GrangeR	8.9	49.1	9.3	48.7	10.0	48.5	10.4	48.2	11.3	46.2
La Trobe	9.5	41.8	9.9	41.3	10.4	41.9	10.6	40.8	11.9	39.1
Rosalind	9.4	45.2	9.3	44.6	10.7	43.1	10.3	43.7	11.4	44.2
Scope CL	9.6	47.3	10.2	46.7	10.6	47.1	12.0	45.2	12.0	44.0
Spartacus CL	10.0	42.0	9.8	40.1	10.6	41.9	11.0	40.6	12.1	40.1
l.s.d. ($P = 0.05$) Protein: N applied = 0.3 t/ha; variety = 0.4 t/ha										
l.s.d. ($P = 0.05$) Grain weight: N applied = 0.74 mg; variety = 2.08 mg										

Lodging

Whilst increasing yield, higher N application rates significantly increased plant height and lodging with a strong linear correlation between N treatments with height and lodging (R^2 = 0.96 and 0.99 respectively). Plant height at maturity and biomass at anthesis had a linear correlation with lodging (R^2 = 0.40 and 0.41 respectively). Compass$^{\Phi}$ and Commander$^{\Phi}$ had the highest lodging scores (Figure 3).

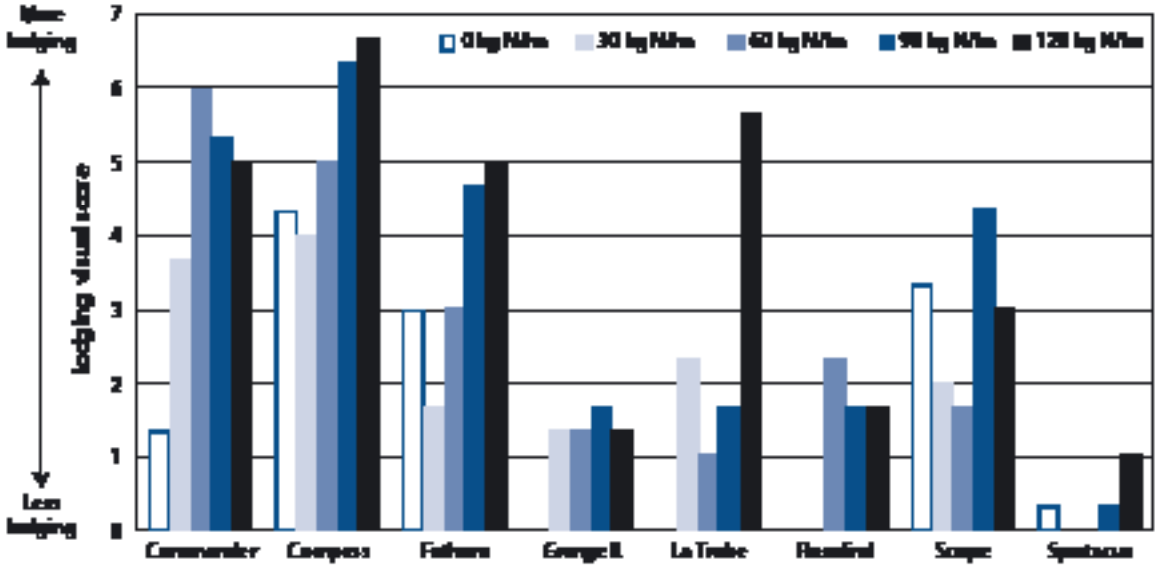

Figure 3. Visual lodging scores of eight barley varieties treated with five N rates. Lodging scores are between 0 (no lodging) and 9 (completely lodged). An absent bar indicates zero lodging observed; l.s.d. within variety (P<0.05) = 0.96.

Summary

Grain yield response to N applications depends on plant available moisture and lodging susceptibility. Nitrogen uptake during the plant's vegetative stage is stored in the photosynthetic tissue of the leaves and stem, increasing tillering and the photosynthetic area of the plant (van Herwaarden et al. 1998). Insufficient water availability during grain fill reduces the plant's capacity to translocate protein and carbohydrates from leaf to grain.

The 1000 grain weight decreased as applied N increased. There was no significant difference in grain weight per tiller but a significant increase in tiller number. In this experiment, increased tillers from higher rates of applied N was the main driver of higher yield. There was no interaction between varieties and N treatments as grain numbers per unit area increased (Figure 1). Sowing a high-yielding variety will produce optimum yields at all N applications.

Physiological factors such as biomass accumulation, tiller weight, straw strength, plant height and maturity all contribute to lodging susceptibility. Resistant varieties such as Rosalind(ϕ) and Spartacus CL(ϕ) are both semi-dwarf with low biomass accumulation. The lodging resistance of GrangeR might be an anomaly because it is late maturing and was harvested closer to its maturity date than the other varieties. Compass(ϕ) and Commander(ϕ) have good early season vigour, tall growth habits and early–medium maturity, which are all factors leading to an increased susceptibility to lodging.

References

Van Herwaarden, AF, Angus, JR, Richards, RA & Farquhar, GD (1998). 'Haying-off', the negative grain yield response of dryland wheat to nitrogen fertiliser II. Carbohydrate and protein dynamics. *Australian Journal of Agricultural Research* 49 (7) pp. 1083–1094.

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