WILD RADISH CONTROL

TAKE HOME MESSAGES

1. In 2014, an estimated 61 per cent of the seed bank germinated throughout the season, enabling a rapid reduction of the wild radish population and having a positive effect on grain yield. However, due to the long dormancy of the seed (six to eight years), 100 per cent control would be needed to eradicate the entire seed bank.

2. Approximately 30 per cent of the seed bank germinated as a result of summer rainfall; best practice is to make the most of seasons that deliver a summer break to get a good knockdown.

3. Aim to control 100 per cent of seed set by using multiple cultural, chemical and mechanical practices to eradicate the seed bank and stop resistance development.

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Disclaimer: Some of the herbicide treatments used in this trial may be off label and were used for research purposes only. **When using herbicides always adhere to label instructions.**

BACKGROUND

From BCG wild radish research trials over the last three years, it is evident that populations are currently in a state of flux, with more incidences of resistance to herbicide Groups B, F and I emerging across North West Victoria. Much of this has been attributed to a heavy reliance on Group B herbicides to control grass weeds such as brome and rye grass. The consistent use of MCPA ester and amine formulations (Group I) is resulting in the effectiveness of these products diminishing. Subsequently the selection pressure being placed on these herbicides is increasing.

To manage herbicide resistant wild radish efficiently, and to avoid its spread, it is necessary to understand its life cycle in the Mallee. This will help growers to identify and implement methods that decrease the radish seed bank in a problem paddock. The weed seed bank is defined as the mature seeds that exist in the soil. Adopting practices that help to reduce the number of viable weed seeds present in the seed bank (predominantly by preventing new plants from setting seed) improves the productivity of the paddock. It also decreases the need for costly herbicides, delaying the onset of further herbicide resistance.

A radish plant can produce up to 5000 seeds which, due to the hard-seeded nature of the pods, can stay in the top soil for up to eight years without germinating. The plants are highly competitive and when present in high numbers can greatly affect crop yields. This is the reason such importance has been placed on controlling 100 per cent of wild radish every year.

AIM

To measure the effectiveness of herbicides used in Clearfield and non-Clearfield cropping rotations to control problematic weeds in the Mallee including wild radish and brome grass.

TRIAL DETAILS

Trial 1: wild radish systems

Location:	Pira
Soil type:	Deep sandy loam without sub-soil constraints
GSR (Apr-Oct):	155mm
Crop type:	Grenade CL Plus wheat and Twilight field peas
Sowing date:	7 May
Seeding equipment:	Knife points, press wheels, 30cm row spacing
Target plant density:	Wheat – 150 plants/m^2, field peas – 50 plants/m^2
Harvest date:	21 November
Trial average yield:	Wheat – 1.8t/ha, field peas – 1.3t/ha

TRIAL INPUTS

Fertiliser:	55kg/ha Granulock Supreme Z + Impact at sowing; 65kg N/ha applied at GS13 to wheat only
Herbicides:	Refer to Table 1

Pests and diseases were controlled to best management practice.

Trial 2: herbicide comparison

The herbicide comparison was carried out in the landowner's Hindmarsh barley crop in the same paddock at Pira.

Herbicide treatments are listed in Figure 1.

Sowing, harvest and pest and disease control were carried out as per standard commercial practice.

METHOD

A paddock at Pira was selected to host BCG's 2014 wild radish research trials after a survey conducted in 2013 determined that it contained wild radish populations with Group B resistance and tolerance to Groups F and I.

Two trials, situated in a high radish population area on a sandhill, were established at the site. The paddock had been fallowed the previous year (2013) and was used as a feed paddock for sheep.

The first trial (Trial 1) is designed to compare the impact of a range of crop sequences and herbicide regimes on wild radish numbers and growth habits, and on subsequent crop performance and profitability. Along with wild radish, the Pira site also had a reasonable population of brome grass. Given the increasing difficulty in managing this weed it was decided to also investigate how the different systems impact on brome grass numbers throughout the duration of the trial.

The second trial (Trial 2) looked more specifically at the efficacy of a range of herbicides and effectiveness on Group B resistant wild radish.

Trial 1: Wild radish systems trial

The wild radish systems investigation, which focused on controlling wild radish and understanding its life cycle in the northern Mallee, was established as a three year trial in 2014. The replicated field trial was sown using a complete randomised block design. Individual plot size was 5.4m x 28m and all treatments were applied using the BCG bulk boom at 80L/ha. The trial comprised eight treatments, representing different farming practices across the Mallee (Table 1).

Assessments included initial weed seed bank, weed counts, and grain yield and quality parameters. The 2014 herbicide treatments are presented in Table 2.

Table 1. Wild Radish systems trial rotation treatments.

Trt.	Treatment description	Rotation	Purpose
1	Non-Clearfield cereal dominated rotation (standard)	2014 wheat 2015 barley 2016 wheat	To replicate a cereal dominated rotation typically used in the Mallee. The effect of not controlling radish on its seed bank, yield and resistance level were determined
2	Non-Clearfield cereal dominated rotation (best practice)	2014 wheat 2015 barley 2016 wheat	To demonstrate the effect of a cereal dominated system that takes a zero tolerance approach to wild radish, using premier herbicides at the ideal timing, on profit and on grass weeds.
3	Clearfield cereal dominated rotation (standard)	2014 CLF wheat 2015 CLF barley 2016 CLF wheat	To replicate a CLF cereal dominated system and its effect on wild radish known to be Group B resistant.
4	Clearfield cereal dominated rotation (best practice)	2014 CLF wheat 2015 CLF barley 2016 CLF wheat	To demonstrate the effect of a CLF cereal dominated system, used in conjunction with premier products, on broadleaf weeds, grass weeds and profitability.
5	Non-Clearfield break crop rotation	2014 field peas (harvested) 2015 canola (Hyola® 525RT) 2016 wheat	To replicate a non-Clearfield break crop rotation and assess the value of new Glyphosate Ready Triazine Tolerant (RT) canola.
6	Clearfield break crop rotation	2014 field peas (harvested) 2015 CLF canola (Hyola® 474) 2016 CLF wheat	To test whether the break crops grown under a CLF system combined with different management and herbicide options are more effective on wild radish control than other cereal dominant systems.
7	2 year break: peas (brown manure) followed by RT canola	2014 field peas (brown manure) 2015 canola (Hyola® 525RT) 2016 wheat	To demonstrate the impact of this rotation on disease and wild radish populations. The brown manure also removes some of risk of growing canola the following year. This rotation still relies on chemicals to control weeds.
8	2 year break: peas (brown manure) followed by barley (hay)	2014 field peas (brown manure) 2015 barley (hay) 2016 wheat	To demonstrate the impact of this rotation on disease and wild radish populations and to assess whether hay is a viable option in controlling wild radish. Hay is the non-chemical control.

Table 2. Wild radish systems trial herbicide treatments and cost per treatment.

2014 herbicide treatments						Total herbicide cost
Trt.	Knockdown	Pre-em	In-crop - early (GS13)	In-crop - standard (mid-late tillering)	Crop-top/ desiccation	($/ha)
1	Hammer® @ 50ml/h + glyphosate @1.5L/ha	TriflurX® @ 2L/ha) + Avadex Xtra® @ 2L/ha		Tigrex® @ 750ml/ha		67.3
2	Hammer @ 50ml/ha + glyphosate @ 1.5L/ha fb. Gramoxone® @ 1L/ha 2 days post	TriflurX @ 2L/ha) + Avadex Xtra @ 2L/ha	Jaguar® @ 500ml/ha	Precept® @ 1L/ha + Lexone® @ 100ml/ha		92.6
3	Hammer @ 50ml/h) + glyphosate @ 1.5L/ha	TriflurX @ 2L/ha + Avadex Xtra @ 2 L/ha	Midas® @ 900ml/ha			80.5
4	Hammer @ 50ml/ha + glyphosate @ 1.5L/ha fb. Gramoxone @ 1L/ha 2 days post	TriflurX @ 2L/ha + Avadex Xtra @ 2L/ha	Midas @ 900ml/ha fb. Jaguar @ 500ml	Precept @ 1L/ha + Lexone @ 100ml/ha		114.8
5	Hammer @ 50ml/ha + glyphosate @ 1.5L/ha fb. Gramoxone @ 1L/ha 2 days post	TriflurX @ 1.5L/ha + Simazine @ 400g/ha + Diuron @ 200g/ha		Brodal® @ 200ml/ha	Gramoxone @ 1.5L/ha	69.2
6	Hammer @ 50ml/ha + glyphosate @ 1.5L/ha fb. Gramoxone @ 1L/ha 2 days post	TriflurX @ 1.5L/ha + Terbyne® @ 1kg/ha fb. Spinnaker® @ 70g/ha PE	Brodal @ 200ml/ha		Gramoxone @ 1.5L/ha	116.1
7	Hammer @ 50ml/ha + glyphosate @ 1.5L/ha fb. Gramoxone @ 1L/ha 2 days post	TriflurX @ 1.5L/ha + Terbyne @ 1kg/ha			Roundup® Attack @ 1.5L/ha fb. Gramoxone @ 1.5L/ha + Sharpen* @ 17g/ha 2 days post	55.6
8	Hammer @ 50ml/ha + glyphosate @ 1.5L/ha fb. Gramoxone @ 1L/ha 2 days post	TriflurX @ 1.5L/ha + Terbyne @ 1kg/ha			Roundup Attack @ 1.5L/ha fb. Gramoxone @ 1.5L/ha + Sharpen® @ 17g/ha 2 days post	55.6

* Sharpen is not registered at this timing. It was included in this trial for experimental purposes only.
fb - followed by

Trial 2: Wild radish herbicide comparison trial

To complement the wild radish systems trial (Trial 1), a herbicide efficacy demonstration was established in the farmer's crop at the Pira research site. The aim of this trial was to compare the performance of new and existing herbicides on Group B resistant wild radish in a cereal rotation.

The trial was sprayed on 23 July, targeting a high radish population in the paddock. The herbicide treatments (Figure 1) were applied with the BCG hand-boom at a water rate of 80L/ha, one week after the rest of paddock (outside of the trial area) had been sprayed by the landowner, according to his standard practice. This allowed us to determine how the herbicide treatments were performing, compared with currently used sprays, at the time of application. The weeds were on the larger side of ideal timing, with the majority being at the 6 to 8 leaf stage. The final weed assessment was completed on 7 October using the European Weed Research Council (EWRC) score, 77 days after application.

Disclaimer: Some of the herbicide treatments may be off label and were used for research purposes only. When using herbicides always adhere to label instructions.

RESULTS AND INTERPRETATION

Seed bank: where we ended up

In the wild radish systems trial, the initial seed bank was assessed to have 214 plants/m^2 across the trial site, ranging between 136 and 317 plants/m^2 for the individual treatments. This was due to the sporadic distribution of the weed seeds. Because of the long dormancy of the radish seed, the belief is that not all of the seed bank has been assessed; it is probably higher than 214 plants/m^2.

From the summer rain, 31 per cent of the seed bank germinated, providing an excellent opportunity to decrease the seed bank before the growing season began. This doesn't happen every year: it is important to take these opportunities as they arise.

A double knock with glyphosate, followed by gramoxone, is a good strategy to control any large radish plants that may have survived the initial glyphosate spray, as was seen in the high input treatments (Table 1). From there, subsequent weed counts indicated that another 30 per cent of the seed bank germinated in crop; a total of 61 per cent for the season.

If it is possible to achieve over 60 per cent seed bank germination every year, then seed bank weed numbers should diminish relatively quickly. Unfortunately, this will not be the case every year, because of varying summer rainfall conditions and dormancy of weed seeds. As the number of seeds germinating every year decreases, the impact of weed pressure on grain yield and productivity will diminish. This does not mean that the herbicide strategy can be relaxed: seeds will continue to germinate for six to eight years. It is recommended that growers aim to control 100 per cent of seed set by using multiple cultural, chemical and mechanical practices to eradicate the seed bank and delay resistance development.

Radish in the cereal rotation: control at what cost?

The wild radish systems trial showed that superior control of wild radish was achieved when premier herbicides were added to the standard herbicide regime, however this had no significant impact on yield in year one. Significantly more radish was controlled by herbicides used in Treatments 2 and 4 ('best practice' non-Clearfield and Clearfield wheat treatments) than the other treatments. By including a double knockdown pre sowing, an early in crop (GS13) spray of Jaguar (+ Midas for Treatment 4) followed by a later application (late tillering) of Precept + Lexone, 100% seed set control was achieved. Although Treatment 1 ('commercial practice' non-Clearfield) and Treatment 3 ('standard Clearfield practice') which included only one application of Tigrex and Midas respectively, were still effective, an average six plants/m^2 survived. These are able to set viable seeds at crop maturity (Table 3).

Table 3. Wild radish weed counts completed in systems trial. Estimated seed production was obtained at 120 seeds/m^2 for wheat and 700 seeds/m^2 for harvested peas treatments.

Treatment	Weed count - Feb (plants/m^2)	Weed count - May (plants/m^2)	Final wild radish maturity count (plants/m^2)	Estimated wild radish seeds produced (seeds/m^2)
1	75	70	7.4^{b}	885
2	98	83	0.0^{a}	0
3	76	93	5.9^{b}	713
4	80	55	0.0^{a}	0
5	66	92	17.2^{c}	3820
6	65	43	3.2^{b}	886
7	28	45	0.3^{a}	1
8	40	21	0.2^{a}	1
P value	-	-	**<0.001**	-
LSD			*	
CV%			**48.8**	

*Statistical analysis performed using log transformation, therefore no LSD presented.

All the plants from the February count were controlled with the summer knockdown spray; the plants targeted by the herbicide treatments (Table 3) were from the May counts.

The early application of Jaguar (GS13) achieved a good percentage kill of the radish, especially of the smaller plants (because it is a contact herbicide). Over 90 per cent control was achieved with the first spray, while in the herbicide demonstration trial, a score of 65 was achieved from spraying at late tillering (Figure 1). This result was also found in a wild radish spray timing trial carried out in 2013 (BCG 2013 Season Research Results, pp. 154).

While an early in-crop application of Jaguar achieved a good percentage kill, when followed by Precept + Lexone at mid to late tillering, all plants that survived the first spray pass, as well as any late germinating plants, were controlled. The Precept + Lexone treatment in the demonstration trial obtained the greatest control score of 97.5. No wild radish was observed to germinate after this spray, which could be attributed to the dry spring. In a wet spring, the Lexone component of the herbicide brew provides some residual to hold back subsequent germinations.

The two treatments with unacceptable control were 1 and 3. The Midas applied in Treatment 3 (at GS13) killed 93.7 per cent of the plants, but by the time of crop maturity, 5.9 plants/m^2 were recorded. The plants that survived the spray had stunted growth, but still produced viable seed by the end of the season. This does raise the question, are these plants resistant to Group B?

A similar effect was seen in Treatment 1 ('standard practice' non-Clearfield), cereal. The Tigrex applied at mid to late tillering in this treatment killed 89.4% of the existent wild radish. The late tillering spray timing enabled all of the germinated radish to be targeted, but with no early in-crop spray, some of the radish had grown quite large and were difficult to control. The surviving plants displayed stunted growth, but still some wild radish survived and produced seed, adding to the seed bank. This situation may be contributing to Group F and I tolerant plants.

In the herbicide comparison demonstration (Trial 2), Paradigm™ (a new Group B herbicide from Dow AgroSciences), Eclipse® (Group B) and Brodal® (Group F) achieved only a EWRC score of 10. Group I herbicides did not achieve a score above 40 (Figure 1). Once again, this illustrated that herbicides containing bromoxynill (Group C) and pyrasulfotole (Group H) were the best performers (Figure 1).

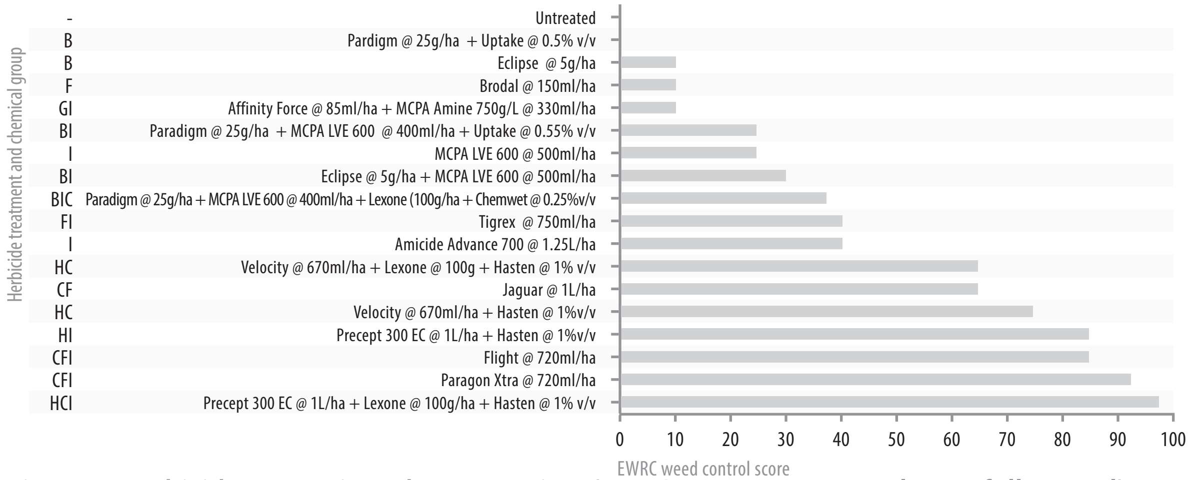

Figure 1. Herbicide comparison demonstration (EWRC score 0=no control, 100=full control).

It is important to remember that this site has suspect developing Group F and I resistance, and confirmed Group B (sulfonylurea) resistance which is why imidazolinone herbicides still worked however Eclipse did not.

It may be thought that in this case, three modes of action (F, C, and I) would be better than one and suggest the use of better products like Flight or Paragon Xtra, however given the suspect developing group F and I resistance this would put further pressure on the remaining group C (bromoxynil) component.

In the pulse rotation, Brodal, (Group F, diflufenican), is a common option for weed management, especially in peas where it is one of the limited options available to tackle wild radish. If in the wheat phase, products like Tigrex (Group F and I), or for that matter Flight or Paragon Xtra (contains 25% of the diflufenican component of Tigrex) become more commonplace, the ability to manage wild radish with diflufenican could become more restricted, and impact on the place of pulses in the rotation.

The trial reiterated that aiming for complete radish eradication, though it does involve a two spray approach, is vital for resistance management and future crop rotation options. If weed escapees are occurring, it is important to rotate your chemical groups to delay the on-set of resistance.

The results of the trials carried out highlighted the messages about Group B, I and F resistance, and the potential impact resistant weeds can have on the productivity and profitability of the paddock. The rise in herbicide resistant wild radish has been attributed to an overuse of Group B products which, in the past, have provided an effective and relatively cheap means of controlling both grass and broadleaf weeds. Continued reliance on these chemicals will eventually lead to full resistance and limited herbicide options.

Break crop rotation: are peas a viable option?

As seen in Table 4, the only acceptable level of weed control was achieved by Treatments 7 and 8 (pea brown manure). The herbicide plans used within Treatments 5 and 6 (break crop rotations) were not sufficiently robust to control wild radish plants to acceptable standards. This can be attributed largely to the non-competitive nature of a pea crop.

In previous BCG trials, the importance of correct spray timing has been highlighted. This was again evident in this trial. When Brodal was applied to peas at the early timing (Treatment 6), as opposed to the later (Treatment 5), significantly fewer radish plants survived and subsequently set seed (Table 2). The earlier Brodal spray timing helped control the smaller plants and reduce the amount of seed set. By the time the pea crop had matured, there was a clear difference between the size of the radish plants in treatments sprayed with Brodal late (larger plants), and those sprayed early. Nevertheless, both field pea treatments which went through to harvest produced unacceptable levels of radish plants which set seed before desiccation could occur.

The non-competitive nature of peas, compared with wheat, was highlighted in the trial, with Treatment 1 (non-Clearfield cereal, 'standard' practice) producing more wild radish plants per square metre than Treatment 6 (Clearfield break crop, 'standard' practice). However, both treatments resulted in the same number of wild radish weed seeds (per/m^2). This finding endorses the superior competitiveness of wheat over peas. On average, wild radish plants in the wheat plots produced 22 seed pods per plant, while radish in the pea plots produced up to 850 seed pods per plant.

The biggest benefit from having peas in the rotation is that they provide a break on brome grass and other grass weeds, which was another aspect investigated in this trial. While peas were used in this case, growers can use other pules or legumes with more success but need to know how those break crops can be integrated into systems reliant on CLF herbicides. It important to challenge yourself by asking: if you cannot grow a break crop due to resistance, how will the rotation look over the next 4-6 years?

Brome grass: Clearfield herbicides still an important part of the program

Brome grass populations were also measured in the wild radish systems trial (Trial 1). In terms of brome grass management by having a Clearfield herbicide program, or peas, in which you could use Verdict or glyphosate for brown manure, it is possible to manage brome grass numbers. The only treatments that had significantly higher brome numbers were the plots that had no in-crop control (Treatments 1 and 2) (Table 5).

Table 5. Brome grass counts completed at crop maturity in Trial 1.

Treatment	Final brome grass count (m^2)
1	2.9^{a}
2	3.3^{a}
3	0.9^{b}
4	0.4^{b}
5	0.6^{b}
6	0.3^{b}
7	0.0^{b}
8	0.0^{b}
P value	<0.001
LSD	*
CV%	93.1

This suggests that group A(fops), B(imidazolinones) and M(glycines) chemistry are still effective at managing the brome grass populations present at the Pira site, however this will continue to be monitored over the next two seasons to see if there is any change.

In this year, the best overall weed control was achieved in the Clearfield wheat when a 'best practice' herbicide regime was applied (Treatments 4) controlling both brome grass and wild radish. Good results were also achieved in the chemical fallow treatments (peas brown manured, Treatments 7 and 8).

Having the best weed control is the desired outcome, but at what cost does it come to the business?

COMMERCIAL PRACTICE

Growers should adopt a 'no survivors' attitude to wild radish and other broadleaf weeds (such as wild turnip and Indian hedge mustard) because one plant can produce thousands of seeds which can germinate up to six or more years later, threatening long term profitability and sustainability.

The best strategies to achieve this are to:

- spray early, using at least a two-spray strategy in cereals
- grow competitive crops
- use a combination of mechanical, cultural and chemical weed control options
- know what herbicide groups have previously been applied and rotate accordingly.

To achieve maximum germination a working or harrowing of the soil may be beneficial to stimulate germinations, however may also place some weeds deeper. A traditional chemical fallow may be cheaper than a brown manure, but may not be as effective in decreasing the seed bank in one year. The brown manure will have an added nitrogen benefit and a break from disease which a conventional fallow would not achieve. This also provides ground cover which will stop erosion occurring across the paddock.

A two spray approach was enough to control the subsequent germinations of radish throughout the year. However, it is important to remember the insufficient spring rainfall of 2014. Currently, the only herbicide options available past GS30 until booting are 2,4-D Amine (Group I), Logran and other Group B options. Group B was not an option at this site because of its resistance status: it is important to hold off using the 2,4-D Amine so that it remains available for late in-crop germinations that may occur in wet springs.

Spray-topping the field pea treatments in this trial would not have been an option to control radish, because much of the radish seed had matured by the time the pea crop reached maturity and was ready to be desiccated. In the brown manure treatments, which had no in-crop sprays, the wild radish had started to produce seed pods by the time of desiccation (24 August). The early Brodal application may control the early wild radish plants (with the larger seed set potential), subsequently the later germinating plants may still need control by spray topping. This will be assessed in the 2015 seed bank data.

It needs to be understood that spraying the late maturing plants is the equivalent of selecting for earlier maturing plants. Consequently, spray-topping crops every year will begin to be ineffective in reducing the seed bank.

If expansive herbicide programs do not suit your system, then it will be important to integrate other cultural and mechanical weed control methods. These may include narrow windrow burning, hay, sheep, chaff carts, Harrington Seed Destructor (HSD) and baling behind the header. New strategies such as leaving the weed seeds in the tram tracks in controlled traffic systems have been used successfully but may increase the spread across the paddock. Hay may be an option to remove some of the weed seeds, but growers should be careful not to spread the resistant weed seeds to another farm or paddock in the bale. They should either cut the crop before the radish starts to set seed or feed the hay into a feed lot. It is advisable to integrate these systems with a robust herbicide program to capture any escapees during the season.

The weed pressure impact on yield was not significant between treatments in the first year of this trial. In Years 2 and 3 we expect to find the Clearfield systems beginning to fail, and Treatment 1 (cereal commercial practice) controlling insufficient weeds, with a resultant increase in the seed bank. Remember, one plant can produce up to 5000 seeds, so assuming on average that only 20 per cent may germinate the following year (this is a lot less that what occurred in the trial this year), there may be 1000 resistant plants next year. As the weed populations are expected to increase, yields will decrease and the best herbicide systems should start to show their value. The two year breaks should run the seed bank down and provide good control on both grasses and broadleaf weeds.

Consider, what impact will this have on the profitability of the business and can this be recovered in the subsequent years?

ON-FARM PROFITABILITY

In 2014, there was no significant difference between the crop yields in this trial. The gross margins were calculated, using an average trial wheat yield of 1.81t/ha at $254/t; pea yields of 1.3t/ha at $280/t; and a hay yield of 2.2t/ha at $200/t. This trial showed that it is possible to control both wild radish and brome grass while still achieving a good gross margin (Figure 2). The only treatments in which wild radish was controlled to acceptable levels were the 'best practice' cereals and brown manured peas (Treatments 2, 4, 7 and 8).

The 'standard' non-Clearfield cereal treatment (Treatment 1) achieved the best gross margin: the wheat yield was not significantly affected by the weed pressure. The expectation is that, in coming years, significant yield penalties will occur with the higher weed pressure.

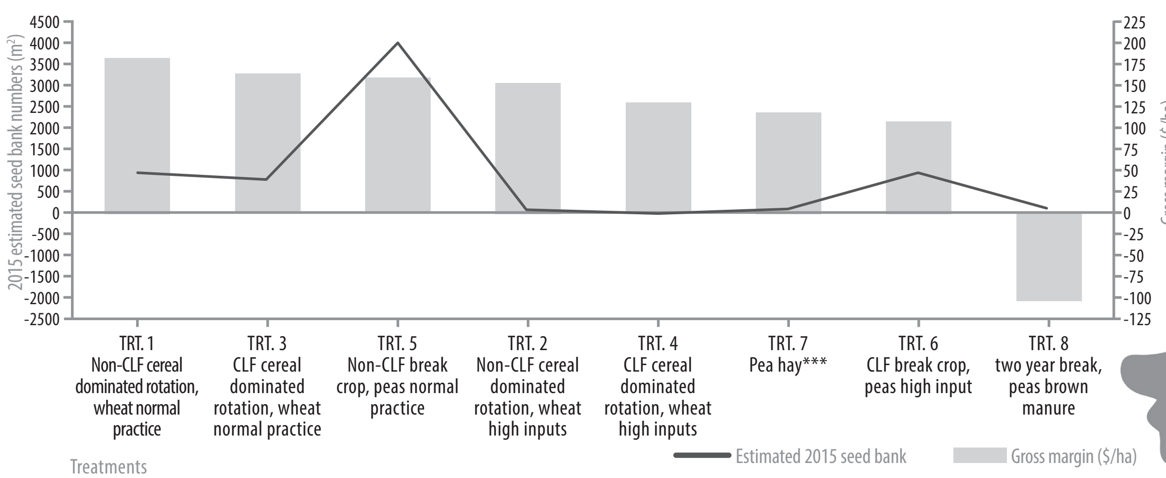

Figure 2. Complete gross margins worked out including all costs (seed, sowing, fertiliser, all sprays, cutting, baling, harvesting, levies, and end point royalties). Both treatment 7 and 8 were brown manured due to machinery restrictions but biomass cuts taken to predict a hay yield.

While the 'best practice' Clearfield wheat treatment (Treatment 4) achieved 100 per cent control of wild radish and good control of brome grass, the high chemical costs ($114.80/ha), before taking into account other production costs, meant that wheat yields above 1.3t/ha were needed to break even for this treatment.

Leading into the season, the Pira site had good summer rains and then received a relativity good break. Given the amount of subsoil moisture, levels of confidence (that a yield of above 1.3t/ha could be achieved) were high. This seemed to justify the decision to apply sufficient inputs to achieve 100 per cent wild radish control. The difference in cost for full control of wild radish and brome grass, as opposed to wild radish control alone, is about $21/ha (Midas at 900g/ha) in the wheat phase.

Including peas in the rotation is a good option in terms of a grass break, but the herbicide options are not sufficiently strong when Group B resistant wild radish is an issue. The highest herbicide cost was required in the high input pea treatment (Treatment 6) at $116/ha, compared with Treatment 4 (Clearfield 'best practice' cereal) at $114/ha. Despite the very high chemical cost, Treatment 4 returned a gross margin and weed control of both wild radish and brome grass that was superior to the other treatments. Treatment 6 produced an unacceptable number of radish seeds and therefore failed to act as a valuable break crop option.

The brown manure treatment (Treatment 8) controlled the wild radish and brome grass well, but may not be an option for some growers, making a loss of $105/ha due to the requirement for a double knock to control all possible survivors.

Pea hay may be an alternative to brown manure. Although not an initial treatment, biomass cuts were taken at the same time that the brown manure treatments were carried out (just before pod formation) and revealed that the peas produced a biomass of 2.2t/ha. With all costs included, the final gross margin if peas had been cut for hay was calculated at $119/ha. In this case, the peas produced a successful break crop that controlled wild radish and brome grass. Added benefits from this option include added nitrogen inputs and increased moisture retention. This decreases the risk of crop failure in the following year and allows for some of the premier wild radish chemicals to be used.

If the farming business is unable to absorb higher input costs, then more attention to populations before they become an issue is imperative. Alternatively, non-chemical options can be used to reduce seed bank. Although the 'standard' wheat treatment (Treatment 1) in this trial had significantly higher numbers of wild radish, there was no significant impact on yield. Potentially, some of the costs saved could be directed towards options to capture and destroy weed seeds at harvest time. The cheapest non-herbicide alternative is narrow windrow burning, but there are other options such as chaff carts, the Harrington Seed Destructor and baling behind the header.

REFERENCES

Taylor C., 2013, 'Fighting the war against weeds: wild radish control in wheat', BCG 2013 Season Research Results, pp. 154 – 160.

ACKNOWLEDGEMENTS

This project was funded by GRDC through its 'Improving IWM practices in the Southern Region – Emerging weeds' project (FR_UA00134).

KEY WORDS

wild radish, resistance, herbicide, rotation, seed bank, weeds