Integration of time of sowing, crop seed rate and herbicides for the control of annual ryegrass and brome grass

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Key findings

- The response of weed density to delayed sowing is influenced not just by the weather conditions, but also by the seed dormancy attributes of the weed populations.
- At Washpool in 2019, a three-week delay in sowing had no impact on in-crop ryegrass density.
- A lower weed density after delayed sowing does not always reduce weed seed set.
- In all trials, delayed sowing in June resulted in a significant yield penalty. Therefore, a decision to delay sowing to manage weeds needs to considered very carefully.
- Higher crop seed rate on the other hand, appears to consistently improve weed suppression especially in the later sown crops.
- The results of this study clearly show that delayed sowing of wheat allows for greater seed set by ryegrass and is also associated with a large yield penalty.

Background

Constantly evolving weed infestations in Australia are responsible for significant annual expenditures ($2.5 billion) and yield revenue losses ($745 million) for grain growers (Llewellyn et al. 2016). Herbicide resistance is a major concern in the southern and western grain growing regions of Australia where 36 weed species have been confirmed resistant to one or more herbicide modes of action. Annual ryegrass has maintained its number one ranking as a weed of Australian cropping systems for many years. However, brome grass has increased in importance and has climbed to be the fourth worst weed in terms of the area infested, as well as yield and revenue loss in grain crops in Australia (Llewellyn et al. 2016).

After the loss of post-emergence (POST) herbicides used in cereals due to widespread resistance, growers now largely rely on pre-emergence (PRE) herbicides for ryegrass control. PRE herbicides, such as Sakura® and Boxer Gold®, are usually not as effective for ryegrass control as the previously used POST herbicides. Furthermore, the efficacy of the PRE herbicides tends to be strongly influenced by the soil moisture conditions at sowing and in the early weed emergence period after sowing. As the autumn-winter rainfall in southern and Western Australia has become more erratic in the last few years, the performance of the PRE herbicides has also become quite variable. Therefore, many cereal crops sprayed with PRE herbicides in dry starts to the season can be quite weedy, which means greater crop yield loss and weed seed set for future infestations.

Previous research has shown the benefits of higher wheat seed rates for the suppression of ryegrass (e.g. Lemerle et al. 2004), which can be easily integrated with herbicide tactics. Delay in crop sowing can be used to manage dense weed infestations by exposing a greater proportion of the weed seedbank to pre-sowing weed control tactics. However, delayed sowing is often associated with lower crop yields, especially in the low to medium rainfall environments. Gill and Kleemann (2013) have also shown that brome grass populations from cropping fields in the Mid-North of South Australia and Victorian Mallee regions can have significantly longer dormancy than those from non-cropped habitats.

Similar patterns of selection for increased seed dormancy have also been observed in ryegrass populations from WA under high cropping intensity (Owen et al. 2015). This adaptation mechanism facilitates avoidance of pre-sowing weed control practices.

In this GRDC funded project, research is being undertaken to investigate the effects of integrating crop sowing time, seed rate and herbicide tactics on ryegrass and brome grass management. Three case studies are presented here to highlight the impact of these management tactics on weed control.

How was it done?

Replicated field trials were undertaken in South Australia in 2018 and 2019 to investigate ryegrass and brome grass management in cereals.

Table 1. Management information on weed control trials.

Detail	Washpool 2019	Minnipa 2018	Marrabel 2018
Weed species	Ryegrass	Ryegrass	Brome grass
Crop (variety)	Wheat (Scepter)	Wheat (Scepter)	Barley (Spartacus CL)
Sowing date	TOS 1: May 15, 2019 TOS 2: June 5, 2019	TOS 1: May 11, 2018 TOS 2: June 25, 2018	TOS 1: May 24, 2018 TOS 2: June 19, 2018
Crop seed rate	100, 150 or 200 seeds/m^2	100, 150 or 200 seeds/m^2	100, 150 or 200 seeds/m^2
Herbicides	1. Control (knockdown only) 2. Boxer Gold® 2.5L/ha IBS 3. Sakura® 118g/ha + Avadex® 1.6 L/ha IBS	1. Control (knockdown only) 2. Boxer Gold® 2.5L/ha IBS 3. Sakura® 118 g/ha+ Avadex® 1.6L/ha IBS	1. Control (knockdown only) 2. Treflan® 2L/ha + Avadex® 2L/ha IBS 3. Treflan® 2L/ha + Avadex® 2L/ha IBS Fb Intervix® 750mL/ha at GS14
Growing season rainfall (mm)	229	186	195

Active ingredients: Boxer Gold = prosulfocarb + s-metolachlor; Sakura = pyroxasulfone; Avadex = triallate; Treflan = trifluralin; Intervix = imazamox plus imazapyr

Results and Discussion

Case study 1: ryegrass management Washpool (Spalding) 2019

There was no evidence at this site of any reduction in ryegrass infestation in wheat by delaying sowing by three weeks between TOS 1 (77 plants/m^2) and TOS 2 (74 plants/m^2). In 2019, the trial site only received 22.6 mm rain during the three weeks between TOS 1 and 2. Dry surface soil conditions during the delay in sowing may have been responsible for the lack of response in ryegrass plant density observed at this site. Weed populations are also known to differ greatly in seed dormancy. It is quite likely that the Washpool population has a high level of seed dormancy, which reduces the rate of ryegrass germination after the season opening rainfall events.

Wheat was much more competitive against ryegrass when it was sown early (TOS 1; Figure 1a). Even in the control (knockdown only), ryegrass head number was significantly lower in TOS 1 than in TOS 2. This trend of superior crop competitive ability against ryegrass was also evident in Boxer Gold® and Sakura® + Avadex® treatments. In-crop ryegrass density was quite similar between TOS 1 and 2; moreover, it can be argued that on a per plant basis, ryegrass was much more competitive against wheat sown under cold conditions of TOS 2 than warmer conditions conducive for the early crop vigour in TOS 1.

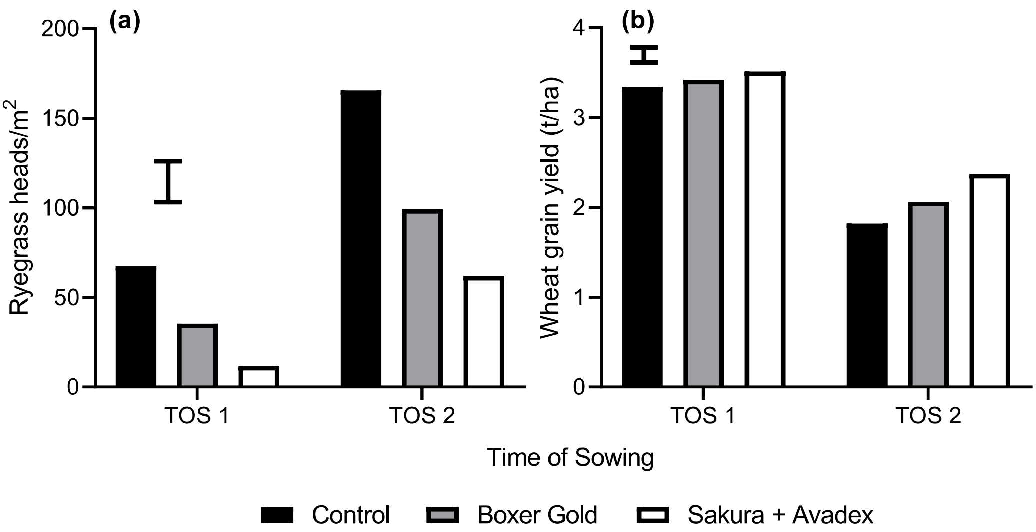

Figure 1. The effect of time of sowing and herbicide treatments on ryegrass head density (a) and wheat grain yield (b) at Washpool in 2019. The error bars represent LSD (P=0.05).

Wheat grain yield at this site was significantly influenced by the time of sowing, seed rate, herbicide treatments, and the interaction between the time of sowing and herbicides (Figure 1b). Wheat was much more tolerant to ryegrass competition when sown early (TOS 1); indeed, there was a small increase in grain yield in herbicide treated plots, but the differences were non-significant. In contrast, there was a significant increase in wheat grain yield in herbicide treatments in TOS 2. The yield gap between TOS 1 and TOS 2 in herbicide treatments ranged from 45% in the control to 40% in Boxer Gold® and 32% in Sakura® + Avadex®. The yield gap between the two sowing dates ranged from 1.14 to 1.52t /ha. The results of this study clearly show that delayed sowing of wheat allows for greater seed set by ryegrass and is also associated with a large yield penalty.

Case study 2: ryegrass management Minnipa 2018

A six week delay in sowing reduced dense establishment of ryegrass in wheat at this site (Figure 2a). This was particularly evident in the untreated control (Figure 2a), as weed density decreased from 262 plants/m^2 (TOS 1) to 139 plants/m^2 (TOS 2). The ryegrass population at Minnipa appears to have low seed dormancy, which allowed it to germinate and establish in response to many small rainfall events in June. Delayed sowing also created a synergistic interaction between the more favourable soil moisture conditions and the reduction in ryegrass density by the knockdown treatment, which collectively improved the efficacy of herbicide treatments in TOS 2 (Figure 2a).

Ryegrass seed production was significantly affected by the time of sowing, herbicide treatments and the interaction between the TOS and the herbicide treatments. PRE herbicides performed much better in TOS 2. (Figure 2b). Sakura® + Avadex® was the most effective herbicide treatment across both times of sowing; however, coupling this treatment with delayed sowing provided a 94% reduction in ryegrass seed set in TOS 2 (53 seeds/m^2). In contrast, seed production exceeded 800 seeds/m^2 for all herbicide treatments in TOS 1. This highlights the value of the knockdown treatment alone, as there was a 53% reduction in seed production with delayed sowing. Boxer Gold® efficacy also exhibited greater response to delayed sowing than Sakura® + Avadex®, with seed production ranging from 35% (TOS1) to 9% (TOS 2) of the control. Sakura® + Avadex® offered greater stability in preventing ryegrass seed production in TOS 1 (13%) and TOS 2 (2%) relative to the control.

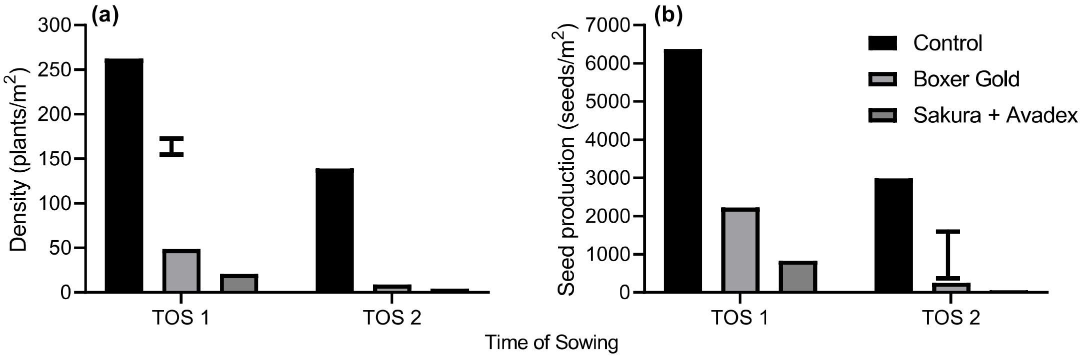

Figure 2. The effect of time of sowing wheat and herbicide treatments on in-crop ryegrass plant density (a) and its seed production (b) at Minnipa in 2018. The error bars represent LSD (P=0.05).

Wheat grain yield at Minnipa was significantly influenced by the time of sowing, seed rate, herbicide treatment, and the interaction between the time of sowing and herbicide treatments. Averaged across the seed rates and herbicide treatments, wheat produced grain yield of 1.67 t/ha in TOS 1, as compared to 1.06 t/ha in TOS 2. Even though the amount of rainfall received in May and June was well below the long-term average, a six-week delay in sowing reduced wheat yield by 36%. Wheat yield increased as seed rate increased from low (1.25 t/ha), to medium (1.41 t/ha) and high (1.44 t/ha). Even though the increase in wheat yield in response to seed rate was only 13%, it was statistically significant. There was no negative effect of crop seed rate on grain screening content, which ranged from 4% in low seed rate, to 3% in the medium and high seed rate treatments.

There were large benefits of delayed sowing on weed control by herbicides in terms of ryegrass plant density, head density and seed production. However, these benefits came at a significant cost in wheat grain yield (Figure 3). Wheat grain yield was reduced in all the herbicide treatments due to delayed sowing. Wheat benefited much more from herbicide treatments in TOS 1, where ryegrass density was much greater than in TOS 2. Therefore, it would not be advisable to delay sowing wheat to manage ryegrass unless weed seedbanks are excessively large. It would be preferable to target the optimum sowing date for wheat in the region and use the most effective herbicide options available to control ryegrass. Based on grain yields achieved and APW prices in 2018, TOS 1 treated with Boxer Gold® provided $291/ha greater gross margin than TOS 2 treated with the same herbicide. The superior levels of ryegrass control achieved by the Sakura® + Avadex® treatment with delayed sowing translated to a $9/ha advantage in gross margin over applying Boxer Gold®.

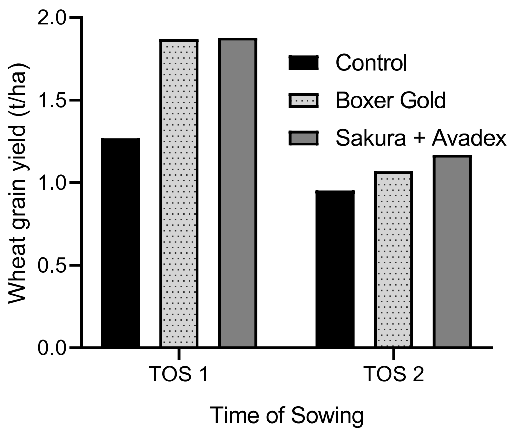

Figure 3. The effect of time of sowing wheat and herbicide treatments on wheat grain yield at Minnipa in 2018.

Case study 3: brome grass management Marrabel 2018

Brome grass plant density was significantly affected by the time of sowing and the herbicide treatments. The four week interval between TOS 1 and TOS 2 extended the opportunity for brome grass seedlings to emerge before sowing. Consequently, barley sown at TOS 2 had 48% lower brome grass infestation (108 plants/m^2) than in TOS 1 (207plants/m^2). As expected, herbicide treatments had a significant effect on brome grass plant density. When averaged across the sowing time and seed rates, the treatment of Treflan® + Avadex® was moderately effective and reduced brome grass density by only 36% (173 plants/m^2) relative to the untreated control (271 plants/m^2). In contrast, the same PRE treatment (Treflan® + Avadex®) followed by Intervix® reduced brome grass density by 90% (28 plants/m^2).

There was a significant interaction between the time of sowing and herbicide treatments. This interaction appears to be mainly associated with improved activity of Treflan® + Avadex® in TOS 2 compared to TOS 1 (Figure 4a). In TOS 2, there was 32.4 mm rainfall during the week before crop sowing, which would have created a moist seedbed and suitable conditions for the activity of trifluralin and Avadex®. In contrast, the total rainfall for the week before and week after sowing for TOS 1 was only 8.8 mm.

Brome grass seed production was significantly affected by the herbicide treatment and the interaction between sowing time and herbicide treatment. The interaction between these two management factors was almost entirely due to significantly lower brome grass seed production in the untreated control in TOS 1 than in TOS 2 (Figure 4b). This result appears to be associated with the lower head density in the control plots in TOS 1 than TOS 2. Delayed sowing reduced the competitiveness of barley with brome grass because the crop emerged under cool conditions in mid-June. Imidazolinone herbicide Intervix® was extremely effective and completely prevented brome grass seed production in this trial. The cheaper herbicide option of Treflan® + Avadex® was weak against brome grass, which was reflected by much higher seed production in TOS 1 (6258 seeds/m^2) than in TOS 2 (5667 seeds/m^2).

Time of sowing barley had a significant effect on its grain yield; TOS 1 produced 940 kg/ha greater barley grain yield than TOS 2. Barley sown in May (TOS 1) was growing in a warmer soil, whereas TOS 2 experienced lower establishment and cooler conditions during early growth. Therefore, barley showed a small response to increased seed rate in TOS 1, but there was a significant increase in yield with seed rate in TOS 2. Herbicide treatment had a large effect on crop yield (Figure 5), which was reflected in a significant increase in grain yield by the herbicide treatments compared to the untreated control. The POST application of Intervix® to the crop treated with Treflan® + Avadex® further increased barley grain yield by 872 kg/ha. Even though there were more brome plants present in all the treatments in TOS 1, barley was able to compete with them effectively and produced consistently higher yields in the early sown crop. Furthermore, when no PRE herbicides were used (control), brome grass produced significantly greater number of seeds in TOS 2 (10048 seeds/m^2) than in TOS 1 (6754 seeds/m^2). This result highlights the superior crop competitiveness of early sown barley.

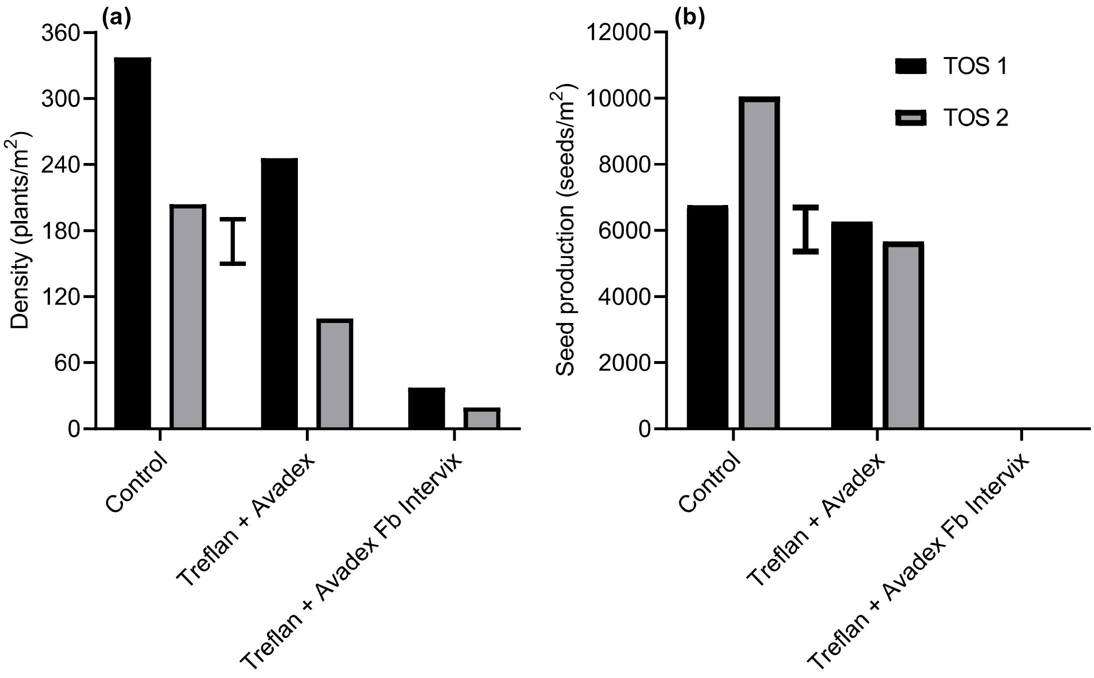

Figure 4. The effect of sowing time and herbicide treatments on brome grass plant density (a) and brome grass seed production (b) at Marrabel in 2018. The error bars represent LSD (P=0.05).

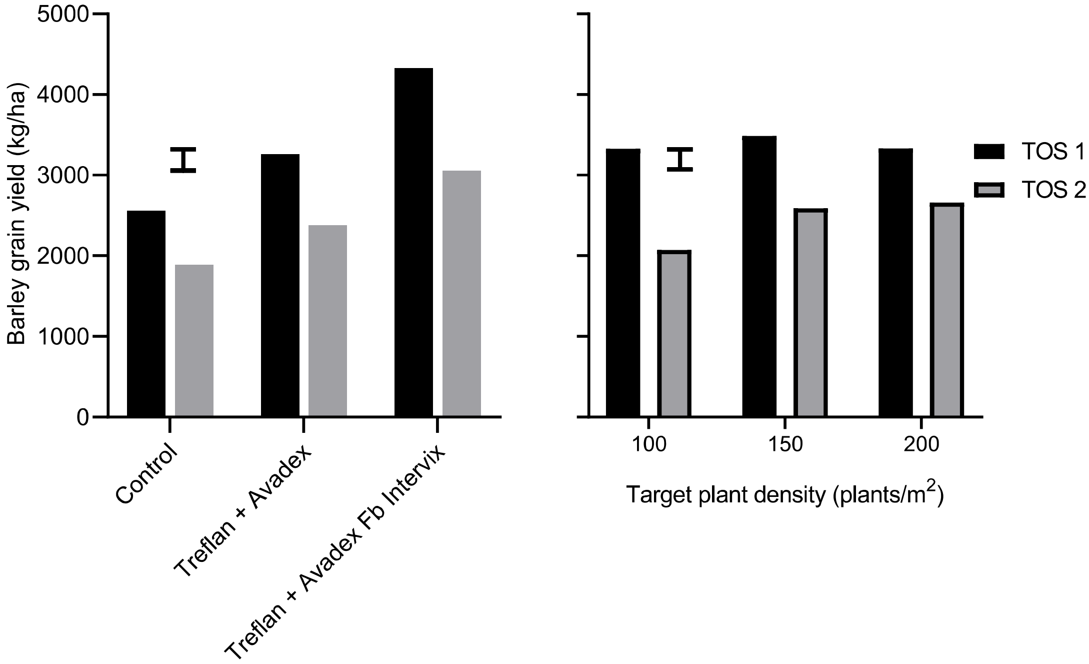

Figure 5. The effect of sowing time and herbicide treatments on barley grain yield (a) and sowing time x seed rates on barley grain yield (b) at Marrabel in 2018. The error bars represent LSD (P=0.05).

Conclusion

Field trial results from Washpool in 2019 showed no reduction in ryegrass in-crop density from the three-week delay in sowing wheat. Furthermore, delayed sowing reduced the competitive ability of wheat, which was reflected in greater ryegrass head numbers in TOS 2 than in TOS 1. Greater head density in weeds is invariably associated with increased seed production. Ryegrass also caused a greater yield loss in wheat in TOS 2 than in TOS 1, which can be seen by the difference between the control and herbicide treatments. Even more importantly, there was a large yield penalty from delayed sowing of 1t/ha due to reduced utilisation of resources, such as water, light and nutrients.

At Minnipa in 2018, delay in sowing of wheat was able to reduce in-crop ryegrass density and its seed production, but it was again associated with a significant yield penalty (25-43%). In the brome grass management trial at Marrabel in 2018, delayed sowing caused a large reduction in brome grass plant density in barley; however, surviving brome plants were more vigorous in TOS 2 and compensated for reduced plant density. The application of POST Intervix® after the PRE herbicide treatment completely prevented weed seed set in TOS 1 and TOS 2. Consistent with the other two trials, delay in barley seeding to improve weed control reduced barley grain yield by 26-29%. Increasing the density of wheat and barley improved the tolerance of these crops to competition from brome grass and ryegrass without negatively impacting on grain quality at all sites.

Growers should carefully consider the emergence patterns of field populations of brome grass and ryegrass, as this will have overarching implications to the both the efficacy of the PRE herbicides, and the water limited yield potential from delayed sowing.

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