Is integrated management of wild radish effective?

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Key messages

Control of wild radish in crop at stem elongation killed late emerging cohorts.

An average of 97% of wild radish seed pods developed on the plant at a height greater than 30 cm, highlighting the value of capturing wild radish seed for harvest seed destruction.

Due to the continuous emergence of wild radish seedlings throughout the year an effective integrated weed management strategy must include harvest weed seed control and summer weed control, in addition to in-crop herbicides.

Aims

In Australia wild radish is the second most expensive weed to manage, after annual ryegrass (Llewellyn *et al.*, 2016). Recent surveys show that wild radish has become an increasingly severe problem in Western Australia over the last two decades, particularly in the northern and central wheatbelt (Borger *et al.*, 2012). This research investigates the long term impact of an integrated weed management (IWM) program, incorporating chemical and non-chemical control options for wild radish.

Method

The trial ran for 4 years at the Department of Primary Industries and Regional Development (DPIRD) Merredin Research Station. The rotation was lupin in 2013, and then wheat from 2014 to 2017. There was very low wild radish density in this trial between 2013 and 2016. Therefore this paper only reports results from the final year of the trial. All aspects of trial management for 2017 are included in Table 1.

Table 1: The date, operation involved in running the trial and agronomic details.

Date	Operation	Agronomic details
18 Jan 2017	Summer weed control	Tank-mix of Roundup® UltraMAX 2 L/ha (glyphosate) + Garlon® 160 mL/ha (triclopyr) + 2,4-D Ester 500 mL/ha + Hammer® 45 g/ha (carfentrazone-ethyl) + ammonium sulphate 2%.
20 Jan 2017	Sow wild radish	Spread 200 pod segments/m^2, where each pod segment contains one wild radish seed. Wild radish pods were harvested from Merredin Research Station in 2016.
18 May 2017	Knockdown	Either Alliance® 2.5 L/ha (amitrole + paraquat) or Roundup® PowerMAX 1 L/ha + Wetter TX 0.2% (to improve control of annual ryegrass). *See treatment schedule in Table 2.*
18 May 2017	Pre-seeding herbicide	Boxer Gold® 1750 mL/ha (prosulfocarb + s-metolachlor).
23 May 2017	Post-seed pre-emergence herbicide	Boxer Gold® 750 mL/ha.
19 May 2017	Seeding	Mace wheat, using knife points and press wheels, at 50 or 100 kg/ha (*see treatment schedule in Table 2*), in 22cm rows, 3-4cm deep. Fertiliser: AgStar® (N:P:S at 14.3:14:9.6 w/w%) at 100 kg/ha, 3cm below the seed.
23 June 2017	Grass selective herbicide	Axial® 300 mL/ha (pinoxaden + cloquintocet-mexyl) + Adigor 1%, to control 2-3 leaf annual ryegrass. Fertiliser: Nitrogen 60 units. Wheat at Z11-12.
14 Jul 2017	First broadleaf selective herbicide	Either Velocity® 670 mL/ha (bromoxynil + pyrasulfotole) or Triathlon® 1 L/ha (MCPA + bromoxynil + diflufenican). Wheat at Z13-14, wild radish at 2-4 leaf stage. *See treatment schedule in Table 2.*
10 Aug 2017	Second broadleaf selective herbicide	Triathlon® 1 L/ha, wheat at Z30, wild radish at 2 leaf to stem elongation. *See treatment schedule in Table 2.*
7 Dec 2017	Harvest	

The trial investigated the cumulative impact of weed control strategies on wild radish, including knockdown treatments, crop seeding rates and in-crop selective herbicides (Table 2). It was a randomised block design, with four replications (plot size of 3.5 m x 20 m).

Table 2: Treatments included in the trial, including knockdown treatments, crop seeding rate and in-crop selective broadleaf herbicides.

Treatment	Knockdown	Seeding rate	First in-crop (Z13-14)	Second in-crop (Z30)
1	Glyphosate	50 kg/ha	No in-crop herbicide	
2	Glyphosate	50 kg/ha	Triathlon®	
3	Glyphosate	50 kg/ha	Velocity®	
4	Glyphosate	50 kg/ha	Velocity®	Triathlon®
5	Alliance®	50 kg/ha	Velocity®	
6	Alliance®	50 kg/ha		Triathlon®
7	Glyphosate	100 kg/ha	No in-crop herbicide	
8	Glyphosate	100 kg/ha	Triathlon®	
9	Glyphosate	100 kg/ha	Velocity®	
10	Glyphosate	100 kg/ha	Velocity®	Triathlon®
11	Alliance®	100 kg/ha	Velocity®	
12	Alliance®	100 kg/ha		Triathlon®

Crop density was assessed from three 1m rows of crop per plot. Weed density was assessed in two random quadrats (50cm by 50cm) per plot at five times during the season. The dry start to the season and wet spring ensured that a series of small wild radish cohorts emerged over several months, requiring multiple weed density assessments. At each count, wild radish seedlings in a new cohort were distinguished from older plants that had survived the knockdown or in-crop herbicide treatment. Those wild radish plants in the treatments with no in-crop herbicide were removed prior to harvest to assess seed pod production and the number of seed pod segments at different heights on the plant. A single wild radish pod can have multiple segments, with a single seed in each segment. Therefore, number of wild radish seed pod segments was assessed as a direct estimate of seed production. Yield of the entire plot was assessed at harvest, and grain samples were removed to assess clean yield (i.e. determine the percent of screenings, chaff and debris from wild radish plants in the grain). An ANOVA was used to analyse each data set, with significantly different means separated by Lsd (VSN International, 2017). Weather data for Merredin was obtained from the Bureau of Meteorology (2017).

Results

Merredin received a total of 315mm of rain in 2017, similar to the long term average of 326mm (weather station 10092, Bureau of Meteorology, 2017). However, the start of the growing season was unusually dry, with 5, 28 and 5mm of rain in April, May and June (Figure 1). As a result, initial wild radish density was low, and wild radish emerged in small cohorts from May to November. The largest cohort occurred in June, and the second largest cohort in November, in response to high rainfall in late winter and early spring.

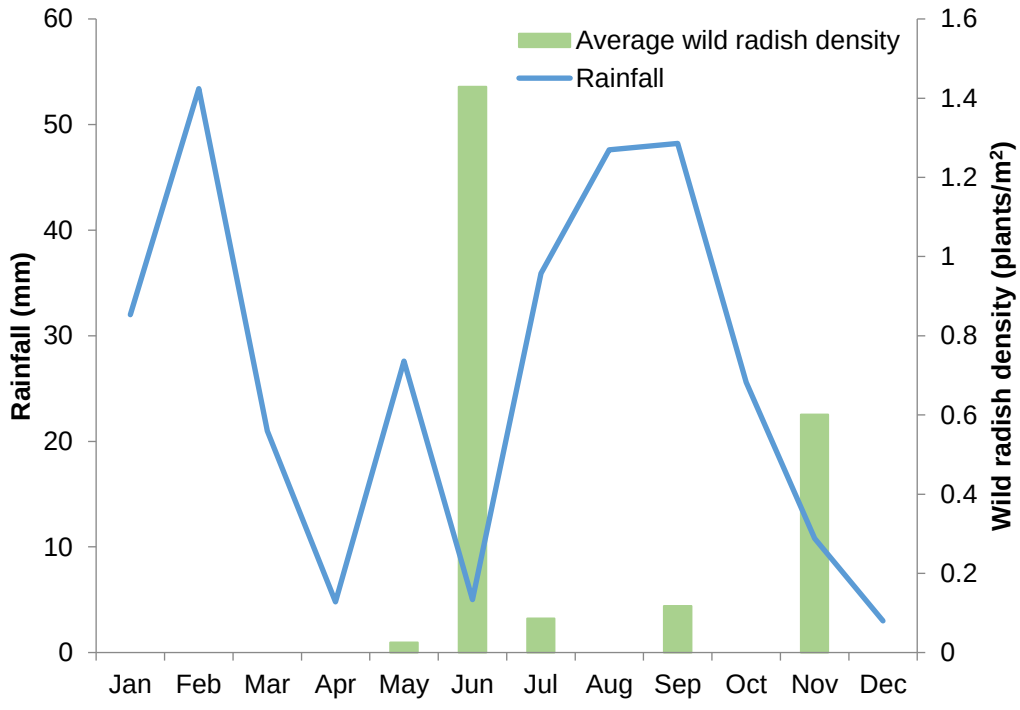

Figure 1: Monthly rainfall at Merredin (weather station 10092, Bureau of Meteorology, 2017), and density of each new wild radish cohort throughout the cropping season (wild radish cohorts were not assessed over December to April).

The 50 kg/ha seeding rate treatments had 200 to 228 plants/m^2, compared to the higher seeding rate treatments with 303 to 363 plants/m^2 (Table 2). Crop density did not have a significant impact on weed density.

Initial wild radish density assessed nine days before seeding was very low (0 to 0.05 plants/m^2), and so all knockdown herbicide treatments killed all weeds (data not presented). However, a later wild radish cohort emerged after seeding prior to the in-crop herbicide application (assessed on 26 June 2017, Figure 1). The first in-crop broadleaf herbicide treatments (Triathlon® or Velocity®) reduced wild radish density compared to the treatments with no in-crop herbicide, with no difference between the two herbicides (Table 2). After the second broadleaf in-crop herbicide treatments (Triathlon®), there were 0 to 0.5 surviving wild radish plants/m^2, compared to 2.4 or 2.5 plants/m^2 in the no in-crop herbicide treatments (Table 2). By harvest, another wild radish cohort had emerged, increasing the final wild radish density (Figure 1). These plants emerged too late to receive a herbicide treatment.

Wheat head number was 32% lower in the 50 kg/ha seeding rate treatments compared to 100 kg/ha treatments (Table 2). None of the other herbicide treatments had an impact on wheat head number. Treatments with no in-crop herbicide (1 and 7) had lower wheat yield, while treatments with two in-crop herbicides (4 and 10) had high yields (Table 2).

Table 2: Wheat density, wild radish density after the first and second in-crop herbicide treatment, wheat head number and clean wheat yield for each treatment, as well as the P value, Lsd and CV values from the analysis. The date of plant assessment is included for each data set.

Treatment	Wheat density (plants/m^2) 23 Jun 2017	Wild radish surviving the first in-crop herbicide (plants/m^2) 20 Jul 2017	Wild radish surviving the second in-crop herbicide (plants/m^2) 7 Sep 2017	Wheat heads (/m^2) 26 Oct 2017	Clean yield (t/ha) 7 Dec 2017
1	206	4.3	2.4	303	1.7
2	224	1.7	0.0	336	1.9
3	200	1.0	0.5	305	1.8
4	228	2.6	0.1	299	1.9
5	207	2.0	0.3	306	1.8
6	222	6.1	0.1	317	1.8
7	345	4.2	2.5	462	1.7
8	363	1.7	0.0	484	2.0
9	303	1.1	0.2	417	1.8
10	333	1.4	0.2	463	2.0
11	333	1.5	0.2	448	1.9
12	347	4.2	0.0	478	1.8
P	<.001	<.001	<.001	<0.001	0.002
Lsd	38.4	0.70	0.16	52.7	0.14
CV	17.2	32.1	35.7	16.9	9.3

The wild radish plants from the plots with no in-crop herbicide (treatments 1 and 7) had an average height of 76 cm. Individual plants had an average of 1563 seed pod segments, which did not shed prior to harvest. Both plant height and seed pod per plant were not affected by crop density. Treatments with no in-crop herbicide (1 and 7) had an average of 2.4 or 2.5 mature plants in crop (Table 2), estimating an average of 3750 to 3890 seed pod segments/m^2 (i.e. wild radish seeds) at harvest. However, the seed pod distribution on plants averaged less than 1 pod segment at 0-15 cm (<1% of pod segments), 44 at 15-30 cm (3%), 254 at 30-40 cm (16%) and 1264 at greater than 45 cm (81%, Figure 2). So 99.9% of the seed pod segments developed on the plants at a height greater than 15 cm and 97% of pod segments developed at a height greater than 30 cm.

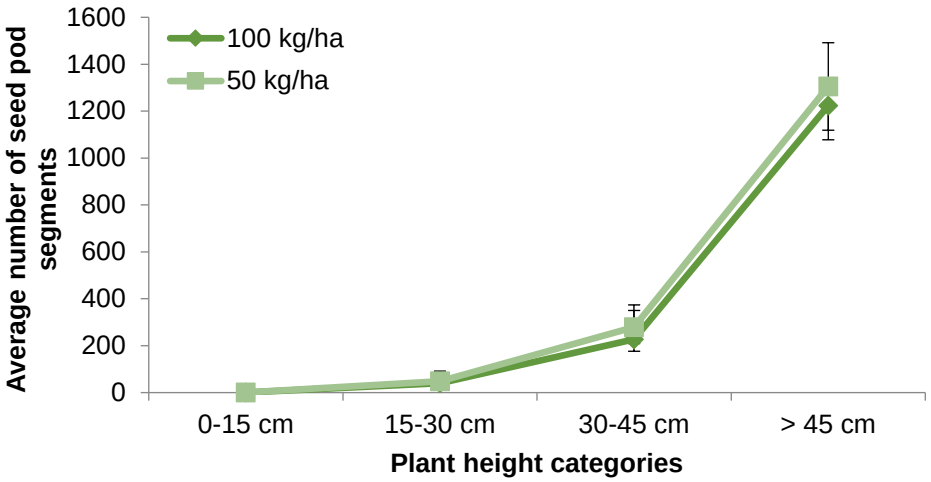

Figure 2: The average number of seed pod segments on wild radish plants, at height increments of 0-15 cm, 15-30 cm, 30-45 cm and greater than 45 cm, taken from crop at a density of 50 or 100 kg/ha. The error bars represent the standard error of 40 replicates.

Conclusion

Excellent weed control was achieved with in-crop herbicides. The late in-crop herbicide offered an excellent opportunity to kill multiple cohorts of wild radish. This trial highlights how multiple wild radish cohorts can establish in a year, and a successful wild radish management program must control plants throughout the year.

At this site in this season it would be easy to collect and destroy wild radish seed through harvest weed seed destruction, since most seed pods developed at a height greater than 30 cm. Prior research indicates that wild radish plants retain 99% of seed at harvest (Walsh & Powles, 2014). In this trial, pods were retained prior to harvest, but the spring was unusually wet (Bureau of Meteorology, 2017). In some seasons, particularly in a dry spring, seed pods may develop at a lower height and shed prior to harvest. The wild radish that emerged in late November would not set seed until after harvest, and would need a post-harvest herbicide to prevent seed set. This plasticity is the reason wild radish is one of Western Australia's most common winter and summer weeds (Llewellyn *et al.*, 2016; Borger *et al.*, 2018).

Key words

Integrated weed management, crop competition, cultivation, knockdown, Velocity®, Triathlon®.

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