G – SUSTAINABLE USE OF IMI-TOLERANT TECHNOLOGY IN HIGH BREAK CROP INTENSITY (HBCI) FARMING SYSTEMS

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KEY FINDINGS

- Use of imidazolinone (IMI) herbicides in two consecutive years, i.e. in the break crop phase and the subsequent cereal crop, did not provide additional benefit for broadleaf weed control.
- The greatest benefit from using IMI herbicides to manage broadleaf weeds was in the break crop phase, with benefits of carryover in the following cereal phase.
- Rotating herbicides with alternative modes of action in the cereal phase {such as LVE MCPA (Group I), clopyralid (Group I), bromoxynil + dicamba (Group C and I), MCPA Amine (Group I), Affinity (Group G), and Paradigm (Group I + B)} improved bifora, bedstraw and vetch control in high break crop intensity systems.
- Use of chlorsulfuron in wheat (on label) instead of lentil (off-label industry practice) provided extra benefits for bifora control in the lentil-wheat sequence.

Background

The introduction of herbicide tolerant break crop options including XT lentil, Clearfield® canola, TT canola, and PBA Bendoc have broadened the weed control options in these crops and have resulted in better management of hard to control grass weeds like brome grass and multiple broadleaf weeds (Boutsalis et al. 2016). This, coupled with better economic returns, has increased their adoption by South Australian growers. Traditionally, break crops were included once every three to six years in the crop rotation. However, the frequency has now increased and, in some regions, has become equal to cereal crops or even greater in some cases.

The increased adoption of herbicide tolerant break crops has resulted in over-reliance on a few modes of action, especially Group B herbicides. Moreover, availability of multiple Clearfield® resistant cereal crops (wheat and barley), and now an IMI-tolerant oaten hay crop, has provided multiple IMI tolerant crop options across both cereal and break crop phases of the cropping rotation. The increased reliance on Group B herbicide tolerant crops and recurrent use of imidazolinone herbicides for broadleaf weed control has increased the risk of shifting the weed flora, and the development of resistant weeds to these herbicides. Recent random surveys (Boutsalis et al. 2016) conducted in different regions of SA that recorded 33% of surveyed paddocks with resistant wild turnip in the SA-Mallee region and 13-14% paddocks with Indian Hedge Mustard resistant to the IMI herbicide Intervix®. Similarly, common sowthistle has been reported to develop resistance to Intervix and Imazapic in 65 and 88% respectively of the high break crop intensity (HBCI) paddocks

(paddocks with at least two break crops in last 5-6 years), in SA (Aggarwal et al. 2019).

Another issue is the development of cross-resistance within a group of herbicides having the same mode of action. A weed population that is resistant to sulfonylureas can be cross-resistant to IMI herbicides even if the population has never been exposed to IMIs (Boutsalis and Powles 1995), and 50% of the common sowthistle populations resistant to sulfonylureas were found to be cross-resistant to IMI herbicides from the paddocks where IMI herbicides were not used in last 5-6 years (Aggarwal et al. 2019). This suggests a need to develop sustainable methods for use of IMI-crops in HBCI systems that involve the regular use of different IMI herbicides with the same mode of action. The inclusion of diverse mode of action herbicides along with reduced use of AHAS chemistries in crop rotations has the potential to increase the heterogeneity of the selection pressure and thereby reduce or delay the build-up of IMI-herbicide resistant weeds (Boutsalis et al. 2016).

In the GRDC-SARDI funded project 'DAS00168 BA', research work was undertaken at the Hart Field site and at a farmer's paddock in Bute in 2018 and 2019 to investigate strategies for sustainable use of IMI chemistries in HBCI systems. The research investigated whether to use IMI herbicides in the break crop phase or cereal phase, the frequency of IMI use in a crop rotation, and the carryover effect on following cereal or break crops with respect to impact on broadleaf weeds.

How was it done?

A canola-wheat-barley-lentil trial was established at the Hart field site (Mid-North) in 2017, to investigate sustainable use of IMI herbicides in HBCI rotations. Vetch and bedstraw seeds were sown in 2017 to build up the weed population at the trial site, with treatments initiated from 2018.

Another lentil-wheat-lentil-wheat trial was established in 2018 within a farmer's paddock at Bute (Yorke Peninsula) having a background population of bifora.

Location: Hart

Plot size	3.5 m × 10 m (12 crop rows)	
Seeding date	June 5, 2018	May 30, 2019
Crop season rainfall	129 mm	132 mm
Design	Split-plot design	

Herbicides used in 2018 and 2019:
Canola: Lontrel (Group I) POST ± OnDuty (Group B) POST
Wheat: Eclipse (Group B) POST + LVE MCPA (Group I) POST + clopyralid (Group I) POST ± OnDuty (Group B) POST
Barley: Bromoxynil + dicamba (Group C and I) POST ± imazamox + imazapyr (Group B) POST
Lentil: Metribuzin (Group C) PSPE + Broadstrike (Group B) or imazamox + imazapyr (Group B) POST

Location: Bute

Plot size	3.5 m × 10 m (12 crop rows)	
Seeding date	June 19, 2018	May 8, 2019
Crop season rainfall	142 mm	182 mm
Design	Split-plot design	

Herbicides used in 2018:
Wheat: {MCPA Amine (I) POST + Affinity (G) POST} ± {Paradigm (I + B) + LVE-MCPA (I)} ± OnDuty (B) POST
Lentil: Metribuzin (C) PSPE + Broadstrike (B) or imazamox + imazapyr (B) POST ± chlorsulfuron (IBS)

Herbicides used in 2019:
Wheat: {MCPA Amine (I) POST + Affinity (G) POST} ± chlorsulfuron ± OnDuty (B) POST
Lentil: Metribuzin (C) PSPE + Broadstrike (B) or imazamox + imazapyr (B) POST ± chlorsulfuron (IBS)

Results and discussion

At Hart, the use of non-IMI herbicides LVE MCPA (Group I) POST + clopyralid (Group I) POST + Eclipse (Group B) POST in wheat, and bromoxynil + dicamba (Group C and I) POST in the barley phase resulted in similar levels of vetch and bedstraw bifora control as achieved with both non-IMI + IMI herbicides (OnDuty POST in wheat, and imazamox + imazapyr POST in barley) in the lentil-canola-wheat-barley system in 2018 and 2019 (Tables 1 and 2). Furthermore, non-IMI herbicides alone provided a similar level of vetch control in canola, and bedstraw in the lentil phase, compared to the use of both non-IMI + IMI herbicides. The use of IMI-herbicides was essential for control of vetch in the lentil phase and bedstraw in the canola phase in 2018. The results were similar in 2019, with the exception that non-IMI herbicides provided effective control of vetch in lentil and bedstraw in canola (Table 2). Very low rainfall (35 mm) following the POST herbicide application until harvest in 2019 may have resulted in lower seed set on stressed vetch and bedstraw plants in non-IMI treatments as well. When an IMI herbicide was used in the 2018 break crop phase, there was no additional benefit in controlling vetch and bedstraw with the additional use of an IMI herbicide in the 2019 cereal crop that followed.

Table 1. Vetch and bedstraw seed set as affected by different herbicide treatments in lentil-canola-wheat-barley system at Hart in 2018.

Crop	Vetch seed set/m²		Bedstraw seed set/m²	
	IMI frequency			
	Only non-IMI herbicides	IMI herbicides + non-IMI herbicides	Only non-IMI herbicides	IMI herbicides + non-IMI herbicides
Canola	0[b]	0[b]	78[a]	0[b]
Wheat	0[b]	0[b]	0[b]	0[b]
Barley	0[b]	0[b]	0[b]	0[b]
Lentil	122[a]	11[b]	0[b]	0[b]

Table 2. Vetch and bedstraw seed set as affected by different herbicide treatments in lentil-canola-wheat-barley system at Hart in 2019.

Crop	Vetch seed set/m²			Bedstraw seed set/m²		
	Only non-IMI herbicides in two years	IMI herbicides only in 2018 + non-IMI herbicides (2018 and 2019)	IMI herbicides twice in two years (2018, 2019) + non-IMI herbicides (2018 and 2019)	Only non-IMI herbicides in two years	IMI herbicides only in 2018 + non-IMI herbicides (2018 and 2019)	IMI herbicides twice in two years (2018, 2019) + non-IMI herbicides (2018 and 2019)
Canola	0	0	0	0	0	0
Wheat	1.4	0	0	0.5	2.5	0
Barley	0.1	0.7	0	0	0.1	1.0
Lentil	0	0.3	0	0	0	0
LSD 5%		NS			NS	

In a lentil-wheat-lentil-wheat system trial at Bute in 2018, the use of non-IMI herbicides (MCPA Amine (I) POST + Affinity (G) POST, and Paradigm (I + B) + LVE-MCPA (I)) in wheat was the best option for controlling bifora, and provided a similar level of weed control to the use of both non-IMI + IMI herbicides (OnDuty POST) (Figure 1). Further, MCPA Amine POST + Affinity POST combination proved equally effective for bifora control (8 bifora seeds/m²) in wheat as the same treatment with additional sprays of Paradigm + LVE-MCPA POST (17 bifora seeds/m²). On the other hand, IMI herbicide was essential for bifora control in lentil. Further, use of imazamox + imazapyr (POST) achieved a similar level of bifora control (107 bifora seeds/m²) compared to the common off-label industry practice of chlorsulfuron (IBS) + imazamox + imazapyr (POST) (158 bifora seeds/m²).

In 2019, again non-IMI herbicides alone were as effective as non-IMI + IMI herbicides in wheat (Table 3). Additional application of chlorsulfuron along with MCPA Amine + Affinity proved a more effective broadleaf weed control strategy in wheat that followed the IMI lentil phase compared to wheat that followed a non-IMI lentil phase. Similarly, there was improved bifora control in lentil that followed a wheat crop with IMI herbicide used in the previous season compared to lentil that followed a wheat crop without IMI herbicide, although overall level of bifora control was higher in wheat plots.

Further, in a lentil-wheat sequence, use of IMI herbicides once in two years in the lentil phase and no-IMI herbicides in succeeding wheat proved as effective as IMI herbicides used both in lentil and wheat crops consecutively (Table 3). Therefore, using IMI herbicides in the break crop phase and saving it in cereal phase proved a better strategy, and using chlorsulfuron in wheat (on label) instead of lentil (off-label industry practice) provided extra benefits for bifora control in the lentil-wheat sequence.

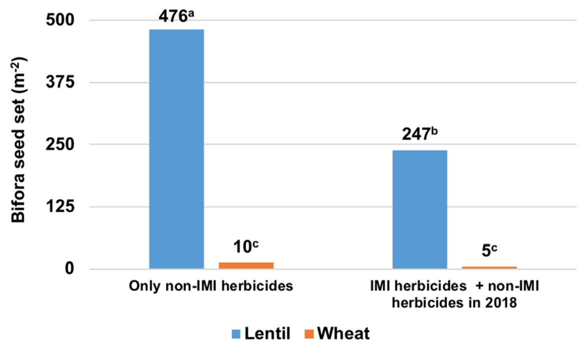

Figure 1. Bifora seed set in wheat and lentil as affected by IMI and non-IMI herbicides at Bute in 2018.

Table 3. Effect of herbicides on bifora management in wheat and lentil at Bute in 2019.

Crop	Strategy	Bifora seed set/m²		
		IMI frequency		
		Twice in two years (2018 and 2019)	Used only in 2018	No IMI use
Lentil	S1 (without chlorsulfuron)	362[c]	940[b]	2458[a]
	S2 (with chlorsulfuron)	1[e]	0[e]	0[e]
Wheat	S1 (with chlorsulfuron)	0[e]	2[e]	23[de]
	S2 (without chlorsulfuron)	16[de]	47[de]	122[cd]

Summary/implications

Broadleaf weeds developing resistance to IMI herbicides is an emerging challenge. The selection pressure imposed by frequent use of IMI herbicides for broadleaf weed control in HBCI systems, has made the current weed management systems unsustainable in the long term. A holistic approach using multiple IMI tolerant crops (wheat, barley, oaten hay, canola, lentil, faba bean) in a sustainable manner in the cropping rotation is essential to maintain this herbicide tolerance technology as a valuable broadleaf management tool. Adopting improved weed management practices by rotating IMI herbicides with other modes of action in a systems approach will reduce the selection pressure on broadleaf weeds, especially for Group B herbicides.

References

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Acknowledgements

The research undertaken in this project (GRDC-SARDI strategic joint investment in DAS00168BA) is made possible by the significant contributions of the Hart Field-Site Group, Green's Family at Bute and Sam Trengove through trial cooperation. The authors also thank GRDC and SARDI for their continued support. Special thanks to SARDI Clare team members for their help with field operations.

AIM: To investigate the management of group A, J & K resistant annual ryegrass in lentils.

Ryegrass management in lentils trial plan

	Bay 1	Bay 2	Bay 3
	Canola	Canola	Canola
	Buffer	Buffer	Buffer
R1	Group C: Propyzamide 1000 (IBS) + Metribuzin (post-emergent)	XT Lentil: Crop topping at RG embryo development stage	Group C: Ultro (IBS) + Metribuzin (PSPE)
R2	XT Lentil: Clipping at reproductive stage	Group C: Ultro (IBS) + Metribuzin (post-emergent)	Group C: Propyzamide 1000 (IBS)
R3	Group C: Propyzamide 1000 (IBS) + Metribuzin (post-emergent)	Group C: Untreated	Group C: Intercept 750 (post-emergent)
R4	Group C: Metribuzin (post-emergent)	XT Lentil: Wick wiping at reproductive stage	Group C: Metribuzin (PSPE)
R5	XT Lentil: Untreated	Group C: Ultro (IBS)	Group C: Ultro (IBS) + Ultro (PSPE)
R6	XT Lentil: Crop topping at RG embryo development stage	Group C: Metribuzin (PSPE)	XT Lentil: Untreated
R7	Group C: Ultro (IBS) + Ultro (PSPE)	Group C: Propyzamide 1000 (IBS) + Metribuzin (PSPE)	Group C: Ultro (IBS) + Metribuzin (post-emergent)
R8	Group C: Propyzamide 1000 (IBS)	Group C: Propyzamide 1000 (IBS) + Metribuzin (post-emergent)	Group C: Ultro (IBS)
R9	XT Lentil: Wick wiping at reproductive stage	Group C: Intercept 750 (post-emergent)	Group C: Metribuzin (post-emergent)
R10	Group C: Ultro (IBS) + Metribuzin (PSPE)	XT Lentil: Clipping at reproductive stage	Group C: Untreated
R11	Group C: Ultro (IBS)	Group C: Propyzamide 1000 (IBS)	Group C: Propyzamide 1000 (IBS) + Metribuzin (PSPE)
R12	Group C: Untreated	XT Lentil: Untreated	XT Lentil: Wick wiping at reproductive stage
R13	Group C: Metribuzin (PSPE)	Group C: Ultro (IBS) + Metribuzin (PSPE)	Group C: Propyzamide 1000 (IBS) + Metribuzin (post-emergent)
R14	Group C: Ultro (IBS) + Metribuzin (post-emergent)	Group C: Metribuz in (post-emergent)	XT Lentil: Crop topping at RG embryo development stage
R15	Group C: Intercept (post-emergent)	Group C: Ultro (IBS) + Ultro (PSPE)	XT Lentil: Clipping at reproductive stage
	Buffer	Buffer	Buffer
	Canola	Canola	Canola

Varieties: PBA Hurricane XT & Group C.