Tailoring barley plant density to specific varieties in order to maximise yield and quality

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Key findings

- In the unusually wet growing season of 2016, increasing the barley plant density did not increase the yield of all varieties.
- High tiller numbers reduced overall grain size.
- In ideal growing conditions, some varieties with lower plant densities of <125 plants/m^2 out-yielded higher density treatments.

Introduction

This experiment investigated the effect of plant density on grain yield and quality of 16 different barley varieties.

Site details

Location	Condobolin Agricultural Research and Advisory Station
Soil type	Red–brown chromosol
Soil nitrogen	30 kg/ha (0–10 cm), 39 kg/ha (10–60 cm)
Experimental design	Randomised complete block design, varieties and seed rates randomised within three replicates
Sowing date	24 May 2016
Sowing	Sown using a six-row DBS plot seeder at 30 cm row spacings; 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 In crop application: Axial® 100EC 300 mL/ha + Adigor® 500 mL/100 L water
Pest control	Targeting aphids: Primor WG® 150 g/ha
Growing season rainfall (1 April–30 September)	467 mm (long-term average is 192 mm)

Treatments

Varieties

Bass⍉, Buloke⍉, Commander⍉, Compass⍉, Fathom⍉, Flinders⍉, GrangeR, Hindmarsh⍉, La Trobe⍉, Oxford, Rosalind⍉, Schooner, Scope CL⍉, Spartacus CL⍉, Urambie⍉, Westminster⍉

Seeding rate

Target established plant density of 75, 100, 125, 150 and 175 plants/m^2

Results

Both variety and plant density significantly affected yield (Table 1). The highest yielding treatments included GrangeR at 175 plants/m^2 and Westminster⍉ at 125 plants/m^2. Both are characterised as long-season varieties, and high yields are likely due to the extended grain-filling period afforded by above-average rainfall in 2016, which is uncharacteristic of the Central West of NSW. A number of other varieties achieved similar yields, including the faster maturing La Trobe⍉ at 100 plants/m^2 and Hindmarsh⍉ at 125 plants/m^2.

There was also a significant ($P<0.001$) difference in tillering between varieties and plant densities, although higher plant densities did not always produce increased tiller numbers (tables 1 and 2).

Table 1. Grain yield of 16 barley varieties (t/ha) sown at five target plant densities at Condobolin, 2016.

Variety	Target plant density (plants/m²)				
	75	100	125	150	175
Bass	5.61	5.27	5.73	5.06	6.10
Buloke	5.61	6.40	4.68	4.94	5.51
Commander	5.22	5.61	5.58	4.93	6.29
Compass	5.33	5.40	5.26	5.02	4.98
Fathom	5.81	5.98	6.47	5.91	5.67
Flinders	5.99	5.28	5.13	5.23	5.79
GrangeR	5.68	5.17	6.18	5.73	6.88
Hindmarsh	5.71	5.44	6.67	6.65	5.78
La Trobe	5.73	6.80	6.00	5.70	5.28
Oxford	5.82	5.78	5.73	6.36	6.52
Rosalind	6.06	6.08	6.01	6.19	5.77
Schooner	4.88	5.17	5.05	4.35	4.76
Scope CL	5.25	5.65	5.33	5.07	5.56
Spartacus CL	5.71	5.43	6.04	5.36	5.41
Urambie	5.99	4.95	5.82	5.34	6.07
Westminster	5.60	5.75	5.89	5.69	5.71
l.s.d (P<0.05)	variety 0.24 t/ha; density 0.13 t/ha				

Table 2. Number of tillers per square metre of 16 barley varieties (t/ha) sown at five target plant densities at Condobolin, 2016.

Variety	Target plant density (plants/m²)				
	75	100	125	150	175
Bass	513	494	571	534	564
Buloke	548	649	614	688	690
Commander	482	516	627	708	712
Compass	567	556	507	650	698
Fathom	474	525	538	651	626
Flinders	595	586	663	641	681
GrangeR	459	460	482	532	604
Hindmarsh	588	577	560	753	684
La Trobe	670	655	689	715	663
Oxford	570	610	635	742	761
Rosalind	557	584	675	618	668
Schooner	559	533	502	482	540
Scope CL	557	663	682	695	692
Spartacus CL	671	707	641	744	750
Urambie	552	548	533	565	697
Westminster	483	542	485	571	591
l.s.d (P<0.05)	variety 66.7 tillers/m²; density 37.3 tillers/m²				

Yield component analysis

In the wet growing season of 2016, there was no relationship between yield and tiller number (R^2 = 0.033). Other yield components analysed were grain weight, grains per tiller and total number of grains per square metre, displayed in Table 3.

The yield component with the most consistent contribution to yield was number of grains per square metre (Figure 1). Grain weight demonstrated a small, but significant, decrease in size as tiller number increased (Figure 2), although the effect of increased plant density was highly dependent on variety, with varying responses in yield components by variety.

Increased seed rates did not affect protein, moisture, retention or screenings in 2016. There was a significant variety × plant density interaction for grain yield, although no other yield components showed an interaction.

Table 3. Performance of barley yield and quality traits at five plant densities. ANOVA F probabilities for plant density (PD), variety (V) and interaction.

	Target plant population (plants/m²)					ANOVA F probability[a]		
	75	100	125	150	175	PD	V	PD × V
Yield component								
Grain yield (t/ha)	5.6	5.6	5.7	5.4	5.8	**	**	**
Tillers/m²	553.4	575.3	587.8	643.0	663.8	**	**	NS
Grains/tiller	21.3	20.6	20.7	18.6	18.7	**	**	NS
Grain weight/tiller (g)	1.04	0.99	0.99	0.87	0.88	**	**	NS
No. grains/m²	11627	11483	11854	11709	12 231	NS	**	NS
No. tillers per plant	7.3	5.7	4.7	4.3	3.7	**	**	NS
Grain harvested per plant (g)	7.5	5.5	4.6	3.6	3.3	**	**	NS
Total weight/m²	1195	1188	1207	1251	1216	NS	**	NS
Quality								
Protein (% db)	9.8	9.6	9.7	9.6	9.6	NS	**	NS
Moisture	9.1	9.1	9.1	9.1	9.1	NS	NS	NS
Retention (%>2.5 mm)	94.98	94.71	94.54	94.73	93.85	NS	**	NS
Screenings (%<2.2 mm)	0.79	0.93	0.85	0.84	0.91	NS	**	NS
Grain weight (mg)	48.8	48.5	48.4	47.1	47.3	**	**	NS
Hectolitre weight (kg/hL)	70.50	70.20	70.22	70.15	70.18	*	**	NS

[a] NS = not significant; * and ** = indicate significance at the 0.05 and 0.01 levels of probability respectively.

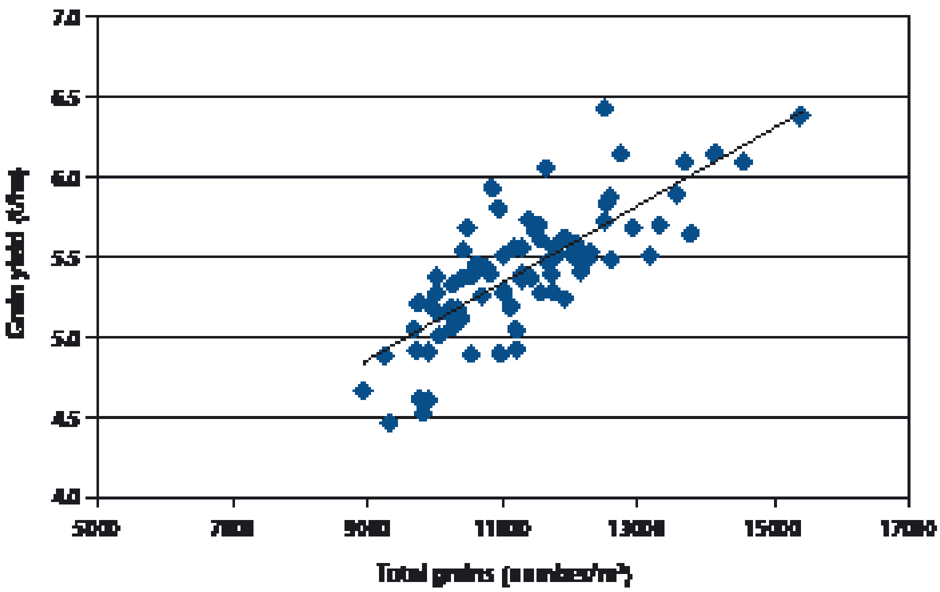

Figure 1. Total number of grains/m² compared with final grain yield (R^2 = 0.66).

Agronomy–cereals

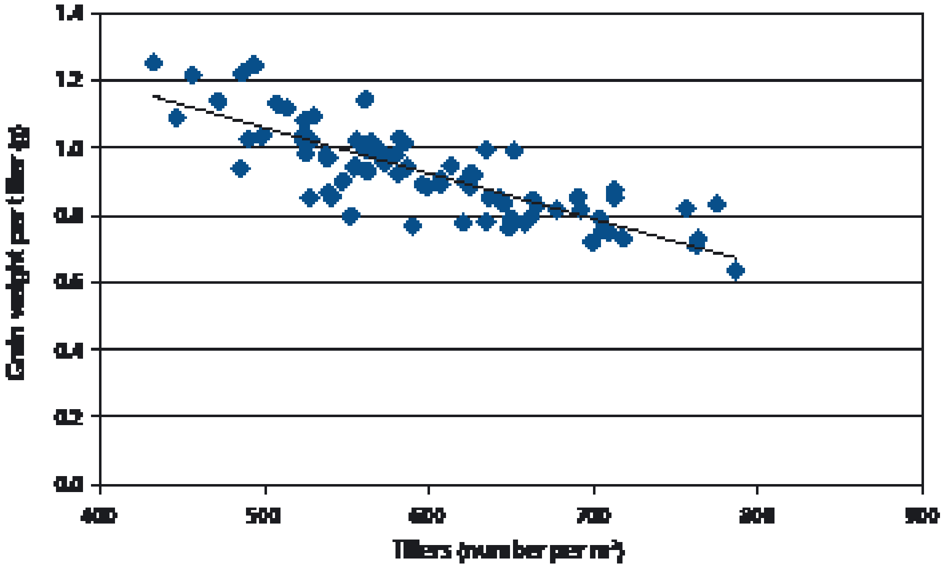

Figure 2. Effect of increased tiller numbers on grain weight per tiller (R^2 = 0.61).

While an increase in plant density did increase tiller numbers, the penalty on grain size and number of grains per head restricts any potential yield gains. As tillers per unit area increased, the number of tillers per plant decreased. Grains per tiller and individual grain weight also decreased as tiller numbers increased. These three variables contributed to grain yield in a manner specific to each variety, resulting in non-linear yield variation as plant density increased.

Summary

Significant differences were observed between varieties and seeding rates, however, there was not a strong relationship between seeding rates, yields and tillers. In 2016, the high rainfall and ideal spring produced an environment that stimulated optimum growth, which is not typical of the average Condobolin growing season.

A lack of differentiation between seeding rates indicated that barley has the capacity to maximise tillering when spacing, nutrients and moisture are sufficient, as was the case at Condobolin 2016.

While there was an interaction between plant density and environment for grain yield, there was no similar interaction for other yield components or quality traits (Table 2), such as protein, screenings and retention – again possibly a direct result of the 2016 growing season.

Grain yield corresponded with number of grains per unit area, rather than individual grain size, which did decrease as seed rates increased. As tillers per unit area increased, grain weight per tiller was decreased. It should be noted that 2016 was a year of uncharacteristically high rainfall with little moisture stress during grain fill. Long-season varieties, normally suited to high rainfall zones, yielded competitively with shorter season varieties more commonly grown around the Condobolin region. An environment with increased heat and moisture stress, particularly toward the end of the year, would have produced different relationships between seed rates and yield.

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