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Contents

This publication discusses the effect on weed management of the inclusion of break crops (lupin, field pea, chickpea, faba bean, lentil and canola) in the cropping rotation compared to a rotation of continuous cereals.

Including break crops in the cropping rotation allows weed management options unavailable or not suited in wheat. For example, growing field peas allows crop-topping/ desiccation for weed seed set control, crop topping cannot be used in wheat without severe yield loss. Problem weeds can be targeted through break crops, for example, grass weeds are generally more easily controlled in break crops than in cereals. Most weed management benefits attributed to break crops depend upon a well grown and well managed break crop.

Using break crops to manage herbicide resistance

Break crops in cropping rotations allow several integrated weed management procedures to reduce the onset of herbicide resistance. These include:

- using herbicides with different modes of action (MOA) (Table 1). Weeds resistant to one herbicide MOA group can be controlled by herbicides belonging to another MOA group.
- combining/changing herbicide MOA groups and non herbicide tactics to reduce selection pressure.
- implementing non herbicide tactics, for example, delayed sowing, wide row cropping (Table 8).

Table 1 Options for herbicide MOA groups in break crops for pre and post-emergent and crop-topping applications

Herbicide group	Wheat	Canola	Lupin	Field pea	Chickpea
A	Y	Y	Y	Y	Y
B	Y	Y*	Y	Y	Y
C	Y	Y*	Y	Y	Y
D	Y	Y	Y	Y	Y
E	Y	Y	Y	Y	Y
F	Y		Y	Y	Y
G	Y	Y			
I	Y				
K	Y	Y			
L			Y		
M		Y*			
N					

Y herbicides with this MOA are available for this break crop

Y* is only for certain varieties, for example, triazine tolerant (TT) varieties, imidazolinone tolerant (IT) varieties, Roundup Ready varieties.

Table 2 Herbicide options for target weeds in break crops

	Canola^		Lupin		Field pea		Chickpea	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Broad-leafed weeds								
Capeweed	√	√	√	S	√	√	√	√
Doublegee	√	√*	WA only		√	√	√	
Fumitory	√	√*	√	X	√	√	√	√
Milk thistle	S	X	X	X	√	√	√	√
Vetch	K	√	K	X	K	X	K	X
Wild radish	√	√	√	√	√	√	√	S
Wild mustard	√	√	√	√	√	√	√	X
Wild turnip	√	√	√	√	√	√	√	√
Wireweed	X	√*	√	S	√	√	√	X
Grasses								
Annual ryegrass	S	√	√	√	√	√	√	√
Brome grass	S	√	S	√	X	√	S	√
Silver grass	√	S	K	S	S	S	S	S
Wild oats	S	√	√	√	√	√	√	√

pre = pre-emergent or post sowing/pre-emergent application timing
post = post-emergent application timing
√ = one or more herbicides registered for use in most states
X = no herbicide registered for use
S = one or more herbicides registered for weed suppression in most states
K = one or more pre-sowing non-selective knockdowns registered in most states
* = registered in IT canola only
^ = herbicides noted for IT and TT canola. All weeds listed can be killed by Roundup pre/post in RR canola

Break crop tactics for weed management

The implementation and / or effectiveness of particular weed management tactics is determined by crop choice. For example, sowing field pea allows the weed management tactics of delayed sowing, swathing and crop-topping to be employed.

Delayed sowing

Delayed sowing as a weed management tool is best used in seasons with an early 'break' and soil moisture levels which will allow a 'later' sowing. Delayed sowing may benefit weed management in two ways:

1. to increase the effectiveness of any knockdown herbicides used. Most of the weed seed bank has germinated and emerged before the application of any knockdown herbicides.
2. to improve the efficacy of any soil active residual herbicides which have been applied 'later' to moist soils.

Consequently, delayed sowing has a long term impact on herbicide resistance with the reduction in weed seed bank numbers and the reduced reliance on selective in crop herbicides.

Weeds effectively controlled by delayed sowing include:

- Annual ryegrass: nearly 80 per cent of the annual ryegrass seedbank emerges after approximately 20 mm of rainfall.
- Barley grass has low levels of hard seed. Over 99 per cent of seeds germinate in the first year after seed set with most of the seed germinating on the autumn break with little further significant germinations during the year.

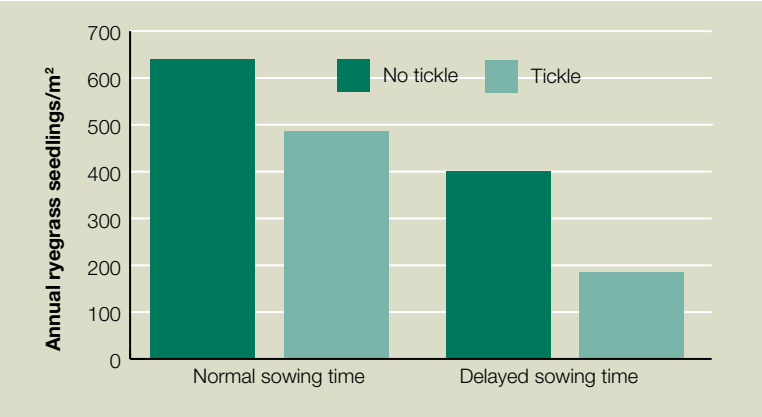

Figure 1 Delayed sowing compared to normal sowing time and the impact of autumn tickle (with follow-up knockdown herbicides used prior to sowing) on annual ryegrass seedling numbers in crop three weeks after sowing, Wongan Hills (Hashem et al. 1998)

- Great brome (*Bromus diandrus*) and rigid brome (*Bromus rigidus*) are both completely dormant at seed set but by the end of summer, seeds move out of their dormant phase and many germinate with the autumn break. The release from dormancy in great brome is rapid and almost all of the seed will germinate shortly after the break of the season. The release from dormancy is much slower in rigid brome and there are late-emerging seedlings. Seed germination of rigid brome is also inhibited by light (not seen in great brome) so an autumn tickle to bury seed is required.
- Wild radish emerging at the beginning of the season produces greater numbers of seed, with greater dormancy than second or third cohorts of emerging radish.

Table 3 Delaying sowing by three weeks reduces the number of ryegrass seeds produced in field pea, barley and wheat crops. (Matthews and Powles 1996)

	Annual ryegrass plants or seeds/m²			
Crop species	Normal sowing		Delayed sowing	
	Plants	Seeds produced	Plants	Seeds produced
Field pea	234	15 995	104	12 011
Barley	367	2240	152	1060
Wheat	419	5557	237	5791

Table 4 Yield penalty (kg/ha/day) with seeding delay of wheat (Anderson and Garlinge 2000)

Location	Optimum time to sow	Flowering window	Yield penalty (kg/ha/day)
North East Mullewa—Merredin	15/5–7/6	25/8–15/9	35
Central Three Springs—Quairading	25/4–15/5	7/9–27/9	25
South Katanning—Varley	7/5–7/6	15/9–5/10	25
South Coast Welstead—Esperance	7/5–7/6	3/9–2/10	17

Table 5 Indicative yield penalty for delayed seeding of lupin (kg/ha/day)

Location	Plant type	Sowing date range	Yield penalty (kg/ha/day)
Wongan Hills	Long season, high yield potential	12 May to 6 June	20–25
Mingenew	Early season, high yield potential	22 May to 25 June	19

While delayed sowing may improve weed control, the penalty is yield reduction. The average rate of yield decline for all crops is greater in low rainfall areas (less than 325 mm) than high rainfall areas (greater than 450 mm).

Generally, as a weed management tactic, delayed sowing is only applicable to the medium and higher (longer growing seasons) rainfall areas. Delayed sowing in the Northern Agriculture Region and low rainfall zones is generally not a viable option due to the high likelihood of missing a sowing opportunity and high rates of yield loss when sowing is delayed in this environment.

Break crops are ideally suited to delayed sowing due to the following factors.

- The potential yield of break crops is less than the potential yield of wheat. Shorter season break crop varieties are available such as Mandelup lupin and PBA Twilight field pea.
- Early sowing promotes many break crop diseases. Consequently, delayed sowing is practised to reduce disease severity, particularly in field pea and chickpea.
- Machinery, labour and time constraints dictate a beginning and an end of sowing programs.

Autumn tickle

Autumn tickle is a shallow cultivation which stimulates weed seed germination by placing the seed in a better physical position in the soil. An autumn tickle is generally associated with delayed sowing as weed seed germination requires adequate moisture levels in the soil. From a weed management perspective, to gain the greatest reduction in weed density, delayed sowing should always be used in conjunction with autumn tickle.

Table 6 Effect of autumn tickle on wild radish soil seed reserves in Western Australia (Cheam et al. 1998)

Treatment	Wild radish seedling emergence per m^2 (pre-sowing)	Wild radish density per m^2 (post-sowing)
with Autumn tickle	160	66
without Autumn tickle	2.5	201

Table 7 Effect of autumn tickle on annual ryegrass seedbank at Wongan Hills and Merredin, Western Australia (Hashem et al. 1998)

Treatment	Depletion of annual ryegrass seedbank before sowing (%)	
	Wongan Hills—Wet	Merredin—Dry
with Autumn tickle	63	51
without autumn tickle	31	1

Wide row cropping

Research on the impact of row size on chickpea, faba bean and lupin yield has found little or no yield reduction when using wide rows (crop rows 50 cm and wider). Wide row cropping allows shielded spraying, in which shields are used to protect the crop rows while weeds in the inter-row are sprayed with a non-selective herbicide. If using recommended non-selective herbicide at the correct rate for the size of weed one can assume 90 to 95 per cent of

all weeds entering the shield and sprayed by the herbicide will be killed.

Crop-topping

Crop-topping is the use of a non-selective knockdown herbicide when the crop is nearing maturity before the majority of weed seeds have reached full viability. Crop-topping aims to prevent seed set of surviving in-crop weeds, to produce a lower weed burden in the following crop. This strategy is particularly useful for reducing ryegrass and wild radish seed numbers.

With this strategy there is often a slight yield penalty to the crop. Timing is critical to the success of crop-topping. Spraying too early will reduce the crop's yield potential, and spraying too late will have little effect on weed seeds. It is important to understand the correct timing for your particular situation as timings differ between crops and between paddocks within crops.

The early maturity of field peas makes them ideally suited to crop-topping. When field pea seeds reach 30 per cent moisture, or when the lower 75 per cent of the pods are brown, with firm seeds and leathery pods, crop-topping will not reduce crop yield greatly. In lupin the corresponding timing is at the 80 per cent leaf drop stage.

At the correct timing crop-topping is likely to reduce 75 per cent of annual ryegrass and 45 per cent of wild radish seed set. The range for the control of ryegrass seed set is 50–95 per cent; for wild radish the range is 15–85 per cent.

Diquat 200 g/L (Reglone®) and paraquat 250 g/L (Gramoxone®) are registered for crop-topping use in canola, lupin and field pea.

Swathing

Swathing is mechanically cutting a crop and bringing the cut material together into a row when it has reached physiological maturity. Swathing is a viable option for break crops, particularly canola and field pea. Some general benefits of swathing include improved quality of harvested grain, reduced harvest losses, and an increase in time available to harvest the swathed crop.

Swathing is also another agronomy procedure which can reduce seed set of annual ryegrass and wild radish, particularly when coupled with a desiccant spray immediately after swathing (at present there are no herbicides registered for this use and timing). Used at the correct timing swathing likely to reduce wild radish and annual ryegrass seed set by 35 per cent (range 15–60 per cent). Another influence of swathing is to concentrate all cut material, including weed seeds, into more defined rows which subsequently allows the burning of the windrows.

Windrow burning

Break crops, because of their low residual biomass relative to wheat, are ideally suited to windrow burning of weed seed. Burning is carried out during the cooler months of March and April. It involves burning the concentrated trash windrows left by the harvester. In the case of narrow header trails the residue exiting the harvester is concentrated by a chute at the rear of the header. The chute has no moving parts and can be quickly attached or removed depending on crop type. Weed seed exiting the harvester in the chaff is dropped into a windrow rather than distributed across the paddock. Reductions of up to 98 per cent annual ryegrass and 75 per cent wild radish weed seed numbers have been measured (Newman and Walsh 2005).

Hay cutting

Hay cutting, conducted earlier than swathing and crop topping, has a large impact on weed seed numbers. Timing of cutting often stops seed development as the plant and any early developed seed are removed from the paddock in the hay. However, in many cases it requires a follow up application of glyphosate to kill the weed when it re-shoots.

Table 8 Procedures to reduce weed seed set in break crops

	Crop-topping	Swathing	Windrow burning	Hay cutting	Chaff cart / Harrington Seed Destructor
Canola	√	√	√	√	√
Brassica juncea	√	√	√	√	√
Faba bean	X	√	√	√	√
Chickpea – Desi	Paddock salvage only, yield loss too great	Paddock salvage only, yield loss too great	√	X	√
Chickpea – Kabuli	Salvage only, yield loss great	Salvage only, yield loss great	√	X	√
Lentil	√	√	√	√	√
Lupin – Narrow-leafed	√	√	√	√	√
Lupin – Albus	X	√?	√		√
Field pea	√	√	√	√	√
Vetch	√	√	√	√	√

Crop competitiveness

The impact of weeds on crop yield can be reduced and the effectiveness of weed control tactics increased by improving crop competition. The relative competitive ability of crops can be ranked as:

Oats > Barley > Wheat > Canola> Field pea > Faba bean > Lupin = Chickpea > Lentil

Oats have the greatest competitive advantage with lupin; chickpea and lentil have the least competitive advantage.

Sowing time seeding rate and row spacing impact on the competitive abilities of break crops. The speed at which the canopy of the crop develops influences its ability to compete. Early sowing, greater seeding rate and narrower row spacing all contribute to a more competitive crop.

Early crop vigour, canopy development and biomass production are all influenced by sowing time. Sowing late in the sowing window reduces early vigour, prolongs canopy development and reduces biomass, thus reducing the ability of these crops to compete with weeds.

Seeding rate directly influences the number of plants competing with weeds. Higher seeding rates provide greater numbers of crop plants to compete for resources of moisture, nutrients and light.

Case studies

Break crop integration reduces ryegrass numbers

by Rod Birch, Coorow—lupin:wheat:canola:wheat rotation

In the 1990s when we were no longer able to control ryegrass in the paddocks, we decided to take an aggressive approach. We found that a lupin:wheat:canola:wheat rotation was good for ryegrass control because it enabled us to use different weed management tools each year. In the wheat rotation we used high seeding rates combined with trifluralin. We swathed canola and often crop-topped lupin to stop ryegrass setting seed. We burned the header windrows of all our crops. Using these tactics we have driven ryegrass numbers from

Table 9 Crop choice options to aid weed management

Crop	Competitive ability	Relative sowing time	Relative maturity	Available herbicide options	Problem weeds	Target weeds	Suitable weed management tactics (other than pre- and post-emergent herbicide application)	Agronomy to enhance weed management
Wheat Quick maturing; short season varieties	Medium	Mid to Late	Early	Many	Multiple resistant annual ryegrass Barley	Broad-leafed weeds, wild oats, annual ryegrass	• Autumn tickle • Burn residues • Delayed sowing • Double knock windrowing	Improved fertiliser placement High sowing rate Narrow row spacing
Canola IT tolerant varieties	Medium	Early	Early	Many for grass. Several for broad-leafed.	Group B resistant brassicas	Grass weeds (brome grass) Groups A and M resistant grass weeds imi susceptible broad-leafed weeds	• Burn residues (not on sandy soils) • Crop desiccation • Seed catching • Windrow/burn residues • Winter clean pastures in previous year	Variety choice Improved fertiliser placement Direct drill using a full cut sowing system following a germination event and the use of a knockdown
Canola conventional varieties	Medium	Early	Early	Several for grass. Limited for broad-leafed.	Group A resistant grasses; brassicas (e.g. wild radish, wild mustards, wild turnip) Fumitory Black bindweed	Grass weeds	• Autumn tickle • Burn residues(not sandy soils) • Crop desiccation • Seed catching • Windrow/burn residues • Winter clean grasses in previous year	Variety choice Improved fertiliser placement Direct drill
Canola TT tolerant varieties	Medium	Early	Early	Many for grass. Several for broad-leafed.	Triazine resistant brassicas	Grass weeds Triazine-susceptible broad-leafed weeds Fumitory	• Autumn tickle • Burn residues (not sandy soils) • Crop desiccation • Seed catching • Windrow/burn residues	Variety choice Improved fertiliser placement
Canola Roundup Ready varieties	As for conventional canola; better than TT	Early	Early	As for conventional canola plus glyphosate	Conventional glyphosate-resistant ryegrass	All weeds including difficult-to-control species and perennials	Control surviving ryegrass to reduce the risk of developing resistance	Reduce losses due to diseases and insects because seed is expensive and low sowing rates are often used.
Lupin	Poor	Early Mid to Late	Late Early	Many for grass. Many for broad-leafed.	Sandplain (blue) lupin	Vulpia spp.	• Residual herbicides • Crop desiccation • Crop-topping • Windrow/burn residues	Variety choice Improved fertiliser placement High sowing rate
Field pea	Medium	Late	Early	Many for grass. Several for broad-leafed.	Fumitory Vetch Wireweed Marshmallow	Grasses	• Autumn tickle • Burn residues(not sandy soils) • Delayed sowing • Double knockdown • Crop desiccation • Seed catching • Windrow/burn residues	Variety choice Improved fertiliser placement High sowing rate
Chickpea	Poor	Mid to Late	Late	Many for grass. Limited for broad-leafed.	Fumitory Black bindweed Wireweed Vetch	None	• Burn residues (not sandy soils) • Double knockdown • Seed catching • Wide row – shielded spraying or band spraying • Windrow/burn residues	Variety choice Improved fertiliser placement High sowing rate

above 300 plants/m^2 down to a few plants/m^2. With future innovations such as the Harrington Seed Destructor, I am confident that we can continue to crop a high percentage of this farm.

Using break crops and multiple measures to reduce ryegrass numbers

by the Obst Family, North Mingenew—lupin:canola:wheat:lupin:wheat rotation

In 1999 ryegrass numbers blew out when grass selective herbicides failed. By 2001, numbers were still around 450 plants/m^2 in the lupin crop but herbicides, crop-topping and the use of a chaff cart helped bring numbers down. By dropping the paddock out for only one year and using a range of weed control measures in subsequent crops, we successfully controlled the ryegrass. We no longer use a chaff cart but are able to keep weed numbers at low levels through other measures such as swathing canola and crop-topping lupin.

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