Broadleaf herbicide resistance targeted survey of Victorian Wimmera-Mallee

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Introduction.

The project outcome was to increase grower and adviser awareness of the increasing incidence of herbicide resistance in broadleaf weeds, particularly Wild Radish (*Raphanus raphanistrum)* and capture the extent of resistance in the Victorian Wimmera-Mallee region.

A range of herbicide options for controlling Wild Radish was applied to commercial paddocks (in strips) where the weed is problematic. BCG, with collaboration of agribusinesses (AgriVision, AgriTech Rural, Tyler's Rural Supplies, Landmark and Elders), identified 20 paddocks (10 x Mallee, 10 x Wimmera) with Radish populations of suspected resistance.

The aim of these demonstrations was to provide the platform for engaging with growers, advisers and industry representatives to increase awareness of developing herbicide resistance in broadleaf weeds.

Research Findings

- Commercial populations of Wild Radish are changing in their level of resistance, particularly to Group I and B herbicides, with those herbicides only controlling 50% of the population. It will be inevitable that these populations will be completely resistant in the short term future.
- Group I (MCPA LVE®) and Group B (Eclipse®) failed to provide commercial acceptable control (70% reduction) of wild radish populations targeted in the survey. Seven out of the 17 paddocks surveyed did not achieve commercially acceptable level of control (>70% weed reduction).
- Flight® and Precept® + Lexone® were superior products/mixes, achieving greater than 80% control in all paddocks surveyed.
- Seed collected from each paddock (tested through Plant Science Consulting), found that three paddocks were resistant to one or more herbicide groups. One site had both group B and I resistance, with 15% resistance to Brodal®.

Key Messages

- Wild radish seeds have a long dormancy in the soil and can germinate four to five times a season with sufficient soil moisture.
- Best chemical control is achieved if spraying early at the 1-2 leaf stage of the weed. Growers should not wait for five leaves or more before application.
- Some radish plants can shield others from contact with spray so a high water rate is required for best plant coverage.
- Research has shown a two-spray strategy is best for high-density radish plants or populations with multiple herbicide resistances.
- Growers are urged to rotate herbicide groups applied to plants so the effectiveness of new Group H chemistry can be prolonged.
- When collecting seeds for resistance testing, ensure samples are taken from a representative population or samples from suspected plants. Susceptible plants can still be present in the population and can give a false illusion of the resistant status.

Background.

Wild radish populations and their level of herbicide resistance are increasing across the Wimmera and Mallee cropping regions. In the low and medium rainfall zones of Western Australia (WA), the problem is much more advanced than in Victoria. In WA, wild radish populations have exploded and widespread resistance to Group B, C, F and I herbicides already exists. The practice of following tight wheat-lupin-wheat-lupin rotations and the limited available alternatives, have significantly contributed to, and exacerbated, the herbicide resistance problem in the west.

While there is greater crop diversity within Victorian cropping regions, growers have commonly selected herbicides according to their ability to control grasses such as ryegrass or brome grass. As a consequence, growers have placed less emphasis on rotating their broadleaf herbicide groups, thereby increasing the potential for resistance to develop in weeds such as wild radish, Indian hedge mustard and turnip.

Due to improved growing conditions over the past three years, farmers have had the option to use canola and pulse crops to reduce grass numbers. Triazine and imidazolinone based herbicides that can be sprayed on Triazine Tolerant (TT) and Imi-Tolerant canola varieties also provide an obvious break for broadleaf weeds. However, the overuse of imi-based herbicides is a big concern for the industry, particularly since growers are taking advantage of improved Clearfield cereal varieties (as well as canola) which allows further use of imidazoline-based herbicides. The fear is that resistance will develop in weeds such as wild radish and wild turnip due the rates at which these products are being used are often low, especially in the Mallee. Additionally, with limited broadleaf herbicides available for use in crops such as lentils and field peas, if resistance continues to develop and population numbers increase, it will put those herbicides under a lot of pressure and crop options in future years will be restricted. Already in Victoria, there are confirmed cases of diflufenican (Brodal® and phenoxy (MCPA LVE) resistant wild radish populations. There are more herbicide options available (with different modes of action) during the cereal phase (wheat and barley) of a cropping rotation. Strategic use of these alternative herbicide groups will help delay the onset of resistance.

Increasing grower and adviser awareness of increasing level of broadleaf weed resistance is needed in an attempt to delay or prevent its onset. In July 2013, GRDC, through its Regional Cropping Solutions Network (RCSN) commissioned BCG (formerly Birchip Cropping Group Inc) to conduct regional paddock surveys to highlight first hand to growers and advisors that resistance is developing.

Research objective.

To demonstrate to Victorian Wimmera and Mallee farmers and advisors the herbicide resistance status of problematic wild radish populations in their district.

Research methodology.

1. *Survey treatments*

The survey was undertaken in 20 commercial paddocks in NW Victoria (10 Mallee & 10 Wimmera) to gauge the extent of herbicide resistance in wild radish populations within the two districts. Local agronomists identified patches in farmers' paddocks with known wild radish infestations. Those patches of wild radish within commercial paddocks were then sprayed with a range of herbicides from different herbicide Groups.

The treatments were applied using a custom built ute mounted Goldacres boom fitted with 12-seperate tanks. The strips were then applied to patches of wild radish in commercial paddocks. Three permanent 50cm square quadrats were established in each strip prior to spraying and the crop was removed to eliminate shading and for extension purposes. The number of radish plants were counted in each quadrat at the time of spray and then at 28 days after application. The 28 day count will reflect the percent reduction in weed control achieved in each quadrat. The placement of each quadrats was specifically chosen to compare treatments of equal size (2-4 leaf) and density. If larger radish plants are present, then observations were made on efficacy compared to smaller plants. Digital photos will be taken at each quadrat with a scale marker, showing the size of plants at the time of treatment for extension purposes later on.

Viable radish seeds were collected at each site at 52 days after spraying. The plants were potted grown out in BCG laboratory. Those seeds were sent to Plant Science Consulting to confirm the population's resistance status.

The treatments were applied in the same order, to facilitate extension of results (e.g. for photos used in guides and in presentations).

Spraying was undertaken with two runs of the boom at each site, in opposite directions so the order of chemicals was reversed. A 50cm control strip separated each treatment pass to visually show the effect of each treatment. Figure 1 illustrates how the trial was laid out.

Trial Layout:

20 m	2	3	4	5	6	7	8	9	10	11

4m

Trial Details:

Spraying date: July 30 to August 20

Target Weed size: 2-leaf to 8-leaf (larger radish plants were removed from the quadrat before spraying)

Plot size: 4m x 20m.

(NB. Plot size may need to change depending on the size and consistency in radish density)

Water rate: 80L/ha

Nozzle selection: TT-02 at 3 bar pressure.

Table 1. List of the treatments used in each survey paddock

Treatment	Active ingredient	Herb. Grou p	Cost ($/ha)	
Control				
LV Agritone 570 @ 440ml/ha	570g/L MCPA present as the 2-ethylhexyl ester	I	$7-9	Low rate (250g MCPA rate in T
LV Ester 680 @ 800ml/ha	680g/L 2,4-D present as the 2-ethylhexyl ester	I	$5-7	To screen for G
Eclipse @ 50ml/ha + Hasten @ 0.5% v/v	100g/L Metosulam + 704g/L ethyl and methyl esters of vegetable oil	B (SA)	$8-10	To screen for G
Ester 680 @ 800ml/ha + Eclipse @ 50ml/ha + Hasten @ 0.5% v/v	680g/L 2,4-D present as the 2-ethylhexyl ester + 100g/L Metosulam + 704g/L ethyl and methyl esters of vegetable oil	I & B (SA)	$13-15	Check if mixtur
Cobber 475 @ 526ml/ha + Affinity 400DF @ 85ml/ha	475g/L 2,4-D (present as dimethylamine and diethanolamine salts) + 400g/kg Carfentrazone-ethyl	I & G	$18-21	Whether the ad control with qui
Tigrex @ 1L/ha	250g/L MCPA present as the ethyl hexyl ester + 25g/L Diflufenican	I & F	$11-13	To screen for G
Jaguar @ 1L/ha	250g/L Bromoxynil present as the octanoate + 25g/L Diflufenican	C & F	$19-21	To promote two
Flight @ 720ml/ha	35g/L picolinafen + 210g/L bromoxynil (present as the N-octanoyl ester) + 350g/L MCPA (present as the ethyl hexyl ester)	C, F & I	$24-26	Use of multiple
Liase @ 1% v/v + Precept 300 @ 1L/ha + Spreadwet @ 0.25% v/v	417g/L Ammonium Sulphate + 250g/L MCPA as the 2-Ethylhexyl Ester + 50g/L Pyrasulfatole	H & I	$30-32	To screen for G
Velocity @ 680ml/ha + Hasten @ 0.5% v/v	210g/L Bromoxynil as its mixed with Heptanoic acid and Octanoic acid esters + 37.5g/L Pyrasulfatole + 704g/L ethyl and methyl esters of vegetable oil	C & H	$21-23	To promote two
Liase @ 1% v/v + Precept 300 @ 1L/ha + Lexone Xtruded @ 100g/ha + Spreadwet @ 0.25% v/v	417g/L Ammonium Sulphate + 250g/L MCPA as the 2-Ethylhexyl Ester + 50g/L Pyrasulfatole + 750g/L Metribuzin + 1000g/L alcohol alkoxylate/s	H, C and I	$32-34	To add another burn out.

Paddock Locations:

The survey paddocks were spread across the Wimmera Mallee region (Figure 2). Sites were selected with the assistance from local agronomists in the region. Chemical restriction zones and weed growth stages made it difficult to establish any other treatments further north of Pira and Hopetoun.

Wind was a major contributing factor in the reason for the spread in application dates across each site. The majority of the paddocks surveyed were sandy loam in texture with dense radish populations.

In a couple of sites, the wrong formulation of Precept was use (150g/L instead of 300g/L). These points were excluded from the final analysis as the rates were essentially half of the intended rate.

Site 9 was unfortunately subjected to grazing after spraying, affecting some treatments and removing markers indicating quadrats. Site 13 was removed from the data after it appeared that the there was some problem with the applications and subsequently confidence in the data set.

Table 2: List of the paddocks and spraying application details

No.	Location	Region	Crop type	Date sprayed	Temp (°C)	Humidity (%)	Wind direction	Wind Speed (km/hr)
1	Corack 1	Southern Mallee	Wheat	6th August	15	61	SSW	19
2	Corack 2	Southern Mallee	Pasture	6th August	15	61	WSW	19
3	Narraport	Southern Mallee	Wheat	30th July	16	38	W	13
4	Oakvale	Southern Mallee	Barley	6th August	15	61	WSW	19
5	Quambatook	Southern Mallee	Wheat	6th August	15	61	WSW	19
6	Pira 1	Central Mallee	Fallow	31st July	16	45	NW	10
7	Pira 2	Central Mallee	Lupins	31st July	16	45	NW	10
8	Hopetoun 1	Mallee	Wheat	8th August	12	62	WSW	7
9	Hopetoun 2	Mallee	Fallow	1st August	15	49	N	15
10	Corack 3	Southern Mallee	Wheat	6th August	15	61	WSW	19
11	Corack 4	Southern Mallee	Barley	6th August	15	61	WSW	19
12	Beulah	Mallee	Barley	8th August	12	62	WSW	7
13	Hopetoun 3	Mallee	Wheat	26th August	16	63	SSW	6
14	Dimboola 1	Wimmera	Wheat	27th August	22	43	NW	17
15	Dimboola 2	Wimmera	Wheat	27th August	22	43	NW	17
16	Dimboola 3	Wimmera	Barley	27th August	22	43	NW	17
17	Dimboola 4	Wimmera	Wheat	27th August	22	43	NW	17
18	Dimboola 5	Wimmera	Barley	26th August	16	63	SSW	6
19	Jeaprit	Mallee	Fallow	26th August	16	63	SSW	6

RESULTS & DISCUSSION:

What herbicides treatments were effective?

Of all the products, Precept + Lexone, Velocity and Flight were superior products for controlling radish in all the survey paddocks (Figure 1). Tigrex and Jaguar also perform well however, there were some paddocks that failed to reach commercially acceptable levels, especially those in the West Wimmera area. Table 3 shows the individual values for each treatment at each of the sites.

By comparing the values for each of the survey paddocks of a particular treatment illustrates the consistency and reliability of each product. At some sites, Group I chemistry worked extremely well, while at others it was poor.

Table 3. Shows the percent reduction of each treatment at the different sites. The values are represented as a % reduction from the quadrat counts at spraying (mean of three quadrats).

Site	**LV Agritone 570** @ 420ml /ha	**Ester 680** @ 800 ml/ha	**Eclipse** @ 50ml /ha + Hasten 0.5 % v/v	**Ester 680** @ 800ml /ha + **Eclipse** @ 50ml/ ha + Hasten @ 0.5% v/v	**Cobber 475** @ 526 ml/ha + **Affinity** 85ml /ha	**Tigrex** @ 1L/ ha	**Jaguar** @ 1L/ ha	**Velocity** @ 680ml/ha + Hasten 0.5% v/v	**Flight** @ 720 ml/ha	**Precept 300** @ 1L/ha + Liase 1% v/v	**Precept 300** @ 1L/ha + **Lexone** 100g/ ha + Liase 1% v/v	**Mean radish population** (plants/m2)
1	58	61	51	93	83	96	82	80	72	89	90	220
2	76	86	88	87	28	96	81	49	97	86	79	140
3	44	97	61	100	92	96	100	96	99	51	95	108
4	36	77	7	23	21	45	50	97	100	100	*	48
5	45	100	56	91	34	86	92	70	94	42	100	68
6	80	82	65	58	78	100	97	99	100	100	100	300
7	38	42	43	88	100	100	100	71	100	100	100	16
8	63	52	70	30	81	100	100	91	88	93	97	124
9	*	*	*	*	*	*	*	*	*	*	*	16
10	43	90	58	38	99	66	80	88	86	99	100	236
11	48	41	97	86	87	99	97	100	98	88	100	132
12	89	84	65	94	95	84	89	99	84	98	99	116
13	*	*	*	*	*	*	*	*	*	*	*	152

14	70	93	69	98	77	80	99	93	100	100	100	164
15	55	50	97	60	54	53	42	65	100	98	100	176
16	54	50	50	61	58	70	79	60	100	87	100	52
17	31	33	68	26	51	48	47	96	93	*	*	120
18	24	0	36	20	72	47	63	75	100	*	*	40
19	56	27	61	60	68	61	77	78	99	*	*	108
Ave	**56**	**63**	**66**	**67**	**71**	**79**	**82**	**83**	**94**	**80**	**97**	**123**

Colour Rating	< 40%	40% - 60%	60-70%	70-90%	90-100%

LV AgriTone 570 (Group I – MCPA)

Used in the survey to determine the activity of diflufenican in Tigrex, the rate at which this treatment was applied is considered low to achieve adequate control when used alone. This was evident across the majority of paddocks, only achieving greater than 70% reduction in 6 of the 19 paddocks. Taken the mean of all the paddocks, this treatment achieved the least amount of weed reduction (56%). It also did not seem to be influenced by population density.

LV Ester 680 (Group I-2,4 D)

Control was less than satisfactory in the majority of paddocks with this treatment. Nine out of the 19 paddocks were below the acceptable level of control. Commercially, this product alone is known to be weak on radish without the addition of either a group B (Eclipse) or other modes of action for improving control. The results would suggest that potentially radish populations are changing in their level of resistance to group I, and the lifespan of this mode of action working is very short term (1-3 years).

Eclipse (Group B)

Similar to the Group I's, Eclipse also failed to achieve satisfactory control in 13 of the 19 sites. It was, on average, marginally better than LV Ester 680 treatment resulting in an overall 66% reduction over the mean of paddocks surveyed. Eclipse had been a standard herbicide for radish control in most of these regions; subsequently the results are not surprising given its over-use.

LV Ester 680 + Eclipse

Mixing the group I and group B together did marginally improve control however they followed similar trends at each site when those herbicides were applied alone. Sites 8 and 10 did have reasonable control when the individual products were applied however, when mixed, their efficacy reduced. Suppression was observed in these plots however it was deemed that those plants would still set seed and subsequently those results were obtained. Given both these product were found to be inferior, mixing the two was likely to give the same result.

Cobber 475 + Affinity 400DF (Group I & G)

Similar to the previous treatments, the addition of the group G seemed to marginally improve control however, results were inconsistent at some sites. Site 2 and 5 had poorer control when the group G was added to the Group I, despite the group I's working relatively well at those sites. The group G is unlikely to greatly improve control if the group I is failing on its own.

Tigrex

Tigrex control was moderately acceptable but the results did show that the majority of the work is being done by the diflufenican component. The AgriTone treatment was specifically included in the survey to breakdown the level of resistance in the population to Diflufenican and MCPA. Thirteen of the paddocks failed to achieve better than 70% control with AgriTone, compared to only 6 out of 19 paddocks with Tigrex. This suggests that Diflufenican is the main active working on radish population. Notably, where Tigrex had failed was when the population density was relatively high.

Jaguar

The addition of bromoxinal to diflufenican did improve control slightly compared to Tigrex. However, at some sites control was still only satisfactory. Jaguar, without the group I, is particularly sensitive to weed size and coverage. This treatment ideally fits in the first spray application timing under a two-spray strategy, when crop shading and weed size is small. Similarly to Tigrex, where Jaguar failed was when the population density was relatively high.

Velocity

This treatment performed consistently well at most sites. It is the only product in the survey (outside Jaguar and Eclipse) that do not rely on group I herbicides. Limited use of bromoxinal and pyrasulfatole means it is unlikely to have widespread resistance issues in the region. Both active ingredients can be affected by lack of coverage and weed size. Velocity performed similarly to Jaguar, achieving good control in 16 out of the 19 sites. Control was not satisfactory at site 2, 15 and 16 which is interesting given Precept worked on these sites. Potentially, the addition of LVE with Velocity could have improved control in those paddocks.

Flight

Flight was the one of the most superior and consistent performing treatment over all the survey paddocks. There was no paddock where Flight failed to satisfactorily control radish. The reduction across the mean of the survey paddocks was 91%, which was only second to Precept + Lexone which achieved 97%. Flights contains 3 modes of action (Group C, F and I) which all work in different best in different situations, making Flight potentially more adaptable to the second application before stem elongation. The only concern with Flight, is that it still puts some pressure on

Precept

Precept, which contains pyrasulfatole, was also found to be very effective on the majority of paddocks sprayed. There was an issue with the wrong formulation (150g/L formulation) being used instead of the 300g/L formulation at some sites. Control in those plots was relatively poor and subsequently that data was not presented. At the other sites, the correct formulation was used. Plant death is typically much slower with Precept compared to other herbicides, subsequently it is plausible that some plants when scored and counted at the 28 days after spraying assessment may still have been controlled, which may have been the case at sites 3 & 5.

Precept + Lexone

With conditions perfect for Lexone, (lots of small rainfall events <5mm) the addition to Precept improved the efficacy dramatically and in all paddocks except where the wrong formulation of Precept was used, control was exceptional. This mixture provides three modes of action (group H, C and I) which arguably has a greater "rotational" fit than Flight because it is not using another hit of group F, protecting this chemistry for the pulse crops with Brodal. This treatment on the other hands needs ideal conditions for the Lexone to work, and can only be used in barley under a minor use permit.

Overall

The paddocks surveyed varied in the density of the population (as shown by the last column in table 3). This is important to quantify the impact if a treatment achieves less than 90% control in high densities. If a treatment achieved only 50% control of a 200 plants/m2 population, then there is still 100plants/m2 able to set seed. In some of these cases, there could have been a compounding effect of shading in such high density populations, rather than resistance, despite water rates being relatively high (100L/ha). Commercially, this is where a second follow up application would be necessary.

It was evident that even with products such as Flight, Velocity and Precept that the second applications was still required to achieve acceptable control. It is evident, that for reliability, the efficacy of Flight, Precept + Lexone and Velocity was superior to that of the rest of the products, however with the second application the grower is not getting anywhere in regard to reducing radish numbers for subsequent crops. This is best illustrated in Figure 3.

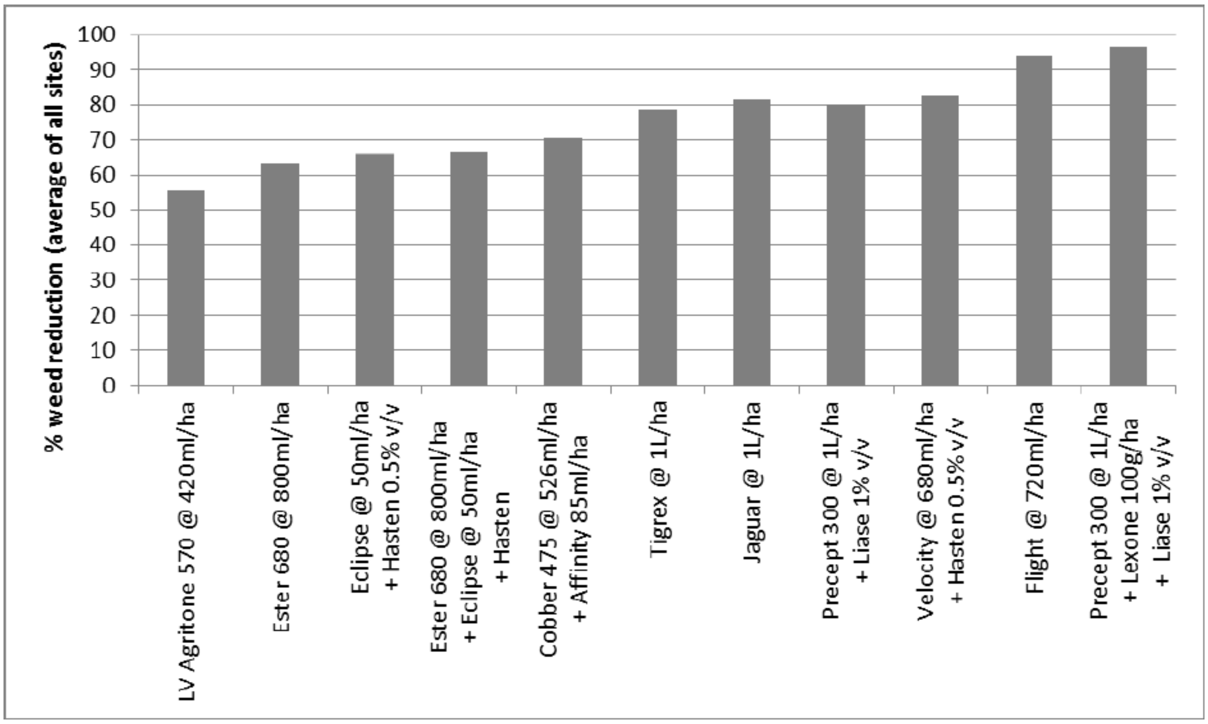

Figure 3. Average reduction (%) of each herbicide mix (17 sites)

The data would indicate that while inferior products are getting some level of control there is still a significant percentage of the populations that has survived and is going to set seed. Looking at each site as a one population, it would appear that not every plant is resistant (e.g. there was some reduction in each treatment). Known for its long dormancy period, it would be valid to assume that a percentage of the population that germinates has not been exposed to as many applications of certain modes of action as the others. The percentage of emerged plants in one season, depending on seasons, can from varying those being dormant for 5-6 years to those that were produced last season. This obviously would mean the resistance status of the paddock, prior to spraying, is going to contain both resistant and susceptible populations. Therefore this would need to be consider when reviewing paddocks and sending samples away for confirmation – samples need to be targeted

Was there an influence of paddock history?

It proved very difficult to find sufficient and accurate herbicide records for the survey paddocks. The farmers either did not record detail paddock and herbicide application records, or the paddock had just been purchased with no paddock records. This made it difficult to draw any conclusion to the influence of paddock history.

That being said, there did not appear to be a particular rotation or management practice that led the results that were found. The paddocks / patches were predominantly located on the lighter soil types, some of which would have been neutral to slightly acid in the topsoil. Where resistance was found (e.g. Pira – site 6), the farmer did say he had used a lot of group B (Eclipse®) herbicides over for at least 10 years to control radish.

It was also observed that the majority of paddocks also had significant ryegrass numbers. Whether this is a correlated or not is uncertain, though managing both resistant ryegrass and radish in the same paddock does pose significant issues to the grower, especially in low rainfall environments where cost of production needs to be kept to a minimum.

Importance of Crop Competition and non-chemical practices to prevent late germination and seed set.

It was evident, even at the 28DAA inspection at some sites, where the crop had been removed (in the quadrats), a second generation of radish plants had begun to emerge. The amount of germination was less obvious where the crop was still present, although there were still the odd few plants that had emerged.

Figure 4: Photo of later germinating radish 28 days after the application at Corack

The obviously highlights that reliance on herbicides alone, especially those with little or no residual, will still require a second spray application to ensure these later germinations are controlled. There are only two other modes of actions registered beyond the end of tillering (GS30); Group I (Ester or Amine) and Group B (Logran). Should populations develop resistance to these groups, which this survey suggests is already occurring, growers will need to adopt other practices to prevent these populations setting seed. Some of these practices could be narrow row spacings, competitive crops, chaff carts, hay, Harrington Seed Destructors, narrow windrow burning or even mouldboard ploughing.

Which had the biggest impact on the results: seed bank or the level of resistance?

Radish pods were collected from each of the paddocks surveyed to confirm the level of resistance. Some of the samples had problems with germination and viability which limited the number of products that could be tested. Despite the survey showing certain products were starting to fail (particularly the Groups I and B), only 4 paddocks came back with a percentage of resistance. The most concerning population was at (Gerang Gerung, site 11) which has multiple stacked resistances to 3 herbicide groups.

The results of the survey do suggest growers will need better understanding of the seed bank they are dealing with and what the level of resistance is.

Did the resistance tests match the survey results?

Confirmation of the resistant levels of the surviving plants from each site, showed there is some level of resistance developing. With some sites having seed viability issues, of those tested 6 out of the 14 paddocks that were tested under laboratory conditions, were found to have some form of resistance. Two of these sites (site 3 and 14) had multiple or stacked resistance, including site 14 which was found to be resistant to group I, B and F herbicides. Not all results matched the results found in the field. Site 6 in particularly was completely resistant to group B herbicides, which was to some extent observed in the field, however the group B herbicide (Eclipse) still manage to control just over 50%. A possible explanation for this is that the population is in a state of transition from partial to complete resistance; and while there are some resistant plants present, there is still a proportion that will be control. This reinforces the need to rotate herbicide accordingly and use multiple modes of action to ensure closer to 100% control occurs.

Table 4: Summary of the resistance tests for each of the paddock locations.

Site	Group I		Group B			Group C	Group F & I	Group F	Group H	Group M
	LVE	2,4 D Amine	SA's (Eclipse)	SU's (Logran)	Imi's (Intervix)	Atrazine	Tigrex	Brodal	Velocity /Precept	Roundup
Site 1	50	60	0	0	0	0	n/a	0	0	0
Site 2	0	0	0	0	0	0	n/a	0	0	0
Site 3	5	5	0	0	0	0	n/a	40	0	0
Site 4	0	0	0	0	0	0	n/a	0	0	0
Site 5	0	0	0	0	0	0	n/a	0	0	0
Site 6	0	0	100	100	100	0	n/a	0	0	0
Site 7	0	0	0	0	0	0	n/a	0	0	0
Site 10	5	5	0	0	0	0	n/a	0	0	0
Site 11	5	5	0	0	0	0	n/a	0	0	0
Site 12	0	0	0	0	0	0	n/a	0	0	0
Site 13	0	0	0	0	0	0	n/a	0	0	0
Site 14	40	n/a	40	n/a	35	n/a	15	n/a	n/a	n/a
Site 15	0	0	0	0	0	0		0	0	0
Site 17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0
Site 18	0	0	0	0	0	0		0	0	0

Conclusion

To delay the onset of the resistance we need to ensure that robust herbicide rates are used to ensure there are few if any survivors. Achieving the right timing for herbicide application is also very important. With only two herbicide groups growers can use later in the season (I-amine and B), it will be important to protect these groups, thus using the products such as Flight and Velocity (Precept + Lexone) will take the pressure off those Group I and B applications later in the season. Precept will still have a reliance on group I so the addition of Lexone is recommended (only in barley).

In the two spray approach to controlling wild radish growers need to consider the control efficacy of herbicides at different crop growth stages, the residual effect of the herbicides and the cost of the herbicide. If a paddock has no resistance to any of the listed herbicides then products such as Jaguar + MCPA LVE and Tigrex will still be effective for controlling young radish and following up with a late application of Precept + Lexone, or Velocity + MCPA LVE, or Flight will control escapes and reduce the likelihood for resistance to develop. However, it should be noted, that each of these premier products can only be used prior to stem elongation (GS30). The only registered products that can used post this timing is Group I and B, so ensuring those premier products are used earlier it may take the pressure off those later herbicides.

Eclipse is still a good product for the control of wild radish in situations with limited group B history and if continued to be used in rotation with other herbicides with a different mode of action the onset of resistance should be delayed. If Group B resistance is present then it is likely that herbicides from this group will be ineffective.

The results of the radish survey have given insight into effective control of wild radish with herbicides. The radish survey showed that products such as Precept + Lexone, Flight and Velocity are performing the best.

Velocity is the fastest acting and has a rapid brown out effect, however it has no residual and being a contact product it requires very good coverage to achieve effective control. The addition of MCPA LVE to Velocity provides the systemic effect and has two modes of action. Best management practices require Velocity to be used at a high water rate and it should be applied when radish plants are actively growing. The issue is that there is no residual to control the next wild radish germination. In the timing trial, Velocity performed well at all three timings, even on very large radish. The addition of MCPA LVE accounted for any potential coverage problems. In the radish survey trial, treatments were designed to test the resistance status of radish in different locations and if a radish plant was not fully controlled it does not necessarily mean it was resistant. Spray coverage, weather conditions at spraying, weed size are all factors that could account for less than 100% control. The addition of MCPA LVE would have seen much better control in the paddock survey trials.

The Precept + Lexone treatment had the best results in the radish survey. Precept on its own works quite slowly and rarely achieved 100% control. The addition of Lexone (group C), did improve radish control whilst providing some residual to prevent further germinations. The use of Lexone at this timing is not registered in all crops, especially wheat therefore, ensure to follow it herbicide labels correctly. BCG (with funding from SAGIT) investigated the use of Lexone on barley applied at the 4-leaf stage for brome grass control on deep sands.

Flight has 3 modes of action (C, F and I) which helps in combating stacked resistance (stacked resistance is where a weed has resistant to multiple herbicides with different modes of action). Flight is fast acting product and works well on larger radish. If the paddock has group F and I resistance then using Flight will put pressure on the Bromoxynil (Group C) component of the herbicide. Bromoxynil is an excellent herbicide for controlling wild radish. Resistance to this herbicide would make control of radish more difficult.

Although the seed tests only showed some level of resistance developing, the counts and the % reduction are arguably just as important, after all that is the reason why we are applying the herbicide and why we are concerned if herbicides fail. The survey showed that in certain populations, there was still going to be substantial seed set if growers relied on those herbicides alone. For growers and advisers to successfully manage wild radish and other broadleaf weed species they need to use a combination of weed control tools; both non-chemical and chemical. Non-chemical tools could be hay, HSDs, chaff charts, crop competition and livestock.

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