How much is the seed rate (changing from 50 to 400 plants/m^2) response of barley influenced by date of seeding?

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Key messages

- There was no evidence in this study to suggest that the target density should be changed if the seeding opportunity is delayed by three to four weeks.
- The optimum plant population for grain yield at the first date of seeding was 132 ± 14 plants/m^2 and 138 ± 11 plants/m^2 at the second date of seeding. This is in line with the suggested target density for barley in Western Australia of 120 to 150 plants/m^2.
- Delayed seeding (a three to four week delay) was more likely to cause downgrading to feed than sowing barley at a high versus low seed rate (ie. 400 versus 50 plants/m^2).

Aims

Decisions on what seed rate to be sown should be based on the target density, seed weight, germination per cent and a likely establishment per cent. The current recommendation for barley in Western Australia to target an establishment density of 120 to 150 plants/m^2 in environments with a yield potential above 1 t/ha.

Paynter *et al*. (2016b) proposed that Granger and Scope CL should be sown at a lower target density than Bass, Flinders and La Trobe. As those varieties differ in their kernel weight the actual seed rate will differ. For a target establishment of 150 plants/m^2 the actual seed rate could range from 67 to 97 kg/ha (for seed weights of 35 to 50 mg).

Imagine this scenario. You calculate your seed rate based on a target density, seed weight, germination per cent and establishment per cent for a mid-May sowing and it doesn't rain, resulting in the seeding opportunity being delayed by three to four weeks. What should you do? Should you reduce your seed rate?

The aim of this study was to determine if:

1. sowing date influences the grain yield and/or grain quality response to seed rate, and
2. reducing the seed rate was warranted when the seeding opportunity is delayed.

Method

This study was undertaken in 2012 and 2013. In each year a core set of 12 'malt' or food barley varieties were evaluated at four locations (Wongan Hills, York, Katanning and Wittenoom Hills) where a seed rate trial was established at two different dates of seeding or times of sowing (TOS) usually three to four weeks apart (Table 1). The 12 varieties sown were evaluated for their response to four different seed rates (50, 100, 200 and 400 plants/m^2) at one level of nitrogen (N) application over three replicates. Trials were sown as a split plot cyclic design with time of sowing as whole plots, variety as subplots and seed rate randomised as sub-subplots.

Nine malt barley varieties Bass, Baudin, Buloke, Commander, Flinders, Granger, La Trobe, Vlamingh and Wimmera and one food barley variety Hindmarsh were sown in all eight trials. Compass (under malt evaluation), Henley (accredited malt variety) and Skipper (withdrawn from accreditation) were also sown, but not in all trials, and data on those three varieties is not presented in this paper.

Trials were established into predominantly canola stubble with small plot seeding equipment and harvested with small plot research equipment. An NPK compound was banded below the seed and the trials were topdressed in front of the seeder with an additional NPK compound supplying a total of 50 kg N/ha. The seed rate (kg/ha) to establish the target densities of 50, 100, 200 or 400 plants/m^2 varied for each variety and year and was adjusted based on their kernel weight and germination per cent. A seed rate of 50 plants/m^2 = 20 to 30 kg/ha, 100 plants/m^2 = 45 to 65 kg/ha, 200 plants/m^2 = 90 to 130 kg/ha and 400 plants/m^2 = 205 to 295 kg/ha (depending on seed weight).

Results are graphed against the measured establishment (determined 2 to 4 weeks after seeding, WAS) rather than against the target densities. Measurements included plant establishment (plants/m^2), NDVI score at 6 WAS, plant height (cm, base of ear), lodging score (9-0) close to harvest, grain yield (t/ha), kernel weight (mg, db), hectolitre weight (kg/hL), screenings (% < 2.5 mm), grain protein concentration (%, db) and grain brightness (Minolta 'L*').

Data was analysed within Genstat (VSN International 2013) with a block structure of (colrep/TOS)/variety/seedrate and a treatment structure of TOS x variety x seed rate. The optimum plant population for grain yield was calculated for each time of sowing at each site as per Paynter (2016) with the point of inflection at 1.5 kg/ha of grain for each extra established plant/m^2.This paper is a sub-set of the data presented in Paynter *et al*. (2016b).

Table 1. Trials details for the eight barley agronomy time of sowing x variety by seed rate (T x V x SR) trials.

Site	Location	Sown (date)	May-Oct rainfall (mm)	Site mean yield (t/ha)	pH_{Ca} (0-10cm)	Soil type
12WH24	Wongan Hills	06-Jun-12	217	2.50	5.9	sand overlying lateritic gravel
		28-Jun-12		1.82		
12NO22	York	05-Jun-12	205	2.72	4.5	red shallow sandy duplex
		25-Jun-12		1.56		
12GS30	Katanning	25-May-12	274	4.20	5.0	brown shallow sandy duplex
		28-Jun-12		3.21		
12ED16	Wittenoom Hills	18-May-12	136	2.79	6.3	alkaline grey shallow sandy duplex
		18-Jun-12		1.68		
13WH15	Wongan Hills	21-May-13	303	4.29	5.5	brown deep sand
		12-Jun-13		3.89		
13NO31	York	15-May-13	261	5.50	5.5	brown loamy earth
		12-Jun-13		5.53		
13GS32	Katanning	13-May-13	353	5.31	4.6	brown duplex sandy gravel
		05-Jun-13		5.36		
13ED20	Wittenoom Hills	07-May-13	264	4.46	6.2	alkaline grey shallow sandy duplex
		28-May-13		4.53		

Table 2. Likelihood of time of sowing, variety, seed rate and their interaction being significantly different across the eight trials. Significance: rarely = occurrence in ≤20% trials, occasionally = 20 to 40% trials, 50% chance = 40 to 60% trials, often = 60 to 80% trials and consistently = ≥80% trials significant.

Trait / Variety	Plant height (cm)	Lodging (9-0)	Grain yield (t/ha)	Kernel weight (mg, db)	Hectolitre weight (kg/hL)	Screenings (%<2.5 mm)	Grain protein (%, db)	Grain brightness ('L*')
TOS (T)	50% chance	often	occasionally	often	occasionally	often	50% chance	consistently
Variety (V)	consistently	consistently	often	consistently	consistently	consistently	often	consistently
T x V	rarely	often	rarely	often	occasionally	often	rarely	often
Seed rate (SR)	consistently	often	consistently	consistently	consistently	consistently	consistently	often
T x SR	occasionally	rarely	occasionally	50% chance	often	50% chance	often	often
V x SR	occasionally	occasionally	occasionally	often	often	consistently	occasionally	consistently
T x V x SR	occasionally	occasionally	occasionally	50% chance	occasionally	often	rarely	50% chance

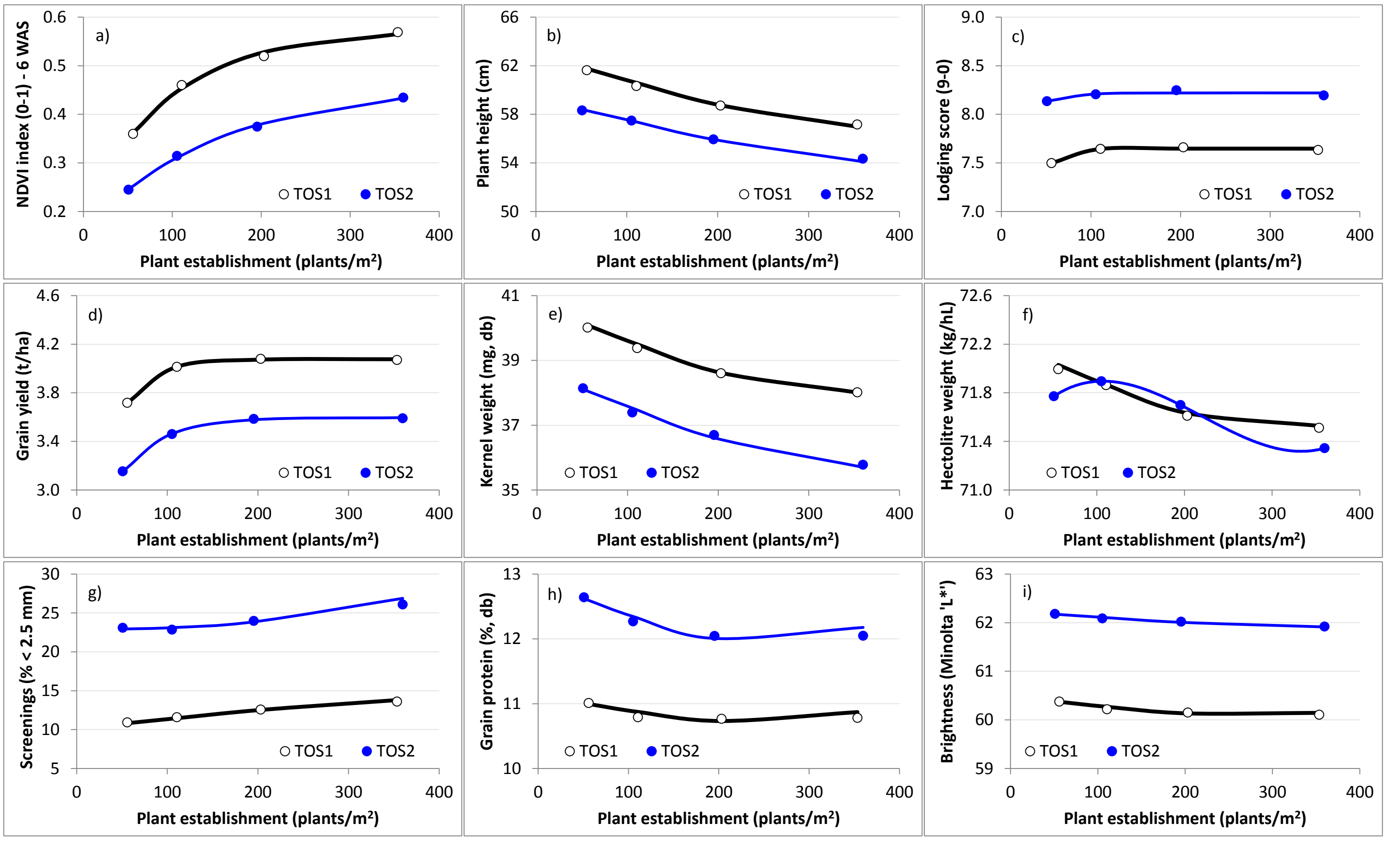

Figure 1. Average response of 10 barley varieties over eight trials at two dates of seeding to increasing seed rate, a) NDVI – 6 WAS, b) plant height, c) lodging score, d) grain yield, e) kernel weight, f) hectolitre weight, g) screenings, h) grain protein concentration and i) grain brightness.

Results

Site and time of sowing

Growing season rainfall (May-Oct) ranged between 136 mm to 333 mm at each site (Table 1). The site mean grain yield ranged from 1.56 t/ha (York TOS2 2012) to 5.53 t/ha (York TOS2 2013) with an average yield of 3.97 ± 0.42 t/ha at the first sowing date (TOS1) and 3.45 ± 0.58 t/ha at the second sowing date (TOS2). TOS2 was only lower yielding than TOS1 at three of the eight locations, York 2012, Katanning 2012 and Wittenoom Hills 2012.

The general impact of delayed sowing was to decrease early biomass, plant height, lodging risk, grain yield whilst increasing screenings, grain protein concentration and grain brightness. These changes however were not present at all sites (Table 2 and Figure 1). Delayed sowing increased the risk of delivering feed grade barley, primarily due to high screenings and high grain protein (Table 3 and Figure 1).

Table 3. Per cent of barley samples meeting GIWA Barley receival standards for each quality trait and overall as either Malt (1 and 2) or Food (1 and 2) barley.

	Per cent of samples meeting specification							
	Time of sowing 1				**Time of sowing 2**			
	Target seed rate (plants/m^2)				Target seed rate (plants/m^2)			
Quality trait	50	100	200	400	50	100	200	400
Hectolitre weight	100%	100%	100%	100%	100%	100%	100%	100%
Screenings	93%	91%	90%	90%	83%	85%	81%	74%
Grain protein concentration	79%	75%	74%	84%	58%	59%	61%	64%
Grain brightness	100%	100%	100%	100%	100%	100%	100%	100%
Received as Malt / Food	**78%**	**74%**	**73%**	**79%**	**58%**	**59%**	**61%**	**60%**

Seed rate and time of sowing

Seed rate consistently (in at least four out of every five trials) influenced early biomass, plant height, grain yield, kernel weight, hectolitre weight, screenings and grain protein, but less frequently for grain brightness (only three out of every four trials) and straw strength (only two in every three trials) (Table 2). The influence of seed rate was however modified by delayed seeding (Table 2 and Figure 1).

The general effect of increasing seed rate was:

1. increased biomass at six weeks after seeding, with a smaller response with delayed seeding (Figure 1a),
2. decreased plant height with no consistent effect of delayed seeding (Table 2 and Figure 1b),
3. no overall effect on straw strength (Figure 1c),
4. increased grain yield before plateauing after 200 plants/m^2 with a similar response to delayed seeding in approximately three of every five trials (Table 2 and Figure 1d). At Wongan Hills 2012 there was a larger response to seed rate at the first sowing date, but a larger response at the second sowing date at York 2013 and Wittenoom Hills 2013. Overall the yield penalty from sowing 50 versus 400 plants/m^2 was larger at the second date of seeding than the first (17% vs 11%),
5. decreased kernel weight with a larger decrease with delayed seeding in one in every two trials (Table 2 and Figure 1e),
6. decreased hectolitre weight with no consistent effect of delayed seeding (Table 2 and Figure 1f),
7. increased screenings with a slightly larger increase in screenings with delayed seeding (Table 2 and Figure 1g). In three trials (Wongan Hills 2012 and 2013, York 2013) there was a larger increase in screenings with delayed sowing but a decrease in screenings with delayed sowing at Katanning 2012,
8. decreased grain protein concentration with a slightly smaller reduction with delayed seeding (Table 2 and Figure 1h), and
9. reduced grain brightness with a slightly larger reduction with delayed seeding (Table 2 and Figure 1i).

The overall effect of delayed seeding was larger than the change due to seed rate for lodging risk, grain yield, screenings, grain protein concentration and grain brightness (Figure 1). They were similar for plant height and kernel weight, whilst time of sowing had a smaller effect on biomass at 6 WAS and hectolitre weight than seed rate.

The impact of increased seed rate on the receival of barley as malt or food was lower than the impact of delayed seeding (Table 3). Increasing seed rate had no effect on the per cent of samples meeting the GIWA Barley receival standards for hectolitre weight or grain brightness, regardless of date of seeding, but did for screenings and grain protein. At the first date of seeding the reduction then increase in per cent receival as malt or food barley were due to changes in the per cent of samples meeting protein standards not screenings standards. At the second date, whilst there was a decrease in the per cent of samples meeting the screenings standards and an increase for grain protein, there was no overall impact of seed rate on the per cent of samples received as malt or food.

The optimum plant population for grain yield ranged between 87 plants/m^2 (York 2013, TOS1) to 221 plants/m^2 (Katanning 2013, TOS1) with an average across sites and for all dates of seeding of 135 ± 9 plants/m^2. The optimum plant population for grain yield was not correlated with the site mean yield (data not shown) and did not change with delayed seeding. The optimum plant population for grain yield at the first date of seeding was 132 ± 14 plants/m^2 and 138 ± 11 plants/m^2 at the second date of seeding.

Varietal interactions with seed rate and time of sowing

Variety consistently (in seven of eight trials) influenced the response to seed rate for screenings and grain brightness, but less frequently (two in every three trials) for kernel weight and hectolitre weight and even less frequently (less than one in every two trials) for biomass at 6 WAS, plant height, lodging, grain yield and grain protein concentration (Table 2).

The largest influence of time of sowing on the response of varieties to increasing seed rate was screenings (two in every three trials), with seeding date only influencing one in every two trials for kernel weight and grain brightness and two in every five trials for hectolitre weight (Table 2).

For kernel weight Granger and Wimmera were more sensitive to increasing seed rate at the first time of sowing, with Buloke and Vlamingh slightly more sensitive at the second (data not shown). For hectolitre weight Vlamingh and Wimmera were the most sensitive at the first sowing and Vlamingh the most sensitive at the second. For screenings Granger and Wimmera were the most sensitive varieties to increasing seed rate at the first time of sowing, with Buloke, Hindmarsh and Vlamingh were the most sensitive at the second. For grain brightness Commander was the most sensitive variety at the first time of sowing, with Hindmarsh the most sensitive at the second

Conclusion

Whilst delayed seeding occasionally influenced the response to seed rate there was no evidence in this study to suggest that the target density should be changed if the target seeding date is delayed by three to four weeks. It should be noted that whilst date of seeding was only significant at three of the eight sites, the optimum plant population at those three sites was the same regardless of date of seeding as with the other five sites. The optimum plant population at the first date of seeding was 132 ± 14 plants/m^2 compared to 138 ± 11 plants/m^2 at the second date of seeding. The optimum plant population observed in this study is in line with the current target plant densities of 120 to 150 plants/m^2 for barley grown in Western Australia. It is also similar to that observed by Paynter (2016) and Paynter *et al*. (2016a and 2016b).

Delayed seeding rather than increased seed rate was more likely to cause downgrading to feed (Table 3), with delayed seeding influencing screenings, grain protein concentration and grain brightness more than seed rate (Figure 1). The opposite was true for hectolitre weight. Whilst there was a slightly larger increase in screenings with increasing seed rate at the second sowing date, any reduction in seed rate to reduce this risk still came with a yield penalty. In fact the yield penalty from sowing barley light (<100 plants/m^2) was larger at the second time of sowing than the first in this study.

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Key words

target plant population, seed rate, barley, grain yield, grain quality

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