Optimal barley grass management

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Summary Grower group driven integrated barley grass management trials were conducted at five sites in Western Australia in 2021. Results indicate that it is possible to prevent seed production of barley grass, if management strategies include both pre-emergent and post-emergent tactics. Break crops or pastures offer an excellent opportunity to include a range of different herbicides and control tactics in a management plan.

Keywords *Hordeum leporinum*, *Hordeum glaucum*, panicles, seed production.

INTRODUCTION

Barley grasses (*Hordeum leporinum* Link or *H. glaucum* Steud.) are one of the most prominent weeds of cropping and pasture systems in Western Australia (Borger et al. 2012). These species are increasingly difficult to control because a) herbicide resistance is increasing, b) many herbicides offer suppression rather than control and c) there is evidence that ecotypes are developing delayed or staggered emergence to avoid pre-sowing and pre-emergent herbicides (Borger et al. 2012; Gill et al. 2021). The staggered emergence indicates that management plans with late season control will be necessary to prevent seed production.

A national GRDC grower group driven project investigated optimal management strategies for local growers in WA, SA and NSW, from 2019 to 2021. In WA, the grower groups LIFT, SEPWA, KDG, MIG and FACEY/WANTFA investigated optimal pre-emergent herbicides, crop competitive ability, post-emergent herbicides, and break crops for optimal barley grass control.

MATERIALS AND METHODS

Each grower group identified a trial site on farm in 2019 to determine the best strategy for optimal control of barley grass over three years (Table 1). Choice of crop rotation at each site was generally dictated by what each grower planned for the field in question. Each trial considered barley grass management plans ranging from inexpensive to more expensive options. All trials were replicated, in a randomised block design. Note that the FACEY/WANTFA trial failed due to poor barley grass establishment in 2019 and was run in 2020 and 2021. Unlike the other sites, the FACEY/WANTFA trial was in a new site each year. The site also used a split plot design, with sowing rate as the main plot factor and herbicides as the sub-plot factor.

For each trial, the weed control treatments applied in 2021 (including herbicide and dates) are specified in the tables in the results section (Table 2-4). Measurements included initial barley grass and crop density, and barley grass panicle number, from 4-10 quadrats per plot. Quadrat size varied from 10 by 25 cm to 50 by 50 cm, depending on weed density. Twenty mature panicles were collected from each plot, and seeds were manually removed and counted to determine seeds per panicle. This value and panicles m^{-2} was used to determine seeds m^{-2}. The harvested seeds were after-ripened in an open glasshouse over summer, and then germinated in moist petri dishes in a germination cabinet with a 12 h temperature cycle of 12/20°C. After two weeks, ungerminated seeds were exposed to a tetrazolium chloride test, to determine total seed viability. Crop yield was determined by harvesting the entire plot.

This paper provides a summary of the third year of results, but full results of all trial sites including trial design, plot size and spray application methods can be found at GRDC Online Farm Trials (https://www.farmtrials.com.au/).

RESULTS

KDG group In the 2021 pasture, the barley grass density and panicle number was not significantly reduced by the imazamox herbicide at the 2-4 leaf stage or Z31 (Table 2). However, barley grass seed production was reduced by the herbicide compared to the control, with less seed production following herbicide at Z31 compared to 2-4 leaf stage. Slashing removed all panicles before maturity and prevented seed set (Table 2). Pasture biomass was high in all treatments and was not affected by barley grass control.

Table 1. Trial site details including grower group, grower, location, and 2021 rainfall, crop sowing details, treatments and harvest date.

Group	KDG	MIG	SEPWA	FACEY/ WANTFA*	LIFT
Grower	Gavin Morgan	Soullier family	Harris family	Gary Lang	Ashton Gray
Location	North Kellerberrin	Yandanooka	Esperance	Wickepin	Tarin Rock
2021 annual (and growing season) rainfall	326mm (223mm)	433mm (361mm)	385mm (269mm)	464mm (370mm)	426mm (356mm)
2021 crop sowing details	Volunteer pasture (wheat and clover)	Canola cv. InVigor®, 2kg ha^{-1}, 16 Apr 2021	Vetch cv. Volga, 40kg ha^{-1}, 22 Apr 2021	Barley cv. Maximus, 40, 80 or 120kg ha^{-1}, 3 Jun 2021	Oats cv. Wandering, 45kg ha^{-1}, 29 Apr 2021, 17 Jun 2021
Treatments 2021	1. Untreated 2. Imazamox at 2-4 leaf 3. Imazamox at 2-4 leaf stage + slashed 4. Imazamox at Z31 5. Imazamox at Z31 + slashed 6. Slashed	1. Glyphosate 2. Trifluralin, glyphosate 3. Glyphosate, quizalofop-p-ethyl 4. Trifluralin, glyphosate, quizalofop-p-ethyl	1. Trifluralin, quizalofop-p-ethyl 2. Trifluralin+diuron, quizalofop-p-ethyl 3. Trifluralin+diuron, quizalofop-p-ethyl+clethodim 4. Carbetamide, quizalofop-p-ethyl+clethodim	Main plot: sowing rate of 40, 80 or 120 kg ha^{-1}. Sub-plot: 1. Trifluralin 960 g a.i. ha^{-1} 2. Trifluralin 1440 g a.i. ha^{-1}	1. Early sowing 2. Late sowing
2021 harvest	NA	19 Oct 2021	NA	NA (header fire)	15 Dec 2021

*Note: in the original trial plan, the sub-plot factor was each rate of trifluralin with or without imazamox/imazapyr 12.3/5.6 g a.i. ha^{-1} (Intervix®) post-emergence. However, the 2021 season was too wet to allow in-crop spraying at this site.

MIG group Barley grass density and subsequent seed production in the 2021 canola crop was lower in all treatments that included multiple herbicides, compared to two applications of glyphosate alone (Table 3). Barley grass panicle number or canola density and yield were not affected by herbicide treatments.

SEPWA group Barley grass density was similar in all treatments, but panicle and seed production were greatest following trifluralin pre-emergent and quizalofop-p-ethyl post-emergent, and reduced in subsequent treatments (Table 4). There was a slight reduction in vetch density following carbetamide pre-emergent and quizalofop-p-ethyl + clethodim post-emergent, but there was no difference in vetch biomass.

FACEY/WANTFA group The crop was sown into moist soil, and both rates of trifluralin provided a high initial rate of barley grass control. Crop density increased with seeding rate (94, 159 and 200 plants/m^2 at seeding rates of 40, 80 and 120kg/ha, P: 0.003, LSD: 34.4). Increasing crop density also reduced barley grass density (6.8, 2.3 and 2.5 barley grass/m^2, P: 0.015, LSD: 2.01). However, further barley grass cohorts emerged late in the season. As stated (see note in Table 1), seasonal conditions made it impossible to apply herbicide post-emergent, and so by the end of the season there was no difference in barley grass panicle and seed number between treatments.

Table 2. KDG barley grass density, panicles, and viable seeds, as well as pasture biomass for each treatment in the 2021 pasture. P and LSD values are included for separation of means. Note that barley grass density, panicle and seed production means are back-transformed from a log_{10}+1 transformation.

Treatment*	Barley grass density m^{-2}	Barley grass panicles m^{-2}	Barley grass seeds m^{-2}	Pasture biomass (t ha^{-1})
Untreated	102	597	2343	3.2
Imazamox at 2-4 leaf stage	32	486	691	2.8
Imazamox at 2-4 leaf stage + slashed	45	1	0	2.6
Imazamox at Z31	109	357	218	1.6
Imazamox at Z31 + slashed	58	0	0	2.5
Slashed	101	0	0	2.3
P	0.201	0.004	<0.001	0.246
LSD	3.2	369.1	229.1	2.51

*Herbicide formulations and application dates: imazamox 31.5 g a.i. ha^{-1} (Raptor®) at 2-4 leaf stage of barley grass (11 July 2021) or at Z31 stage of barley grass (2 July 2021); slashing (20 September 2021).

Table 3. MIG canola density, barley grass density, panicles, and viable seeds, as well as yield in the 2021 canola crop. P and LSD values are included for separation of means. Note that barley grass panicle data is back-transformed from a square root transformation, and 'NS' indicates 'not significant'.

Herbicide*	Canola density m^{-2}	Barley grass density m^{-2}	Barley grass panicles m^{-2}	Barley grass seeds m^{-2}	Canola yield (t ha^{-1})
Glyphosate	26	14.2	6.1	281	2.0
Trifluralin, glyphosate	24	6.9	1.3	49	2.0
Glyphosate, quizalofop-p-ethyl	27	4.2	0.5	12	1.9
Trifluralin, glyphosate, quizalofop-p-ethyl	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

*Herbicide formulations and application dates: trifluralin 720 g a.i. ha^{-1} (TriflurX®) pre-emergent (15 April 2021); glyphosate 621 g a.i. ha^{-1} (Roundup Plantshield®) applied twice, at 2 leaf (14 May 2021) and tillering (8 June 2021); quizalofop-p-ethyl 50 g a.i. ha^{-1} at 3-5 leaf (14 June 2021).

Table 4. SEPWA vetch density, barley grass density, panicles, and seeds, as well as biomass in the 2021 vetch pasture. 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, and 'NS' indicates 'not significant'.

Herbicide*	Vetch density m^{-2}	Barley grass density m^{-2}	Barley grass panicles m^{-2}	Barley grass seeds m^{-2}	Vetch biomass (t ha^{-1})
Trifluralin, quizalofop-p-ethyl	47	1.5	19.3	588	4.6
Trifluralin + diuron, quizalofop-p-ethyl	45	0.9	7.1	185	3.6
Trifluralin + diuron, quizalofop-p-ethyl + clethodim	45	0	0	0	4.3
Carbetamide, quizalofop-p-ethyl + clethodim	41	0	0.5	4	5.0
P	0.031	0.261	0.001	<0.001	0.196
LSD	3.88	NS	2.46	7.9	NS

*Herbicide formulations and application dates: trifluralin 576 g a.i. ha^{-1} (Treflan®) pre-emergent (22 April 2021); diuron 450 g a.i. ha^{-1} pre-emergent (22 April 2021), carbetamide 990 g a.i. ha^{-1} (Ultro®) pre-emergent (22 April 2021); quizalofop-p-ethyl 25 g a.i. ha^{-1} post-emergent (12 June 2021); clethodim 120 g a.i. ha^{-1} post-emergent (12 June 2021).

LIFT group The time between early and late sowing in the 2021 oat crop was 7 weeks (Table 1). Initial oat density was much lower in the late sown plots, due to cold, water-logged conditions in June (average density of 115 and 51 oat plants m^{-2}, P<0.001, LSD: 11.5). As a result of this poor emergence, oat yield was lower for late sown plots (3.2 and 1.8 t ha^{-1}, P<0.001, LSD: 0.39).

Late sowing controlled all barley grass. Initial barley grass density was much lower in the late sown plots (275 and 0.3 barley grass m^{-2}, P<0.001, LSD: 98.8). As a result, late sowing reduced barley grass panicles and seed set to zero (178 or 0 panicles m^{-2} in the early and late sown plots, P<0.001, LSD: 55.4, and 3466 or 0 seeds m^{-2} in the early and late sown plots, P<0.001, LSD: 1328.7).

DISCUSSION

This research concludes that multiple control tactics to target early and late season barley grass emergence is necessary to prevent seed production. The MIG and SEPWA sites both demonstrated that a combination of pre-emergent and post-emergent herbicides are required for zero seed set. The FACEY/WANTFA site failed to achieve seed set control because it was not possible to use post-emergent weed control. The LIFT group site achieved zero seed production using only delayed seeding, but seven weeks is an unusually large delay to seeding and was highly detrimental to crop yield. Earlier trials indicated that a four week delay was not sufficient to control barley grass (Borger and Whisson 2021).

Staggered cohorts and development of delayed emergence to avoid pre-seeding herbicides has previously been noted in barley grass in South Australia (Fleet and Gill 2012; Gill et al. 2021). Delayed emergence due to enhanced dormancy is less common in Western Australian populations of barley grass (Gill et al. 2021). However, dry sowing and warmer autumn conditions (reduced opportunity for early cold stratification of seeds) ensures that delayed and staggered emergence will become more common (Gill et al. 2021). If barley grass emergence is delayed, the competitive ability of this species will be reduced compared to other weed species. However, delayed emergence means that late season control is required for effective management of all barley grass cohorts (Gill et al. 2021).

The KDG found that late season control alone (slashing) in pasture was sufficient to prevent seed set. However, slashing or spray topping in pasture varies due to seasonal conditions and potential regrowth. The barley grass RIM model suggests these tactics only control 70% of the population (Monjardino et al. 2022).

In cereal crops, late season control is difficult. With the spread of resistance there are fewer options for selective control in cereal crops (Borger et al. 2012; Gill et al. 2021). Crop topping and harvest weed seed control has limited impact on barley grass due to variable maturity and early shedding (Gill et al. 2021). Break crops like canola or pasture/vetch rotations offer a wide range of herbicides, from different modes of action, including in-crop selective herbicides to control late emerging cohorts.

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