Weed resistance and management in high break crop intensity rotations

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Abstract

Controlling Group A and B herbicide resistant annual ryegrass and Group B resistant common sowthistle is becoming increasingly challenging in high break crop intensity (HBCI) systems in South Australia. Ryegrass resistance to recently released pre-emergence herbicides such as Boxer Gold® and Sakura® has been confirmed in HBCI systems. New herbicide Ultro® (active ingredient carbetamide, Group E), currently under development and expected for registration in 2020, provided significant control of dim-resistant ryegrass in lentils. Ultro® will offer an additional tool to support herbicides with alternative modes of action to control ryegrass in break crops. Imidazolinone resistant common sowthistle was detected in paddocks with and without Imidazolinone herbicides use in the past 5 years. Cross-resistance to sulfonylurea herbicides was also confirmed in common sowthistle. Increased crop competition offered by higher plant density of PBA Bendoc was found to have potential to reduce seed set of broadleaf weeds. The adoption of effective and diverse weed management strategies will aid in reducing the risk of resistance developing in HBCI rotations.

Keywords

Crop-weed competition, ryegrass, vetch, medic, plant density

Introduction

A number of improved herbicide tolerant break crop options are available, including triazine tolerant (TT) canola, imidazolinone (IMI) tolerant (Clearfield®) canola, PBA Hurricane XT lentil (Group B resistant) and PBA Bendoc faba bean (Group B resistant). The relatively higher pulse prices, improved agronomic and disease characteristics, and improved harvest efficiency have resulted in expansion of the area sown to pulses and canola in South Australia. This uptake of pulses has largely occurred in the Yorke Peninsula and Mid North, and of canola in the Lower Eyre Peninsula and South-East. The total area under break crops in these regions is higher than the national average (Figure 1). A benefit of pulses and canola in a cropping rotation is the increased use of Group A dim chemistry herbicides compared with that used in the cereal phase, particularly for grass weeds.

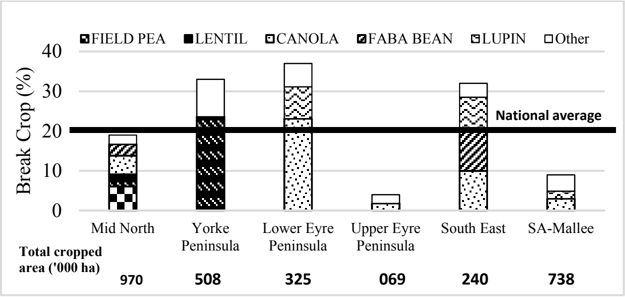

Figure 1. Distribution of break crops across different regions of South Australia compared to the national average (Source: PIRSA crop estimates 2017)

Heavy reliance on Group A chemistry in break crops has contributed to increased ryegrass resistance to these herbicides, making its control challenging. Consequently, herbicides with different modes of action (Groups D, J, and K) are used to manage dim-resistant ryegrass in high break crop intensity (HBCI) rotations. Careful use of Group D, J, and K herbicides is required to minimise selection for resistance to any single mode of action. The introduction of TT canola, IMI tolerant canola and lentil have also improved broadleaf weed control options with triazines and IMI herbicides. However, they have resulted in a decreased frequency of other weed control tactics in these break crops (Storrie, 2014). Over-reliance on triazines and IMI herbicides for improved broadleaf weed management in herbicide tolerant break crops could result in shifts in the weed spectrum and increase the incidence of herbicide resistance. This has occurred in Canada with the evolution of sulfonylurea (SU) and IMI resistant wild mustard (Warwick et al, 2005) from overuse of acetolactate synthase (ALS)-inhibiting herbicides. Resistance in broadleaf weeds presents a significant challenge for IMI tolerant lentil (Menalled, 2010).

The adoption of effective diverse strategies can aid in reducing the risk of resistance developing in HBCI rotations. The present study was carried out as part of a project jointly funded by GRDC and SARDI. The aim is to monitor changes in resistance of ryegrass and broadleaf weeds in HBCI systems, and to develop effective management strategies to control problematic weeds of break crops.

Methods

Paddock survey

A focus paddock survey was initiated in 2017 across different regions of South Australia. The objective was to increase understanding of potential changes in weed flora and herbicide resistance in response to low or high use of imidazolinone (IMI) herbicides in high break crop intensity (HBCI) rotations (at least two break crops in the last 5-6 years). A total of 45 focus paddocks with HBCI rotations were selected (Mid North-16, Yorke Peninsula-11, Lower Eyre Peninsula-8, Upper Eyre Peninsula-2, South East-4, Mallee-4). The selected paddocks had a high frequency of IMI tolerant break crops such as PBA Hurricane XT lentil or Clearfield® canola. In addition, two non-IMI break crops (conventional lentil, conventional canola/TT canola, field pea, chickpea, faba bean, lupin) were included. Seeds of ryegrass and two dominant broadleaf weed species were collected prior to harvest in 2017. They were screened for resistance in outdoor pot trials conducted between autumn and spring in 2018 by Plant Science Consulting.

Research trials

Two research trials were conducted during 2017 at the Hart field site (Mid North) and Maitland (Yorke Peninsula), investigating different pre-emergent herbicides for controlling dim-resistant ryegrass in lentil in a randomised complete block design with three replicates. At Hart, dim-resistant annual ryegrass seed was broadcast at 160 seeds/m^2 ahead of seeding, and incorporated prior to herbicide application. The Maitland site had a background population of dim-resistant annual ryegrass. Another trial was established at Turretfield Research Centre in 2017 and 2018, focussing on agronomic tactics to increase faba bean competitiveness over vetch and medic. In both years, vetch seeds were broadcast prior to sowing at 50 seeds/m^2 to contribute to the existing background medic weed population. Site details are summarised in Table 1. The statistical analysis was carried out using GENSTAT software (VSN International, 2017).

Table 1. Site details of research trials conducted at Hart, Maitland and Turretfield, 2017 and 2018.

Location	Sowing date	Variety	Soil type	Crop season rainfall (mm)
Hart 2017	31 May 2017	PBA Hurricane XT	Clay loam	148
Maitland 2017	6 June 2017	PBA Hurricane XT	Clay	285
Turretfield 2017	19 June 2017	PBA Bendoc	Light clay over medium clay	278
Turretfield 2018	4 June 2018	PBA Bendoc	clay	188

Results

Paddock survey

Herbicide resistance in ryegrass

Ryegrass was the dominant grass weed in high break crop intensity (HBCI) focus paddocks (Table 2). Ryegrass resistant to sulfonylureas (SU) and Dens (Axial) was detected in almost all paddocks (Table 2). The high incidence of resistance to imidazolinone (IMI) in ryegrass was significant in both high IMI-history paddocks (56% of samples) and no-IMI history paddocks (63% of samples). A total of 46% of ryegrass populations were confirmed resistant, and 21% were developing resistance to clethodim in HBCI paddocks. Such resistance limits the effectiveness of break crops as rotational tools. Resistance to Group J and K herbicides Boxer Gold® and Sakura®, albeit at low levels, was confirmed in ryegrass samples and is a concern for HBCI rotations. One quarter of the ryegrass populations exhibited resistance to Boxer Gold® (≥20% survivors). Half of the ryegrass biotypes resistant to Boxer Gold® originated from HBCI paddocks on Lower Eyre Peninsula where canola was the dominant break crop. One third of ryegrass populations were classified as developing resistance to Sakura®, predominantly from Lower Eyre Peninsula.

Table 2. Herbicide resistance in annual ryegrass collected from high break crop intensity paddocks in SA. Resistance (where ≥ 20% survival was confirmed in pot tests) and developing resistance (where 1-20% survival was confirmed in pot tests).

Weed	Samples tested	Trifluralin	Propyzamide	Boxer Gold	Sakura	Clethodim	Glean	Axial	Intervix
Resistant ryegrass populations									
Ryegrass	24	17 (71)*	0	6 (25)	0	11 (46)	22 (92)	22 (92)	14 (58)
Ryegrass populations with developing resistance									
Ryegrass	24	3 (13)	0	4 (17)	8 (33)	5 (21)	1 (4)	1 (4)	2 (8)

*numbers (percent)

Herbicide resistance in broadleaf weeds

Common sowthistle was the dominant broadleaf weed specie detected in the HBCI focus paddocks (Table 3). More than half of the common sowthistle biotypes exhibited resistance to SU and IMI herbicides. The majority of SU resistant populations exhibited cross-resistance to imazapic (93% of samples) and Intervix® (imazamox + imazapyr) (73% of samples). Only one population was confirmed to be susceptible to both SU and IMI. All common sowthistle populations from paddocks with high IMI-use history were resistant to imazapic, and 69% were resistant to Intervix®. It is concerning that 50% of populations from paddocks with non-IMI history were resistant to both IMI herbicides. The target site of all Group B herbicides is the enzyme acetolactate synthase (AHAS). Multiple target site mutations in the AHAS gene have been confirmed in resistant weeds, and led to resistance across chemical families of AHAS-inhibiting herbicides (Tranel and Wright 2002). AHAS target site cross-resistance to SU and IMI was observed in common sowthistle and is of concern for the sustainability of HBCI rotations dominated by IMI tolerant crops. One population of common sowthistle from the Mid North was confirmed resistant to the Group I herbicide 2,4-D and exhibited weak cross-resistance to IMI. No resistance to IMI herbicides from the pot trials was detected to other broadleaf weed species including bedstraw, bifora, marshmallow, wild radish, wild turnip, Indian hedge mustard and medic (Table 3) although only relatively low sample numbers were tested.

Table 3. Percentage of resistant broadleaf weeds (≥ 20% survivors) observed in high break crop intensity paddocks of South Australia, samples taken in 2017.

Weed	Ally	Intervix	Imazapic	2,4-D	Brodal	Bromoxynil	MCPA	Imazethapyr	Glean	Lontrel
Common sowthistle (17)*	88	65	88	6	0	-	-	-	-	-
Bedstraw (3)	-	0	0	-	-	0	0	0	-	-
Bifora (3)	-	0	0	-	-	0	0	0	0	-
Marshmallow (4)	0	0	0	50	0	-	-	-	-	-
Wild turnip (2)	0	0	0	0	0	-	-	-	-	-
Wild radish (1)	0	0	0	0	0	-	-	-	0	-
Indian Hedge Mustard (1)	0	0	0	0	0	-	-	-	-	-
Medic (1)	0	0	0	0	-	-	-	-	-	0

*Figures in parenthesis are the number of samples tested

Research trials

Management of dim-resistant ryegrass in lentil

The use of propyzamide resulted in the lowest ryegrass spikes and seed set at both locations, and was similar to Ultro®*, Sakura® and Boxer Gold® (Table 4). Ultro®* (carbetamide, Group E), which is currently in development, provided a 98% reduction in ryegrass seed set over unweeded control at both sites. Additionally, Ultro®* produced similar lentil yield to propyzamide, Sakura® and Boxer Gold®. Registration of a Group E should reduce selection pressure on Group A, D, J and K herbicides.

Table 4. Ryegrass seed heads and seed set at maturity, and lentil yield, at Hart and Maitland in 2017. Numbers with different letters are significantly different means (P<0.05).

Herbicide	Hart 2017			Maitland 2017		
	Head counts (m^{-2})	RG seed set (m^{-2})	Yield (t/ha)	Head counts (m^{-2})	RG seed set (m^{-2})	Yield (t/ha)
Ultro (IBS)* + Clethodim (POST)	6.5^b	352^b	1.95^b	4.8^b	269^b	3.62^b
Boxer Gold (IBS) + Clethodim (POST)	9.4^b	440^b	1.98^b	28.1^b	1697^b	3.39^b
Sakura (IBS) + Clethodim (POST)	10.2^b	549^b	2.02^b	9.6^b	585^b	3.85^b
Propyzamide (IBS) + Clethodim (POST)	4.9^b	120^b	1.8^b	0.5^b	23^b	3.71^b
Control	203.8^a	15364^a	1.38^a	179.6^a	13595^a	2.66^a

*Unregistered herbicides were included for experimental purposes only. The results within this document do not constitute a recommendation for that particular use by the author or author's organisation.

Crop-competition for managing vetch and medics in Group B tolerant faba bean

The increase in PBA Bendoc density from 12 to 36 plants/m^2 resulted in improved crop competition with broadleaf weeds in 2017, most likely due to significant increase in crop biomass and plant height (Table 5). The increased crop competitiveness significantly reduced vetch pods and seed set, and medic pod set, and also resulted in increased crop yield (Table 5). In 2017, increasing faba bean density to 36 plants/m^2 resulted in 42% and 44% reduction in vetch seed and medic pod set respectively. Similarly, in 2018, the reduction was 55% and 20% respectively. Vetch seed set was reduced significantly by increasing faba bean density up to 30 plants/m^2 over grower's practice of 24 plants/m^2. A further increase in plant density to 36 plants/m^2 did not result in significant improvement in weed suppression and crop yield compared to 30 plants/m^2. The present study suggests that increased crop competitiveness through agronomic tactics has the potential to reduce seed set by broadleaf weeds, especially in crops such as faba bean that are sown at low plant densities and have slow initial growth. This practice requires further investigations across different seasons and locations to assess yield, disease, and lodging implications.

Table 5. Faba bean density effects on vetch and medic at Turretfield Research Station in 2017. Numbers with different letters are significantly different means (P<0.05).

Year	Treatment	Crop biomass* at flowering (t/ha)	Plant height at flowering (cm)	Vetch pods/ plant	Medic pods/ plant	Vetch seed set/m^2	Medic pod set/m^2	Grain yield (t/ha)
2017	Density (m^{-2})							
	12	1.13^{c}	52.2^{c}	12.4^{a}	53.0^{a}	772^{a}	745^{a}	1.92^{a}
	24	2.55^{b}	59.1^{b}	9.7^{b}	27.1^{b}	660^{a}	289^{b}	2.83^{b}
	36	3.72^{a}	68.4^{a}	7.3^{b}	14.3^{c}	380^{b}	161^{b}	3.25^{c}
2018	12	1.50^{c}	44.0^{a}	9.4^{a}	10.9^{a}	541^{a}	146^{a}	0.77^{a}
	18	2.21^{b}	45.1^{a}	7.4^{ab}	7.8^{ab}	365^{ab}	102^{ab}	0.95^{b}
	24	2.48^{ab}	45.6^{a}	8.6^{a}	7.6^{ab}	409^{a}	40^{bc}	0.98^{b}
	30	2.88^{a}	46.7^{a}	5.2^{bc}	5.9^{bc}	218^{bc}	40^{bc}	1.14^{c}
	36	2.99^{a}	45.9^{a}	4.4^{c}	3.6^{c}	184^{c}	32^{c}	1.19^{c}

*Crop biomass was recorded at pod development stage in 2018

Conclusion

Diverse strategies including rotating modes of actions in high break crop intensity (HBCI) systems are important to delay herbicide resistance. The tactical use of imidazolinone technology is needed to sustain it as a broadleaf management tool in break crops. The increase in competitive ability of faba bean was found to have potential to reduce seed set of broadleaf weeds. Such agronomic tactics need further investigations in different soil types and rainfall zones, to develop sustainable integrated weed management strategies for HBCI systems.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions for growers through both trial cooperation and support of GRDC and SARDI. The authors are highly thankful to the weed scientists of the University of Adelaide and CSIRO for their input. The selection of focus paddocks would not have been possible without the help of consultants and respective growers. The assistance received from Ruwan Lenorage in herbicide resistance screening work is gratefully acknowledged. Authors also thank Ashley Pilkington for making available the herbicide Ultro®.

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