Weed trimming – a successful non-chemical seed bank reduction technique

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Summary Blanket wiping or crop topping at crop maturity are often performed to reduce weed seed set but off-label issues and herbicide resistance are a problem. Although swathing is a physical way of preventing weed seed set in some crops such as canola, the limitation of this practice is many weed seeds would mature before swathing is done and mature seeds are likely to shed. Weed seed shedding, with or without swathing, is a serious limitation of weed seed collection systems, such as chaff carts, at harvest. One way to alleviate this problem is to remove the weed seeds at the flowering stage before seeds are mature. In 2005, Indian hedge mustard seed set was reduced by 35% in chickpeas by trimming weeds above the crop. In 2006, wild oat seed and volunteer wheat seed in the harvested chickpea seed was reduced by 20% and 85% respectively. Trimming reduced the wild radish seed number in the harvested lupin grain by 30% at Wongan Hills in 2008. Trimming lupins at Wongan Hills in 2009 reduced wild radish in-field seed number returned to the soil to 11% of the untreated control. Trimming plus glyphosate was the most effective treatment in reducing the in-field wild radish seed production to 4.6% of the untreated control.

Keywords Lupins, chickpeas, annual ryegrass, weed control, herbicide resistance, organic agriculture, weed trimming, weed seed set, wild radish, wild oats.

INTRODUCTION

Pulse crops such as lupins (*Lupinus angustifolius* L.) and chickpeas (*Cicer arietinum* L.) are considered a break crop from cereals in Western Australia (WA) so that diseases of cereals can be reduced. Weed control in pulse crops is a problem as these crops are less competitive than cereals against weeds (French and Maiolo 2006). Selective spraying at the flowering stage of weeds, blanket wiping or crop topping at crop maturity are often performed to reduce weed seed set in WA (Hashem 2000, Cheam and Lee 2006). These practices not only promote use of off-label herbicides but also involve increased frequency of herbicide applications that may contribute to the development of herbicide resistance. Success of swathing is also limited by seeds maturing, in many weeds, prior to application. Weed seed shedding, with or without swathing, is a serious limitation of weed seed collection systems, such as chaff carts, at harvest. One way to reduce this problem is to remove the weed seeds at the flowering stage.

Johnson and Hultgreen (2002) and Hultgreen *et al.* (2003) called weed trimming 'weed clipping', and showed that this removed 90% of the immature weed seed heads and flowers above the crop canopy using a modified swather and swather/flail system. Their long term results indicated a reduced weed seed bank, cleaner crops, reduced weed dockage and a potential for increased crop yields.

A swather or harvester that can be raised above crop canopy may be used to trim or cut the seed heads of weeds with minimum damage to crops in a tramline farming system where the harvester wheels run on permanent tramlines. Weed seed head removal by hand trimming late in the 2004 season at Merredin showed that 79% of the wild radish (*Raphanus raphanistrum* L.) pods were above the lupin canopy (S.M. Pathan, Department of Agriculture and Food, Western Australia, unpublished data).

The aim of this paper was to investigate chemical and non-chemical (weed seed head trimming) methods to reduce weed seed set in lupins and chickpeas.

MATERIALS AND METHODS

Experiments were conducted in 2005 and 2006 at Merredin (31°29'S, 118°14'E), and 2006, 2008 and 2009 at Wongan Hills (30°51'S, 16°42'E). In Merredin an 11 m wide Case 1040 harvester belt front was converted to swathing on a Case 2366 harvester (Figure 1). At Wongan Hills a 5 m wide Power Take Off (PTO) MacDon Prairemac™ tractor-drawn swather was used (Figure 2).

All experiments followed a randomised block design, where treatments were applied to plots within each of four replicate blocks. Plots were 12 × 20 m at Merredin and 7 × 20 m at Wongan Hills. Grain yield was measured outside of the wheel track area.

The 2005 and 2006 treatments were: (1) Untreated, (2) Trimming weed heads at the maximum flowering stage of the weeds, (3) Trimming at the late flowering stage and (4) Trimming both at the maximum and late flowering stage of weeds.

Figure 1. The harvester front used to trim wild radish and wild oats above a chickpea crop at Merredin in 2006.

Figure 2. Prairiemac swather used for weed trimming at Wongan Hills in 2006, 2008 and 2009.

There were no crop topping herbicides registered for wild radish control so the following treatments were tried in 2008 and 2009: (1) Untreated, (2) Trimming at the latest stage of the weed seed development, (3) Trimming plus 1 L ha^{-1} glyphosate, (4) Trimming plus 800 mL ha^{-1} paraquat and (5) Crop topping with 800 mL ha^{-1} paraquat.

In 2006 the wild radish seed in the trimmed material was tested for viability, which was determined as a percentage of normal seedlings in a growth cabinet at 20°C for 7 days on moist blotter paper.

The shed wild radish pod number was measured just before harvest using three quadrats (0.2 × 0.2 m) per plot and there was, on average, 8.0 seeds per pod. The harvested grain sample was weighed and split eight times using a two way 18 slot splitter (13.6 mm wide slots) and wild radish seed number counted in the reduced sample.

All analysis of variance (AOV) statistics were done using GENSTAT V11.1.0.1504 and least significant differences (LSDs) were at the 5% level.

RESULTS

Lupins Weed seeds collected on 14 September 2005 from the weed seed cut at the early flowering stage of weeds at Merredin showed no viability of wild oats (*Avena fatua* L.) or wild radish when tested after a 12 month dormancy break period. The weed seeds cut at the late flowering stage of weeds (5 October) showed no viable wild radish seed, but up to 40% of the wild oat seed was viable. The lupin yield was reduced by the trimming techniques (Table 1).

Table 1. Lupin grain yield (t ha^{-1}) as affected by time of weed seed head trimming at two stages of weeds at Merredin (MD) and Wongan Hills (WH) in 2005 and 2006.

Treatment	2005 MD	2006 MD	2006 WH
1. Untreated	0.948 a[A]	1.63 a	0.553 a
2. Max flower	0.842 ab	1.72 a	0.556 a
3. Late flower	0.817 ab	1.72 a	0.741 a
4. Max and Late	0.718 b	1.80 a	0.621 a
LSD (P<0.05)	0.131	n.s.	n.s.
P-value	0.022	0.267	0.377
CV (%)	9.8	6.0	26.2

[A] Values with the same letter in a column are not significantly different (P <0.05).

The wild radish seed number collected in the harvested grain showed no treatment effect, which was probably due to the variation in density and patchiness of the wild radish plants above the crop canopy.

In 2006, the cut height was better controlled just above the lupin canopy and the lupin grain yield was not affected by trimming (maximum flowering 20 Sept, late flowering 13 Oct) at Merredin (Table 1).

The wild radish and wild oats seed collected in the harvested grain was used as an indication of the effectiveness of the trimming treatments, but the untreated treatment had shed most of the seeds before harvest. All trimming treatments appeared to reduce the weed seed numbers by about half compared to the untreated at Merredin in 2006.

At Wongan Hills in 2006, the wild radish density was high and variable across the site. The lupin yields were similar for all treatments (max flower 25 Sept, late flower 6 Oct) and there appeared no treatment effect on the wild radish seed number collected in the harvested grain (Table 1).

In 2008 at Wongan Hills the radish density was very high, which caused the lupin yield to be relatively low with no significant differences between any treatments (Table 2).

Table 2. Machine harvested lupin yield and radish seed in the harvested sample at Wongan Hills in 2008.

Treatment	Lupin yield (t ha^{-1})	Radish in lupin seed (seeds m^{-2})	Log_{10} radish (seeds m^{-2})
1.Untreated	0.97	969	2.95 a[A]
2.Trim	1.09	677	2.81 ab
3.Trim + glyphosate	0.98	226	2.32 cd
4.Trim + paraquat	0.96	158	2.18 d
5.Crop top paraquat	0.90	303	2.45 c
P-value	0.63	<0.001	<0.001
LSD P <0.05	n.s.	324	0.18
CV%	22.0	43.4	4.8

[A] Values with the same letter in a column are not significantly different (P <0.05).

There was unusually high rainfall in Sept–Oct 2008 (47 mm more than normal) so the radish regrew very well after trimming. The wild radish seed collected in the grain sample showed the trimming was not effective but trimming followed by glyphosate or paraquat reduced seed numbers by an average of five times from the untreated control. The trimming followed by paraquat reduced the in-grain wild radish seed number by 48% over just paraquat alone although the shed seed was not measured.

At Wongan Hills in 2009 the lupins were relatively thick and the wild radish tended to grow tall and thin with most wild radish pods above the crop canopy. The trimming timing appeared to be optimal as few wild radish seeds had embryos developed. The lupin yield was low and there was no significant difference between treatments (Table 3).

The trim plus glyphosate treatment in 2009 produced the lowest wild radish seed in the harvested grain and on the ground (Table 3). Crop topping with paraquat produced a large amount of shed seed, which may be the reason this treatment has been ineffective in the past as a wild radish control technique. Trimming plus paraquat tended to be not as effective as trimming plus glyphosate. Trimming alone reduced the shed or remaining in-field wild radish seed number to around 11% of the untreated control. This may be a viable option for organic growers, although the harvested grain would have to be cleaned of radish seed immediately to avoid lupin seed germination problems, which is an added cost. However, the most effective treatment was trimming plus glyphosate, which reduced the shed or remaining in-field wild radish seed number to 4.6% of the untreated control. The wild radish seed collected from the trimming and in the harvested grain samples are still to be assessed for viability.

Chickpea In 2005 at Merredin, the chickpea yield was generally low regardless of treatments due to frost damage. One trimming at either stage produced statistically similar yields to the untreated control. Two trimmings reduced chickpea yields in 2005 compared with the untreated control probably due to poor cut height control (Table 4). The numbers of Indian hedge mustard (*Sisymbrium orientale* L.) seeds collected in the harvest samples were significantly reduced in all trimming treatments (Table 4).

In 2006 the chickpea site at Merredin had a range of weeds, such as wild oats, wild radish and wheat (*Triticum aestivum* L.). The chickpea yield was not affected by the weed seed trimming treatments, which was probably due to better setting of the cutting height

Table 3. Effect of trimming treatments on the grain yield and wild radish seed production of lupin at Wongan Hills in 2009.

Treatment	Lupin yield (kg ha^{-1})	Wild radish in harvested grain (seeds m^{-2})	Wild radish shed (seeds m^{-2})	Total radish seed production (seeds m^{-2})
1. Untreated	213	1750	6580	8330
2. Trim only	310	2380	750	3130
3. Trim + glyphosate	282	290	300	590
4. Trim + paraquat	403	1060	420	1480
5. Crop top paraquat	325	680	3200	3880
LSD (P <0.05)	n.s.	550	1280	1470
P-value	0.099	<0.001	<0.001	<0.001
CV %	28.2	28.8	37.1	27.4

using the height indicator on the harvester and travelling in the direction of sowing (Table 5).

The numbers of wild oat seeds in the harvested grain were also significantly reduced by trimming at the late flowering stage although most of the wild oat seeds had shed before harvest (Table 5).

Table 4. Effect of weed seed head trimming on chickpea grain yield and weed seed number in the harvested grain at Merredin in 2005.

Treatment	Chickpea yield ($t\ ha^{-1}$)	Indian hedge mustard (seeds m^{-2})
1. Untreated	0.422 a[A]	223 a
2. Max flower	0.467 a	145 b
3. Late flower	0.486 a	154 b
4. Max and Late	0.347 b	137 b
LSD (P <0.05)	0.064	40.5
P-value	0.005	0.007
CV (%)	9.2	14.2

[A] Values with the same letter in a column are not significantly different (P <0.05).

Table 5. Effect of weed seed trimming on chickpea grain yield and weed seed numbers in the harvested grain at Merredin in 2006.

Treatment	Chickpea yield ($t\ ha^{-1}$)	Wild oats (seeds m^{-2})	Volunteer wheat (seeds m^{-2})
1.Untreated	0.523 a[A]	1.30 a	0.85 a
2.Max flower	0.472 a	1.04 a	0.12 b
3.Late flower	0.455 a	0.03 b	0.02 b
4.Max and Late	0.466 a	0.19 b	0.00 b
LSD (P <0.05)	n.s.	0.63	0.325
P-value	0.685	0.066	0.024
CV (%)	17.6	71.5	101.2

[A] Values with the same letter are not significantly different (P <0.05).

DISCUSSION

Weed seed head trimming prior to weed seed maturity could be a useful tool in reducing the number of weed seeds set if the weed seeds are above the crop canopy and the cutting height is controlled in a tramline farming system.

Trimming is most effective when the weed seed is well above the crop. A dense crop forces wild radish above the crop probably due to etiolation, and the seed head could be safely trimmed. Trimming plus glyphosate was very effective on wild radish in lupins.

The lupin yield in 2006 may have been reduced due to the cutting height being set too close to the top of the crop and two cuts reduced the yield even further.

If wild oats are the main weed in a chickpea crop, perhaps one cut at late flowering stage would be useful and an early harvest may capture more wild oat seeds.

The cost of contract trimming would be similar to swathing, which is around $25 per hectare and this is also similar to one selective herbicide spray.

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