

CONTROL OF BARLEY GRASS IN THE LOW RAINFALL ZONE FARMING SYSTEMS



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General introduction

Key messages

- Resistance to Group 1 and 2 herbicides is increasingly widespread – these products should be used with care to delay further resistance development.
- Late, staggered emergence makes barley grass difficult to control. The most successful management plans need early and late-season control.
- Break crops such as canola or pasture rotations offer a range of herbicides from different groups for early and in-crop control.
- Crop competition can be highly effective for barley grass management.
- Spray-topping in pasture has highly variable results. It can be logistically difficult to get the timing right.

Over the past 10 years, many growers in southern and western Australia have reported an increase in barley grass infestation in cereal crops. There are several possible explanations. Adoption of early sowing (sometimes dry seeding) has increased in this region, which could allow some of the barley seedbank to escape pre-sowing weed control. Less effective pre-sowing weed control increases reliance on pre-emergent herbicides for barley grass control in cereals. Another possibility is that barley grass populations have developed adaptive mechanisms to escape pre-sowing weed control practices used in cereals. Earlier research showed that barley populations collected from cropping fields in the Eyre Peninsula and the Mid North regions of SA had a much longer seed dormancy than did those from non-crop habitats.

Barley grass control has relied heavily on the effectiveness of the Group 2 imidazolinone herbicides in cereal crops and Group 1 grass-selective herbicides in broadleaf crops. There is evidence of increasing resistance to these important herbicide groups, which will limit growers' ability to cost-effectively control barley and could reduce production. Recent research into singular control tactics of barley grass has shown some promising chemical and cultural management tools, which should be incorporated into localised integrated weed management (IWM) strategies and tested.

The project 'Demonstrating and validating the implementation of integrated weed management strategies to control barley grass in the low rainfall zone farming systems' tested localised IWM strategies against barley grass using large plot-replicated demonstration sites in key areas of the low-rainfall zones. This booklet summarises the project findings and provides a go-to resource for managing barley grass.

Grower survey of barley grass management practices in low rainfall zone farming systems

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Key messages

- Initial and exit surveys received 334 responses from growers aligned with the different farming systems groups participating in this project.
- More than 66 per cent of the grower respondents identified barley grass as having a medium to high impact on their farming systems in crop and 71 per cent in pasture.
- 50 per cent of the grower respondents felt that barley grass emergence patterns had changed over the past 10 years and that it now emerged later in the season.
- 48 per cent of growers thought barley grass had become more common in their cropping paddocks.
- Some of the factors considered responsible for the increase in barley grass included delayed emergence and early seed-set, low efficacy of pre-emergence herbicides particularly during dry starts to seasons, resistance to Group 1 herbicides, continuous cereal cropping in the system and wide crop row spacing.

Background

A critical first step in developing management solutions to the problem of barley grass in crops is to understand its impact on production and the current management strategies being used. This includes observing any changes in weed establishment pattern or evolution of resistance to different herbicide groups and assessing the effectiveness of different management practices. Understanding growers' perceptions is important in targeting research and extension activities.

Methods

An initial grower survey of practice and attitudes towards barley grass was undertaken in 2019 and an exit survey was completed in early 2022. The surveys were conducted online using Survey Monkey. The link to each survey was distributed via email to the grower members of the different farming systems groups collaborating in this project. The exit survey included the same questions as the initial survey plus some additional questions. Respondents had the opportunity to leave general comments at the end of the surveys about their thoughts on grower management practices and their attitudes towards barley grass.

Results

From grower groups across the southern and western cropping regions, 224 growers responded to the initial survey and 100 to the final survey. The first survey question asked respondents which farming systems group they most commonly associated with (Table 1).

The survey also aimed to understand the level of effectiveness of current management strategies (high, medium, low or do not use). Management practices rated the most effective in both surveys were:

- inclusion of break crops within the rotation;
- two-year breaks; and
- spray-topping or crop-topping.

The least commonly used management strategies for barley grass were crop competition using splitter boot systems, burning, spraying out potential or known resistant barley grass patches in-crop and using clethodim and butoxydim as a mix. Management strategies being used with moderate success were increasing spray rates of clethodim and crop competition by increasing seeding rate.

The survey also investigated the level of effectiveness of current herbicides for barley grass management. In the 2019 initial survey, using grass-selective herbicides in pastures and other break crops was reported to be the most effective strategy. In the exit survey, imidazolinone (IMI) herbicides (not asked about in the initial survey), pyroxasulfone (Sakura®) and grass-selective herbicides in break crops were rated as the most effective.

The most common response in both the initial and exit surveys was that growers believed barley grass was now germinating later in-crop than it did 10 years ago (Table 2).

Table 1: Grower responses to: ‘What farming systems do you most associate with?’ in the initial (2019) and exit (2022) surveys.

Question	Farming systems group association	Initial survey response (%)	Exit survey response (%)	Difference (percentage points)
What farming systems do you most associate with?	Birchip Cropping Group (BCG)	3	2	1 ↓
	Central West Farming Systems (CWFS)	4	12	8 ↑
	Agricultural Innovation and Research Eyre Peninsula (AIR EP) – previously Eyre Peninsula Agricultural Research Foundation (EPARF)	27	16	11 ↓
	Grain Orana Alliance (GOA)	8	22	14 ↑
	Kellerberrin Demonstration Group	4	4	0 ↑
	Lakes Information and Farming Technology (LIFT)	2	7	5 ↑
	Mallee Sustainable Farming (MSF)	8	15	7 ↑
	Mingenew Irwin Group (MIG)	1	1	0 ↑
	South East Premium Wheat Growers Association (SEPWA)	4	1	3 ↓
	Upper North Farming Systems (UNFS)	11	13	2 ↑
	WA No-Tillage Farmers Association (WANTFA)	10	1	9 ↓
	Other (please specify)	19	6	13 ↓

Table 2: Responses to: ‘Do you feel your barley grass germination pattern has changed over the last 10 years?’ in the initial (2019) and exit (2022) surveys.

Question	Possible answers	Initial survey response (%)	Exit survey response (%)	Difference (percentage points)
Do you feel your barley grass germination pattern has changed over the last 10 years?	No	19	20	1 ↑
	Yes, it now germinates earlier in crop	15	10	5 ↓
	Yes, it now germinates later in crop	39	50	11 ↑
	I am not sure	26	20	6 ↓

Grower responses to questions in the exit survey indicated an increase in the impact of barley grass in crops and pasture since the first survey in 2019. In the initial survey, 39 per cent reported medium to high impact in-crop; this increased to 68 per cent in the exit survey. In pasture, 28 per cent reported a medium to high impact in the first survey and 77 per cent in the exit survey (Figure 1). Such a large increase in barley grass impact on crops and pastures over three years may be associated with increasing awareness through extension messages emerging from this project.

About half of respondents thought barley grass had become more common in their cropping paddocks. The proportion of respondents who did not believe herbicide resistance was an issue in barley grass decreased from the initial to the exit surveys (Table 3). There was the most concern about Group 1 resistance and some concerns about Group 2 sulfonylurea (SU) herbicides. Over 60 per cent of the exit survey respondents had changed their barley grass control management strategies in the previous three years (Figure 2).

Figure 1: Respondents rating barley grass impact as medium to high in crops and pastures.

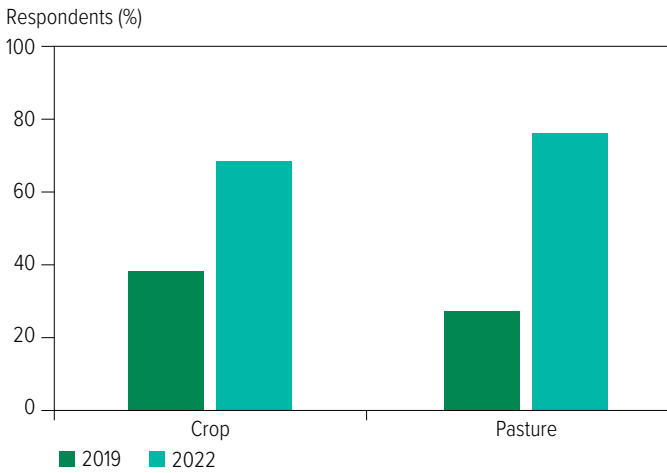


Figure 2: Response to: 'For barley grass management, have you changed any of your management strategies in the previous three years?'

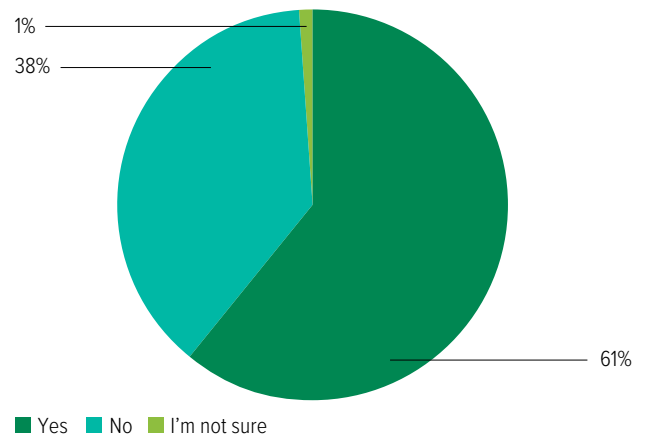


Table 3: Responses to: ‘Do you think you may have herbicide resistance issues in barley grass? If Yes, which herbicides are affected?’ in the initial (2019) and exit (2022) surveys.

Question	Possible answers	Initial survey response (%)	Exit survey response (%)	Difference (percentage points)
Do you think you may have herbicide resistance issues in barley grass?	Yes	23	29	6 ↑
	Yes – it was tested as part of the GRDC Low rainfall barley grass management project	NA	10	NA
	No	53	34	19 ↓
	I’m not sure	24	27	3 ↑
If Yes, which herbicides are affected?	Group 2 – SU herbicides	3	19	16 ↑
	Group 2 – IMI herbicides	3	3	-
	Group 1 – FOP herbicides (such as quizalofop, haloxyfop) or DIM herbicides (such as clethodim, butoxydim)	66	51	15 ↓
	Group 9 – glyphosate herbicides	3	7	4 ↑
	Group 22 – Spray.Seed®	4	2	2 ↓
	Other (please specify)	4	18	14 ↑
	NA	17	NA	NA

Management implications of the survey results

More than two-thirds of participating growers reported barley grass was having a medium to high impact in the cropping and pasture phases of their farming system. About half of respondents stated it had become more prevalent in the past three years. Major factors responsible for the increase in barley grass perceived by the respondents included:

- delayed emergence and early seed-set;
- low efficacy of pre-emergence herbicides particularly during dry starts to seasons;
- resistance to Group 1 herbicides;
- continuous cereal cropping; and
- wide crop row spacing.

Rotation/break crops, two-year breaks and pasture or crop-topping were reported to be the most effective management strategies. IMI herbicides and pyroxasulfone (Sakura®) were also reported by growers as being highly effective on barley grass. Grass-selective herbicides in break crops and pastures were also considered important. However, growers have serious concerns about resistance to Group 1 herbicides. The respondents who did not perceive herbicide-resistant barley grass as an issue decreased from 53 per cent in the 2019 survey to 34 per cent in the 2022 survey. Despite the free herbicide resistance testing offered to the participants in this project, only a small number of respondents to the final survey had taken up this opportunity. A significant proportion of respondents in both 2019 and 2022 were still unsure of the herbicide resistance status of their barley grass. It must be noted, however, that the exit survey had a significantly higher number of respondents from GOA and a lower number from the Eyre Peninsula, which could have influenced the survey results.

Half the respondents to the exit survey believed barley grass now germinated later in-crop. This observation is consistent with the study of seed dormancy in barley grass undertaken in this project (see page 15). Later germination of barley grass within farming systems is likely to reduce the effectiveness of pre-sowing knockdown herbicides. Therefore, residual herbicides such as pyroxasulfone (Sakura®) and post-emergent use of IMI herbicides have become even more important.

Overall, the project appears to have contributed to an increase in grower awareness of barley grass behaviour and management options within their farming systems. Although less than half of the respondents were aware of the project in their region, 83 per cent of respondents indicated that ongoing investment into barley grass management was important to them.

Acknowledgements

We thank the following grower groups for encouraging their members to participate in this survey: Birchip Cropping Group (BCG), Central West Farming Systems (CWFS), Agricultural Innovation and Research Eyre Peninsula (AIR EP, previously Eyre Peninsula Agricultural Research Foundation (EPARF)), Grain Orana Alliance (GOA), Kellerberrin Demonstration Group, Lakes Information and Farming Technology (LIFT), Mallee Sustainable Farming (MSF), Mingenew Irwin Group (MIG), South East Premium Wheat Growers Association (SEPWA), Upper North Farming Systems (UNFS), WA No-Tillage Farmers Association (WANTFA).

Herbicide resistance status of barley grass populations in low rainfall zones of southern and western Australia

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Key messages

- None of the barley grass samples from 2018 showed resistance to glyphosate (Group 9) or paraquat (Group 22). Resistance to FOP (Group 1) herbicide quizalofop (Leopard®) was present but rare.
- Resistance to the imidazolinone (IMI) herbicide imazamox + imazapyr (Intercept®) was only detected in two populations of barley grass from the Eyre Peninsula. These populations also exhibited cross-resistance to mesosulfuron (Atlantis®).
- There were large regional differences in the level of resistance detected. Populations from NSW and Victorian Mallee showed no resistance.
- Resistance to the sulfonylurea (SU) herbicide mesosulfuron (Atlantis®) was identified in 16 per cent of the samples collected in SA and WA.
- FOP-resistant populations showed that butoxydim (Factor®) offered greater control of Group A-resistant populations of barley grass than did clethodim. In the short term, it may be possible to improve weed control of clethodim-resistant populations in the field by adding butoxydim to the mixture or using it on its own.
- Targeted sampling of barley grass (that is, samples tested due to suspected resistance) in SA and Victoria in 2019 and 2020 showed higher levels of resistance to Group 1 herbicides than in the random survey of 2018.
- Resistance to knockdown herbicides glyphosate and paraquat was identified in Victoria in 2020.

Background

Group 1 and 2 herbicides have been widely used for barley grass control in crops and pastures for many years. Therefore, it is quite feasible that some populations have evolved herbicide resistance that could be contributing to the increase in barley grass in cropping areas of southern Australia. At this stage, the extent of resistance to these herbicide groups in barley grass is unclear. In a

previous survey of barley grass in Upper North and Eyre Peninsula in 2012 by Shergill et al. (2015), Group 1 resistance was detected in 15 per cent of samples. It is important to determine changes in the extent of herbicide resistance in this species since the previous survey. This project aimed to quantify the level of resistance to major herbicide groups used to control barley grass in the low-rainfall zone of Australian grain production.

Methods

Sampling

Barley grass samples (n = 143) were collected from farms in NSW, Victoria, SA and WA in late spring and summer of 2018 (Figure 1). Samples were selected randomly on the basis of presence of barley grass from different regions without any consideration of previous control failures or management history. This was done to avoid any bias towards presence of herbicide resistance. Additional targeted barley grass sampling was undertaken in 2019 and 2020 in southern Australia. Most of these samples were from populations suspected of being herbicide resistant (Table 1).

Figure 1: Locations across Australia from where barley grass samples (n = 143) were collected in 2018.

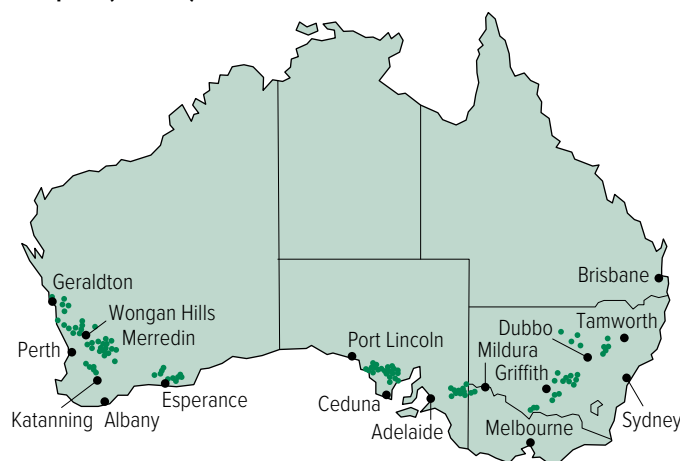


Table 1: Details of barley grass populations collected in the random and targeted surveys.

Year	Number of populations	Sampling area
2018	143	NSW, SA, WA
2019	32	Eyre Peninsula (22) and Mid to Upper North regions (10)
2020	27	Eyre Peninsula (12) and Victoria (15)

In April of each year, barley grass seeds were sown into potting mix in seedling trays and irrigated if needed. At the one-leaf stage, barley grass seedlings were carefully uprooted and transplanted into pots (10 plants/pot) for resistance screening.

Herbicide resistance screening

Barley grass seedlings were sprayed with rates of Group 1, 2, 9 and 22 herbicides (Table 2). Adjuvants recommended by the manufacturers were added to the spray solution of all herbicides. Herbicide treatments were applied in a spray chamber, which was calibrated to deliver 100 litres per hectare (L/ha) through a single TeeJet® 8002E (TeeJet® Technologies, Illinois, United States) flat-fan nozzle at a speed of 3.6 kilometres per hour (km/h). A herbicide-susceptible barley grass population collected from Yaninee, SA, in 2006 was used as the susceptible control in all herbicide resistance trials. Plants were assessed for survival four weeks after the herbicide treatment, and individuals with new shoot growth were counted as survivors.

Cross-resistance to Group 1 herbicides

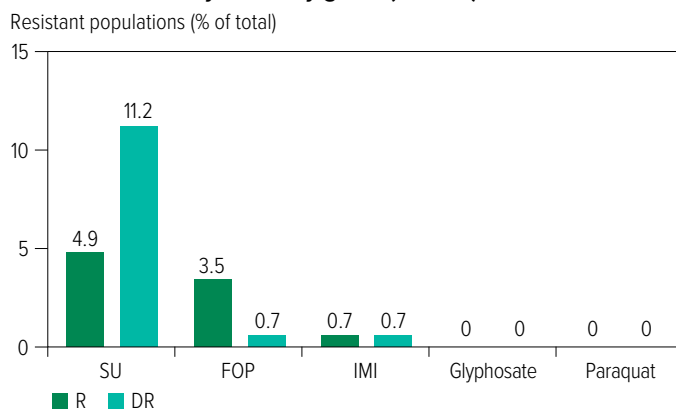
Patterns of cross-resistance between FOP and DIM herbicides were investigated in five quizalofop-resistant populations of barley grass. Methods for herbicide application and assessment of plant survival were consistent with the description for the initial screening. Two FOP herbicides (quizalofop and haloxyfop) and two DIM herbicides (clethodim and butoxydim) were selected for this experiment. Barley grass plants were sprayed at the early tillering stage. The rates of herbicides used represent the lowest and the highest rate shown on herbicide labels.

Results and discussion

Herbicide resistance screening 2018-19

Resistance to the SU herbicide Atlantis® was identified in 16.1 per cent of the populations tested (Figure 2). The level of growth inhibition of barley grass plants differed considerably between Atlantis®-resistant populations. Some of the populations showed 100 per cent survival and no reduction in plant growth when sprayed with Atlantis®, whereas others showed high survival but >50 per cent reduction in barley grass height and biomass. It is quite likely that the mechanisms of resistance present in these two types of populations are different. The presence of resistance to the imidazolinone herbicide Intervix® was relatively low (1.4 per cent). All populations of barley grass collected in NSW and Victoria had no resistance (Figure 2). Some samples from SA and WA showed resistance to Group 1 and 2 herbicides.

Figure 2: Detection of resistance to different herbicide groups in a random survey of barley grass (n = 143).



SU = Atlantis® (Group 2); IMI = Intervix® (Group 2); FOP = quizalofop (Leopard®, Group 1); glyphosate = Weedmaster® DST® (Group 9); paraquat = Para-Ken® (Group 22). R = resistant (>20% survival) and DR = developing resistance (6% to 19% survival).

Table 2: Herbicides used in screening barley grass populations.

Active ingredient (group)	Trade name, manufacturer	Dose
Mesosulfuron (Group 2)	Atlantis® OD, Bayer	330 and 600 millilitres per hectare (mL/ha)
Imazamox + imazapyr (Group 2 IMI)	Intervix®, BASF	375 and 600mL/ha
Quizalofop (Group 1 FOP)	Leopard® 100, Adama	250 and 375mL/ha
Haloxyfop (Group 1 FOP)	Verdict® 520, Corteva Agriscience	50 and 75mL/ha
Clethodim 240 grams per litre (g/L) (Group 1 DIM)	Clethodim 240, FMC Australia	175 and 250mL/ha
Butoxydim 250 grams per kilogram (g/kg) (Group 1 DIM)	Factor® WG, Nufarm	90 and 180 grams per hectare (g/ha)
Glyphosate 470g/L (Group 9)	Weedmaster® DST®, Nufarm	770mL/ha
Paraquat 250g/L (Group 22)	Para-Ken 250, Kenso Agcare	1.2L/ha

Resistance to the FOP herbicide quizalofop (Leopard®) was detected in 4.2 per cent of the barley populations tested. Four of these populations came from the Upper Eyre Peninsula in SA and two from WA. Survivors of this herbicide were vigorous and showed no inhibition in growth (Figure 5). There is no doubt that the presence of resistance to Group 1 and 2 herbicides in the southern and western regions will complicate management of barley grass in break crops and pastures.

No resistance to glyphosate or paraquat was detected in barley grass samples in this survey. However, previous research has confirmed paraquat resistance in barley grass populations from lucerne-growing areas in Victoria and SA, as well as from areas in SA with a long history of no-till cropping. Glyphosate resistance has also been confirmed in a population of barley grass from the Yorke Peninsula of SA.

Cross-resistance to Group 1 herbicides 2018-19

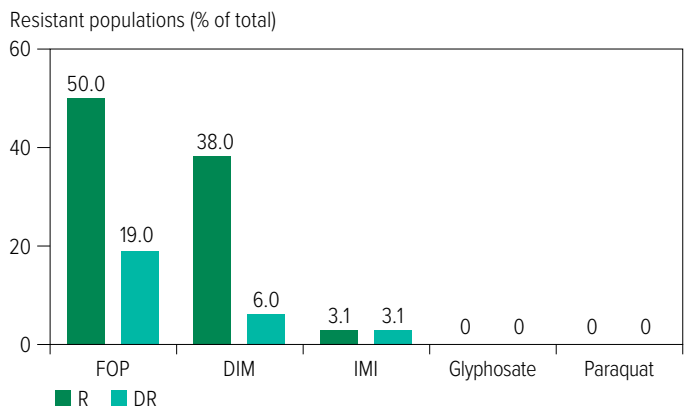
Five barley grass populations confirmed to be resistant to quizalofop (Leopard® 100) were also resistant to haloxyfop (Verdict®) (Table 3). Four of the five FOP-resistant populations also showed complete (95 to 100 per cent) survival when sprayed with clethodim. However, one of the resistant populations from WA was more sensitive to clethodim than to quizalofop and showed a much lower plant survival (15 to 30 per cent). The different response of one population may be associated with the presence of a different resistance mechanism. Butroxydim (Factor®) provided much greater control of barley grass than did quizalofop, haloxyfop and clethodim. At the higher rate of butroxydim (Factor® 180g/ha), there was a complete kill of all barley grass plants even in resistant populations that had 100 per cent survival when sprayed with clethodim. This unexpected greater sensitivity of Group 1-resistant barley grass to butroxydim may be beneficial for weed control in the short term. However, integrated weed management practices would be needed to delay the onset of butroxydim resistance.

Screening of targeted barley grass populations 2019-20

There was a high level of resistance to the FOP herbicide quizalofop (Leopard® 100) in barley grass samples collected from Eyre Peninsula and the Mid to Upper North of SA. Out of 32 barley grass populations investigated, 50 per cent were resistant and 19 per cent were developing resistance (Figure 3). The frequency of resistance to clethodim (44 per cent) was slightly lower than to quizalofop (69 per cent) but still a cause for concern. As expected, the level of resistance to the FOP herbicide quizalofop in the targeted survey of 2019-20 was much greater than in the random survey of 2018-19 (69 per cent versus 4.2 per cent).

Barley grass populations sprayed with glyphosate (Weedmaster® DST® at 760mL/ha) or paraquat (Para-Ken® 250 1.2L/ha) were completely killed and showed no resistance to these herbicides. Susceptibility to these important knockdown herbicides was also observed in the survey and testing of 2018-19.

Figure 3: Detection of resistance to different herbicide groups in a targeted sample of barley grass from Eyre Peninsula and Mid to Upper North regions of SA (n = 32) in 2019-20.

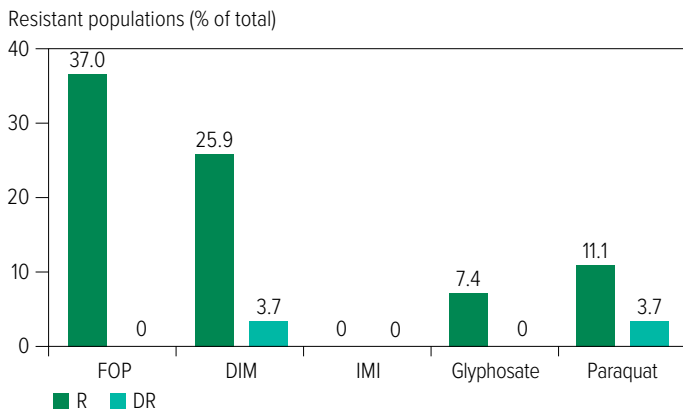


FOP = quizalofop (Leopard®, Group 1); DIM = clethodim (Grasimid®, Group 1); IMI = Intervix® (Group 2); glyphosate = Weedmaster® DST® (Group 9); Paraquat = Para-Ken® (Group 22). R = resistant (>20% survival) and DR = developing resistance (6% to 19% survival).

Table 3: Percentage survival of Group 1-resistant populations (from SA, WA) and the control (susceptible) population (from Yaninee) when treated with quizalofop, haloxyfop, clethodim and butroxydim at two different rates of application.

Population	Barley grass survival (%)							
	Quizalofop (Leopard® 100)		Haloxyfop (Verdict®)		Clethodim (Clethodim 240)		Butroxydim (Factor®)	
	250mL/ha	375mL/ha	50mL/ha	75mL/ha	175mL/ha	250mL/ha	90g/ha	180g/ha
SA1	100	100	100	100	100	100	50	10
SA2	100	100	100	90	100	100	20	0
SA3	100	100	100	100	95	100	35	0
WA1	80	50	75	80	15	30	0	0
WA2	100	100	100	100	100	100	75	0
Yaninee (S)	0	0	0	0	0	0	0	0

Figure 4: Detection of resistance to different herbicide groups in a targeted sample of barley grass from Eyre Peninsula (n = 12) and Victorian Mallee (n = 15) in 2020-21.



FOP = quizalofop (Leopard®, Group 1); DIM = clethodim (Grasidim®, Group 1); IMI = Intervix® (Group 2); glyphosate = Weedmaster® DST® (Group 9); paraquat = Para-Ken® (Group 22). R = resistant (>20% survival) and DR = developing resistance (6% to 19% survival).

Resistance to imidazolinone (IMI) herbicide Intervix® was very low; one population was resistant and one population was developing resistance. This low frequency of IMI resistance is consistent with the results from resistance screening of samples from the previous year. It is important to note that this IMI-resistant population from Eyre Peninsula showed no adverse response to the IMI herbicide Intercept® at 375 or 750mL/ha. Interestingly, this IMI-resistant population is not resistant to the FOP or DIM herbicides, which indicates direct selection through the use of acetolactate synthase (ALS)-inhibiting herbicides. This result also highlights the importance of resistance testing when planning weed management strategies.

Consistent with the results from 2018-19, Factor® (butroxydim) provided effective control of most clethodim-resistant barley grass populations. At the higher rate of Factor® (180g/ha), only one barley grass population survived compared with three populations that were resistant to the higher rate of clethodim. This result also highlights the presence of some Factor®-resistant barley grass populations on SA farms. Therefore, growers will need to use this important herbicide within the framework of integrated weed management to maximise its effective life.

Screening of targeted barley grass populations 2020-21

Resistance to quizalofop and clethodim was confirmed in both regions even though the level of resistance was higher in the samples from Eyre Peninsula. No resistance was detected to the Group 2 herbicide Intervix® in 2021 testing or to glyphosate or paraquat in barley grass samples from Eyre Peninsula. However, some samples from the Victorian Mallee were resistant to either glyphosate (13 per cent) or paraquat (27 per cent) (no samples possessed resistance to both) (Figures 6 and 7). Samples with paraquat resistance came from paddocks with extensive use of paraquat in lucerne, which is consistent with previous reports of paraquat resistance in barley grass in Australia.

Resistance screening of barley grass over the three years confirmed resistance to Group 1 and 2 herbicides. As expected, the level of resistance detected to Group 1 herbicides in particular was much lower in the random survey 2018 than in targeted sampling in 2019 and 2020. As a rule, Group 2 herbicides are considered most prone to resistance evolution in weeds. However, this was not supported by the evidence from barley grass resistance testing where resistance to Group 1 FOP and DIM herbicides was much more common than to the IMI herbicide Intervix® (Group 2). This disparity in resistance to these two groups may simply be related to the differences in exposure to these herbicides. Growers planning to use Clearfield® crops should make serious efforts to diversify crop rotations and herbicide use as well as integration of non-chemical control tactics. These studies also confirmed the presence of resistance to glyphosate and paraquat in samples collected in the Victorian Mallee. Therefore, growers in other regions will need to be vigilant so that the problem can be detected early before a large build-up in weed populations.

References

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- Shergill LS, Fleet, B, Preston, C and Gill, G (2015) Incidence of herbicide resistance, seedling emergence, and seed persistence of smooth barley (*Hordeum glaucum*) in South Australia. *Weed Technology* 29: 782–792.

Figure 5: Response of the susceptible (S) and quizalofop-resistant populations (BG4) from Eyre Peninsula when sprayed with quizalofop (Leopard®) (Q) at 250 and 500mL/ha. The treated plants had high survival and high vigour.

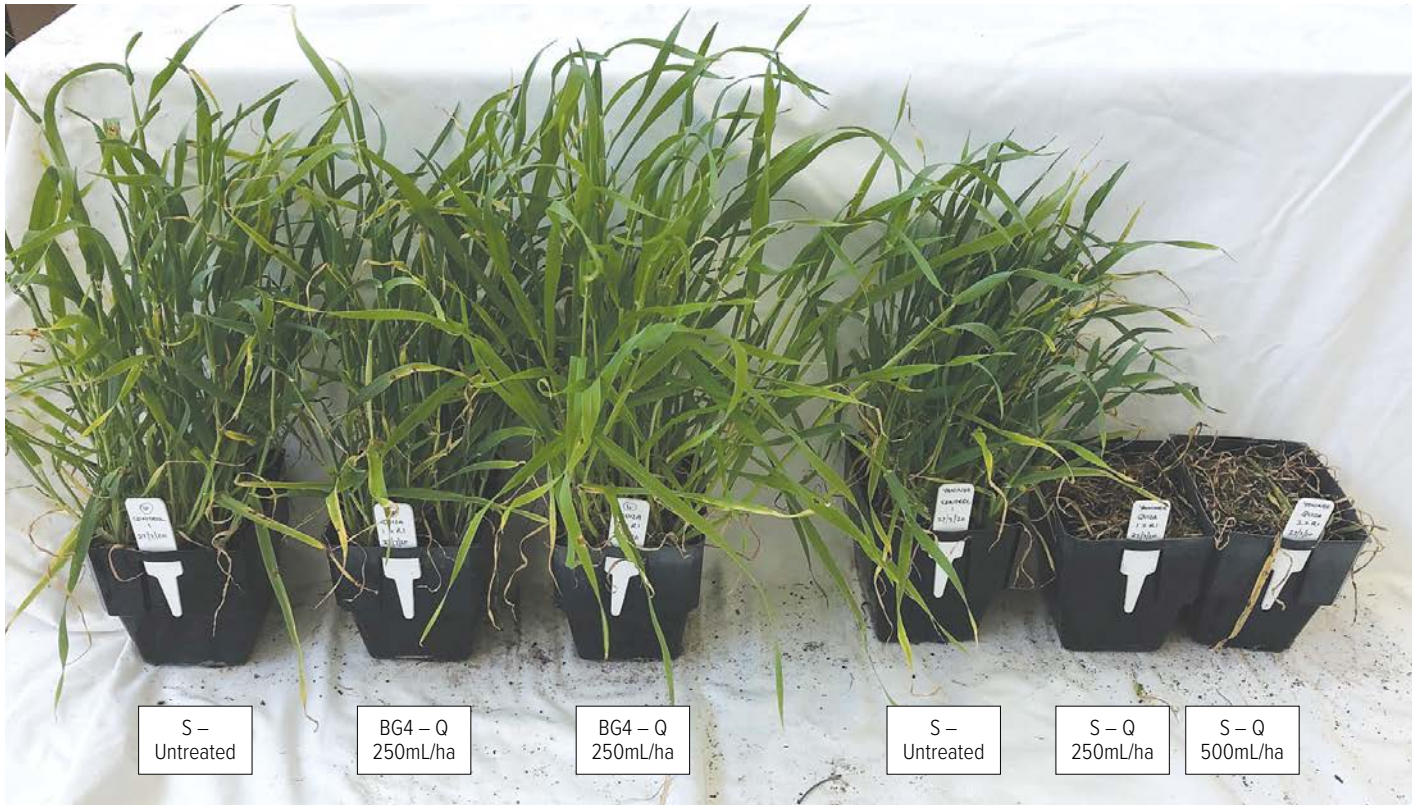


Photo: Ben Fleet, University of Adelaide

Figure 6: Response of the susceptible (S) and paraquat-resistant (BG29) population from Victoria when sprayed with paraquat (P) at 1.2L/ha. The treated plants had high survival but stunted growth.

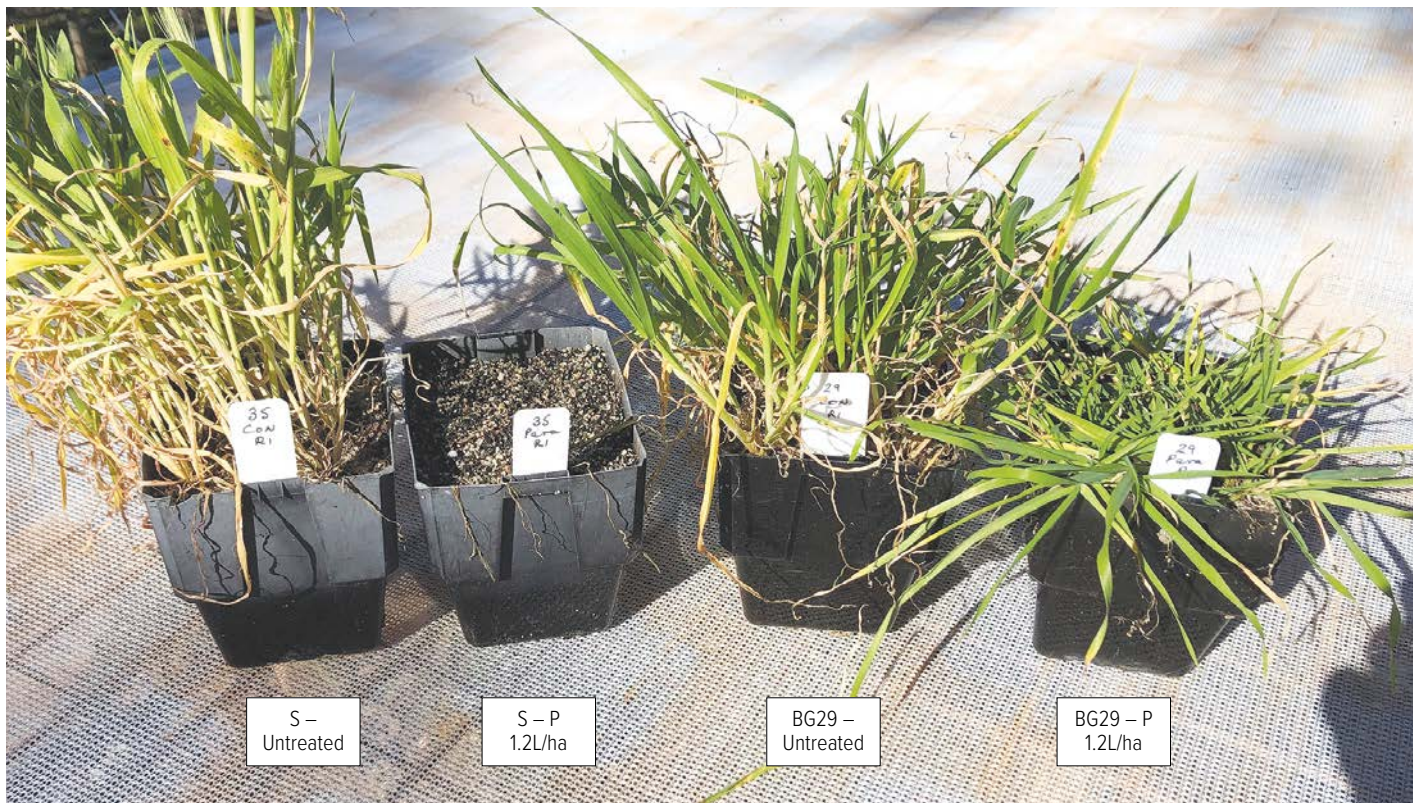


Photo: Ben Fleet, University of Adelaide

Figure 7: Response of susceptible (S) and glyphosate-resistant (BG31) populations from Victoria when sprayed with Weedmaster® DST® at 770mL/ha. The treated plants had high survival but stunted growth.



Photo: Ben Fleet, University of Adelaide

Seed dormancy in barley grass populations in the low rainfall regions of southern and western Australia

Gurjeet Gill, Daniel Petersen and Ben Fleet,
University of Adelaide

Key messages

- There were large differences between seed dormancy of different barley grass populations. The least dormant population came from the NSW southern plains and the most dormant population was from the Upper Eyre Peninsula.
- Large differences in seed dormancy were present within most of the sampling regions in this survey; this is most likely related to the differences in paddock management practices.
- On a regional basis, populations from the southern plains of NSW had the lowest dormancy. In contrast, barley grass populations from the Upper Eyre Peninsula in SA had the highest seed dormancy.
- In highly dormant populations, a greater proportion of seedlings are likely to emerge after the sprays of knockdown herbicides, and some seedlings may also emerge after the pre-emergent herbicides have been degraded in the soil to sublethal levels. Such populations are likely to be more difficult to manage than those that emerge as a single flush after the opening rains (that is, populations with low dormancy).

Background

Previous research has shown that some barley grass populations have developed adaptive mechanisms to escape pre-sowing weed control practices used in cropping fields. Fleet and Gill (2012) showed that barley populations collected from the cropping fields of the Eyre Peninsula and the Mid North of SA had a much longer seed dormancy than did those from non-crop habitats. Similar differences in seed dormancy between barley grass populations from crop and non-crop habitats were confirmed by subsequent research.

One of the aims of the barley grass management project was to determine the level of variation in seed dormancy in barley grass populations present in the low-rainfall areas. Understanding the variation in seed dormancy will be helpful for developing strategies to manage this weed species.

Methods

Coordinated sampling of barley grass populations from the low-rainfall zones in NSW, Victoria, SA and WA was undertaken in the summer of 2018. A total of 143 samples was collected from grower paddocks in this region (Table 1).

Table 1: Regions from where barley grass samples were collected in 2018.

Region	Number of samples
NSW Southern Plains (NSP)	12
NSW Central Plains (NCP)	20
NSW Northern Plains (NNP)	10
Victorian Mallee	3
Northern SA Mallee	15
SA Upper Eyre Peninsula (SEP)	29
WA Geraldton Port Zone (WG)	5*
WA Kwinana West Port Zone (WKW)	8*
WA Kwinana East Port Zone (WKE)	23
WA Northern Albany Port Zone (WNA)	6
Esperance Port Zone (E)	12
Total	143

*WG – one sample of brome grass; WKW – two samples of brome grass

Seeds of barley grass samples were removed from panicles and sown by weight (2g per tray) into seedling trays filled with potting mix in the first week of April. After spreading the seeds in trays, seeds were covered with one centimetre (cm) of potting mix, placed outside and watered if there were more than three days without rainfall to maintain soil moisture in the trays close to field capacity. There were two replicates of each barley grass population. Weed seedlings were counted and removed carefully from the trays throughout the growing season. Data collection ceased in mid-August when no new seedlings emerged in any of the trays over two consecutive counts.

Cumulative seedling emergence data were analysed in GraphPad Prism. The barley grass seedling emergence pattern fitted well to a sigmoidal function with R^2 values exceeding 0.9 (that is, explained >90 per cent of variation). To avoid leverage of data by a few early or late-emerging individuals, populations with <40 barley grass seedlings in the two trays were removed from the analyses. Actual reasons for low seed viability in these populations is not known but could include drought or spray-topping with herbicides. Out of 146 populations, 113 had seedling emergence greater than the threshold of 40 seedlings (77 per cent) and were used for the statistical analyses to determine the time taken to reach 50 per cent of seasonal seedling emergence (t_{50}).

Figure 1: Barley grass populations at Roseworthy (SA) during the 2019 growing season. Emerged seedlings were regularly removed and counted until emergence ceased.



Photo: Daniel Petersen, University of Adelaide

Results and discussion

There were large differences between barley grass populations in the rate of seedling emergence, which reflected seed dormancy. Based on the time taken to reach 50 per cent of total seasonal seedling emergence (t_{50}), the least dormant population came from the southern plains in NSW (NSP) ($t_{50} = 2.2d$) and the most dormant population was from the Upper Eyre Peninsula of SA (SEP) ($t_{50} = 50.6d$). In the example shown in Figure 2, two populations of barley grass from the Upper Eyre Peninsula possessed contrasting seed dormancy. The population SEP-AC3 was collected from a paddock of oats on a farm and SEP-KV2 from a wheat crop on a different farm in the region. This example clearly illustrates large differences in seed dormancy between different populations of barley grass within the same region. These differences in seed dormancy are likely to be related to different management history of these paddocks. Practices such as cropping intensity and sowing time can impose huge selection pressure on seed dormancy and shift the time of seedling emergence of weed populations.

As a group, populations from the southern plains of New South Wales (NSP) were the quickest to germinate and emerge ($t_{50} = 8.9 \pm 1.08d$) (Figure 3). In contrast, barley grass populations from the Upper Eyre Peninsula in SA (SEP) had the highest t_{50} ($32.6 \pm 3.17d$). There were relatively small differences in seed dormancy between the other regions (Table 2). Average t_{50} for the other regions ranged from 13.2d for the Central Plains of NSW (NCP) to 18.5d for the populations from the Victorian and SA Mallee. The average t_{50} for WA populations ranged from 13.8 to 17.7d. Within most regions there were sizeable differences between the least and the most dormant populations. Therefore, the differences in

seed dormancy are not just geographical in nature but are likely to relate to differences in weed management practices used in the paddocks where these samples were collected.

Due to the higher levels of staggered germination, growers on the Upper Eyre Peninsula are likely to face more difficulties in achieving effective control of barley grass before sowing their crops, and they will need to use suitable selective herbicides for weed control. A few populations in other regions also showed delayed seedling emergence and are expected to pose more serious management challenges in the future. When higher seed dormancy and herbicide resistance co-occur, management of barley grass is likely to become extremely challenging.

As a general biological principle, including long pasture phases is likely to favour low seed dormancy because an early emerging individual will have a competitive advantage over those that emerge later in the growing season. Conversely, systems with a high frequency of cropping will favour selection for high seed dormancy, due to pre-sowing kill of early established individuals of barley grass. Removal of early germinating plants in a weed population (low dormancy) is likely to enrich the population with genes for high seed dormancy.

Reference

Fleet, B and Gill, G (2012) Seed dormancy and seedling recruitment in smooth barley (*Hordeum murinum* ssp. *glaucum*) populations in southern Australia. *Weed Science* 60: 394–400.

Table 2: Descriptive statistics of the time to 50% seedling emergence (t_{50}) in days of barley grass populations collected in 2018. The collection regions are described in Table 1.

	NSP	NCP	NNP	VIC & SA Mallee	SEP	WG & WKW	WKE	WNA & E
Number of samples	12	19	10	16	20	12	10	14
Minimum (days)	2.2	7.9	10.1	4.5	12.7	9.9	6.3	11.7
Maximum (days)	15.4	34.2	18.1	39.3	50.6	22.6	27.7	40.3
Mean	8.9	13.2	13.4	18.5	32.6	14.7	13.8	17.7
Standard error of the mean (SEM)	1.08	1.30	0.89	2.65	3.17	0.87	1.84	1.88

Figure 2: An example of contrasting seed dormancy in two barley grass populations collected from the Eyre Peninsula of SA in 2018. Time taken to 50% seedling emergence (t_{50}) was 13d in SEP-AC3 and 46d in SEP-KV2. The sigmoidal regression model had an $R^2 > 0.9$.

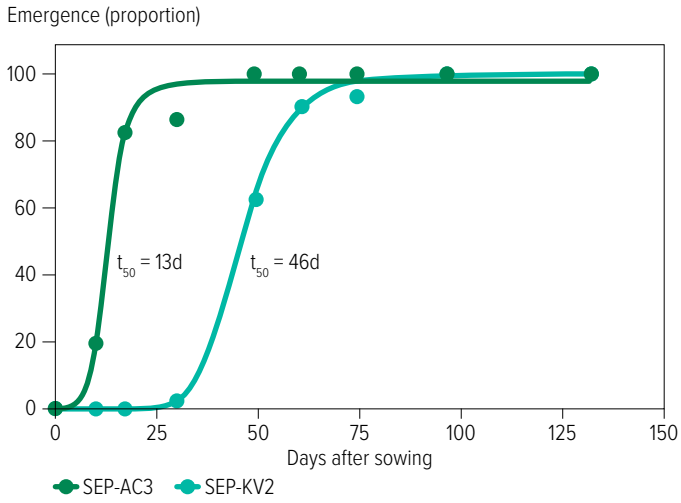
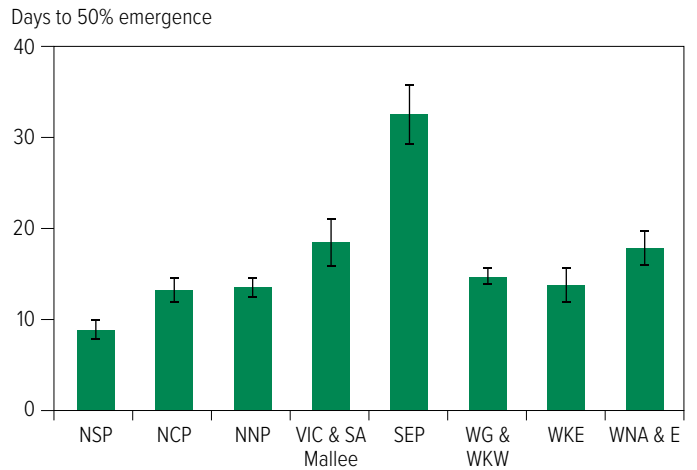


Figure 3: Average time taken by barley grass samples from each region to reach 50% of final seasonal seedling emergence. The collection regions are described in Table 1. Error bars represent the standard error of the mean (SEM).



Barley grass management in the Upper North region of South Australia

(UPPER NORTH FARMING SYSTEMS)

By the late **Matt McCallum**, Upper North Farming Systems (UNFS); **Beth Humphris**, Elders Jamestown; and **Gurjeet Gill**, University of Adelaide

Key messages

- In this trial, sowing the barley crop after the break to the season reduced in-crop barley grass plant density by more than 90 per cent compared with dry sowing, which indicates rapid germination after the opening rains due to presence of low seed dormancy in this population. Therefore, dry sowing crops should only be used in paddocks with very low weed infestations.
- Including pasture phases can play a vital role in managing barley grass provided seed-set can be prevented. In this trial, spray-topping in spring with glyphosate followed by paraquat caused a large reduction in both barley grass panicle density in 2020 and infestation in the next crop (2021).
- Even though the pasture phase reduced barley grass density in the next crop to less than one plant per square metre (plant/m²), it was unable to eliminate the weed population. Future management programs should consider tactics that prevent bounce back in barley grass infestation.

SNAPSHOT

OWNER: Ross McCallum

LOCATION: Willowie, SA (between Booleroo and Melrose)

FARM SIZE: 200ha (cropped), 400ha pasture running sheep

ANNUAL AVERAGE RAINFALL: 500 millimetres (mm) (450 to 600mm)

SOIL TYPES: medium to heavy red sandy loam with boron toxic subsoils (60 to 100cm)

ENTERPRISES: wheat, barley, self-regenerating medic pasture, sheep

Background

In the Upper North region of SA, barley grass is well adapted to the local climate and is a major weed of pastures. Growers usually value barley grass for its contribution to animal feed in early stages of the growing season. However, barley grass can cause physical injury to livestock in spring and summer and it is also known to be a host of fungal root diseases affecting cereal crops grown in the rotation. If barley grass is allowed to set seed in the pasture, it can produce a very large seedbank that is difficult to manage. As barley grass is quick to mature, determining the best timing for pasture topping to achieve seed-set control, without damaging desirable pasture species, can be difficult.

As this region has a much shorter growing season than in the Lower North, many growers have adopted dry sowing of crops. This practice allows maximum utilisation of growing season rainfall, but it makes weed management more difficult. There are mixed views on the value of sowing crops after the break in this farming systems group. Therefore, the Upper North Farming Systems (UNFS) group decided to investigate crop sowing time as a highly relevant management factor for its members.

Methods

A large unsprayed area from 2018 provided a challenging population of barley grass for this trial. There were initially two distinct high and low-density strips at this site but they blended into one over the three years. This is likely to be due to the movement of barley grass seeds with wind and livestock over summer. Testing of this barley grass population did not detect resistance to any herbicides used for grass weed control. Spartacus CL[®] barley was chosen in the first year of the trial (2019) to minimise the risk of crop damage from an imidazolinone herbicide used in 2018. In 2020, the whole trial site was in a pasture phase, which can be highly effective in weed management. Barley grass and medic pasture was grazed by livestock and then spray-topped with glyphosate to prevent seed-set. As 2020 was an above-average rainfall season, barley grass was able to partially recover from glyphosate spray-topping and produce some additional panicles. Therefore, it was decided to spray-top the trial site again but with paraquat. The whole trial site was sown to Spartacus CL[®] barley in 2021 to determine the effectiveness of weed management tactics used in the previous two growing seasons. Details of treatments implemented in this trial are shown in Table 1.

The site near Willowie in the Upper North of SA has a long-term average annual rainfall of 315.3mm and growing season rainfall (GSR) of 214mm. Over the three years, the trial site received below-average rainfall in 2019 and 2021 but well above the long-term average in 2020.

Table 1: Management systems investigated for barley grass management.

Agronomic detail	2019	2020	2021
Total (growing season) rainfall	164.1mm (126.1mm)	444.1mm (288.5mm)	286.7mm (167.8mm)
Crop sowing details	Barley Spartacus CL [®] sown dry or after the break Seed rate: 60kg/ha	Self-regenerating pasture	Barley Spartacus CL [®] Seed rate: 60kg/ha
Sowing date	Dry sown: 16 April Sown after the break: 22 May	N/A	28 April
Herbicide treatments	16 April: trifluralin 720g/ha + triallate 1000g/ha 22 May: glyphosate 810g/ha Trifluralin 720g/ha + triallate 1000g/ha	28 August: glyphosate 162g/ha 4 November: spray-topping with paraquat at 200g/ha	Blanket spray of trifluralin 720g/ha + triallate 1000g/ha over the whole trial site

Results

2019 barley

The delay in sowing barley until after the season opening rains in May resulted in >90 per cent reduction in barley grass density in barley (Figure 1). Both high and low-density strips of barley grass showed very similar reductions in barley grass infestation. In 2019, the trial site experienced above-average rainfall in the month of May. Good rainfall leading up to later crop sowing on 22 May created ideal soil moisture conditions for barley grass emergence. Plants that established in response to these rainfall events in May were killed by the knockdown with glyphosate, which resulted in contrasting barley grass densities in dry-sown barley and the crop sown after the break. Rapid emergence of barley grass in response to the opening rains at this site in May indicated the presence of low seed dormancy in this population. Weed assessments in the unsprayed strips and herbicide-treated plots showed that trifluralin + triallate (Treflan + Avadex[®] Xtra) provided about 50 per cent reduction in barley grass density. Such a moderate level of weed control would be inadequate in situations where high barley grass densities were present.

Figure 1: The effect of barley sowing time on in-crop barley grass plant density. Sowing barley after the break reduced weed density by 90% in the high-density strip and 97% in the low-density strip.

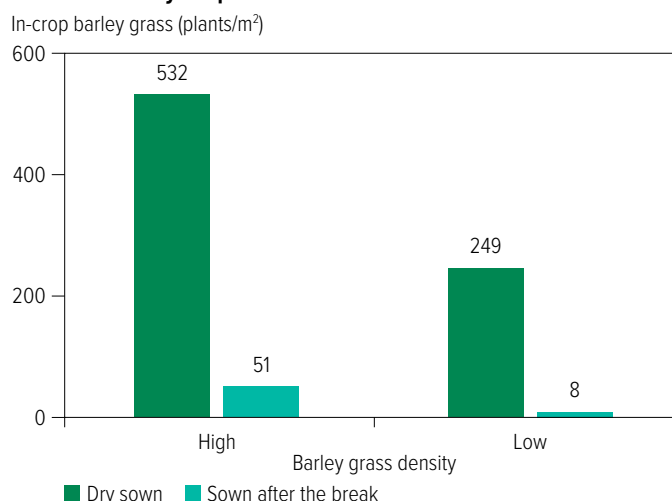
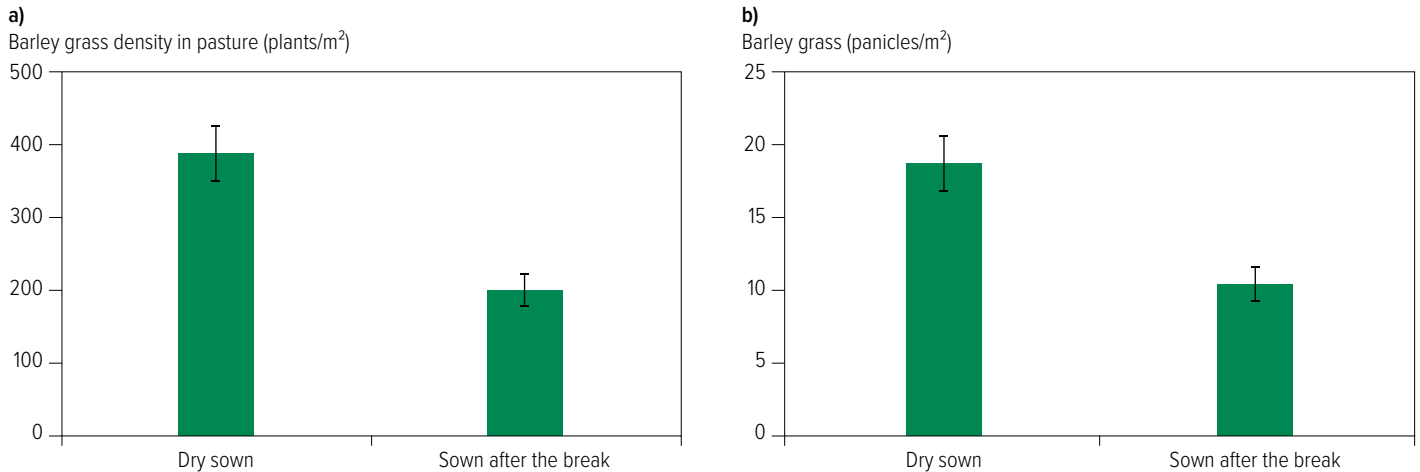


Figure 2: Large differences in barley grass density in barley sown dry (left) and sown after the break (right) in 2019.



Photos: The photos were taken on 27 August 2019 by the late Matt McCallum

Figure 3: Barley grass plant density (a) and panicle density (b) observed in 2020 pasture in plots sown to barley either dry or after the opening rains in 2019. Spray-topping of the trial site in spring with glyphosate followed by paraquat caused a large reduction in panicle density compared with plant density recorded earlier in the season. Error bars represent the SEM.



2020 pasture

Consistent with the trial plan, the trial site was in self-regenerating pasture in 2020. Alternating cropping and pasture phases is a common practice in this region, especially if the seasonal outlook indicates below-average rainfall. As it turned out, 2020 received above-average rainfall at this site. Despite this, the pasture phase was implemented to maintain consistency with the trial plan. As expected from the 2019 observations, the trial site had a high infestation of barley grass. There were still clear carryover effects of crop sowing time from the previous season, where delayed crop sowing had reduced barley grass plant density by more than 90 per cent. Barley grass plant density in plots sown in the previous year (2019) after the opening rains had about 50 per cent less barley grass than plots where the crop was sown dry (Figure 3a).

Barley grass panicle density was reduced dramatically to less than 20 panicles/m² by the spring spray-topping with sequential blanket application of glyphosate and paraquat in the pasture phase. Nevertheless, there were clear differences in barley grass panicle density between the plots sown dry or after the break in 2019 (Figure 3b). This result highlights the carryover benefits of good weed control in the previous season. Interestingly, there were no clear differences in barley grass density between the original high-density and low-density strips observed in 2019, therefore the results for these two strips were combined.

2021 barley

Excellent barley grass control achieved by the spray-topping of pasture with glyphosate and paraquat in 2020 was reflected in a very low barley grass plant density (<0.3 plants/m²) in the 2021 barley crop (data not shown). Although such low weed densities are unlikely to reduce barley grain yield, these plants were able to produce 2 to 6 panicles/m² (Figure 4) and so contributed to the seedbank. It is interesting to note that the differences in weed kill from crop sowing time in 2019 (dry sown vs sown after the break) were still visible in 2021.

Figure 4: Barley grass panicle density in barley crop in 2021 on sites where barley was dry sown or sown after the break in 2019. Note pre-emergent trifluralin + triallate (Treflan® + Avadex® Xtra) spray treatment was applied over the whole trial site in 2021. Error bars represent the SEM.

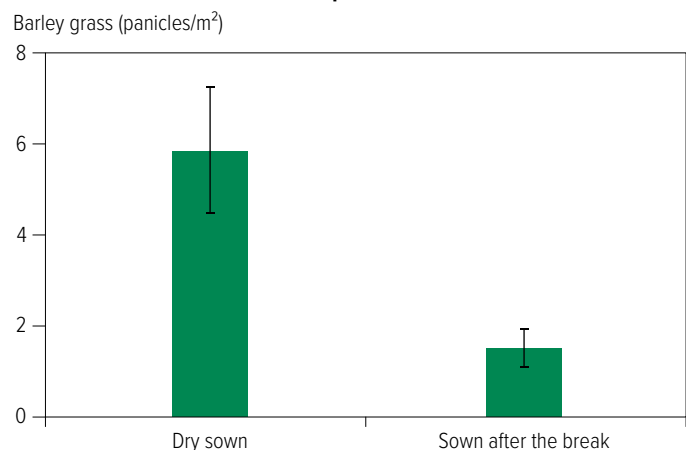


Figure 5: Matt McCallum and Gurjeet Gill on a crop walk with the Eastern Hub Group at the trial site on 11 September 2019.



Photo: Daniel Petersen, University of Adelaide

Management implications

- Dry sowing of crops in this environment can lead to a large build-up in barley grass infestations. Ideally, dry sowing should be only implemented in paddocks with very low weed infestations.
- Use of trifluralin + triallate (Treflan® 1.5L/ha + Avadex® Xtra) provided 50 to 56 per cent control of barley grass in dry-sown barley in this trial in 2019. Trial evidence from other sites indicates pre-emergent pyroxasulfone (Sakura®) can provide superior barley grass control in wheat in such situations and may be worth investigating.
- Greater knowledge among growers about seed dormancy characteristics of their weed populations is likely to assist in making informed decisions about tactics such as crop sowing time.
- Inclusion of pasture phases can play a vital role in the management of barley grass provided seed-set can be prevented. In this trial, the spring spray-topping with glyphosate followed by paraquat had a large impact on barley grass infestation in the next crop.
- Even though effective barley grass management in the pasture phase was able to reduce barley grass plant density in the next crop to less than one plant/m², it was unable to eliminate the weed population. Future management should consider tactics that prevent a bounce back in barley grass infestation.

Barley grass management in the Victorian northern Wimmera and Mallee (BIRCHIP CROPPING GROUP)

Gurjeet Gill, University of Adelaide,
and Kate Maddern, ex Birchip Cropping Group

Key messages

- High barley grass seed-set in the trial paddock in 2018 was reflected in high barley grass plant density (477 plants/m²) in the traditional practice of volunteer pasture in 2019. The other three crop management strategies had 97 to 99 per cent lower barley grass plant density, which is likely to be the result of excellent performance of pre-sowing glyphosate and pre-emergent herbicides.
- Although the differences between management strategies in barley grass panicle density were non-significant due to site variability, break crops where pre and post-emergent herbicides were used had the lowest barley grass panicle density (0.7 panicles/m²). In contrast, barley grass was able to produce some panicles (26 panicles/m²) for seed-set in the intensive hay strategy.
- Good grain and hay prices in the 2019 season resulted in high gross margins, with the cost of weed control being a good investment. The highest gross margins were obtained in wheaten hay (\$1289/ha), which was closely followed by a barley grain crop (\$1231/ha).
- Barley grass plant and panicle densities continued to decline in 2020 in response to management strategies implemented. Three out of four management strategies had no barley grass panicle production in 2020, which meant there was no build-up in the barley grass seedbank.
- The barley grass population present at this trial site appeared to have low seed dormancy and a short-lived seedbank. This allowed effective management tactics to virtually eliminate this population in two years.
- Targeted surveys of barley grass in the Victorian Mallee have identified populations resistant to FOPs (Group 1), glyphosate (Group 9) and paraquat (Group 22). Management of such herbicide-resistant populations will be much more difficult than in the Nullawil population investigated by the BCG in this trial.

SNAPSHOT

OWNER: Cameron Warne

LOCATION: Nullawil, Victoria

FARM SIZE: 4800ha

ANNUAL AVERAGE RAINFALL: 360mm

SOIL TYPES: sandy loam (70%) and some clay loam

ENTERPRISES: continuous cropping with some opportunistic long fallow

Background

Barley grass is a major weed in the Victorian and SA low-rainfall cropping regions, causing \$144,900 worth of annual revenue loss to grain growers in the Mallee (Llewellyn et al. 2016). As management of barley grass continues to rely heavily on herbicides, resistance is becoming more evident for quizalofop, clethodim, glyphosate and paraquat. Advisers from north-west Victoria have seen extensive resistance to Group 1 (FOP) herbicides. Agronomist Darren Jones, who has seen resistance to Group 1s in his clients' paddocks in the northern Wimmera and southern Mallee, believes the root of the problem lies in repeated use of the same product. This places intense selection pressure on barley grass populations and leads to evolution of herbicide resistance.

Barley grass resistance to glyphosate also appears to be increasing in the Victorian Mallee. Matt Bissett, an agronomist from Swan Hill, has also noticed more barley grass surviving pre-sowing knockdowns where glyphosate is being used. Simon Mock, who practises agronomy in the Wimmera and Mallee, has observed paraquat resistance in his clients' barley grass populations.

Methods

A grower member of the Birchip Cropping Group (BCG) raised the issue of large increases in barley grass infestations after the oaten hay pasture. As barley grass reaches maturity well before oaten hay is ready to cut, many seeds are already shed before hay cutting or they are shed while the hay is drying in the paddock. A paddock with high seed-set of barley grass in 2018 on a farm at Nullawil was selected for this case study. Before the trial began, a discussion forum was held with BCG members to identify strategies of interest for the management of barley grass. Four management strategies were selected for the demonstration trial (Table 1). The participating grower had no concerns about herbicide resistance in the barley grass population present at the trial site.

Table 1: Management strategies investigated for barley grass management by BCG at Nullawil.

Year	Traditional practice (S1)	Intensive hay (S2)	Break crops (S3)	Clearfield® crops (S4)
Year 1 – 2019	Pasture	Wheaten h�y	Lentils	Clearfield® barley
	Low-cost pasture with spring brown manure (glyphosate 900g/ha in August)	Pre-emergent herbicides:	Pre-emergent herbicides:	Pre-emergent herbicides:
		Trifluralin 720g/ha*	Trifluralin 840g/ha*	Trifluralin 720g/ha*
		Triallate 1000g/ha*	Propyzamide 500g/ha*	Triallate 1000g/ha*
		Glyphosate 900g/ha	Glyphosate 900g/ha	Glyphosate 900g/ha
			Post-emergent herbicides:	Post-emergent herbicides:
			Haloxypop 39g/ha	Imazamox 16.5g + imazapyr 7.5g/ha
			Clethodim 72g/ha	Glyphosate 900g/ha (post harvest)
			Roundup 900g/ha (post harvest)	
Year 2 – 2020	Wheat	Oaten hay	Triazine-tolerant (TT) canola	Clearfield® lentil
	Pre-emergent herbicides:	Pre-emergent herbicides:	Pre-emergent herbicides:	Pre-emergent herbicides:
	Trifluralin 720g/ha*	Diuron 250g/ha*	Simazine 990g/ha*	Trifluralin 840g/ha*
	Triallate 1000g/ha*	S-metolachlor 480g/ha*	Trifluralin 720g/ha*	Propyzamide 500g/ha*
	Glyphosate 900g/ha	Glyphosate 900g/ha	Glyphosate 900g/ha	Glyphosate 900g/ha
		Post-harvest herbicide:	Post-emergent herbicides:	
		Glyphosate 1350g/ha	Haloxypop 39g/ha	
			Atrazine 990g/ha	

*Applied IBS (incorporated by sowing).

Results

2019

The trial was established in a paddock recently purchased by the grower co-operator. Prior to purchase this paddock had been under a low-input grazing system for many years, which meant the barley grass population present was likely to have low seed dormancy and low herbicide resistance. High seed-set in the trial paddock in 2018 was reflected in high barley grass plant density (477 plants/m²) in the traditional practice (S1) in 2019 (Table 2). There were significant differences between the management strategies in 2019, with the traditional practice showing the highest weed infestation in winter. The other three management strategies had 97 to 99 per cent lower barley grass plant density, which is likely to be the result of pre-sowing glyphosate and pre-emergent herbicides. Even the pre-sowing application of trifluralin + triallate + glyphosate (S2) only resulted in 3.2 plants/m² of barley grass. These results suggest low seed dormancy in this population, which enabled pre-sowing glyphosate to kill most of the weed population. Even though the brown manuring of pasture (S1) in spring with glyphosate was highly effective, barley grass was still able to produce 23 panicles/m² and would have produced some seed for future infestations (Table 2).

Although the differences between management strategies in barley grass panicle density were non-significant due to site variability, break crops where pre and post-emergent (Group 1) herbicides were used (S3) had the lowest barley grass panicle density (Table 2). However, barley grass was still able to produce some panicles (26 panicles/m²) in the intensive hay strategy (S2). These results are consistent with grower observations in this region and fit well with the thoughts of a local agronomist, Matt Bissett, who said: “Unlike ryegrass and brome, hay is not an effective control strategy, due to early maturity of barley grass and the ability of hay equipment to spread its seed.”

All treatments yielded well due to the favourable 2019 season and management (Table 3). As a result of effective weed management, barley grass was present in low densities, which was unlikely to have had an impact on yield. Both lentils and barley received the highest quality grade. The good grain and hay prices in the 2019 season resulted in high gross margins (Table 3), with the cost of weed control being a good investment. The highest gross margins were obtained in wheaten hay (\$1289/ha), which was closely followed by a barley grain crop (\$1231/ha).

Figure 1: A pasture plot in which the barley grass has germinated beside a cropped plot which has been sprayed and cultivated (13 May 2019).



Photo: Kate Maddern, BCG

Table 2: Barley grass plant and panicle density at Nullawil in 2019. Different letters after the mean indicate significant differences (P = 0.05).

Management strategy	Plants/ m ²	Panicles/ m ²
Traditional practice (S1)	476.9 a	23.3
Intensive hay (S2)	3.2 b	26.3
Break crops (S3)	3.6 b	0.7
Clearfield® crops (S4)	14.3 b	26
P	0.001	0.094
Least significant difference (LSD) (P = 0.05)	174.3	NS

Table 3: Average yield, income and gross margin for each treatment. All costs taken from the South Australian Grains Industry Trust *Farm gross margin and enterprise planning guide 2019*. S1 Pasture gross margin was calculated using gross margin grazing value derived from dry sheep equivalent grazing days on 3.14(t/ha) of biomass, hence there is no figure for \$/t.

Treatment	Mean yield (t/ha)	\$/t	Income (\$/ha)	Input costs (\$/ha)	Gross margin (\$/ha)
S1 Pasture (biomass prior to seed-set)	3.14	–	\$602	\$58	\$544
S2 Wheaten hay (hay cut @ GS65, less 15% for baling height)	7.80	\$250	\$1950	\$662	\$1289
S3 Lentils (grain)	1.82	\$496	\$905	\$315	\$589
S4 CL Barley (grain)	5.62	\$283	\$1590	\$359	\$1231

Table 4: Barley grass plant and panicle density at Nullawil in 2020.

Management strategy	Plants/m ²	Panicles/m ²
Traditional practice (S1)	0.5	0.0
Intensive hay (S2)	1.3	0.4
Break crops (S3)	0.1	0.0
Clearfield® crops (S4)	1.1	0.0
P	0.17	0.07
Least significant difference (LSD) (P = 0.05)	NS	NS

Management implications

- The barley grass population present at this trial site appears to have low seed dormancy and a short-lived seedbank. This allowed effective management tactics to virtually eliminate this population in 2 years.
- As the crop was sown after the break in all management strategies in both years, soil moisture conditions were suitable for the activity of pre-emergent herbicides, and the knockdown glyphosate also provided excellent control.
- It seems likely that some barley grass issues in the Mallee are associated with the trend towards dry sowing of crops. This observation is consistent with a local agronomist who said, “Sowing in some of problem paddocks has been delayed until a breaking rain can provide a chance for a good knockdown”.
- Targeted surveys of barley grass in the Victorian Mallee have identified populations resistant to FOPs (Group 1), glyphosate (Group 9) and paraquat (Group 22). Management of such herbicide-resistant populations will be much more difficult than in the Nullawil population investigated by the BCG in this trial.

Reference

Llewellyn, R, Ronning, D, Clarke, M, Mayfield, A, Walker, S and Ouzman, J (2016) *Impact of weeds in Australian grain production: the cost of weeds to Australian grain growers and the adoption of weed management and tillage practices*. Grains Research and Development Corporation, Canberra.

Acknowledgements

Thank you to Cameron Warne for hosting this trial. Special thanks to Matt Bissett, Darren Jones and Simon Mock for phone interviews.

2020

Barley grass plant and panicle densities continued to decline in 2020 in response to management strategies (Table 4). Three out of four management strategies had no panicle production in 2020, which means there was no build-up of the barley grass seedbank. Even the intensive hay strategy (S2) only produced 0.4 panicles/m². Considering the sharp decline in barley grass plant density from 2019 to 2020 and almost no seed-set occurring in 2020, it was decided to terminate the trial. If the trial had been continued in 2021, it is highly likely that most management strategies would have had no barley grass infestation.

Management of barley grass in the South Australian Mallee (MALLEE SUSTAINABLE FARMING)

Michael Moodie and Tanja Morgan,
Mallee Sustainable Farming, and Gurjeet Gill,
University of Adelaide

Key messages

- The barley grass population present on this farm at Lameroo appeared to have a short-lived seedbank. This can be clearly seen by the sharp decline in barley grass density from as high as 150 plants/m² to <1 plant/m² in year two of the trial.
- Wheat/medic/wheat (S1), a common practice in this region, was found to be the weakest strategy for barley grass control due to its reliance on glyphosate spray-topping, which proved ineffective in the wet spring of 2020. Barley grass establishment in 2021 in this strategy was 87 plants/m² and it produced 272 panicles/m² with an estimated seed-set of 6000 seeds/m².
- In contrast, very few (<10/m) barley grass plants emerged in the three other strategies, and an application of IMI herbicide in the Clearfield® wheat or Clearfield® barley ensured that no plants survived to set seed in 2021.
- Crop grain yields were compared in the final year (2021) when all management strategies were in the cropping phase. The high IMI strategy (S2), which had the lowest barley grass panicle density over the three years of this trial, also produced the highest grain yield in the final year; it was 48 per cent higher than the traditional practice wheat/medic/wheat (S1).

Background

In the Lameroo area, grass weeds such as barley grass and brome grass have become more problematic over time. This has resulted in management changes such as increasing the frequency of crops in the rotation to increase weed management tools such as crop competition, herbicide use and the ability to crop-top. Pastures are usually sown as vetch with Group 1 herbicides used for winter cleaning and then an application of glyphosate at the end of the season to prevent weed seed-set. The cropping program consists of rotations based on paddock type – wheat, barley, canola, lupins, vetch, oats (grain), oats (hay).

Ryegrass, barley grass and brome grass have become the biggest weed issues mainly due to the grazing phase of the cropping rotation. A weed blowout in one year takes three to four years to get back to manageable levels. The introduction of imidazolinone-tolerant (Clearfield®) crops has increased the level of grass control but poses other issues in the low-rainfall zone with plant-backs and staggered weed germinations.

Some of the newly acquired and leased land has had a strong grazing focus with cropping only occurring once in three to four years. Minimal grass weed control in pastures often leads

SNAPSHOT

OWNER: Brenton and Bec Pudney

LOCATION: Lameroo, SA

FARM SIZE: 5700ha total area; 50:50 cropped and pasture over a mix of leased and owned land

ANNUAL AVERAGE RAINFALL: 300mm long-term average

SOIL TYPES: Mostly sandy loams with some water-repellent sand hills and some heavy flats with high boron levels and frost susceptibility (<10%)

ENTERPRISES: Merino sheep, Australian white prime lamb/wool and mixed cropping

CROP PROGRAM (2021): 1500ha wheat, 700ha barley, 200ha canola, 200ha oats, 80ha lupins

SEEDING: 12.0m Pillar disc seeder, dual shute, Flexi-Coil box – triple-box set-up, side delivery of seed and deep banding of fertiliser. Triple box allows on-the-go fertiliser blending. Soil testing occurs as a check and nutrition is maintained on a replacement basis

SPRAYING: self-propelled Miller Nitro Spray Air – dual lines, 36m

HARVEST: crop-topping in registered crops for barley, brome and ryegrasses

to a rapid build-up of grass weeds with a large seedbank. The cropping phase allows a reduction in grass weeds through crop competition and herbicides in herbicide-tolerant crops.

The high levels of infestation of barley grass in the trial paddock have led to high levels of crown rot as shown by a PREDICTA® B test. Regular occurrences of barley grass in this problem paddock have raised questions from the grower regarding the seedbank life of barley grass seed. Multiple germinations of barley grass have been observed during the season.

Methods

The paddock selected for the trial had been in medic pasture in 2016, wheat in 2017 and Compass[®] barley in 2018. The barley crop in 2018 failed due to high densities of barley grass. The three-year trial was conducted in this paddock from 2019. This paddock was chosen because barley grass had been an ongoing issue.

After a planning forum with local growers and researchers, a three-year management plan was developed (Table 1).

Table 1: Crop and herbicide treatments investigated over three years at Lameroo.

Year	Traditional practice (S1)	High IMI (S2)	Low IMI (S3)	High diversity (S4)
2019	Wheat	Barley hay	Medic pasture	Medic pasture with barley at 15kg/ha tickled in
	<p>Knockdown: Glyphosate 900g/ha</p> <p>Pre-emergent: Trifluralin 720g/ha + triallate 1000g/ha</p>	<p>Knockdown: Glyphosate 900g/ha</p> <p>Spray-topping: Glyphosate 285g/ha in September and then cut for hay</p>	<p>Post-emergent: Clethodim 120g/ha + quizalofop 24.9g/ha</p> <p>Spray-topping: Glyphosate 285g/ha in September</p>	<p>Spray-topping: Glyphosate 285g/ha in September and cut for hay</p>
2020	Medic pasture	Clearfield® wheat	Wheat	TT canola
	<p>Spray-topping: Glyphosate 285g/ha in spring</p>	<p>Knockdown: Glyphosate 900g/ha</p> <p>Pre-emergent: Trifluralin 720g/ha + triallate 1000g/ha</p> <p>Post-emergent: Imazamox 19.8g/ha + imazapyr 9g/ha (14 July)</p>	<p>Knockdown: Glyphosate 900g/ha</p> <p>Pre-emergent: Trifluralin 720g/ha + pyroxasulfone 100g/ha</p>	<p>Knockdown: Glyphosate 900g/ha</p> <p>Pre-emergent: Propyzamide 500g/ha + simazine 1350g/ha</p> <p>Post-emergent: Clethodim 60g/ha + haloxyfop 39g/ha (14 July)</p>
2021	Scepter ^d wheat	Clearfield® barley	Clearfield® barley	Clearfield® wheat
	<p>Pre-emergent: Trifluralin 720g/ha + triallate 1000g/ha</p>	<p>Pre-emergent: Trifluralin 720g/ha + triallate 1000g/ha</p> <p>Post-emergent: Imazamox 19.8g/ha + imazapyr 9g/ha</p>	<p>Pre-emergent: Trifluralin 720g/ha + triallate 1000g/ha</p> <p>Post-emergent: Imazamox 19.8g/ha + imazapyr 9g/ha</p>	<p>Pre-emergent: Trifluralin 720g/ha + triallate 1000g/ha</p> <p>Post-emergent: Imazamox 19.8g/ha + imazapyr 9g/ha</p>

Results

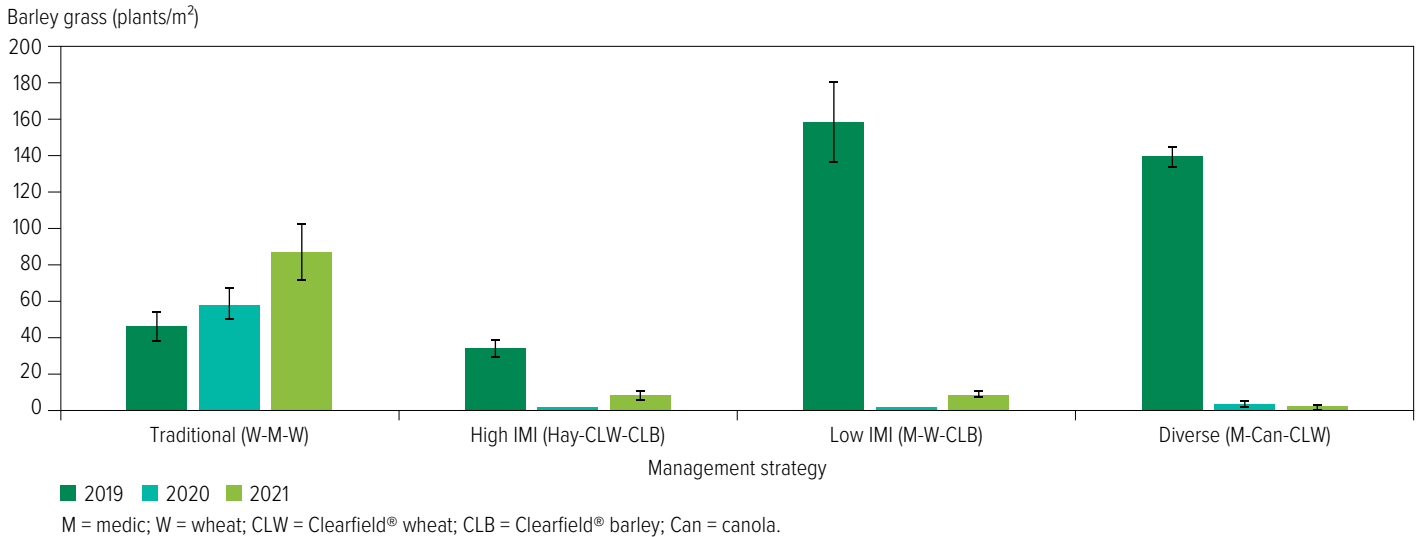
Barley grass plant density

In the first year of this field trial (2019), medic alone (low IMI, S3) or in mixture with barley (high diversity, S4) had the highest barley grass plant density (Figure 1). This is understandable because these plots did not receive any knockdown herbicide treatment, which allowed barley grass plants to establish at a high density. In contrast, use of glyphosate knockdown before seeding wheat (traditional practice, S1) or barley for hay (high IMI, S2) caused a large reduction in barley grass plant density.

More interesting trends in barley grass density were observed in 2020 and 2021. In the traditional system of wheat/medic/wheat, barley grass was able to set seed each year, which contributed to a steady increase in its plant density. In contrast, treatments where effective herbicide options were used caused a sharp decline in

barley grass plant density. This included use of IMI herbicides in Clearfield® cereals in the high IMI strategy (S2). Even in the low IMI (S3) strategy, use of pyroxasulfone (Sakura®) was highly effective and reduced barley grass plant density to < 1 plant/m² (Figure 1). Barley grass plants did establish in high IMI and low IMI strategies in 2020 (year 3) but they were killed effectively by IMI herbicide used in Clearfield® barley. In the high diversity (S4) strategy, there was a high barley grass density in year one that was managed in spring by spray-topping and cutting for hay. Use of TT canola with pre and post-emergent herbicides was highly effective for controlling barley grass in year 2 (2020). Integration of Clearfield® wheat in this strategy in 2021 was able to reduce barley grass plant density to two plants/m².

Figure 1: Barley grass plant densities under different management strategies. The management strategies are described in Table 1. Error bars represent the SEM.



Barley grass panicle density

General trends observed in barley grass plant density over three years were also reflected in its panicle density, which is vital for seed production. However, in many management strategies the trends were even more striking, resulting in virtual elimination of barley grass panicle production (Figure 2). The traditional wheat/medic/wheat strategy (S1) maintained a high level of barley grass density throughout the three-year period. Use of trifluralin + triallate in wheat in 2019 initially reduced barley grass panicles in subsequent medic to 75 panicles/m². However, weak competition from medic in 2020 and high seasonal rainfall resulted in a large rebound in barley grass panicle density in wheat in 2021. The other three management strategies proved highly effective with barley grass, only producing zero to 2.6 panicles/m².

Grain yield

Barley grass management strategies had a significant influence on crop grain yield in the final year (2021) of this trial (Figure 3). The high IMI (S2) strategy, which had the lowest barley grass panicle density over the three years of this trial, also produced the highest grain yield in the final year; it was 48 per cent higher than the traditional wheat/medic/wheat practice (S1). The low IMI (S3) and high diversity (S4) management strategies also produced 18 per cent and 21 per cent greater crop grain yield than did the traditional practice (Figure 3). Growing season rainfall received at Lameroo in 2021 (148.8mm) was well below the long-term average (198.4mm). Dry growing conditions may have reduced the yield gap between highly effective weed management strategies and the traditional wheat/medic/wheat practice.

Figure 2: Changes in barley grass panicle production in response to different management strategies. The management strategies are described in Table 1. Error bars represent the SEM.

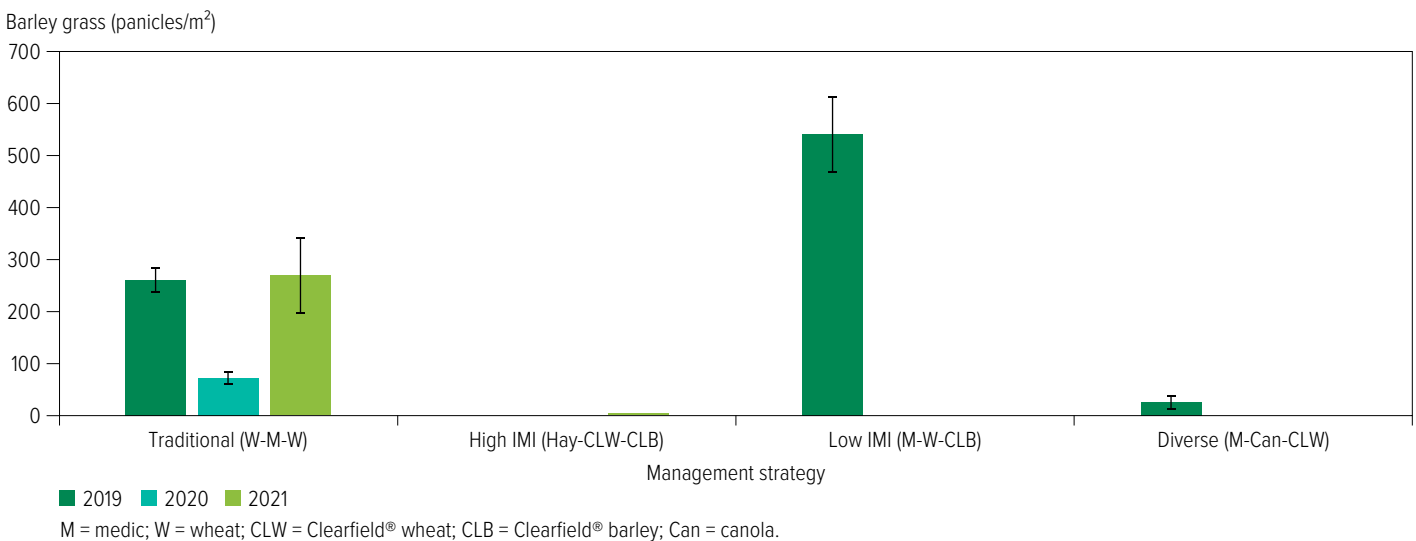
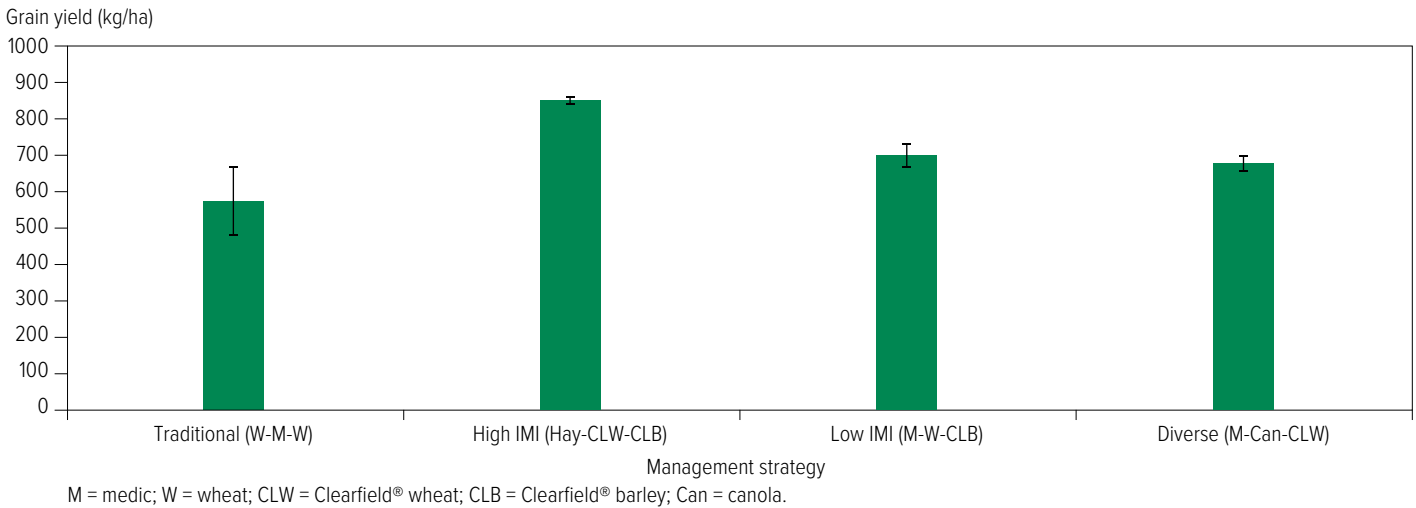


Figure 3: Grain yield of cereal crops in the final year (2021) of different management strategies. Error bars represent the SEM.



Management implications

- Wheat/medic/wheat, which has been a common practice in this region, was found to be the weakest performer for barley grass control. Even though glyphosate was used for spray-topping in 2020, wet spring conditions resulted in poor efficacy of this treatment. This was reflected in high barley grass establishment in Scepter[®] wheat in the following year (2021).
- Use of herbicide-tolerant crops such as Clearfield® cereals and TT canola provides excellent options for barley grass control.
- High barley grass plant and panicle density observed in medic in the low IMI (S3) strategy in 2019 may be related to Group 1 herbicide resistance. This group must be used cautiously as barley grass can evolve high levels of resistance. When faced with a control failure, growers should undertake a herbicide resistance test of their barley grass populations.
- Cutting pasture for hay after spray-topping in year one in the high IMI and diverse strategies was highly effective in reducing barley grass density in subsequent years.

In response to the learnings from this demonstration trial, the grower and his adviser have developed a three-year management program to reduce barley grass numbers to manageable levels. This approach is consistent with research conducted at Minnipa and the University of Adelaide.

New management plans are based on providing strong crop competition to reduce grass numbers and being able to use a combination of crop competition, herbicide-tolerant Clearfield® crops and triazine herbicides for multiple weed control options as follows:

- Year 1 vetch (grazing) and two grass-selective herbicides;
- Year 2 canola – TT or Clearfield® hybrid; and
- Year 3 Clearfield® wheat or barley.

Acknowledgements

A special thank you to Brenton and Bec Pudney for allowing the trial to occur on their property.

Figure 4: Different crops growing at the trial site in the spring of 2020.



Photo: Chris Preston, University of Adelaide

Barley grass management on the Upper Eyre Peninsula (AG INNOVATION & RESEARCH EYRE PENINSULA)

Amanda Cook, South Australian Research and Development Institute (SARDI), and Gurjeet Gill, University of Adelaide

Key messages

- Management tactics found to be effective on barley grass included imidazolinone herbicides, the use of TT canola and a late hay freeze with paraquat.
- Even though imazamox + imazapyr (Intervix®) worked well in the year of application (2019), barley grass was able to establish next year from the seedbank and its population increased in the sown pasture system in the following season.
- This demonstration trial could not identify a management strategy capable of eliminating barley grass in a single year. Therefore, barley grass management and lowering weed seed-set needs to be a focus in all seasons in low-rainfall farming systems.

SNAPSHOT

OWNER: Government of South Australia

LOCATION: Minnipa Agricultural Centre (MAC), Minnipa, SA

FARM SIZE: 1200ha

ANNUAL AVERAGE RAINFALL: 325mm

SOIL TYPES: red sandy loam

Background

Barley grass possesses several biological traits that make it difficult for growers to manage in low-rainfall zone farming systems. Early onset of seed production, which reduces effectiveness of crop-topping or spray-topping in pastures, is one of the traits that make barley grass difficult to control. A reduction in weed seed control effectiveness is also apparent as barley grass seeds are shedding well before harvest begins in-crop – compared with weeds such as ryegrass that have much higher seed retention. Delayed emergence caused by an increase in seed dormancy is reducing the success of knockdown herbicides for weed control. Barley grass has also developed an increasing resistance to Group 1 herbicides, which are used to control grass weeds in the pasture phase and legume crops. Growers in the Eyre Peninsula region have observed many control failures of barley grass.

Methods

In March 2019 growers, MAC staff and Dr Gurjeet Gill met to discuss the issue of barley grass in Eyre Peninsula farming systems. A three-year trial plan was developed and implemented on the MAC farm (Table 1). The paddock demonstration trial had three replicated broadacre strips of three seeder widths (27m wide) in MAC paddock S3. Crop establishment, dry matter, barley grass numbers pre-sowing, in-crop and at barley grass seed-set, grain yield and quality were assessed during the growing seasons. Stubbles and pastures were grazed by sheep over the summer period. The barley grass population present at the trial site was confirmed to be resistant to Group 1 herbicides, especially the FOP herbicide quizalofop.

Table 1: The five different management strategies, crops, pastures and herbicide treatments for each season (2019 to 2021) at Minnipa Agricultural Centre, paddock S3.

Strategy	2019	2020	2021
District practice (S1)	17 May: Compass [®] barley sown @ 68kg/ha Glyphosate 540g/ha + trifluralin 720g/ha	Self-regenerating medic pasture Clethodim 79.2g/ha post-emergence	2 June: Scepter [®] wheat sown @ 75kg/ha Glyphosate 540g/ha + trifluralin 720g/ha
Strategic control (S2)	17 May: Scope CL [®] barley sown @ 68kg/ha Glyphosate 540g/ha + trifluralin 720g/ha 16 July: post-emergence imazamox 23.1 g + imazapyr 10.5g/ha	26 April: Sultan [®] -SU medic 3 June: post-emergence clethodim 79.2g/ha	2 June: Scepter [®] wheat sown @ 75kg/ha Glyphosate 540g/ha + trifluralin 720g/ha
Continuous cereals (S3)	17 May: Compass [®] barley sown @ 95kg/ha Glyphosate 540g/ha + trifluralin 720g/ha 3 September: hay freeze with glyphosate 846g/ha	12 May: Scepter [®] wheat sown @ 70kg/ha Pre-emergence trifluralin 720g/ha	10 June: Spartacus CL [®] barley sown @ 70kg/ha 6 August: post-emergence imazamox 23.1 g + imazapyr 10.5g/ha
Two-year break (S4)	Self-regenerating grass-free pasture 17 May: propyzamide 500g/ha 2 July: quizalofop 38g/ha + clethodim 60g/ha 3 September: spray-topping with paraquat 300g/ha	26 April: HyTTec [®] Trident TT canola sown @ 1.8kg/ha Glyphosate 675g/ha + carfentrazone 20g/ha + trifluralin 384g/ha + simazine 400g/ha 3 June: clethodim 79.2g/ha 11 June: atrazine 720g/ha	2 June: Scepter [®] wheat sown @ 75kg/ha Glyphosate 540g/ha + trifluralin 720g/ha
Cultural control (S5)	17 May: Compass [®] barley double seeded @ 120kg/ha 17 May: glyphosate 540g/ha	Self-regenerating grass-free pasture 3 June: clethodim 79.2g/ha 6 Sep: early spring application of paraquat 300g/ha	2 June: Scepter [®] wheat double sown 2 June: glyphosate 540g/ha + trifluralin 720g/ha

Results

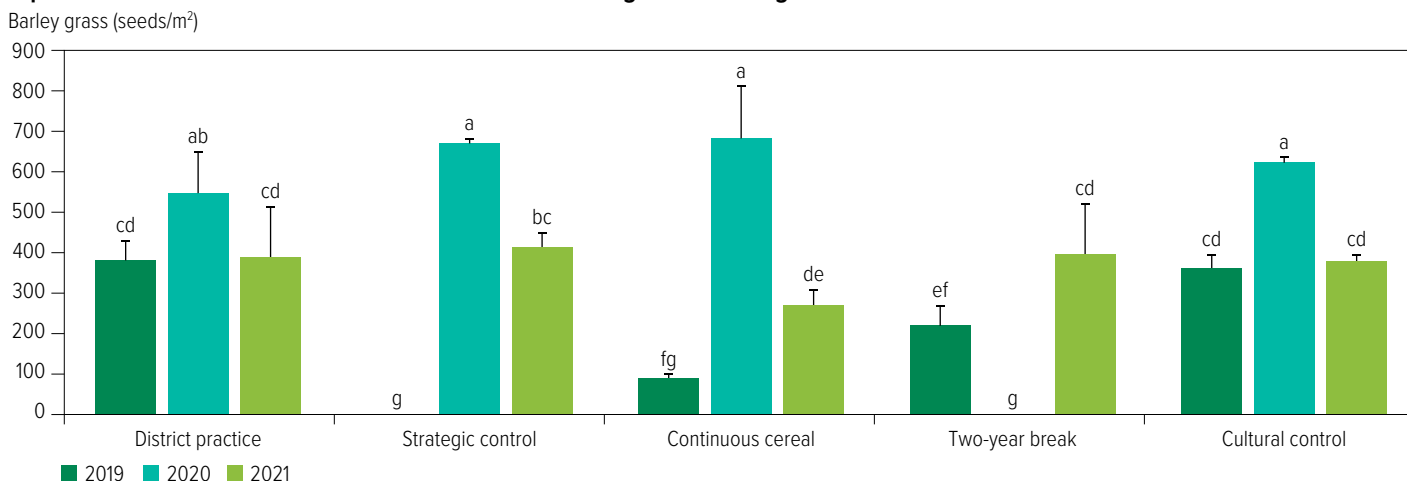
2019

Barley grass plant numbers in June to August ranged from 0 to 130 plants/m². However, treatments with only 3 plants/m², district practice (S1) and cultural control (S5), managed to produce more than 300 seeds/m². In contrast, use of imazamox + imazapyr (Intervix[®]) in Scope CL[®] barley in strategic control (S2) had no barley grass weed seed-set in 2019. Compass[®] barley in the district practice and cultural control strategies had very similar barley grass seed-set. Compass[®] barley crop-topped before cutting for hay (continuous cereals, S3) reduced barley grass seed-set in 2019. The two-year break with self-regenerating pasture in 2019 (S4) had higher barley grass plant numbers during the 2019 season, but late paraquat application in early September in the pasture phase lowered weed seed-set.

2020

The majority of the barley grass germinated in mid-July to August, thereby avoiding the early weed control with pre-sowing herbicide applications. All crops established well but below-average rainfall in May, June and July resulted in very slow crop growth until August and September. The 2020 herbicide applications to the break crop systems of the canola and medic crops reduced barley grass plant numbers, with the TT canola strategy (S4) giving the best later barley grass weed management. Despite excellent weed control in 2019 by the imidazolinone herbicide in S2, barley grass plants and seed-set in 2020 were as high as in the other three strategies (Figure 1). It is highly likely barley grass was able to establish in this system from its residual seedbank.

Figure 1: Barley grass weed seed-set in five different management strategies over three years (2019 to 2021) at Minnipa Agricultural Centre, paddock S3. Treatments with different letters are significantly different at P = 0.05 (LSD = 138). Error bars represent standard deviation of the treatment. The management strategies are described in Table 1.



2021

Some barley grass plants started to germinate by early July in 2021, but like previous years most barley grass germinated in mid-July to August, which was reflected in the higher late barley grass numbers in September. The continuous cereal strategy (S3) sown with Spartacus CL[®] barley had high early barley grass numbers, but imazamox + imazapyr applied in early August reduced the barley grass density and lowered the seed-set (Figure 1). All other management strategies, which were sown to Scepter[®] wheat, had a similar barley grass seed-set of greater than 370 seeds/m². There were no differences in grain yield between weed management strategies in 2021.

Management implications

- The barley grass population at the Minnipa Agricultural Centre S3 paddock is a later-germinating population that requires cold temperatures to trigger germination (vernalisation), thereby avoiding pre-sowing knockdown herbicide.
- Management tactics found to be effective on barley grass included imidazolinone herbicides, the use of TT canola and a late hay freeze with paraquat.
- Even though imazamox + imazapyr (Intervix[®]) worked well in the year of application (2019), barley grass was able to establish the following year from the seedbank and its population increased in the sown pasture system in the following season.
- This demonstration trial failed to identify a management strategy capable of eliminating barley grass in a single year. Therefore, barley grass management and lowering weed seed-set needs to be a focus in all seasons in low-rainfall farming systems.
- While the imidazolinone herbicides worked well at MAC, they must be used strategically to maximise the effectiveness and long-term use of this system. Growers need to be aware of the risk of herbicide resistance and also herbicide residues and plant-back periods, especially in low-rainfall seasons.

Future management plans

- With confirmed resistance to FOP herbicides in MAC's barley grass populations, switching to clethodim could be effective in the short term. Generally, a higher rate of clethodim (500mL/ha) appears to be effective on most populations. Recent work has shown butoxydim (Factor[®]) was highly effective against most FOP and clethodim-resistant populations of barley grass (Gill and Fleet, 2021). However, resistance to the higher rate is likely to evolve with sustained use over the next few years.
- With Group 1 resistance becoming more common and widespread, there needs to be less reliance on their use in the pasture phase and alternative weed control strategies right across the rotation are required. If barley grass herbicide resistance is suspected, the first step is to test the population to know which herbicides can be used effectively.
- To ensure Group 1 resistance is kept in check, growers should ensure any suspected resistant plants are dealt with in pasture systems by following up with a knockdown herbicide as early as possible to prevent seed-set. Always have follow up options to control any survivors and to preserve Group 1 herbicides.

Figure 2: Minnipa and Poochera farmer group visiting the Minnipa Agricultural Centre in September 2020.



Photo: Amanda Cook, SARDI

Barley grass control in a low rainfall pasture/crop rotation

(KELLERBERRIN DEMONSTRATION GROUP)

Catherine Borger, Department of Primary Industries and Regional Development (DPIRD), Northam, WA, and Brad Joyce, ConsultAg

Key points

- Early control with selective herbicides in pasture or pre-emergent herbicides in cereals alone is not sufficient for full control. While there may be initial control, there can be late emergence of barley grass.
- Late control in pasture can be achieved by spray-topping or slashing, but timing is critical. This can be difficult if barley grass is not the only weed species to target, or in a dry spring where panicles mature quickly.
- An integrated weed management plan including early barley grass control with a selective herbicide, late control tactics (spray-topping or slashing) and grazing is required to remove barley grass in pasture.

SNAPSHOT

OWNERS: GA and AP Morgan

LOCATION: North Kellerberrin, WA

FARM SIZE: 2500ha, cropping 1600ha

ANNUAL AVERAGE RAINFALL: 325mm

SOIL TYPES: Salmon gum duplex, York gum sandy loam, Tammam sand

ENTERPRISES: wheat, barley, lupins, oats, sheep

CROP PROGRAM: 1000ha wheat, 300ha barley, 180ha lupins, 110ha oats

SEEDING: Seeding rig past 20 years 9m John Deere bar 550lbs breakout, knife points and press wheels, 25cm spacing. JD bin with two compartments. No Flexi N and urea applied in response to seasonal conditions. SOA spread at sowing, where required. Upgrading to 12m JD ConservaPak for 2022, with Simplicity 9t, three-bin cart and small seeds bin, 30cm spacing with paired rows

SPRAYING: Hardi tug along 6000L (30m), auto height and sectional control towed by JD 7210R FWA tractor

HARVEST: JD 9650 STS, contract cartage to Kellerberrin. Chaff spread only

Background

The common rotations on this property are lupins followed by three years of wheat or barley, or pasture/wheat. In both systems, the most common weeds are wild radish, annual ryegrass, barley grass and brome grass. Testing indicated no evidence of herbicide resistance in barley grass. This weed is a problem in pasture that does not get an early application of Group 1 herbicides. The grower does not rely on barley grass for early feed. However, application timing has a large effect on the efficacy of barley grass control. Barley grass may not be the first weed targeted for control, making timing of barley grass control more variable.

Methods

The trial was located within a continuous clover pasture/wheat rotation (Table 1). In the first year of the trial, the site had dense, uniform barley grass in pasture. The pasture treatments (in 2019 and 2021) included early (two to four-leaf) application of a selective herbicide and late-season control from spray-topping or slashing. In wheat (2020), the plots were split to allow application of Treflan alone, or pyroxasulfone (Sakura®) and Treflan. In all treatments, panicles were collected from barley grass and seed numbers were assessed. In the pasture rotations, seed viability was also assessed to determine seed-set control from spray-topping or slashing.

Table 1: Agronomic details from 2019 to 2021.

Agronomic detail	2019	2020	2021
Total (and growing season) rainfall	192mm (183mm)	225mm (125mm)	326mm (223mm)
Crop sowing details	Volunteer regenerating pasture (wheat and clover)	Wheat cv. Scepter [®] , 50kg/ha, 25cm row spacing	Volunteer regenerating pasture (wheat and clover)
Sowing date	NA	27 May 2020	NA
Herbicides	5 Jul 2019: quizalofop-p-ethyl 25g/ha post-emergence 24 Sep 2019: paraquat 100g/ha spray-topped	27 May 2020: trifluralin 960g/ha or pyroxasulfone 100g/ha + trifluralin 960g/ha IBS	11 Jun 2021: imazamox 31.5g/ha post-emergence 20 Sep 2021: slashing
Barley grass treatments			
1 (\$40/ha)*	Quizalofop-p-ethyl at 2 to 4 leaf	Trifluralin IBS**	Imazamox at 2 to 4 leaf
2 (\$43/ha)	Quizalofop-p-ethyl at 2 to 4 leaf + spray-top	Trifluralin IBS	Imazamox at 2 to 4 leaf + slashing
3 (\$17/ha)	Spray-top	Trifluralin IBS	Slashing
4 (\$80/ha)	Quizalofop-p-ethyl at 2 to 4 leaf	Pyroxasulfone + trifluralin IBS	Imazamox at 2 to 4 leaf
5 (\$83/ha)	Quizalofop-p-ethyl at 2 to 4 leaf + spray-top	Pyroxasulfone + trifluralin IBS	Imazamox at 2 to 4 leaf + slashing
6 (\$57/ha)	Spray-top	Pyroxasulfone + trifluralin IBS	Slashing
Harvest	Grazing	6 Nov 2020	Grazing

*Cost of the herbicide for the barley grass treatments listed, based on Nutrien Ag Solutions 2020 prices, where quizalofop-p-ethyl (Targa[®]) was \$12/L, paraquat was \$67/L, trifluralin (TriflurX[®]) was \$7/L, pyroxasulfone (Sakura[®]) was \$343/kg and imazamox (Raptor[®]) was \$504/kg. **IBS: incorporated by sowing.

Results

2019 pasture

Quizalofop-p-ethyl (Targa[®]) at the 2-to-4-leaf stage (treatments 1, 2, 4 and 5) killed all barley grass. The dry season, with 192mm of rain compared with the average of 325mm, prevented new barley grass cohorts from emerging later in the year. By the end of the season there was no barley grass seed production in these plots (Figure 1). Spray-topping was not necessary in the quizalofop-p-ethyl at 2 to 4 leaf + spray-top treatment.

Spray-topping alone did not prevent seed-set, with 54 panicles and 318 seeds/m² (Figure 1 and Figure 2). The timing of spray-topping is difficult, and in the trial paddock spray-topping also aims to control annual ryegrass and brome grass. Panicles of different grass species reach maturity at slightly different times. Also, the dry season caused panicles to mature and senesce within one to two weeks. Rapid maturity and senescence of the panicles makes it impossible to apply spray-topping herbicide to all pasture on the farm at the correct growth stage.

Pasture biomass was lower following spray-topping alone than following quizalofop-p-ethyl. Early weed control with quizalofop-p-ethyl allowed improved growth of the more desirable clover, which probably improved the nutritional value of the pasture. The current research did not assess feed quality.

Figure 1: Pasture biomass ($P < 0.001$, $LSD = 0.075$) and viable barley grass seeds ($P < 0.001$, $LSD = 1.2$) in 2019, assessed in early November.

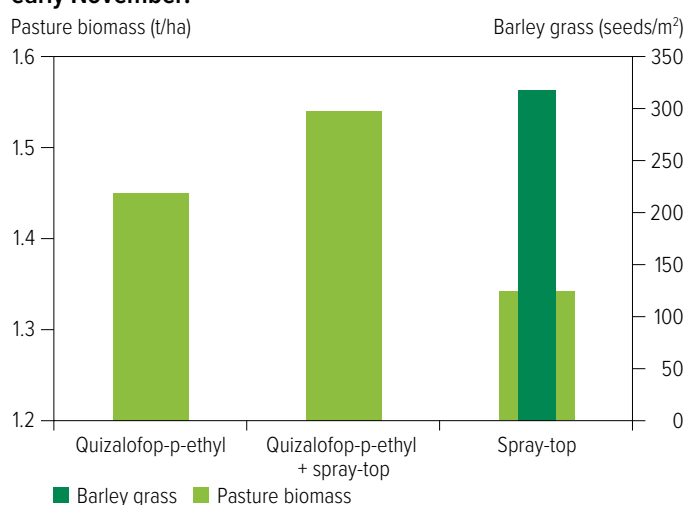


Figure 2: Barley grass heads can go from being immature to senesced in less than a week in a dry spring, making it difficult to ensure optimal timing for spray-topping. This technique is even more difficult if spray-topping aims to control multiple grass species, as different species often reach maturity at different times.



Photo: Nerys Wilkins, DPIRD

2020 wheat

Even though quizalofop-p-ethyl killed all barley grass plants in 2019 and seed-set was zero, there was still dense weed emergence in 2020 from the dormant seedbank. The 2020 wheat crop with trifluralin alone had greater barley grass density than the crop with pyroxasulfone + trifluralin, regardless of the 2019 control tactics.

By the end of the season, barley grass seed production was high in all treatments with trifluralin alone (Figure 4, top). However, barley grass seed production after trifluralin alone or pyroxasulfone + trifluralin in 2020 was highest when the 2019 pasture treatment was spray-topped (Figure 4, bottom).

Where quizalofop-p-ethyl was used in pasture in 2019 and pyroxasulfone + trifluralin in 2020 wheat, barley grass seed production was 8 to 11 seeds/m² (Figure 4, bottom). These plots also had the highest wheat yield (1.5t/ha). Price of APW1 for the local (Kwinana) port zone was \$285/t, so the price difference of \$57 between a yield of 1.5t/ha or 1.3t/ha (the highest yield achieved with trifluralin alone) was sufficient to justify the additional cost of pyroxasulfone (at \$40.5/ha).

Figure 3: Wheat in 2020 with trifluralin alone had an average of 82 barley grass plants/m² (left) compared with wheat with pyroxasulfone (Sakura[®]) and trifluralin with an average of 11 barley grass plants/m² (right).

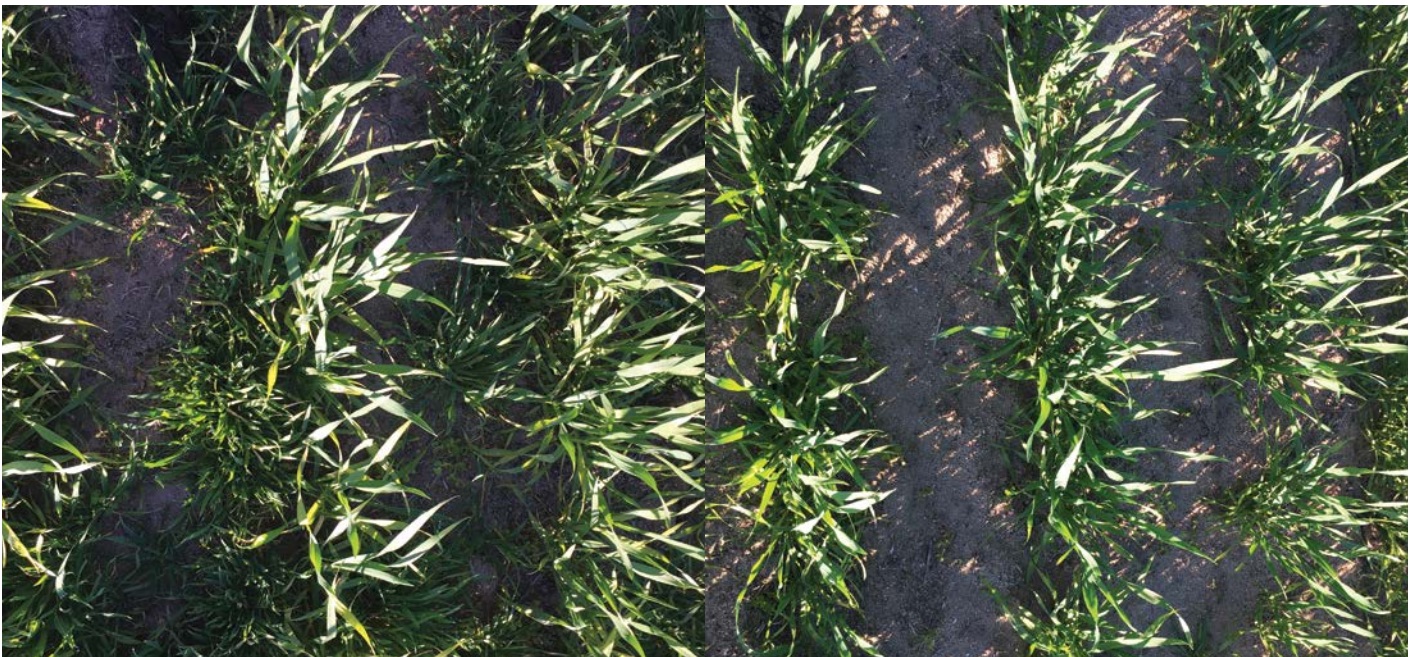
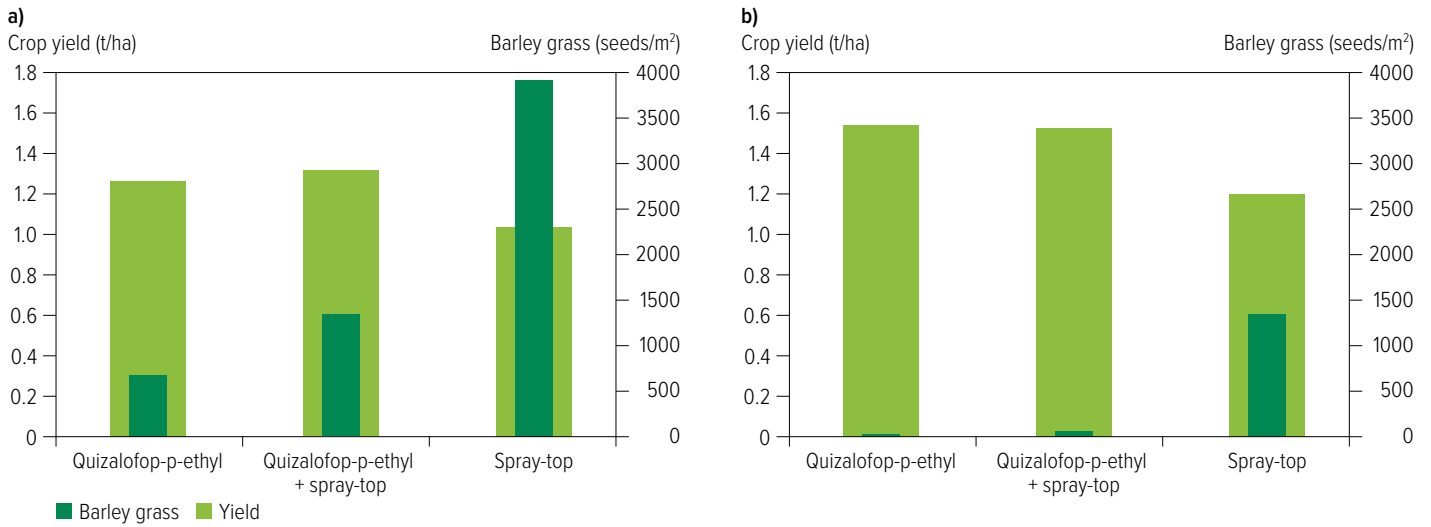


Photo: Catherine Borger, DPIRD

Figure 4: Wheat yield ($P < 0.001$, $LSD = 0.2$) and barley grass seed number ($P = 0.003$, $LSD = 3.4$) in 2020 following trifluralin alone (a) or pyroxasulfone (Sakura®) + trifluralin (b) treatment in 2020. The x-axis labels indicate the 2019 pasture treatments (quizalofop-p-ethyl or spray-topping). The P and LSD values indicate significant differences between the interaction of 2019 and 2020 treatments.



2021 pasture

In 2021, all treatments with pyroxasulfone + trifluralin in 2020 had lower barley grass density than treatments with trifluralin alone (28 or 166 barley grass plants/m²). However, the 2020 treatments had no impact on panicle number or barley grass seed production in 2021, so the 2021 data shown in Figure 5 was averaged over the two 2020 treatments (trifluralin alone or pyroxasulfone + trifluralin).

Early imazamox application in 2021 did not control all barley grass. By the end of the season, the survivors had produced 691 seeds/m² (Figure 5). It is likely that the wetter season allowed emergence of late barley grass cohorts after the initial cohort was controlled by the herbicide. While the paddock was grazed, grazing usually does not remove all barley grass plants. Slashing in spring removed all panicles and prevented seed-set.

Pasture biomass was high due to favourable seasonal conditions in 2021 and was not affected by weed control tactics, although biomass was slightly lower following the slashing treatment. Note that pasture biomass was assessed soon after slashing, so while the panicles had been cut off, the biomass was still present on the ground to be sampled.

Figure 5: Pasture biomass ($P = 0.246$, LSD not significant) and viable barley grass seeds ($P < 0.001$, $LSD = 229.1$) in 2021, sampled in late October. Note that data is averaged over the 2020 treatments of trifluralin alone or pyroxasulfone + trifluralin in wheat.

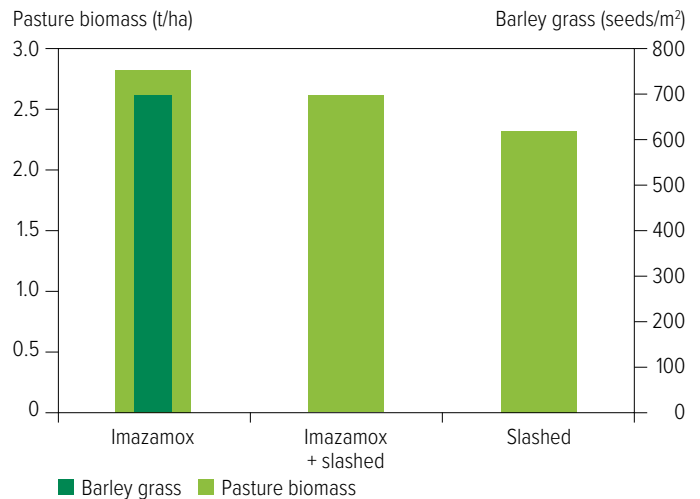


Figure 6: Brad Joyce and Geoff Fosbery discuss barley grass control by pre-emergent herbicides in wheat in 2020.



Photo: Catherine Borger, DPIRD

Future management plans

- A single control option in pasture may have variable results due to unavoidable seasonal variability. Early chemical control cannot remove all barley grass if seasonal conditions allow late staggered emergence. Optimal timing of late-season control tactics such as spray-topping is difficult to determine if a dry spring results in rapid maturity of barley grass panicles.
- Early chemical application was the most expensive control option in pasture and did not always increase pasture biomass, but removing barley grass to allow improved growth of more desirable pasture species such as clover would improve feed quality (which was not tested here). Further, early control prevents barley grass seed injuring stock and contaminating wool or carcasses.
- Both early season control and late-season control in pasture, along with grazing, can ensure zero barley grass seed-set. Depending on seasonal conditions, early grazing and high grazing pressure may even increase barley grass panicle emergence, to make late-season control more effective.
- Pyroxasulfone provided excellent residual control of barley grass and a reduction in seed production but is an expensive option. The value of this herbicide, as determined by the increase in yield, will be influenced by seasonal conditions and wheat price.

Acknowledgements

We would like to thank Gavin Morgan for providing the trial site, staff at ConsultAg, and Nerys Wilkins and Pete Gray (DPIRD, WA) for their assistance with the trial management and measurements.

Pre-emergent or post-emergent herbicides in a wheat/barley/pasture rotation (SOUTH EAST PREMIUM WHEAT GROWERS ASSOCIATION)

Catherine Borger, Department of Primary Industries and Regional Development (DPIRD), Northam, WA, and Sam Stubna, South East Premium Wheat Growers Association (SEPWA)

Key points

- Barley grass can have late, staggered emerging cohorts, so full control needs to consider pre and post-emergent options.
- Clearfield® crops or legume pasture allow excellent in-crop control and reduction of barley grass seed production.
- Herbicide resistance remains very low at this site. A diverse crop rotation allows a rotation of herbicide groups to avoid resistance developing.

SNAPSHOT

OWNERS: Geoff and Maryann Harris with Brayden Harris and Digby Harris

LOCATION: Grass Patch, WA

FARM SIZE: Mixed farming enterprise; 1450ha wheat, 1450ha barley, 880ha vetch, running sheep

ANNUAL AVERAGE RAINFALL: 325mm

SOIL TYPES: sand over clay; grey clays, kopi boron toxic subsoils

ENTERPRISES: wheat, barley, canola (2022), vetch, sheep

CROP PROGRAM (2021): 1450ha wheat, 1450ha barley, 880ha vetch

SEEDING: 56-foot John Deere ConservaPak, Bourgault bin and liquid cart

SPRAYING: John Deere SP (36m)

HARVEST: John Deere 680 – chop and spread straw/chaff component behind header

HARVEST WEED SEED CONTROL (HWSC): No specific HWSC system. Weed seed removal in wheat hay (cv. Baroota Wonder) and vetch hay

Figure 1: Digby Harris, Geoff Harris, Maryann Harris and Brayden Harris explored optimal chemical use in a crop/pasture rotation in a field where barley grass was problematic but levels of herbicide resistance were low.



Photo: Sam Stubna, SEPWA

Background

The biggest winter weed issues on this property are annual ryegrass, wild turnip and barley grass. Early feed from barley grass is often useful, but forage biomass reduction from barley grass competition and seed contamination of livestock are an issue later in the season.

Testing indicated no evidence of herbicide resistance in barley grass, and this weed is most severe when there is a dry start and pre-emergent herbicides are less effective. Barley grass is also common in areas of the property with soil constraints, specifically, water repellence or kopi patches. Both types of soil have poor crop emergence, leading to poor crop-weed competition. Water-repellent soil causes late, staggered weed emergence and extends the life of the dormant seedbank. That means that barley grass cohorts escape early control and in-crop selective herbicides are needed to target all cohorts.

Methods

The trial was conducted in a paddock with kopi soil patches and boron toxicity at depth. Crop establishment and growth were very poor in these patches, leading to weed blow-outs. The trial ran for three seasons exploring four treatments representing different levels of weed control inputs (Table 1).

Table 1: Agronomic details from 2019 to 2021.

Agronomic detail	2019	2020	2021
Total (and growing season) rainfall	197mm (155mm)	318mm (183mm)	385mm (269mm)
Crop sowing details	Wheat cv. Mace [®] , 65kg/ha, 30cm row spacing	Barley cv. Spartacus CL [®] , 40 or 60kg/ha, 30cm row spacing	Vetch cv. Volga [®] , 40kg/ha, 30cm row spacing
Sowing date	14 Jun 2019	30 Apr 2020	22 Apr 2021
Herbicides	30 May 2019: glyphosate 1080g/ha 3 Jun 2019: paraquat 720g/ha + saflufenacil 12g/ha pre-emergence treatments 14 Jun 2019: pre-emergence treatments (below)	30 Apr 2020: trifluralin 960g/ha IBS 29 Jun 2020: Intercept [®] post-emergence treatments	22 Apr 2021: paraquat 360g/ha 22 Apr 2021: pre-emergence treatments. 12 Jun 2021: post-emergence treatments
Harvest	18 Nov 2019	18 Nov 2020	Grazed
Barley grass treatments			
1 (\$35/ha)*	Trifluralin 960g/ha IBS#	Barley 40kg/ha, imazamox + imazapyr 12.4 + 5.6g/ha post-emergence	Trifluralin 576g/ha IBS, quizalofop-p-ethyl 25g/ha post-emergence
2 (\$71/ha)	Pyroxasulfone 100g/ha IBS	Barley 40kg/ha, imazamox + imazapyr 16.5 + 7.5g/ha post-emergence	Trifluralin 576g/ha + diuron** 450g/ha IBS, quizalofop-p-ethyl 25g/ha post-emergence
3 (\$59/ha)	Pyroxasulfone 100g/ha + trifluralin 960g/ha IBS	Barley 65kg/ha, imazamox + imazapyr 12.4 + 5.6g/ha post-emergence	No treatment***
4 (\$51/ha)	Cinmethylin 375g/ha IBS	Barley 65kg/ha, imazamox + imazapyr 16.5 + 7.5g/ha post-emergence	No treatment***

*Cost of the herbicide for the barley grass treatments listed, based on Nutrien Ag Solutions 2020 prices, where trifluralin (Treflan) was \$7/L, pyroxasulfone (Sakura[®]) was \$343/kg, cinmethylin (Luximax[®]) was \$74/L, imazamox + imazapyr (Intercept[®]) was \$28/L, quizalofop-p-ethyl (Quiz 200g/L) was \$12/L, and diuron was \$13/kg.

**A rate was used to correspond to the typical mixed infestation of annual ryegrass, barley grass and broadleaf weeds.

***In treatments 3 and 4, plots were not treated in 2021. #IBS: incorporated by sowing.

Table 2: Wheat and barley grass density, barley grass panicle and seed production and wheat yield for each treatment. P and LSD values are included for separation of means. Note that barley grass panicle and seed production means are back-transformed from a square root transformation.

Treatment	Wheat density (plants/m ²)	Barley grass density (plants/m ²)	Barley grass panicles/m ²	Barley grass seeds/m ²	Wheat yield (t/ha)
1. Trifluralin 960g/ha	111	12.9	43.2	279	0.28
2. Pyroxasulfone 100g/ha	122	6.5	25.1	189	0.33
3. Pyroxasulfone 100g/ha + trifluralin 960g/ha	110	8.0	23.4	136	0.34
4. Cinmethylin 375g/ha	114	9.1	44.6	346	0.31
P	0.058	0.033	0.098	0.036	0.029
LSD	8.86	4.41	NS	25.13	0.042

Results

2019

Pyroxasulfone gave the best initial control of barley grass and had the lowest barley grass seed production when mixed with trifluralin (Table 2). Trifluralin alone (treatment 1) or cinmethylin (treatment 4) plots had higher seed production at the end of the season. Herbicides had no impact on wheat establishment. Wheat yield was very low due to the dry conditions (see rainfall in Table 1) but was lowest in the trifluralin plots where weed density was greatest.

Figure 2: The grey clay soil has 'kopi patches' with toxicity in the subsoil. Crop emergence is always sparse on these patches, leading to poorly competitive crop and potential weed blow-outs. The use of Intervix® in this 2020 barley (Spartacus CL^(b)) ensured good control of barley grass (where the barley grass in this image is the yellow plants that are dying off).



2020

In 2020 there was no difference in initial density of the barley crop (ranging from 52 to 67 plants/m²), even though sowing rate varied from 40 to 65kg/ha. Crop establishment was low and variable due to dry conditions and soil variability. Initial barley grass was uniform across the trial (with an average of 78 plants/m²). Due to a very dry start to the season, the pre-emergent application of trifluralin did not provide effective weed control.

Imazamox + imazapyr herbicide provided excellent weed control across the trial, particularly evident in the kopi patches where the crop was sparse (Figure 2). By the end of the season, there were 13 barley grass seeds/m² following high rates of imazamox + imazapyr compared with 48 seeds/m² at low rates of imazamox + imazapyr. The difference in early weed control by imazamox + imazapyr was evident in the yield (Figure 3).

The soil constraints in this field exacerbated the weed issues. Soil amelioration options to try include use of surfactants and high seeding rates to improve establishment on the water-repellent soils. While high seeding rates had no impact in this season due to a very dry start, they are generally a good option where establishment is poor. On the kopi patches, application of gypsum in combination with stubble retention would probably improve structure and increase leaching of boron or salts, but gypsum is a long-term solution (10 to 20 years) and the value is reduced if the soil is saline. Any kind of mulch (sand, gravel, organic) would reduce evaporation and allow salts or boron to leach deeper into the soil profile, but this option is costly. Since soil amelioration programs can be expensive, it is often best to trial solutions such as mulching over a smaller area. Careful consideration should be given to the best type of amelioration, overall cost, and potential benefit in terms of improved crop growth and weed control.

2021

After late, staggered cohorts of barley grass in 2019 and 2020, control of late-germinating barley grass was emphasised in 2021. With high rainfall in 2021, pre-emergent herbicides gave good control of barley grass (Table 3). The very high rainfall also ensured good vetch emergence across the site, masking the soil constraints evident in 2020 (Figure 4).

Figure 3: Barley yield following imazamox + imazapyr at 12.4 + 5.6g/ha or 16.5 + 7.5g/ha (P = 0.05, LSD = 0.225).

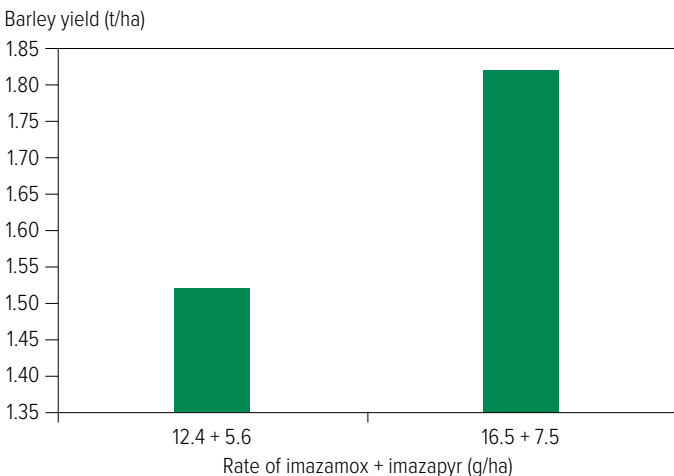


Table 3: Vetch and barley grass density, barley grass panicles, barley grass seed production and pasture biomass. P and LSD values are included for separation of means. Note that barley grass density, panicle and seed production data is back-transformed from a log+1 transformation.

Treatment	Vetch density (plants/m ²)	Barley grass density (plants/m ²)	Barley grass panicles/m ²	Barley grass seeds/m ²	Vetch/pasture biomass (t/ha)
1. Trifluralin 576g/ha IBS, quizalofop-p-ethyl 25g/ha post-emergence	47	1.5	19.3	588	4.6
2. Trifluralin 576g/ha + diuron 450g/ha IBS, quizalofop-p-ethyl 25g/ha post-emergence	45	0.9	7.1	185	3.6
P	0.031	0.261	0.001	<0.001	0.196
LSD	3.88	NS	2.46	7.9	NS

Figure 4: The vetch cv. Volga[Ⓛ] had high biomass and low weed density across the trial site. A pasture break crop is an excellent opportunity to use a wider range of herbicide groups and clean up problematic weeds.



Photo: Sam Stubna, SEPWA

Acknowledgements

We would like to thank the Harris family for providing a site and running the trial, and Michelle Handley, Niki Curtis and Andrea Carmody (SEPWA), Greg Warren and Richard Scott (Farm & General) and Nerys Wilkins (DPIRD) for their assistance with the trial management and measurements. The trial was sponsored by BASF. Thanks are also due to Steve Davies and David Hall (DPIRD) for advice on soil constraints.

Future management plans

- Late, staggered barley grass cohorts are a problem. Control requires pre and post-emergent herbicide applications.
- Resistance remains very low on this farm, and a diverse rotation with pasture or Clearfield[®] crops will allow good in-crop control with a rotation of herbicide groups.
- Soil amelioration to address the issues of water repellence or toxic kopi patches is challenging and expensive, but it would improve crop establishment and competitive ability against weeds and reduce late weed emergence.

Excellent barley grass control in break crops: pasture/wheat/canola rotation (MINGENEW IRWIN GROUP)

Catherine Borger, Department of Primary Industries and Regional Development (DPIRD), Northam, WA, and Tiarna Kanny, Mingenew Irwin Group

Key points

- Three years of control reduced barley grass density from more than 1000 plants/m² to 2 to 14 plants/m² across the whole site.
- The diverse rotation, including pasture and canola break crops, allowed a range of herbicides from different mode of actions and control of late-emerging barley grass cohorts.
- Two years of seed-set prevention was not sufficient to completely remove barley grass. Barley grass has a seedbank that lasts at least three to four years and is widely dispersed so can frequently re-invade paddocks.

SNAPSHOT

OWNER: Phil Soullier

LOCATION: Grass Yandanooka, WA

FARM SIZE: 3800ha cropped, 800 ewes on 600ha pasture

ANNUAL AVERAGE RAINFALL: 300mm

SOIL TYPES: red clay/loam

ENTERPRISES: wheat, canola, lupins, sheep

SEEDING: DBS bar (15m, 30cm spacing), John Deere box

SPRAYING: Case Patriot (36m), Beverley Hydra Boom (36m)

HARVEST: John Deere S770

Background

Barley grass in pasture years often provides early feed. If allowed to set seed, it can produce very large seedbanks that are difficult to get under control. As barley grass is quick to mature, the timing of spray-topping in pasture is difficult, especially when barley grass is not the only weed to control. The grower has also noticed later emergence or multiple emergence times, so early non-selective and pre-emergent herbicides are not always effective.

Given the difficulty of controlling barley grass, the grower has contemplated a move towards permanent pasture paddocks or permanent cropping paddocks in future.

Methods

The trial (Table 1) was in a paddock previously used for volunteer pasture in 2017 and oats for hay in 2018. 2017 was dry so barley grass was an important feed source and no control was attempted. As a result, the seedbank was well established and the 2019 pasture had a dense barley grass population (Figure 1). The trial ran for three seasons, exploring four treatments representing increasing levels of herbicide use (Table 1).

Figure 1: Madi George (MIG) found more than 1000 barley grass plants/m² in the 2019 pasture; this was due to a decision in this and previous years to maintain the barley grass as pasture biomass. The grower would like to remove the barley grass to return the field to a permanent cropping system.



Photo: Catherine Borger, DPIRD

Table 1: Agronomic details from 2019 to 2021.

Agronomic detail	2019	2020	2021
Total (and growing season) rainfall	237mm (233mm)	104mm (86mm)	433mm (361mm)
Crop sowing details	Volunteer pasture	Wheat cv. Chief CL Plus [†] , 40 or 120kg/ha, 22cm	Canola cv. InVigor®, 2kg/ha, 22cm
Sowing date	NA	30 Apr 2020	16 Apr 2021
Herbicides	26 Aug 2019 and 17 Sep 2019: brown manure 2,4-D ester at 340g/ha, glyphosate at 1080g/ha, plus 0.2% wetter and 1% Amsul** 17 Sep 2019: slashing	17 Mar 2020: glyphosate 1080g/ha and 2,4-D ester 340g/ha (knockdown applied to multiple species) 30 Apr 2020: pre-emergence herbicide treatments 25 Aug 2020: brown manure paraquat + diquat 202.5 + 172.5g/ha over the whole trial area	15 Apr 2021: trifluralin 720g/ha IBS# 14 May 2021 and 8 Jun 2021: glyphosate 621g/ha post-emergence 14 Jun 2021: quizalofop-p-ethyl 25g/ha post-emergence
Barley grass treatments			
1 (\$60/ha)*	Brown manure, early	Wheat 40kg/ha, trifluralin 720g/ha IBS	Two × glyphosate 621g/ha post-emergence
2 (\$60/ha)	Slash to prevent seed-set	Wheat 40kg/ha, trifluralin 720g/ha + sulfosulfuron 19g/ha IBS	Trifluralin 720g/ha IBS, two × glyphosate 621g/ha post-emergence
3 (\$104/ha)	Brown manure, late	Wheat 120kg/ha, trifluralin 720g/ha + pyroxasulfone 100g/ha IBS	Two × glyphosate 621g/ha post-emergence, quizalofop-p-ethyl 25g/ha 3 to 5 leaf
4 (\$123/ha)	Brown manure, early and late	Wheat 120kg/ha, cinmethylin 375g/ha + sulfosulfuron 19g/ha IBS	Trifluralin 720g/ha IBS, two × glyphosate 621g/ha post-emergence, quizalofop-p-ethyl 25g/ha 3 to 5 leaf
Harvest	NA	NA	19 Oct 2021

*Cost of the herbicide for the barley grass treatments listed, based on Nutrien Ag Solutions 2020 prices, where 2,4-D ester was \$9/L, glyphosate 540 was \$6/L, trifluralin (TriflurX®) was \$7/L, sulfosulfuron (Monza®) was \$273/kg, pyroxasulfone (Sakura®) was \$343/kg, cinmethylin (Luximax®) was \$74/L, glyphosate 690 (Roundup Plantshield®) was \$19/kg and quizalofop-p-ethyl (QPE) was \$12/L.

**A rate was used to correspond to the typical mixed infestation of annual ryegrass, brome grass, barley grass and broadleaf weeds.

#IBS: incorporated by sowing.

Results

2019

There was an even density of more than 1000 plants/m² of barley grass at the start of the season and barley grass remained a significant proportion of the pasture throughout the season. Both herbicide treatments and slashing resulted in 100 per cent control of barley grass seed heads. The dry conditions prevented regrowth, even after early herbicide application. There was zero seed-set across the whole trial.

2020

The higher wheat seeding rate increased initial crop density (Table 2). By August there was no difference in wheat tillers due to a dry start to the season (with less than 10mm rainfall in March, April, May and July).

Barley grass density was relatively high across the trial given that seed-set was prevented in 2019. However, we know that the dormant barley grass seedbank can last at least three to four years. Barley grass density was lowest following trifluralin and pyroxasulfone but none of the pre-emergent herbicides offered full control, possibly due to the low rainfall at the start of the season (Table 2).

Due to poor crop growth, brown manuring using paraquat + diquat was applied to the whole trial area to avoid excessive barley grass seed production. After brown manuring, none of the barley grass seed were found to be viable.

Table 2: Wheat and barley grass density, barley grass panicle and seed production and wheat yield for each treatment. P and LSD values are included for separation of means. Note that barley grass panicle and seed production means are back-transformed from a square root transformation.

Treatment	Wheat seeding rate	Herbicide	Crop density (plants/m ²)	Barley grass density (plants/m ²)	Barley grass panicles/m ²
1	40kg/ha	Trifluralin 720g/ha IBS*	63	9.9	24
2	40kg/ha	Trifluralin 720g/ha + sulfosulfuron 19g/ha IBS	62	9.7	12
3	120kg/ha	Trifluralin 720g/ha + pyroxasulfone 100g/ha IBS	100	2.8	43
4	120kg/ha	Cinmethylin 375g/ha + sulfosulfuron 19g/ha IBS	83	12.7	10
P			0.09	0.045	0.413
LSD			33.9	1.73	24.3

*IBS: incorporated by sowing.

2021

Barley grass density and seed production were highest when glyphosate 690 was used alone (Table 3, Figure 2). The addition of complementary herbicides pre-emergent and post-emergent provided benefits for barley grass control. The crop was healthy and highly competitive in 2021 and barley grass density did not affect yield (Table 3).

Figure 2: Barley grass control with two applications of glyphosate alone did not control all barley grass (left) but using an application of trifluralin pre-seeding and quizalofop-p-ethyl in-crop controlled all barley grass (right).



Photo: Catherine Borger, DPIRD

Table 3: Canola and barley grass density, barley grass panicle number, barley grass seed number and canola yield for each treatment. P and LSD values are included for separation of means. Note that barley grass panicle data is back-transformed from a square root transformation.

Treatment	Herbicide	Crop density (plants/m ²)	Barley grass density (plants/m ²)	Barley grass panicles/m ²	Barley grass seeds/m ²	Yield (t/ha)
1	Two × glyphosate 621g/ha post-emergence	26	14.2	6.1	281	2.0
2	Trifluralin 720g/ha IBS*, two × glyphosate 621g/ha post-emergence	24	6.9	1.3	49	2.0
3	Two × glyphosate 621g/ha post-emergence, quizalofop-p-ethyl 50g/ha 3 to 5 leaf	27	4.2	0.5	12	1.9
4	Trifluralin 720g/ha IBS, two × glyphosate 621g/ha post-emergence, quizalofop-p-ethyl 50g/ha 3 to 5 leaf	26	1.7	0	0	1.9
P		0.860	0.004	0.114	0.045	0.522
LSD		NS	5.56	NS	195.8	NS

*IBS: incorporated by sowing.

Long-term outcome of barley grass treatments modelling with RIM Barley Grass

Barley grass treatment plans 1 and 4 (from Table 1) were modelled with RIM Barley Grass. When using the model, the default settings were used (that is, for average grain price, animal gross margins, control options etc.). Herbicides were added to control options, including cinmethylin (95 per cent control) pre-emergent for wheat and glyphosate (98 per cent control) post-emergent for canola. The wheat seeding rates were changed to 40kg/ha for low seeding rate and 120kg/ha for high seeding rate.

The 'strategies' for barley grass treatment plans 1 and 4 included a 10-year rotation of volunteer pasture, wheat and canola.

Options in the model for treatment plan 1 were:

1. Volunteer pasture, with standard grazing, spray-top;
2. Wheat, dry sowing, trifluralin, no-till, standard sowing rate; or
3. Canola, dry sowing, no-till, standard sowing rate, two applications of glyphosate post-emergent.

Options in the model for treatment plan 4 were:

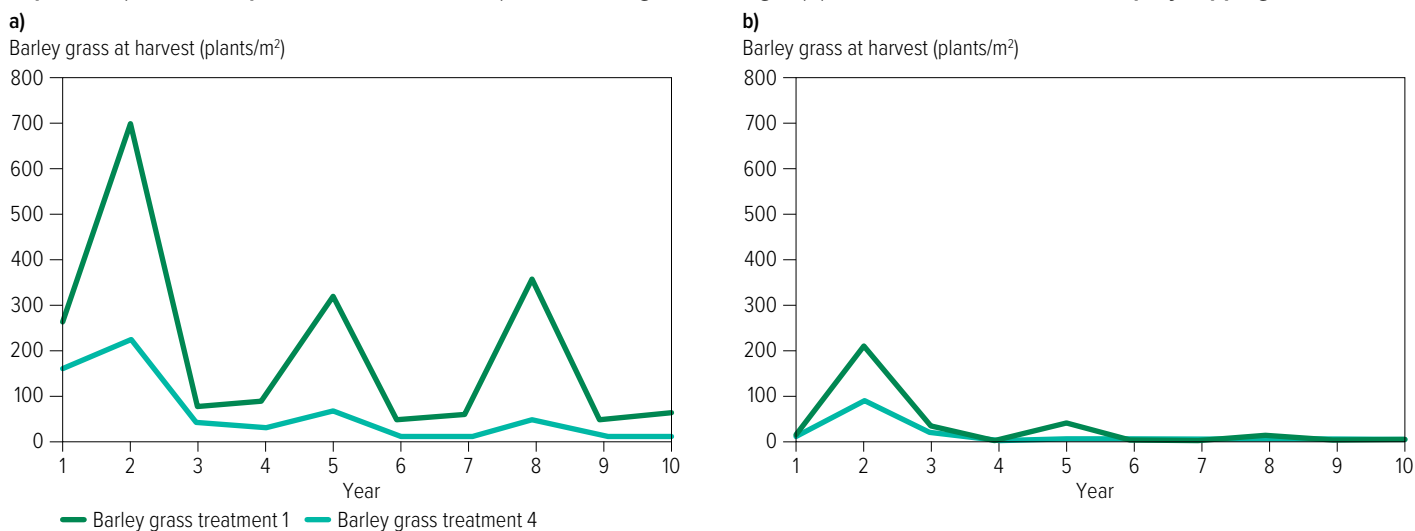
1. Volunteer pasture, with standard grazing, two applications of spray-top;
2. Wheat, dry sowing, cinmethylin, no-till, high sowing rate; or
3. Canola, dry sowing, no-till, standard sowing rate, trifluralin, two applications of glyphosate post-emergent, Targa®/Verdict® (that is, Group 1 herbicide similar to quizalofop-p-ethyl).

The model assumes that spray-topping or slashing can only control 70 per cent of barley grass. In the current rotation, control was 100 per cent in pasture, with 2,4-D ester at 340g/ha and glyphosate at 1080g/ha. The model was tested with 70 per cent barley grass control in pasture (Figure 3, left) or 98 per cent control in pasture (Figure 3, right).

When control in pasture was only 70 per cent, treatment plan 4 with high herbicide inputs was required to get barley grass under control (Figure 3, left). The average gross margins over 10 years in the model was \$62 to \$63/ha/year for both treatments. Treatment plan 1 lost yield due to high barley grass density and treatment plan 4 had high cost of control from herbicides.

When control in pasture was 98 per cent, both treatment plans got barley grass under control (Figure 3, right). However, treatment plan 1 had lower herbicide costs and a gross margin of \$103/ha/year in the RIM model compared with a gross margin of \$78/ha/year for treatment 4.

Figure 3: The number of barley grass plants at crop harvest in years 1 to 10 of a volunteer pasture/wheat/canola rotation using barley grass treatment 1 or 4 (with treatments defined in Table 1). The image on the left (a) assumes 70% control from spray-topping in pasture (the default parameter in the model) and the image on the right (b) assumes 98% control from spray-topping.



Future management plans

- Break crops offer excellent control, the opportunity to use herbicides from a wide range of modes of action and in-season control to remove late-emerging barley grass cohorts.
- Brown manuring crop prevents seed-set but is only profitable where crop growth is very poor and weed density is high.
- Where initial barley grass density is high, two years of complete seed-set prevention is not enough to remove the population. A barley grass seedbank lasts three to four years, and potentially longer if dry conditions or non-wetting sands prevent all seed from germinating.
- Chemical control and slashing in pasture can prevent seed-set and allow barley grass to provide early feed, but in some seasonal conditions regrowth of heads will occur. Seed heads will injure livestock and contaminate wool and carcasses.
- In the long term, consistent control (including late-season control with glyphosate in canola or herbicide and/or slashing in pasture) will reduce barley grass to very low levels. If pasture control is very high, the cost of herbicides in cereal and canola crops can be reduced.

Acknowledgements

We would like to thank the Soullier family for providing the site, Madi George and staff at MIG and Nerys Wilkins (DPIRD) for their assistance with the trial management and measurements.

Pasture manipulation and late sowing – great weed control, but at what cost?

(LAKES INFORMATION AND FARMING TECHNOLOGY GROUP)

Catherine Borger, Department of Primary Industries and Regional Development (DPIRD), Northam, WA, and Ben Whisson, ConsultAg and Lakes Information and Farming Technology Group (LIFT)

Key points

- Early application of selective herbicide (Group 1) gave excellent control of barley grass. While fewer barley grass plants meant less pasture biomass, it is important to remember that the seeds on the mature barley grass would injure livestock. Further, these barley grass plants could host cereal crop disease.
- Spray-topping prevented viable seed-set of barley grass while leaving the greatest pasture biomass.
- Late sowing of barley in 2020 (delayed four weeks) was relatively ineffective in controlling barley grass and yield was slightly reduced.
- Late sowing of oats in 2021 (delayed seven weeks) gave excellent weed control, but yield was severely reduced.

SNAPSHOT

OWNERS: Ken Gray & Co

LOCATION: Tarin Rock, WA

FARM SIZE: 5500ha cropped, 2000ha pasture running sheep

ANNUAL AVERAGE RAINFALL: 330 to 350mm

SOIL TYPES: medium lateritic loam

ENTERPRISES: canola, barley, oats, sheep, wheat, lupins

CROP PROGRAM (2019): 2000ha barley, 300ha lupins, 500ha oats

SEEDING: 12m controlled-traffic farming system, equaliser, liquid system

SPRAYING: Accuspray 8500L, 36m

HARVEST: Chaff cart

Background

On this property, the most common winter weeds are barley grass, capeweed, annual ryegrass and wild radish. Barley grass is a huge issue in the pasture phase, causing contamination of livestock, so this species is the focus of the integrated weed management program in pasture.

Some resistance first appeared in 2017 to Group 1 (FOP) herbicides. Since 2017, the barley grass has developed resistance to Group 2 herbicides, including imidazolinone and sulfonylurea herbicides. The barley grass is still fully susceptible to Group 9 (glyphosate) and Group 22 (paraquat + diquat). Resistance is the biggest problem for management.

Methods

Prior to the trial (Table 1), the field was sown to barley in 2017 with in-crop control using Group 2 herbicide (imazamox + imazapyr) and pasture in 2018 with Group 1 herbicide (quizalofop-p-ethyl). In 2018, pasture manipulation timing was slightly late, and the barley grass was also less susceptible to herbicide because the plants were stressed by spot type net blotch.

In 2019 the treatments for the trial included various pasture manipulation tactics (Table 1). In 2020 and 2021 the previous pasture manipulation treatment plots were split. Half of those plots had early sowing of barley in 2020 and oats in 2021 and half had late sowing.

Results

2019

There was an average of 1966 barley grass plants/m² in the trial in 2019 (Figure 1). Quizalofop-p-ethyl killed almost 100 per cent of plants and ensured very low seed-set (Figures 1 and 2). Resistance testing confirmed that this population of barley grass did not have resistance to Group 1 herbicides. Pasture biomass was greatest in the plots with barley grass, but seeds from these mature barley grass plants could injure livestock and contaminate wool and carcasses. Further, barley grass hosts cereal root diseases and net blotch of barley.

Table 1: Agronomic details from 2019 to 2021.

Agronomic detail	2019	2020	2021
Total (and growing season) rainfall	176mm (171mm)	206mm (127mm)	426mm (356mm)
Crop sowing details	Pasture. Oats, clover and vetch, 27.7cm	Barley cv. Scope CL [Ⓛ] , 50kg/ha, 27.7cm	Oats cv. Wandering, 45kg/ha, 27.7cm
Sowing date	6 Jun 2019	28 Apr 2020 (early) or 27 May 2020 (late)	29 Apr 2021 (early) or 17 Jun 2021 (late)
Herbicides	23 Jul 2019: quizalofop-p-ethyl 30g/ha post-emergence** 5 Sep 2019: glyphosate 216g/ha spray-top**	28 Apr 2020: trifluralin 1200g/ha, diuron 270g/ha IBS# and paraquat 150g/ha 27 May 2020: trifluralin 1200g/ha, IBS paraquat 500g/ha	Directly prior to sowing: trifluralin 768g/ha, diuron 270g/ha, s-metolachlor 576g/ha, paraquat 250g/ha
Harvest	Grazing	19 Nov 2020	15 Dec 2021
Barley grass treatments			
1	Untreated	Early sowing	Early sowing
2 (\$4)*	Quizalofop-p-ethyl 3 to 5 leaf	Early sowing	Early sowing
3 (\$2)	Spray-top glyphosate	Early sowing	Early sowing
4	Untreated	Late sowing	Late sowing
5 (\$4)	Quizalofop-p-ethyl 3 to 5 leaf	Late sowing	Late sowing
6 (\$2)	Spray-top glyphosate	Late sowing	Late sowing

*Cost of the herbicide for the barley grass treatments listed, based on Nutrien Ag Solutions 2020 prices, where quizalofop-p-ethyl (Targa[®]) was \$12/L and glyphosate was \$6/L.

**A rate was used to correspond to the typical mixed infestation of annual ryegrass, brome grass and barley grass.

#IBS: incorporated by sowing.

Figure 1: Pasture biomass ($P < 0.001$, $LSD = 72$) and barley grass panicle production ($P < 0.001$, $LSD = 191$) for each treatment in 2019.

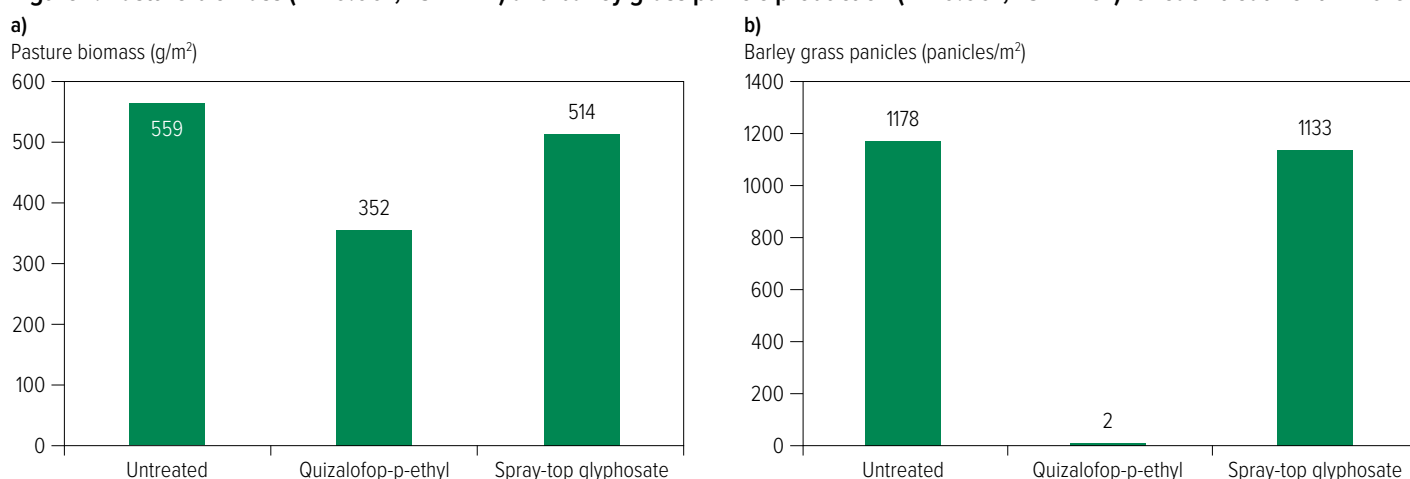
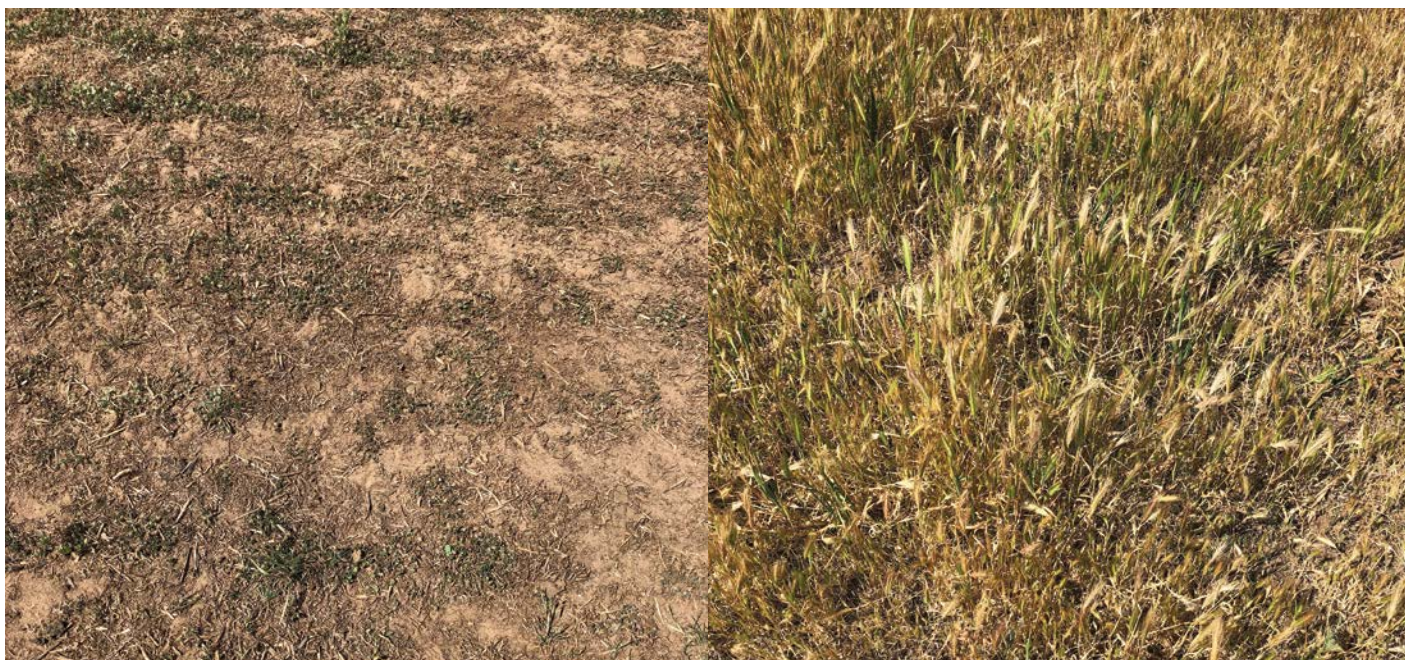


Figure 2: In 2019, early application of quizalofop-p-ethyl at the 3 to 5-leaf stage (left) gave excellent control of barley grass in pasture compared with no early control (right).



Photos: Ben Whisson, ConsultAg

2020

At the beginning of 2020, barley grass density was much lower in the plots with quizalofop-p-ethyl or spray-topping in 2019 compared with plots untreated in 2019 (Table 2). This confirms that spray-topping glyphosate in 2019 did a fantastic job of reducing viable barley grass seed-set.

Late sowing in 2020 significantly reduced barley grass density and panicle number in the untreated plots (Table 2). Panicle number in 2020 after 2019 quizalofop-p-ethyl or spray-topping was equally low in the early and late sowing plots.

Late-sown plots had higher crop density than the early-sown crop, with 71 and 96 barley plants/m². However, early sown crop had a higher yield (Table 3), as well as higher hectolitre weight and fewer screenings. In early or late-sown crop, yield was lowest in the plots with no herbicide in 2019 due to competition from the high density of barley grass.

2021

In 2021, it was still easy to see the impact of excellent control from pasture manipulation in 2019 in the early sown crop. There were 291 barley grass panicles in the untreated plots, compared with 106 to 137 panicles in the plots that had herbicide in 2019. In the late-sown crop, there was no barley grass in any plots.

While weed control was fantastic in the late-sown crop, the very cold, wet conditions made crop emergence and early vigour poor, with an average of 115 oat plants/m² in the early sown crop and 50 plants/m² after late sowing (Figure 3). As a result, yield was much lower in the late-sown crop (Table 4).

Table 2: Barley grass panicle production (panicles/m²) in the 2020 barley and 2021 oat crop. Treatments included pasture manipulation in 2019 (quizalofop-p-ethyl or spray-topping) and time of crop sowing (early or late) in 2020 and 2021. P and LSD values are included for separation of means.

Treatments 2019	Treatments 2020-21	2020 barley	2021 oats
Untreated	Early sowing	962	291
Quizalofop-p-ethyl 3 to 5 leaf	Early sowing	48	106
Spray-top glyphosate	Early sowing	97	137
Untreated	Late sowing	676	0
Quizalofop-p-ethyl 3 to 5 leaf	Late sowing	106	0
Spray-top glyphosate	Late sowing	72	0
P value		<0.001	<0.001
LSD		197	55

Table 3: Yield (t/ha) of barley in 2020 and oats in 2021. Treatments included pasture manipulation in 2019 (quizalofop-p-ethyl or spray-topping) and time of crop sowing (early or late) in 2020 and 2021. P and LSD values are included for separation of means.

Treatments 2019	Treatments 2020-21	2020 barley	2021 oats
Untreated	Early sowing	1.1	2.7
Quizalofop-p-ethyl 3 to 5 leaf	Early sowing	2.0	3.6
Spray-top glyphosate	Early sowing	2.0	3.3
Untreated	Late sowing	0.8	1.6
Quizalofop-p-ethyl 3 to 5 leaf	Late sowing	1.4	1.9
Spray-top glyphosate	Late sowing	1.6	1.8
P		<0.001	<0.001
LSD		0.39	0.39

Figure 3: Late-sown oats (left) in 2021 encountered very cold, wet conditions and emergence and early vigour were poor, compared with the neighbouring early sown oats (right).



Photo: Ben Whisson, ConsultAg

Figure 4: Ben Whisson (ConsultAg) and the LIFT group wanted to explore optimal pasture manipulation and time of sowing for barley grass control in a field with resistance to in-crop selective herbicides.



Photo: courtesy of Justine Tyson, ConsultAg

Future management plans

- Pasture manipulation gives excellent barley grass control when the timing is right.
- Early pasture control is necessary to prevent panicles and thereby prevent seeds contaminating stock and potentially affecting wool or carcass quality.
- Late sowing can be good for weed control, except for ecotypes with very high dormancy (leading to late staggered emergence). However, late sowing consistently reduces crop yield. This would only be a good option when in-crop herbicides and crop competition were not providing sufficient control.
- Regular resistance testing is a key part of developing the integrated weed management plan.

Herbicides and high-density crop for barley grass control

(FACEY GROUP AND WESTERN AUSTRALIAN NO-TILL FARMERS ASSOCIATION)

Catherine Borger, Department of Primary Industries and Regional Development (DPIRD), Northam, WA; Amy Bowden, FACEY Group; and David Minkey, Western Australian No-Tillage Farmers Association (WANTFA)

Key points

- Trifluralin at higher rates (1440g/ha rather than 960g/ha) can improve barley grass control, but this herbicide only offers suppression and alone is not sufficient to control barley grass.
- Imazamox + imazapyr provided excellent control in-crop in 2020, preventing panicle production.
- Increased seeding rate increased crop density and reduced barley grass density in 2021.

SNAPSHOT

OWNER: Garry Lang

LOCATION: Wickepin, WA

FARM SIZE: 5337ha, cropping 4860ha

ANNUAL AVERAGE RAINFALL: 370mm

SOIL TYPES: mixed from red and grey clays to duplex sand over clay and some sand and gravel

ENTERPRISES: canola, barley, wheat, oats, lupins, wool and XB lambs

CROP PROGRAM: 902ha wheat, 1607ha barley, 1210ha canola, 684ha oats and 457ha lupins

SEEDING: 12.0m wide DBS bar on 30cm rows with a Simplicity 13000I TQS air cart 4000L FlexiN tank

SPRAYING: Self-propelled Miller Nitro 6000 series, 36m

HARVEST: 10.90 New Holland with iHSD

Background

The most common weeds on this property include annual ryegrass, wild radish, capeweed and wild oats. In general, barley grass does not need to be specifically targeted. The grower uses livestock grazing in addition to chemical control methods aimed at other weed species, which normally keep barley grass under control. Testing indicated no barley grass resistance on the property.

Methods

This project ran two separate trials in two separate paddocks (Table 1). The 2020 paddock had low weed density. The 2021 paddock had been recently acquired and had a higher known barley grass population, but testing again indicated no herbicide resistance. A cereal-dominated rotation coupled with seasonal conditions caused an ineffective knockdown, which contributed to an increased barley grass density.

The trials investigated standard and high rates of trifluralin for initial and residual barley grass control. Imazamox + imazapyr was utilised for in-crop herbicide control. Crop density ranged from 40 to 120kg/ha to determine the impact of crop competition.

Results

2020

Trifluralin at either rate provided good early weed control, but later in the season there was lower barley grass density, panicles and seed production in plots with trifluralin at 1440g/ha rather than 2960g/ha (Table 2).

Imazamox + imazapyr gave excellent control of barley grass plants and prevented seed-set (Table 2, Figure 1).

Table 1: Agronomic details in 2020 and 2021.

Agronomic detail	2020	2021
Total (and growing season) rainfall	274mm (170mm)	525mm (424mm)
Crop sowing details	Barley cv. Spartacus CL [♠] , 40, 80 or 120kg/ha, 30cm row spacing	Barley cv. Maximus [♠] CL, 40, 80 or 120kg/ha, 30cm row spacing
Sowing date	27 May 2020	3 June 2021
Herbicides	9 April 2020: triclopyr 60g/ha, 2,4-D ester 204g/ha** 21 May 2020: glyphosate 900g/ha pre-emergence 3 June 2020: trifluralin 960g/ha or 1440g/ha, paraquat 375g/ha IBS# 8 July 2020: imazamox + imazapyr 12.4 + 5.6g/ha post-emergence	25 March 2021: metsulfuron-methyl 1.8g/ha, triclopyr 48g/ha, glyphosate 675g/ha, 2,4-D ester 240g/ha** 2 June 2021: glyphosate 1170g/ha 3 June 2021: trifluralin 960g/ha or 1440g/ha IBS, paraquat 500g/ha, oil 0.35L/ha Note that imazamox + imazapyr could not be applied due to very wet conditions.
Barley grass treatments		
1 (\$14)*	Trifluralin 960g/ha IBS, no post-emergent herbicide, with barley sown at 40, 80 or 120kg/ha***	
2 (\$26)	Trifluralin 960g/ha IBS, imazamox + imazapyr 12.4 + 5.6g/ha post-emergent, with barley sown at 40, 80 or 120kg/ha	
3 (\$21)	Trifluralin 1440g/ha IBS, no post-emergent herbicide, with barley sown at 40, 80 or 120kg/ha	
4 (\$33)	Trifluralin 1440g/ha IBS, imazamox + imazapyr 12.4 + 5.6g/ha post-emergent, with barley sown at 40, 80 or 120kg/ha	
Harvest****	6 Nov 2020	Header fire

*Cost of the herbicide for the barley grass treatments listed, based on Nutrien Ag Solutions 2020 prices, where trifluralin (TriflurX[®]) was \$7/L and imazamox + imazapyr (Intervix[®]) was \$30/L.

**A rate was used to correspond to the typical mixed infestation of annual ryegrass, barley grass and broadleaf weeds.

***Cost of seeding barley was \$15 at 40kg/ha, \$29 at 80kg/ha or \$44 at 120kg/ha.

****Yield was not available due to an error in downloading harvest data in 2020 and a header fire in 2021.

#IBS: incorporated by sowing.

Table 2: Barley grass density following pre-emergent and in-crop herbicide treatments. P and LSD values are included for separation of means. Note that the barley grass density data is back-transformed from a cube root transformation, and the barley grass panicle data is back-transformed from a log10+1 transformation.

Pre-emergent herbicide	In-crop herbicide	Barley grass density (plants/ha)	Barley grass panicles/ha	Barley grass seeds/ha
Trifluralin 960g/ha		3989	6917	38,903
Trifluralin 960g/ha	Imazamox + imazapyr 12.4 + 5.6g/ha	2	0	0
Trifluralin 1440g/ha		3695	467	1317
Trifluralin 1440g/ha	Imazamox + imazapyr 12.4 + 5.6g/ha	25	0	0
P		0.002	0.067	0.059
LSD		57.8	1636	4334

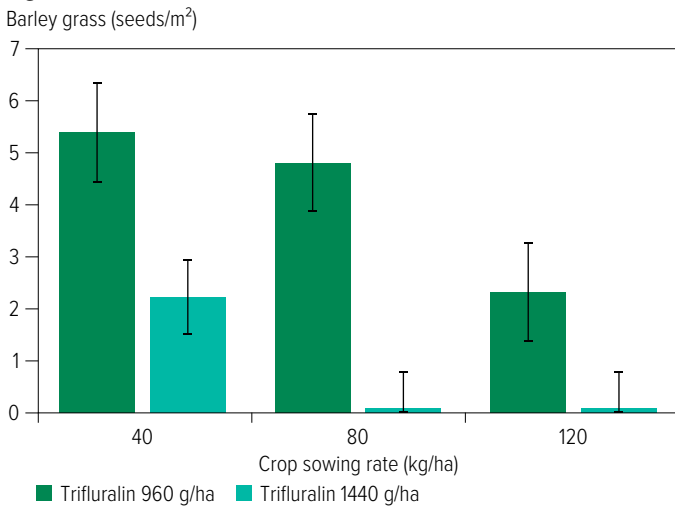
Figure 1: Barley grass on 12 August 2020, following imazamox + imazapyr (left) or no in-crop herbicide (right).



Photo: Chris Hetherington, FACEY Group

As expected, crop density increased with sowing rate (75, 119 and 135 plants/m² at a sowing rate of 40, 80 or 120kg/ha). Crop growth was not affected by herbicide. Barley grass seed production was low across the whole site, but seed production was reduced from about five seeds to zero to two seeds/m² when sowing rate increased from 40 to 120kg/ha (Figure 2).

Figure 2: Barley grass seeds/m² at a crop seeding rate of 40, 80 and 120kg/ha, following trifluralin at 960g/ha or 1440g/ha (averaged over the imazamox + imazapyr treatments). Error bars represent the SEM. Note that the effect of seeding rate and interaction between seeding rate and herbicide was not significant.



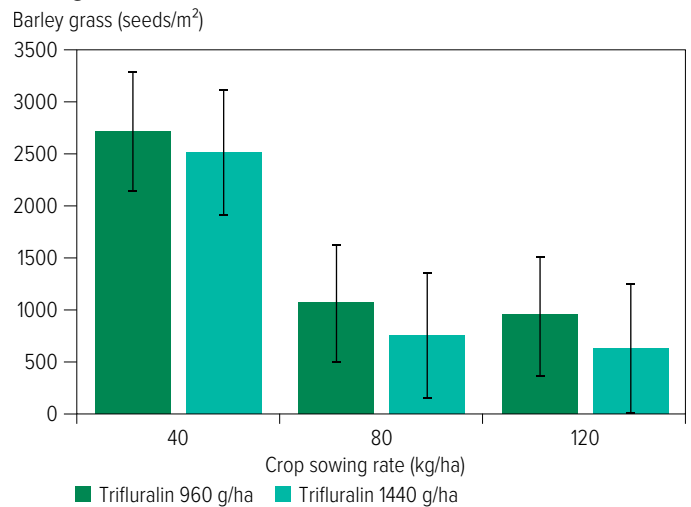
2021

Trifluralin gave excellent initial barley grass control in all treatments in 2021. There was high rainfall in this year, and trifluralin has increased efficiency when incorporated into moist soil.

Due to the very wet season, it was not possible to apply imazamox + imazapyr post-emergence.

Again, crop density increased with seeding rate (94, 159 and 200 plants/m² at seeding rates of 40, 80 and 120kg/ha). Increased crop density also reduced barley grass density (6.8, 2.3 and 2.5 barley grass plants/m²). By the end of the season there was a consistent trend of reduced barley grass panicles or seeds at increased sowing rate (Figure 3).

Figure 3: Barley grass seeds/m² at a crop seeding rate of 40, 80 and 120kg/ha, following trifluralin at 960g/ha or 1440g/ha. Error bars represent the SEM. Note that the effect of seeding rate and interaction between seeding rate and herbicide was not significant.



Future management plans

- Trifluralin at 1440g/ha reduced barley grass panicles and seed production more than did trifluralin at 960g/ha. Where imazamox + imazapyr is used, the higher rate of trifluralin is not necessary for full control, but it can be valuable in non-Clearfield® barley where there is greater reliance on pre-emergent herbicide control and crop competition.
- Imazamox + imazapyr provided excellent control in 2020, preventing barley grass seed production. However, resistance to imazamox + imazapyr can develop, and it is important to use this herbicide in rotation and ensure that it is combined with other tactics as part of an integrated weed management program.
- Increased seeding rate increased crop density and reduced barley grass density and barley grass seed production. The height and competitive ability of barley grass varies widely between different populations. It is important to be aware of the characteristics of individual populations.

Acknowledgements

We would like to thank Gary Lang for providing the trial site and running the trial, Facey Group and WANTFA for designing and managing the trial, and Amy Bowden (Facey Group) and Nerys Wilkins (DPIRD) for assistance with trial measurements.

Useful resources

Ecology of Major Emerging Weeds (2021), grdc.com.au/ecology-of-major-emerging-weeds

Understanding how weeds grow and interact with other species helps support good weed control practices. Current knowledge about each weed's ecology is covered and includes information about the weed's background, description and seed.

Integrated Weed Management Manual (2019), grdc.com.au/IWMM

The Integrated Weed Management Manual provides information on the latest tools and techniques to help manage current weeds and weeds of emerging economic importance, and at the same time maintain the arsenal of herbicide modes of action into the future.

WeedSmart, weedsmart.org.au

WeedSmart delivers science-backed weed control solutions to growers and advisors. It also delivers a national stewardship campaign to encourage attitudes and actions to reduce crop weeds and sustain herbicide use through the implementation of WeedSmart's Big 6 – six practical ways for growers to fight herbicide resistance.

