Evaluation of pre-emergent herbicides for brome grass in barley

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Key findings

- Brome grass is increasing in prevalence across southern Australia and control in cereals is heavily reliant on Group B herbicides (sulfonylurea and imidazolinones).
- Experimental herbicides evaluated in this study were effective on brome (>90% control), but were also unsuitable for barley causing severe crop damage; trials undertaken this season (2017) will focus on wheat.
- Identifying effective but safe herbicide options for brome in cereals remains a high priority.

Why do the trial?

Achieving effective control of brome with pre-emergent herbicides has become more difficult as cropping populations have been selected for greater dormancy and extended seedling emergence during the growing season. These high-dormancy populations can reduce early weed control by germinating after the activity of residual herbicides has diminished. Pre-emergent herbicides can enhance the performance of grass selective herbicides such as Crusader®, Atlantis® and Intervix® by reducing the amount of brome requiring in-crop control. Such combinations also help to delay onset of herbicide resistance as herbicides from several different MOA's can be used within a single cropping phase.

In cereals, only Group B herbicides can be used for post-emergent control of brome grass. The over-reliance on sulfonylurea herbicides has resulted in increasing resistance in this spp. in South Australia and Victoria (Peter Boutsalis, pers. comm.). Growers have responded by sowing Clearfield cereals and using imidazolinone herbicides for weed control. In recent years, resistance to the imidazolinone herbicides has been identified in some populations of brome from South Australia and Victoria. There is an urgent need to identify suitable alternatives to imidazolinone herbicides for brome grass control in cereals.

Here we report results from a field trial undertaken at Balaklava in 2016 to evaluate the performance of several different pre-emergent herbicides and their mixtures on brome infestation in barley. Previous pot studies had identified experimental herbicides Expt_A, Expt_B, and Expt_C as potential options for brome. Therefore, these herbicides were investigated in this field trial.

How was it done?

The trial was established in a RCBD (randomised complete block) design, with four replicates of each treatment. The trial site, which has been under no-till management for the past 10 years, had a modest to high background population of great brome (*Bromus diandrus*).

Table 1. Crop management and herbicide application details for pre-emergent herbicide trial at Balaklava.

Seeding date	Barley cultivar	Seeding rate (*kg/ha*)	IBS application date
1 June	Compass	70	29 May

The trial was sown into a wheat stubble using a standard knife-point press wheel system on 27 cm (11") row spacings. Sowing and fertiliser rates were undertaken as per district practice (Table 1). Herbicide treatments were developed for experimental purposes only and many are not currently registered (Table 2). Herbicide treatments were incorporated by sowing (IBS) within a few days of application. This minor delay in incorporation was not considered an issue as these herbicides are highly stable (non-volatile). Assessments included brome grass control (reduction in plant and panicle density), crop establishment and growth (vigour and height), grain yield and quality (seed size and contamination).

Table 2. Pre-emergent herbicide treatments evaluated at Balaklava in 2016.

Herbicide treatment	Herbicides applied
1	Nil
2	*Sakura (118 g/ha)
3	Avadex Xtra (3.2 L/ha)
4	Terbyne Xtreme (1.2 kg/ha)
5	*Sakura (118 g/ha) + Avadex Xtra (3.2 L/ha)
6	Expt_A (250 g/ha)
7	Expt_A (250 g/ha) + Avadex Xtra (3.2 L/ha)
8	Expt_A (250 g/ha) + Terbyne Xtreme (1.2 kg/ha)
9	Expt_B (1.56 kg/ha)
10	Expt_B (1.56 kg/ha) + Avadex Xtra (3.2 L/ha)
11	Expt_B (1.56 kg/ha) + Terbyne Xtreme (1.2 kg/ha)
12	Expt_C (4 kg/ha)
13	Expt_C (4 kg/ha) + Avadex Xtra (3.2 L/ha)
14	Expt_C (4 kg/ha) + Terbyne Xtreme (1.2 kg/ha)

*Sakura is not registered for use in barley, and was used for experimental purposes only.

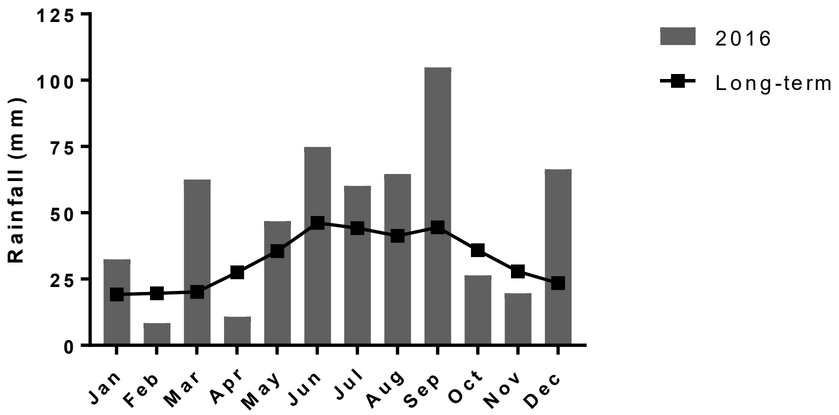

Figure 1. Long-term and monthly total rainfall at Balaklava in 2016.

Results and discussion

The site received above average rainfall from sowing through Winter to early Spring (Figure 1). The month of June alone received nearly double (75 mm) the long-term average rainfall (46 mm) resulting in favourable conditions for pre-emergent herbicide activity. Therefore good brome control (>70%) was found seven weeks after sowing (WAS) with 10 out of 13 of the herbicide treatments evaluated (Table 3). Even Terbyne, known for its inconsistency against brome, provided control as high as 86%. However, herbicides Expt_A and Avadex provided <58% control of brome relative to the untreated nil (495 plants/m^2). Similar to other triazine herbicides, Terbyne's (terbuthylazine) activity is known to be highly sensitive to soil moisture and poor grass control is usually associated with dry soil conditions.

In this season however, wet soil conditions throughout Winter would have maintained a high level of activation and herbicide absorption by weed seedlings with Terbyne control persisting beyond 12 WAS (93%). Not surprisingly, herbicide mixtures with Terbyne were also effective with Expt_A + Terbyne, Expt_B + Terbyne and Expt_C + Terbyne providing 90-96% control respectively.

Table 3. Effect of pre-emergent herbicide treatments on brome grass control at Balaklava in 2016.

Treatments	Brome grass (plants/m^2)		Brome grass (panicles/m^2)
	7 WAS	12 WAS	
Nil	495	429	244
*Sakura (118 g/ha)	146	125	143
Avadex Xtra (3.2 L/ha)	207	246	218
Terbyne Xtreme (1.2 kg/ha)	68	31	61
*Sakura (118 g/ha) + Avadex Xtra (3.2 L/ha)	160	169	146
Expt_A (250 g/ha)	259	297	269
Expt_A (250 g/ha) + Avadex Xtra (3.2 L/ha)	127	117	153
Expt_A (250 g/ha) + Terbyne Xtreme (1.2 kg/ha)	55	19	53
Expt_B (1.56 kg/ha)	91	62	85
Expt_B (1.56 kg/ha) + Avadex Xtra (3.2 L/ha)	63	30	90
Expt_B (1.56 kg/ha) + Terbyne Xtreme (1.2 kg/ha)	77	42	39
Expt_C (4 kg/ha)	81	52	116
Expt_C (4 kg/ha) + Avadex Xtra (3.2 L/ha)	124	67	116
Expt_C (4 kg/ha) + Terbyne Xtreme (1.2 kg/ha)	71	41	88
LSD ($P \leq 0.05$)	89.7	111.1	67.4

*Sakura is not registered for use in barley, and was used for experimental purposes only.

In contrast to Expt_A, both Expt_B and Expt_C were far more effective against brome (85-88% versus 31% control). Even though severe bleaching of brome was observed initially from Expt_A, this bleaching appeared transient in nature, and the plants appeared to recover quickly. Brome was also strongly bleached from Expt_B, but the symptoms appeared to persist; whereas Expt_C stunted plant growth.

Sakura plus Avadex, which has consistently performed well in wheat (>90% control), was less effective in this study (61%), which could be related to the high brome density (>400 plants m^2) at the site. Similarly Avadex at 3.2 L/ha proved ineffective (43% control) but was better when applied as a tank-mix with Expt_A (73%) and Expt_B (93%). Whilst the exact reason for improved control with mixtures of Avadex is unclear, it could simply be related to differences in primary uptake (i.e. more coleoptile rather than root uptake) and position of germinating brome in the soil (i.e. additional control of deeper germinating brome via coleoptile uptake).

Terbyne and its mixtures with Expt_A, Expt_B and Expt_C provided the greatest reduction in brome panicle density (<90 panicles/m^2); whereas other treatments resulted in unacceptable and similar seed production to the control (244 panicles/m^2; Table 3). The extended persistence of Terbyne was clearly evident even after 12 WAS with brome showing strong symptoms of PSII inhibitor (i.e. severe leaf chlorosis followed by necrosis). Even though Spring conditions were favourable these plants were unable to fully recover, and seed set was subsequently lower for these treatments.

Regardless of herbicide treatment there was a strong hyperbolic relationship (r^2=0.89) between brome plant and panicle density (Figure 2). The slope of the relationship showed that seed production per plant increased sharply at lower plant densities but began to plateau at densities above 300 plants/m^2, most likely because of greater intraspecific competition between brome plants.

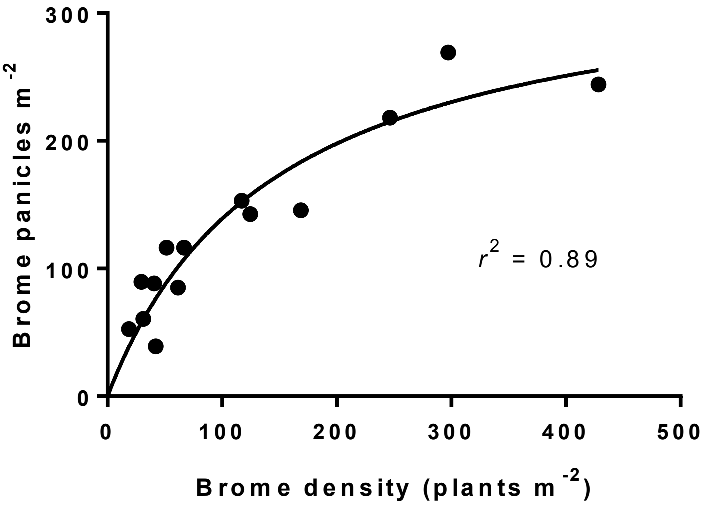

Figure 2. Relationship between average plant density and average panicle density of brome grass across all herbicide treatments at Balaklava. Each data point represents the average of four replicates.

In this study, herbicides which were most effective on brome were also the most damaging to the barley crop. Finding safe yet effective herbicides for brome in cereals has been elusive. In a preliminary pot study (Preston and Lenorage 2016) many of these herbicides at low rates appeared safer in wheat than barley, but damage to barley was generally <10%. Given the herbicide damage observed to barley in this field trial, evaluations planned for this season (2017) will focus on wheat.

Crop establishment was significantly (P<0.05) reduced relative to the control (100 plants/m^2) in seven of the 13 herbicide treatments (Table 4). Whilst the symptoms varied, Terbyne, Expt_B and Expt_C were all damaging to barley. Combination of Terbyne and Expt_B was the most damaging treatment, significantly (P<0.05) reducing barley emergence, growth (vigour and height), and ear density relative to the untreated nil. The combination of low clay and OM content of the soil with above average rainfall would have increased the mobility and uptake of these herbicides by the crop. Despite the initial setback in crop emergence by Expt_B and Expt_C, barley in these treatments appeared to compensate for lower density by increasing tiller production. As a consequence, ear numbers and subsequent grain yield for these treatments were similar to the nil (Table 4 and Figure 3).

Table 4. Effect of pre-emergent herbicide treatments on barley establishment, vigour, ear no. and anthesis height at Balaklava in 2016.

Treatments	Barley density (plants/m^2)	Barley vigour (1=poor; 10=good)	Ear no. (ears/m^2)	Anthesis height (cm)
Nil	96	10.0	254	77.6
*Sakura (118 g/ha)	98	5.5	222	69.9
Avadex Xtra (3.2 L/ha)	107	8.8	273	80.3
Terbyne Xtreme (1.2 kg/ha)	74	5.1	171	70.1
*Sakura (118 g/ha) + Avadex Xtra (3.2 L/ha)	100	6.6	275	70.5
Expt_A (250 g/ha)	102	9.3	273	77.3
Expt_A (250 g/ha) + Avadex Xtra (3.2 L/ha)	104	7.6	291	78.7
Expt_A (250 g/ha) + Terbyne Xtreme (1.2 kg/ha)	73	3.4	150	66.7
Expt_B (1.56 kg/ha)	73	3.8	272	70.1
Expt_B (1.56 kg/ha) + Avadex Xtra (3.2 L/ha)	68	3.5	278	69.2
Expt_B (1.56 kg/ha) + Terbyne Xtreme (1.2 kg/ha)	45	2.5	90	61.7
Expt_C (4 kg/ha)	83	3.6	241	70.8
Expt_C (4 kg/ha) + Avadex Xtra (3.2 L/ha)	76	3.8	229	65.9
Expt_C (4 kg/ha) + Terbyne Xtreme (1.2 kg/ha)	65	3.6	178	68.1
LSD ($P \leq 0.05$)	13.7	1.2	59.3	8.0

*Sakura is not registered for use in barley, and was used for experimental purposes only.

There was a significant ($P \leq 0.05$) effect of herbicide treatment on barley yield (Figure 3a). Although 2016 received well above average Winter and Spring rainfall (Figure 1), barley yields were highly variable (0.92 to 4.01 t/ha) in response to weed control but also herbicide damage. Furthermore, grain yield was strongly ($P \leq 0.001$) and positively ($r^2 \geq 0.9$) correlated to crop growth and barley ear density. About ½ of the herbicide treatments resulted in a modest yield improvement relative to the nil (Figure 3.). Despite the improved weed control with Terbyne, and its tank-mix with either Expt_A, Expt_B or Expt_C, these treatments produced significantly less grain (0.92 to 2.05 t/ha) compared to the untreated nil (3.12 t/ha). Herbicide damage was so severe in these treatments that even though weed competition was reduced, barley could not benefit from reduced weed competition.

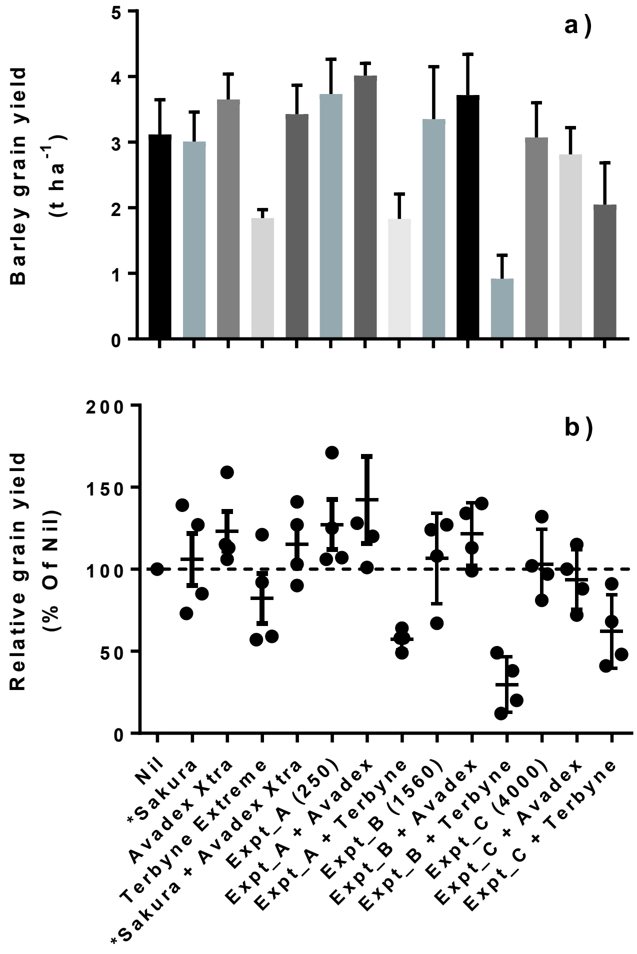

*Figure 3. Effect of pre-emergent herbicides on grain yield (a) and relative grain yield (% of nil) of barley (b) at Balaklava in 2016. *Sakura is not registered for use in barley, and was used for experimental purposes only.*

Conclusions

This field trial clearly demonstrated that experimental herbicides Expt_A, Expt_B and Expt_C applied as a tank-mix with Terbyne were capable of providing effective residual brome control (>90%). However, these treatments are unsuitable for use in barley because of severe crop damage. Consequently herbicide evaluations planned for this season (2017) will focus on wheat, which was shown to have superior tolerance to these herbicides.

As a consequence of the increasing prevalence of brome across southern Australia, the need to identify effective but safe herbicides for use in cereals remains a high priority.

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