Effect of sowing time x seed rate x herbicides on ryegrass management in barley (Minnipa, SA)

Key messages

- Three week delay in seeding barley reduced annual ryegrass (ARG) plant density by 45% in the control (knockdown only) and by 28% for the weaker Trifluralin treatment. However in the most effective herbicide treatments (Boxer Gold and Overwatch), high levels of ARG control was achieved in both TOS 1 and TOS 2.
- The interaction between sowing time and herbicide ($P<0.001$) was reflected in 45-50% lower ARG spike density in TOS 2 than in TOS 1 for the control and Trifluralin treatments. However, no such effect of delayed sowing was observed for the more effective treatments of Boxer Gold and Overwatch that reduced ARG spike production by 81% and 78%, irrespective of sowing time.
- Barley seed rate did have a significant effect on ARG seed production ($P=0.022$) with crop sown at 150 and 200 seeds/m^2 having 29% and 21% lower ARG seed set than seed rate of 100 seeds/m^2. It is a serious cause for concern that ARG was able to set 7705 and 8700 seeds/m^2 in the most effective herbicide treatments Boxer Gold and Overwatch. These results highlight the need for growers to integrate tactics such as improved crop competitiveness and harvest weed seed control along with herbicides to achieve a decline in the seedbank of this difficult to manage weed.
- Herbicide treatment had a significant effect on barley grain yield with Trifluralin (1.99 t/ha) increasing grain yield by 16%, Overwatch (2.30 t/ha) 34% and Boxer Gold (2.33 t/ha) by 36% compared to the control (1.72 t/ha). These yield gains approximately equate to a 5:1 return on the cost of Trifluralin, a 4.5:1 return on Overwatch and a 5.8:1 return on Boxer Gold.

Introduction

Change in crop sowing time can have multiple effects on crop-weed competition. Delayed sowing can provide opportunities to deplete weed seedbank before seeding the crop but weeds that establish in late sown crops can be more competitive on a per plant basis. This is one of reasons why farmers who have adopted early seeding have reported excellent results in crop yield and weed suppression. Therefore, it is important to investigate sowing time in combination with other practices across different rainfall zones. The review of Widderick et al. (2015) also recommended research on sowing time in many crops. Delayed sowing can also reduce crop yield so the gains made in weed control may be completely nullified by the yield penalty.

There has been some research already on influence of crop seed rate on weed suppression but none of these studies have investigated the benefits of higher crop density in factorial combinations with sowing time and herbicide treatments. Crop seed rate is an easy tactic for the growers to adopt provided they are convinced of its benefits to weed management and profitability. Furthermore, growers in the low rainfall areas tend to be reluctant to increase their seed rate due to concerns about the negative impact of high seed rate on grain screenings.

This field trial at Minnipa was undertaken to investigate factorial combinations of sowing time, seed rate and herbicides on the management of annual ryegrass in barley.

Methods

This field trial investigated combinations of the following management tactics.

1. **Sowing time (2)**: mid May and early June
2. **Seed rate (3)**: 1x (200 seeds/m^2), 0.75x (150 seeds/m^2), 0.5x (100 seeds/m^2)
3. **Herbicides (4)**:

(i) Nil (knockdown treatment only)
(ii) Trifluralin 1.5 L/ha IBS
(iii) Overwatch 1.25 L/ha IBS
(iv) Boxer Gold 2.5 L/ha IBS

Variety: Compass

Trial design: split plot design

Replicates: 3

Measurements: pre-sowing weed seedbank, crop density, weed density, ARG spike density, ARG seed production, wheat grain yield.

Trial Management

Table 1. Key management operations undertaken.

Operation	**Details**
Location	Minnipa, SA
Seedbank soil cores	9 April, 2021
Plot size	1.5 m x 10 m
Seeding date	TOS 1: 20 May, 2021 TOS 2: 9 June, 2021
Fertiliser	At sowing – MAP (10:20) @ 55 kg/ha
Variety	Compass barley
Seeding rate	100 seeds/m^2 150 seeds/m^2 200 seeds/m^2
Herbicides	20 May and 9 June, 2021 (applied just before seeding) Boxer Gold 2.5 L/ha IBS Overwatch 1.25 L/ha IBS Trifluralin 1.5 L/ha IBS Control (knockdown treatment only)

All data collected during the growing season was analysed using the Analysis of Variance function in GenStat version 20.0.

In 2021, annual rainfall received at Minnipa was 25% above the long-term average but the growing season rainfall was close to the long-term average. The rainfall

received in June, July and November was greater than the long-term average with other months being close to average, except for April and September that were well below the long-term average (Table 2).

Table 2. Rainfall received at Minnipa in 2021 and the long-term average for the site (Bureau of Meteorology).

	Rainfall (mm)	
Month	**2021**	**Long-term rainfall**
Jan	18.0	11.5
Feb	16.2	14.7
Mar	9.6	18.6
Apr	2.6	15.8
May	21.8	27.5
Jun	72.4	37.8
Jul	53.4	35.0
Aug	29.2	38.2
Sep	4.4	26.8
Oct	26.2	21.8
Nov	101.4	19.6
Dec	3.0	18.4
Annual total	358.2	286.8
GSR total	210.0	202.9

Results and Discussion

Barley plant density

Barley establishment was affected by the interaction ($P<0.001$) between sowing time and seed rate (Figure 1). As a general trend, barley seedling establishment efficiency reduced as seed rate increased. There was clearer separation between the seed rate treatments in TOS 2 where SR200 had significantly higher barley plant density than in TOS 1. Higher crop establishment in TOS 2 than in TOS 1 might be associated with above-average rainfall received after sowing in June.

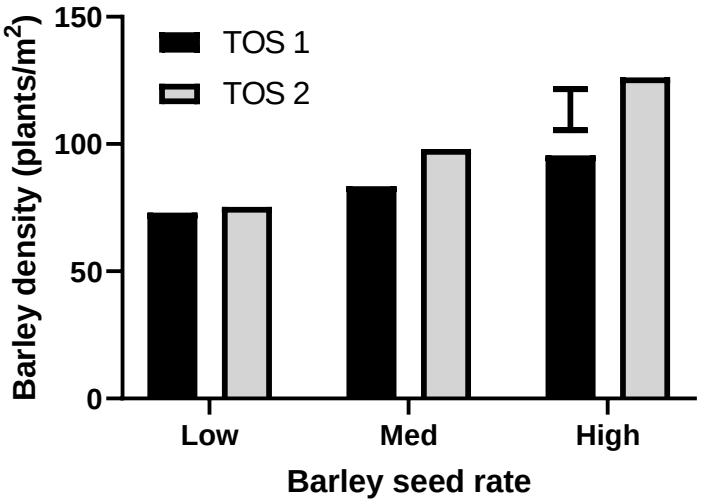

Figure 1. The effect of seed rate on barley plant density in time of sowing 1 (TOS 1) and time of sowing 2 (TOS 2). The vertical bar represents the LSD (P=0.05).

Annual ryegrass seedbank and plant density

The average seedbank of annual ryegrass (ARG) at the site was 7969 ± 2961 seeds/m^2. ARG plant density was significantly influenced by herbicide treatment (P<0.001) and the interaction between the time of sowing and herbicide (P=0.001).

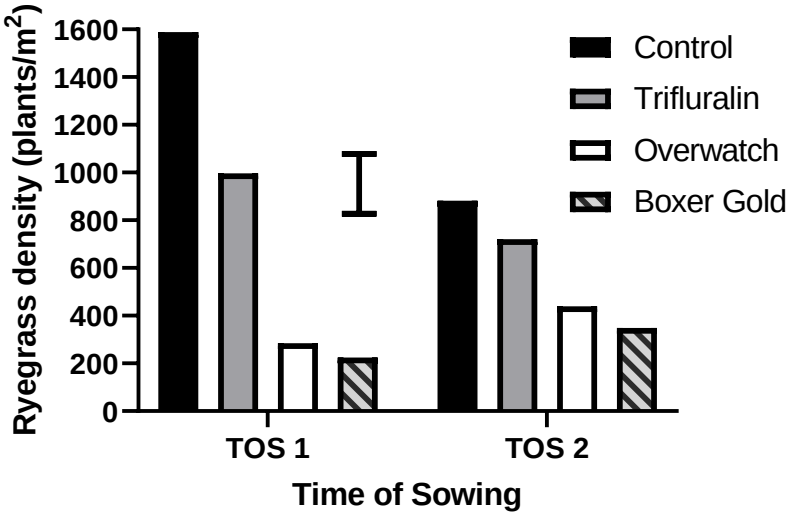

Figure 2. The interaction between the time of sowing and herbicide treatments (P<0.001). The vertical bar represents the LSD (P=0.05).

There was a large impact of the 3 week delay in seeding barley on ARG plant density (Figure 2). This was particularly evident in the untreated control in which ARG density decreased from 1589 plants/m^2 in TOS 1 to 882 plants/m^2 in TOS 2 (45% reduction). This large response of ARG density to 3 week delay in sowing is most likely related to rainfall events in May and early June, which would have caused weed emergence

prior to knockdown herbicides at seeding (Figure 2). Minnipa population of ARG has low seed dormancy and emerges rapidly after rainfall events. The reduction in ARG plant density due to delayed seeding was also evident in the weaker Trifluralin herbicide treatment (Figure 2) where TOS 2 had a 28% lower ARG density than TOS 1. However in the most effective herbicide treatments (Boxer Gold and Overwatch), high levels of ARG control was achieved in both TOS 1 and TOS 2, making any benefits from delayed sowing largely redundant.

Annual ryegrass spike density and seed production

ARG spike density was significantly influenced by the time of sowing (P=0.039), herbicide treatment (P<0.001) as well as the interaction between the TOS and herbicide treatment (P<0.001). However, there was no effect of barley seed rate on ARG spike density (P=0.307). When averaged across the seed rates and herbicide treatments, the three week delay in seeding at Minnipa reduced ARG spike density from 808 spikes/m^2 to 504 spikes/m^2 (38% reduction). The interaction between sowing time and herbicide (P<0.001) followed a similar trend to ARG plant density, where TOS 2 had 45-50% lower ARG spike density than in TOS 1 for the control and Trifluralin treatments. No such difference was observed for the two more effective herbicide treatments (Boxer Gold and Overwatch), where sowing time made no significant difference (Figure 3). These results clearly highlight the ability of Boxer Gold and Overwatch to manage the large ARG seedbank present at this site. ARG spike production across the site was reduced by 81% and 78% for Boxer Gold and Overwatch, respectively.

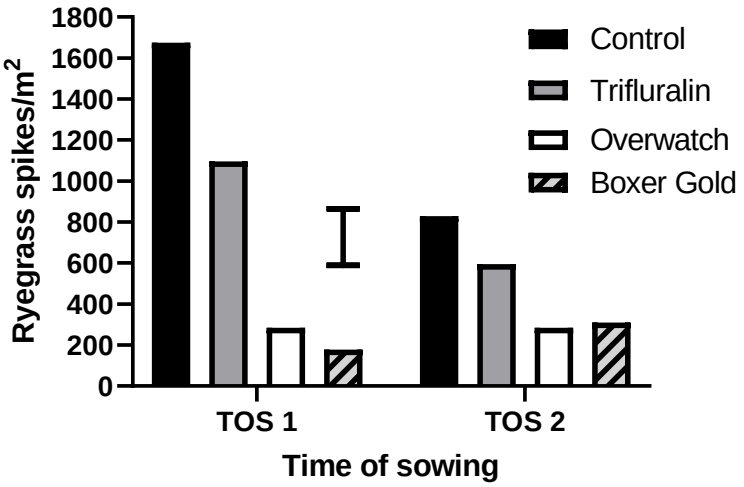

Figure 3. The effect of interaction between the time of sowing and herbicide treatments (P<0.001) on ARG spike density. The vertical bar represents the LSD (P=0.05).

Consistent with the trends observed for ARG spike density, ARG seed production was also significantly influenced by the time of sowing (P=0.011), herbicide treatments (P<0.001) and the interaction between the TOS and the herbicide treatments (P<0.001). Barley seed rate did have a significant effect on ARG seed

production (P=0.022) with crop sown at 150 and 200 seeds/m^2 having 29% and 21% lower ARG seed set than barley sown at 100 seeds/m^2, respectively. The interaction between sowing time and herbicide (P<0.001) followed a similar trend to both ARG plant and spike densities. TOS 2 had significantly lower ARG seed set than in TOS 1 for the control (57%) and Trifluralin (55%). However, no reduction in ARG seed set in TOS 2 was detected for Overwatch and Boxer Gold treatments (Figure 4). These results clearly highlight the ability of Boxer Gold and Overwatch, under good soil moisture conditions, to manage high levels of ARG seedbank present at this site. It is somewhat alarming to note that ARG was able to set 7705 and 8700 ARG seeds even when treated with Boxer Gold or Overwatch. Therefore, sizable seedbank of ARG will be present in the next crop grown in the rotation. These results highlight the need for growers to integrate tactics such as improved crop competitiveness and harvest weed seed control along with herbicides to cause a large decline in the seedbank of this difficult to manage weed.

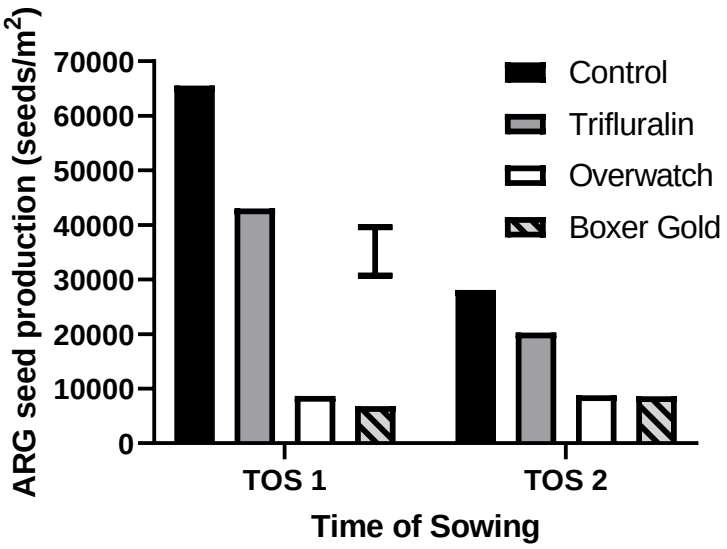

Figure 4. The effect of interaction between the time of sowing and herbicide treatments (P=0.001) on ARG seed production. The vertical bar represents the LSD (P=0.05).

Barley grain yield

Barley seed rate (P<0.001), and herbicide treatment (P<0.001) had a significant effect on grain yield. Barley yield increased as seed rate increased from low (1.840 t/ha), to medium (2.097 t/ha) and high (2.318 t/ha) (Figure 5). The increase in barley yield as seed rate increased from low to high was 26% and is consistent with previous trials in wheat and barley. Increased seed rate had no negative influence on the percentage of barley screenings; however barley screenings reduced with increased control of annual ryegrass with herbicides.

Herbicide treatment had a significant effect on barley grain yield with Trifluralin (1.99 t/ha) increasing grain yield by 16%, Overwatch (2.30 t/ha) 34% and Boxer Gold (2.33 t/ha) by 36% compared to the control (1.72 t/ha) (Figure 6). These yield gains

approximately equate to a 5:1 return on the cost of trifuralin, a 4.5:1 return on Overwatch and a 5.8:1 return on Boxer Gold.

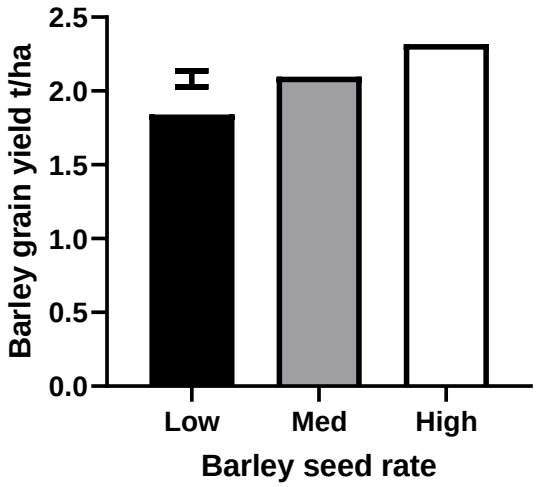

Figure 5. The effect of barley seed rate treatments (P<0.001) on barley grain yield. The vertical bar represents the LSD (P=0.05).

The three week delay in sowing barley did result in a small, but significantly increase in grain yield (P=0.028). This is in complete contrast to a similar trial on wheat in 2018 where a 6 week delay in sowing reduced wheat grain yield by 36%, However, these results from 2021 are similar to 2019 barley trial where a three week delay did not significantly affect barley yield (P=0.644). This lack of impact of delay in sowing barley on its yield is most likely related to its greater early vigour and earlier maturity (i.e. shorter life-cycle) than wheat. These results give some confidence in using a short delay in sowing barley to achieve ARG control compared to wheat, however the cost of that delay would be dependent on seasonal conditions and the variety of barley grown. Compass barley grown in this trial is quite weed competitive and well adapted to a short growing seasons. If a long season barley like Planet or less competitive barley like Spartacus was grown, the penalty from delayed seeding could be larger.

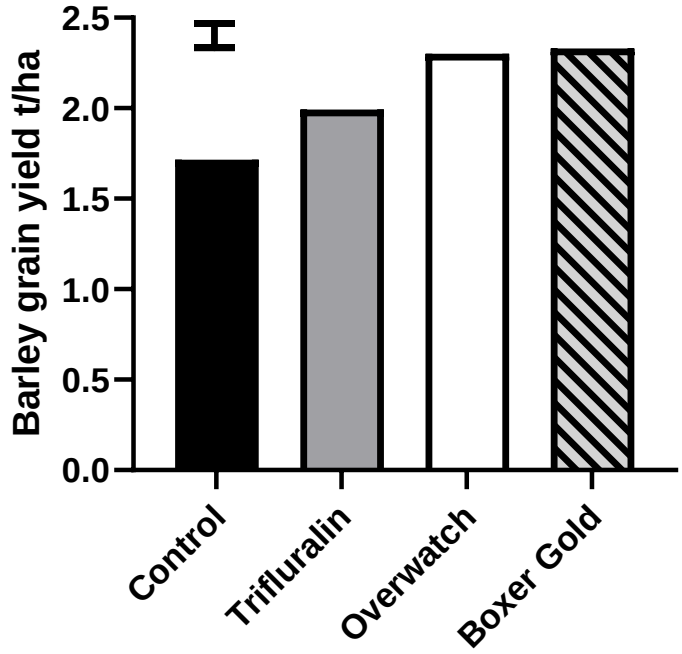

Figure 6. The effect of herbicide treatments (P<0.001) on barley grain yield. The vertical bar represents the LSD (P=0.05).