

Investigation of combinations of cropping sequence and herbicides for the management of brome grass

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Key findings

- Management systems based on integration of crop type (wheat, barley, canola and lentil) with herbicide options are being investigated for brome grass management at a trial site near Snowtown in the Mid North of SA.
- The soil cores taken from trial site showed presence of a large and uniform brome grass seedbank (5849 ± 631 seeds/m²).
- Systems where pre-emergent herbicides were followed by post-emergent Group 1 herbicides in break crops (lentils and canola) virtually eliminated brome grass plants.
- Brome grass panicle density provided the clearest separation between management systems. Wheat treated with Sakura + Avadex was the worst performer with >500 panicles/m². In contrast, the lowest density of brome panicles was found in canola and lentil-based systems where post-emergent herbicides were used.
- Barley systems based on Clearfield (Intercept post-emergent) or CoAXium system provided 78- 93% reduction in brome grass panicle density. In contrast, Barley CL based on pre-sowing Sentry herbicide had a significantly higher number of brome grass panicles than the same barley variety treated with Intercept post-emergent.
- There were large differences in brome grass seed set on an area basis with Calibre wheat sprayed with Sakura + Avadex producing more than 8000 seed/m². The lowest weed seed production was observed in lentils and canola, which ranged from 41 to 118 seeds/m².
- Lentil based management systems provided excellent brome grass control and produced good grain yields (>2 t/ha). The canola system with Group 1 post-emergent herbicide also gave effective control of brome grass. Among cereals, Clearfield barley and CoAXium barley (T4, 5 and 7) produced similar grain yield (3.11-3.39 t/ha).

Introduction

Brome grass is currently ranked the fourth worst weed in Australia in terms of the area infested, as well as yield and revenue loss in grain crops (Llewellyn et al. 2016). Brome grass tends to be difficult to effectively control with pre-emergent herbicides that are registered for use in cereal crops. However, development of herbicide tolerant cereal varieties has opened options for growers to manage brome grass effectively in the cereal phase of the rotations.

Integration of herbicide tolerant cereals with break crops such as pulses and canola offer opportunities to effectively deplete brome grass seedbank and minimise the risk of buildup in its populations. Fortunately, the frequency of resistance to Group 1 and 2 herbicides in brome grass is still low (<2%).

It is important to demonstrate the potential effectiveness of combinations of cropping sequences with herbicides, for the management of brome grass in different agroecological environments. To achieve this objective, a three-year field trial was implemented during the 2024 growing season near Snowtown in the Mid North region of South Australia. This trial is a collaborative effort between the University of Adelaide, the Hart Field-Site Group and Trengove Consulting.

Methods

Site selection and rainfall

A field trial was established in a randomised complete block design with seven treatments (Table 1) on a commercial farm near Snowtown in the Mid North region of South Australia. This farm has a loamy textured soil which is suitable for brome grass. Visual inspection of the site in autumn showed presence of brome grass residue and confirmed suitability of this site for this investigation.

Prior to seeding, soil cores were taken to determine seedbank of brome grass at the trial site. Twenty cores of 10 cm diameter were taken from each replicate block and bulked and taken to Roseworthy. Soil samples were placed in seedling trays (pots) in May and watered as required to maintain ideal moisture conditions for seed germination and seedling emergence. Established brome grass seedlings were counted and removed each week until seedling emergence ceased. This data was used to determine brome grass seedbank and its seedling establishment pattern, which is an indicator of seed dormancy.

The trial was sown on May 22 with a double shoot knife point press wheel system on 25 cm spacings after the application of IBS (incorporated by sowing) treatments. Plots were 15 m long and there was one buffer plot of Spartacus CL barley between each experimental plot to minimise the risk of spread of weed seeds to neighbouring plots during crop harvest or by wind dispersal and minimise the risk of herbicide drift from an adjacent plot to a sensitive crop. Information on crop varieties and other management practices used in this trial can be found in Table 1.

Table 1. Details of the experimental site including location and seeding details.

Operation	Details
Location	Snowtown, SA (-33.74190, 138.18355)
Seedbank soil cores	May 10, 2024
Plot size	1.5 m x 15 m
Seeding date	May 22, 2024
Seeder information	No-till 6-row experimental seeder
Fertiliser application	At seeding 80kg MAP + Zn1% on all plots plus 100 kg urea to wheat, barley and canola plots. All fertiliser was applied 30 mm below the seed. In-crop application of urea to wheat and canola on August 14
Crop varieties	Wheat - Scepter Canola - HyTTec Trophy Lentil XT - GIA Thunder Barley CL - Maximus CL Lentil XT - GIA Thunder Barley AX - Titan AX
Crop establishment	July 2, 2024
Weed assessments	Brome plant density – July 2 and October 1 Brome panicle density – November 1
Crop grain yield harvest	November 4 (desiccation of canola and lentil on November 1)

The summer months of 2024 were extremely dry with no follow up rainfall from March to April (Table 2). Conditions following seeding were dry with below average rainfall received for May (15 mm), with 10 mm follow-up rainfall eight days later.

Above average rainfall in June and average rainfall in July were important for stimulating crop growth. The site also received above-average rainfall in the month of October, which played an important role in grain filling of crops. The site also received 139.5 mm out of season rainfall, most of which occurred in December 2023 (96.5 mm). Based on 25% conservation of summer rainfall with good management practices, it is estimated there was 38 mm additional stored soil water at this site.

Table 2. Manual rainfall records for 2024 season at the Snowtown trial site.

Month	Rainfall in 2024 (mm)
Jan	22.0
Feb	0.0
Mar	0.0
Apr	0.0
May	15.0
Jun	71.8
Jul	40.5
Aug	21.0
Sep	10.0
Oct	53.5
Nov	0.0
Dec	0.0
Annual total	233.8
Growing season rainfall	211.8

Rationale for management systems selected

Crops grown widely in the Mid North region were selected and trialed with various herbicide regimes (Table 3 and 4). System 1 represents the best option currently available for use in non-herbicide tolerant varieties. This system typically provides 60-70% control and brome grass plants often recover late in the season to set seed. Therefore, brome grass population in this system is likely to remain stable or increase steadily.

The duration of break years represents the period of effective control during the three-year sequence. Two Clearfield® barley systems were selected; post-emergent imidazolinone (IMI) herbicide treatment, which is likely to be highly effective and PRE IMI system, which is likely to have a lower efficacy. In addition to pre-emergent and post-emergent herbicides, crop-topping will be used in lentils to prevent seed set by brome grass.

Table 3. Management systems to be investigated for brome grass control at Snowtown, SA.

Trt #	System	2024	2025	2026
1	Weaker control	Wheat	Wheat	Barley
		Sakura + Avadex (IBS)	Overwatch + Avadex (IBS) Fb Crusader (POST)	Treflan + Avadex + Met (IBS)
2	1 year break	Canola	Wheat	Barley
		Propyzamide + simazine (IBS) Clethodim + atrazine (POST)	Sakura + Avadex (IBS)	Treflan + Avadex + Met (IBS)
3	1-year break	Lentil XT	Wheat	Barley
		Propyzamide (IBS) Fb Factor + clethodim + Intercept (POST) Fb crop topping	Overwatch (IBS)	BoxerGold (IBS)
4	2-year break (POST IMI)	Maximus CL	Lentil XT (soaker)	Wheat
		BoxerGold + Treflan (IBS) Fb Intercept (POST)	Propyzamide (IBS) Fb Group 1/A (2x POST timings) Fb crop topping	Sakura + Avadex (IBS)
5	2-year break (PRE IMI)	Maximus CL	Lentil XT (soaker)	Wheat
		BoxerGold + Treflan + Sentry (IBS)	Propyzamide (IBS) Fb Group 1/A (1x POST timings) Fb crop topping	Sakura + Avadex (IBS)
6	3-year break	Lentil XT	Canola XC	Wheat CI+
		Propyzamide (IBS) Fb Group 1/A + Group 2/B (POST) Fb crop topping	Propyzamide or Overwatch (IBS) Fb Crucial + Group 1/A (POST) Fb Crucial TBC (POST)	Sakura + Avadex (IBS) Fb Intercept (POST)
7	3-year break (no IMI)	Barley AX	Metro Lentil	Canola TF
		Treflan + Avadex + Metribuzin (IBS) Fb Aggressor (POST)	Ultra + Metribuzin (IBS) Fb group 1/A herbicide (POST)	Propyzamide (IBS) Fb Crucial + Group 1/A herbicide (POST) Fb Crucial (POST)

Table 4. Information about the herbicides to be used for brome grass control in the trial at Snowtown in 2024.

Product name	Active ingredient	Label rate
Sakura®	Pyroxasulfone 850 g/kg	118 g/ha
Boxer Gold®	Prosulfocarb 800 g/L and S-metolachlor 120 g/L	2.5 L/ha
Avadex®	Triallate 500 g/L	3.2 L/ha when used as incorporated by sowing in no-till
Treflan®	Trifluralin 480 g/L	1.5-3.0 L/ha when used in min or no-till knifepoint press wheel system and incorporated by sowing
Intercept®	33 g/L imazamox and 15 g/L imazapyr	375-750 mL/ha for brome grass
Sentry®	525 g/kg imazapic and 175 g/kg imazapyr	40-50 g/ha
Propyzamide	Propyzamide 500 g/L	1 L/ha
Simazine	Simazine 900 g/kg	1 kg/ha in triazine tolerant canola
Clethodim	Clethodim 240 g/L	175-500 mL/ha
Factor®	250 g/kg butroxydim	80-180 g/ha
Metribuzin 750 WG	750 g/kg metribuzin	
Crucial®	Glyphosate 600 g/L	1-1.5 L/ha (in Truflex canola)
Aggressor® AX	Quizalofop 185 g/L	200 mL/ha

Results and Discussion

Crop establishment

Seedling establishment for all crops was lower than the target density (Table 5). For example, wheat target density was 150 plants/m² but the actual density was only 81 plants/m². The exact reason for lower-than-expected crop plant density are unclear. However, distribution of crop plants within plots was uniform and representative of grower establishment and allowed crops to produce good grain yields.

Table 5. Crop density established in different management systems. Information on herbicides used for brome grass control are shown in Table 2.

Treatment	Crop grown in 2024	System	Crop establishment (plants/m ²) ¹
1	Wheat	Weaker control	81 ^b
2	Canola TT	1-year break	18 ^a
3	Lentil XT	1-year break	73 ^b
4	Barley CL	2-year break (POST IMI)	77 ^b
5	Barley CL	2-year break (PRE-IMI)	95 ^b
6	Lentil XT	3-year break	67 ^b
7	Barley AX	3-year break (no IMI)	93 ^b

¹Means within a column followed by a different letter indicate significant differences at $p \leq 0.05$. PRE and POST refer to pre-emergent and post-emergent herbicide application.

Brome grass seedbank and plant density

Data from seedling emergence census in pots at Roseworthy during autumn and winter months was used to determine brome grass seedbank at the trial site. The analysis of this data showed the site had a large and uniform brome grass seedbank ((5849 ± 631) seeds/m²), thus making it ideal for this three-year investigation. Data from seedling establishment pattern was used to determine time taken to 50% emergence (t_{50}), which is an indicator of seed dormancy status of a weed population. Seedling emergence data fitted well ($R^2=0.99$) to a logistic function and showed t_{50} of Snowtown population to be 14-days, which indicates a moderate level of seed dormancy (Figure 1).

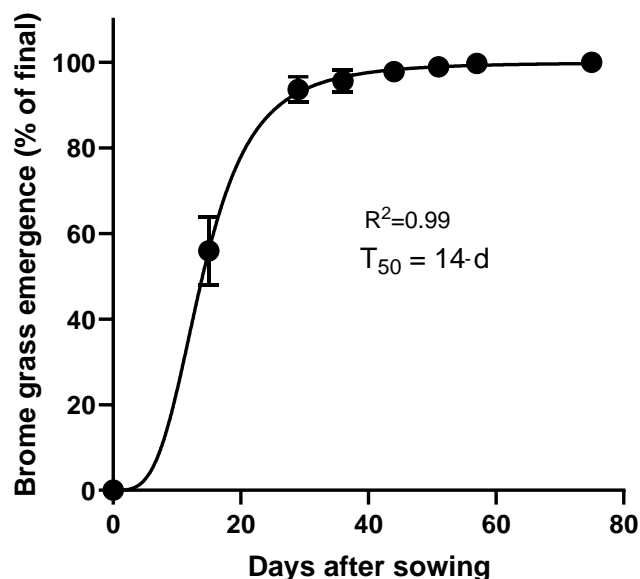


Figure 1. Emergence pattern of brome grass population sampled from the trial site at Snowtown.

Brome grass plant density

There were no differences between the management systems in initial brome grass plant density (July 2) most likely due to this assessment occurring before the pre- and post-emergent herbicides had exerted their full effect (Table 6). There was only 16.2 mm rainfall in four weeks after seeding, which created dry soil conditions after crop sowing that were not conducive for the activity of pre-emergent herbicides, particularly Sakura. The final brome density count (October 1) provided clear separation between the treatments.

Systems where pre-emergent herbicides were followed by post-emergent Group 1 herbicides in break crops (lentils and canola) achieved significant control of brome grass plants. Barley CL (T5 – 410 plants/m²), which relied on pre-emergent IMI herbicide Sentry had similar efficacy as Sakura + Avadex only in Calibre wheat (T1 – 316 plants/m²). Brome grass plant density in Barley AX treated with Aggressor[®] herbicide (Treatment 7) was also very high (298 plants/m²).

Clearly brome grass plants were still dying at the time of final assessment of brome grass density on October 1. This argument is strongly supported by the sharp reduction in brome panicle density (November 1) compared to brome plant density (Figure 2).

Table 6. The effect of different management systems on brome grass density. Shaded values in each column indicate best performing treatments.

Treatment	Crop grown in 2024	System	Brome density ¹ (Ju 21) (plants/m ²)	Brome density ¹ (Oct 1) (plants/m ²)	Reduction (%)
1	Wheat	Weaker control	1777	316 ^{cd}	82
2	Canola TT	1-year break	1284	0 ^a	100
3	Lentil XT	1-year break	1348	4 ^a	100
4	Barley CL	2-year break (POST IMI)	2389	89 ^b	96
5	Barley CL	2-year break (PRE IMI)	1200	410 ^d	66
6	Lentil XT	3-year break	1337	8 ^a	99
7	Barley AX	3-year break (no IMI)	1712	298 ^c	83
P-value			0.055 (NS)	<0.001	

¹ Initial and final brome grass density data was square root transformed before undertaking ANOVA. Means within a column followed by a different letter indicate significant differences at $p \leq 0.05$. PRE and POST refer to pre-emergent and post-emergent herbicide application.

Brome grass panicle density

Brome grass panicle density provided the clearest separation between the management systems (Table 7). Wheat (T1) treated with Sakura + Avadex was the worst performer with > 500 panicles/m². It should also be noted that brome grass panicle density was greater than plant density only in this treatment, indicating an average of 1.7 panicles per plant. This result is somewhat expected as no post-emergent herbicides were applied to suppress growth of escaped weeds.

In contrast, the best control of brome panicles occurred in TT canola and lentil-based systems. Clearfield or CoAXium barley systems provided 78-93% reduction in brome grass panicle density (Table 7). Clearfield barley with Sentry herbicide applied IBS (T5) had significantly higher brome grass panicles than the same variety treated with Intercept post-emergent (T4).

Table 7. The effect of different management systems on brome grass panicle density. Shaded values in each column indicate best performing treatments.

Treatment	Crop grown in 2024	System	Brome panicle density ¹ (panicles/m ²)	Reduction (%) relative to wheat (control)
1	Wheat	Weaker control	526 ^d	0
2	Canola TT	1- year break	1 ^a	99.7
3	Lentil XT	1-year break	4 ^a	99.3
4	Barley CL	2-year break (POST IMI)	35 ^{ab}	93.4
5	Barley CL	2-year break (PRE IMI)	115 ^c	78.1
6	Lentil XT	3-year break	1 ^a	99.7
7	Barley AX	3-year break (no IMI)	70 ^{bc}	86.7
P-value			<0.001	

¹ Final brome grass density data was square root transformed before undertaking ANOVA. Means within a column followed by a different letter indicate significant differences at $p \leq 0.05$. PRE and POST refer to pre-emergent and post-emergent herbicide application.

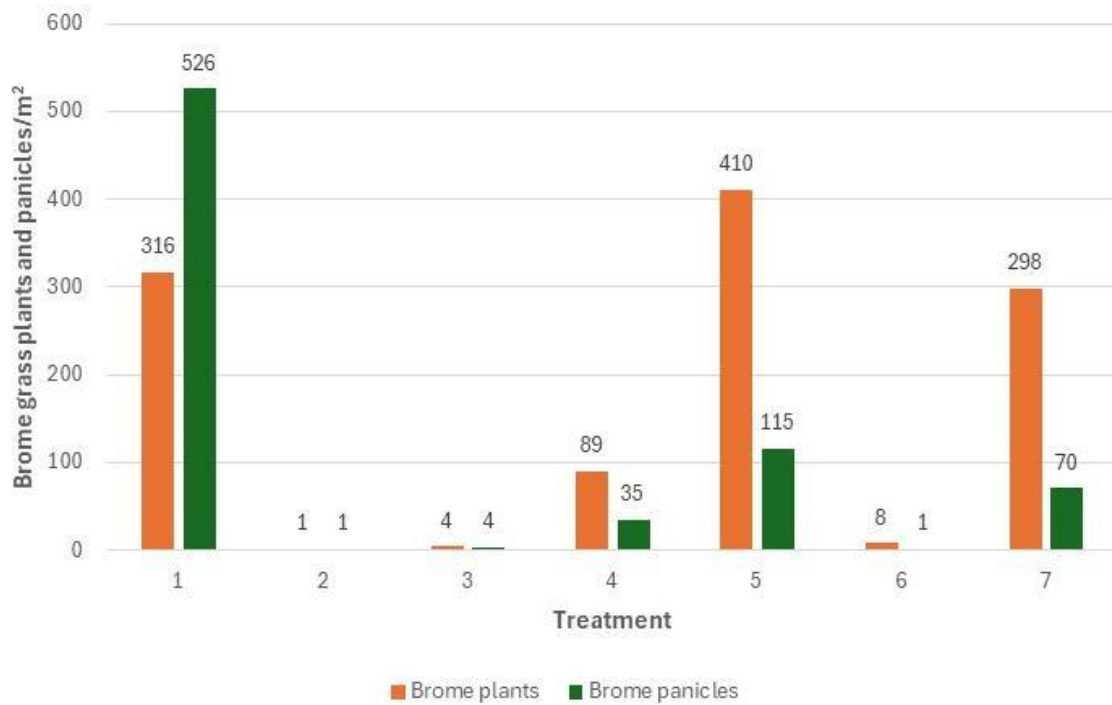


Figure 2. The response of brome grass plant density (October 1) and panicle density (November 1) to different management systems. Note panicle density was greater than plant density only in treatment 1. These results suggest significant mortality in brome grass plants after the assessment of final plant density as indicated by <1 panicle/plant for most treatments.

Brome grass seed production

Even though brome grass panicle production in lentils and canola was extremely low, panicles produced were large and produced >28 seeds/panicle. Calibre wheat treated with Sakura + Avadex (T1) not only produced the highest panicle density, but it also set 16 seeds/panicle (Table 8). Herbicide tolerant barley varieties (T4, 5 and 7) had the lowest seed set per panicle (5-7 seeds/panicle). The lowest seed set in barley may be associated with the herbicide tolerance trait and its highly competitive ability with weeds.

There were large differences in brome grass seed set on an area basis with Calibre wheat sprayed with Sakura + Avadex producing more than 8000 seed/m² (Table 8). The lowest weed seed production was observed in lentils and canola, which ranged from 41-118 seeds/m². There was a significant difference in seed set between the two Barley CL treatments (T4 and 5) with Intercept applied post-emergent allowing lower weed seed production than the system reliant on pre-emergent Sentry. Barley AX system with Aggressor herbicide had an intermediate performance of the two barley systems.

Table 8. The effect of different management systems on brome grass seed production. Shaded values in each column indicate best performing treatments.

Treatment	Crop grown in 2024	System	Brome seeds ¹ per panicle	Brome seed set ¹ (seeds/m ²)
1	Wheat	Weaker control	16.4 ^{ab}	8004 ^c
2	Canola TT	1-year break	38.7 ^b	71 ^a
3	Lentil XT	1-year break	30.4 ^b	118 ^a
4	Barley CL	2-year break (POST IMI)	5.2 ^a	184 ^a
5	Barley CL	2-year break (PRE IMI)	6.4 ^a	763 ^b
6	Lentil XT	3-year break	28.6 ^b	41 ^a
7	Barley AX	3-year break (no IMI)	7.2 ^a	345 ^{ab}
P-value			0.007	<0.001

¹Brome grass seeds per panicle and seed set data were square root transformed before undertaking ANOVA. Means within a column followed by a different letter indicate significant differences at P=0.05. PRE and POST refer to pre-emergent and post-emergent herbicide application.

Crop grain yield

Lentil based management systems provided excellent brome grass control and produced good yields (>2 t/ha, see Table 9). Canola system also gave effective brome grass control, but its suboptimal crop density (18 plants/m²) may have reduced yield. Among cereals, Clearfield and CoAXium barley (T4, 5 and 7) produced similar grain yield (3.11-3.39 t/ha). These herbicide tolerant barley varieties provide excellent options for integration with oilseed and pulse crops to develop multi-year crop sequences for effective brome grass management. In contrast, Calibre wheat with the best currently available pre-emergent herbicide options had 526 brome panicles/m² and produced significantly lower grain yield than herbicide tolerant barley (1.77 vs >3 t/ha).

Contrasting levels of weed control and brome grass seed production in different management systems in this field trial has nicely set the scene for an informative three-year investigation on brome grass management in locally adapted cropping systems.

Table 9. The effect of different management systems on crop grain yield.

Treatment	Crops grown in 2024	System	Grain yield (t/ha) ¹
1	Wheat	Weaker control	1.77 ^b
2	Canola TT	1-year break	1.01 ^a
3	Lentil XT	1-year break	2.08 ^c
4	Barley CL	2-year break (POST IMI)	3.11 ^d
5	Barley CL	2-year break (PRE IMI)	3.39 ^d
6	Lentil XT	3-year break	2.21 ^c
7	Barley AX	3-year break (no IMI)	3.21 ^d
P-value			<0.001

¹ Means within a column followed by a different letter indicate significant differences at P=0.05. PRE and POST refer to pre-emergent and post-emergent herbicide application.

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Photo: Brome grass management trial site at Snowtown pre-seeding in 2024.