Adding value through pasture and fodder break crops – is the current break crop broken?

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Key messages

- Rotations are complex and depend on preference, the problem and opportunities- there is no 'right way'.
- The break species can be selected for multiple benefits including grazing value, fodder conservation, nitrogen fixation and improving soil conditions.
- If weeds are the problem, focus on targeting the weeds that come late in the season, these are the ones getting through in a continuous crop rotation.
- Weeds can be reduced by up to 90% in two years by stopping weed seed set through fodder removal, whilst providing ample fodder.

Background

Identifying suitable break crop rotations is becoming a major challenge for farmers and advisors in Southern Victoria. Canola has traditionally been the main break crop used, but the high input costs, establishment challenges, susceptibility to frost and dry finishes makes it high risk. Following this report, commentary from Agvise Services David Watson sums up the role of canola as a break crop (*TT Canola – is the break crop broken?*). There is also perception canola yields are declining with its repeated use in the rotation. Weeds, especially annual ryegrass, emerging herbicide resistance, root diseases and the depletion in soil nitrogen are major reasons for seeking alternatives to canola.

The current crop rotation in southern Victoria does not include a reliable legume. In 2010, a national benchmarking report of 2,400 farmers with crop and livestock enterprises, indicated the average amount of legume per farm in Southern Victoria was only 18 ha, the lowest of all cropping regions in Australia (Roberts Evaluation, 2010). The same report showed farmers and advisors saw legumes as highly appropriate in the crop rotation, but within the regions surveyed, Southern Victoria scored the lowest in their confidence to implement these rotations. The potential livestock and whole farm system benefits from grazing or making fodder from break crops was also poorly understood.

Fodder conservation is a practical option for growers in the high rainfall zone of southern Australia. The area still has a vibrant livestock industry and Victoria's largest dairy region is close by. The market for fodder (both hay and silage) exists and is likely to grow.

Farmers and advisors want approaches that address multiple solutions during a break phase. Rotation length and sequencing of break crop options need to be considered, with analysis focusing on the net benefits over time and not simply one crop.

Grain legumes such as peas and beans have been the focus of promising crop sequencing research in recent years, with more suitable varieties being bred and refined management strategies making this break crop more profitable and less risky. The Pastures in Crop Sequencing work concentrates on the role of pastures and fodders in a crop rotation, given the abundance of mixed farming enterprises and the opportunities available in certain regions (dairy etc.).

Interviews conducted by David Watson and Cam Nicholson (2010) revealed three significant variables that influenced the type of fodder break crops that may be appropriate at any point in time. These were preference toward livestock, the problems that need solving and the prevailing conditions or opportunities when the choice needs to be made. The results from the survey suggested there are numerous combinations of species, applications and desired benefits from the break crop phase. This creates a complexity because there is a multitude of 'right answers' depending on an individual farming circumstance.

Finding alternative fodder break crops to canola and determining the appropriate place and application of these alternatives is critical to the longevity of cropping in Southern Australia.

Spotlight on weeds

The complexity of rotation selection means that there is no 'recipe' that can be applied broadly. Preference, specific problems to be solved and opportunity need to be considered when making these decisions. Due to this, and the long term nature of some rotational benefits, the problem to be focused upon in this paper will be weeds and the use of pasture and fodder rotations to control weeds and drive down the weed seed bank.

More comprehensive soil measurements, (nitrogen, soil carbon and overall soil health) will be available at the conclusion of the project (end of 2015) as well as economics to inform these decisions.

There are many tactics that can be applied across the year to manipulate and control weeds (Figure 1).

The most common approach to weed control has been to focus on knockdown herbicides early in the season and herbicides mid-season (pre or post emergent). However over the life of this research, our thinking has moved from early and mid-season weed control to also consider control of the weeds later in the season.

Management options early in the season are fairly straight forward and still seem to be quite reliable. It is the late germinating weeds, the ones that strike and mature after the opportunity for in crop herbicide has passed that seem to be carrying over. These late germinating weeds are missing traditional control methods in the conventional rotation, but have set seed by the time the crop is ready to be harvested. In the continuous cropping rotation adopted, we are selecting for late germinating weeds, leaving ourselves with limited options as to how to remove these weeds from the system. Figure 1 indicates there are many options for 'late season' tactics, including manuring, spray topping and fodder conservation.

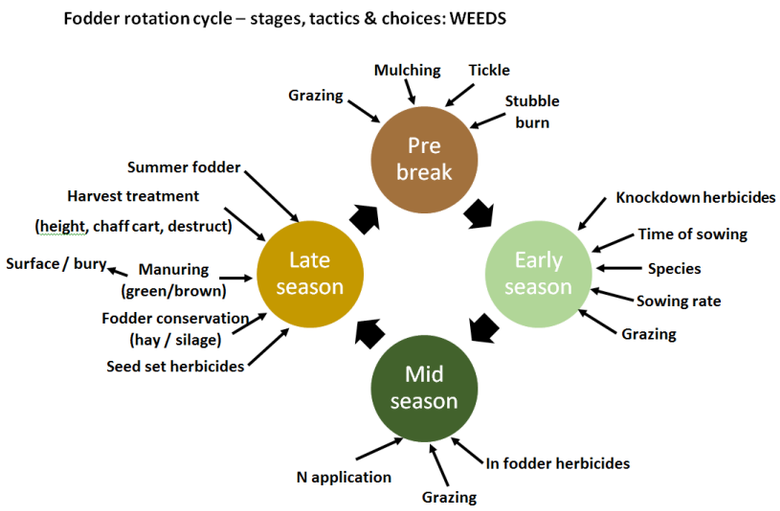

Figure 1. Fodder rotation cycle outlining various options and timings to target weeds.

Figure 2. Stopping weed seed set through removal of forage at key weed growth stages to run down the seed bank. Large amounts of dry matter and nitrogen fixation add value to this method of weed control.

Seed set control relies on intercepting the seed production of weeds that have survived earlier attempts at control (McGillon and Storrie 2006). Therefore the timing of a seed removal operation is more critical than the method of seed removal, and the use of multiple seed removal tactics will ensure better control (Figure 2).

Results

Numerous trials have been conducted in the past six years where weed populations have been measured. These include tactics applied at pre break (grazing, autumn 'tickle', stubble burn) and in season (time of sowing, species, sowing rate, grazing, fodder conservation, manuring and summer fodder crops). This paper focusses on two main weeds, annual ryegrass (ARG) and wild radish (WR) and three of these tactics;

- Sowing rate.
- Duration of break crop.
- Species used (and the associated management options these species lend themselves to).

Firstly two words of caution. Weed populations are dynamic and can fluctuate markedly from year to year. This is the result of dormancy strength conferred at seeding, fluctuations in temperature and moisture over summer, timing of the autumn break, predation, depth of burial and if it is grazed (Grundy 2003). In order to conclude that a treatment has altered a population, the results need to be compared to a control treatment.

In addition weed populations are often uneven across a site which means there can be large variability even within

replicates of the same treatment. This means statistical significance is often not measured, even if the differences appear large. Therefore readers are encouraged to proceed with caution when interpreting results.

Competition arising from sowing rate

There was no significant difference on weed populations or dry matter production at double or triple sowing rates compared to the recommended sowing rate (Table 1). The current 'common' sowing rate of species appears sufficient to provide competition to weeds and optimum dry matter production.

Table 1. Change in annual ryegrass (ARG) populations from June 2012 to June 2013 under three different species sown at common, double and triple sowing rate. Weed numbers are not significant (p=0.05).

Species	Sowing rate (kg/ha)	Establishment (pl/m²)	Dry matter (kg/ha)	ARG 2013 (pl/m²)	% Reduction in ARG
Balansa clover					
Common	6	113	5176	19	89
Double	12	202	5812	34	78
Triple	18	248	4031	19	90
Peas					
Common	100	43	5637	23	89
Double	200	74	6393	25	82
Triple	300	81	4785	26	81
Forage oats					
Common	100	187	8802	56	82
Double	200	279	7824	23	91
Triple	300	447	9681	33	89

These results support other pasture research (Burge and Nie 2012) that shows that the only advantage to higher sowing rates is achieving ground coverage faster. A higher sowing rate does not necessarily translate to more dry matter production, or as shown here, a greater reduction in weed populations. If looking to sow at lower rates than recommended, there is a risk that the weed competition may not be sufficient due to low crop numbers and could encourage weed growth.

Duration of break crop

Seed bank dynamics are different between annual ryegrass and wild radish. McGowan (1970) found that with ARG, you could expect 75-85% germination on the first couple of rain events in autumn. Most of the remaining seeds will germinate after June, with about five per cent carrying over to germinate the following year. The weeds we are allowing to go through in a conventional crop (allowing late season weeds to set seed) is almost selecting for weeds that we will never control with pre sow or early in crop tactics. With this in mind, stopping seed set is critical but different thinking needs to be applied to ARG and WR.

Wild radish seed banks appear to be far more difficult to run down due to dormancy and longevity of the seed. Cheam (1996) reported that up to 70% of WR seeds are still dormant at the start of the cropping season, making early season management ineffective on the majority of the population. Once seed has set, it can remain viable in the seedbank for up to 20 years (Kurth, 1963). Continual control of WR should be at the forefront of management decisions to prevent turning a small manageable problem into a bigger one that forces a management change rather than gives a choice.

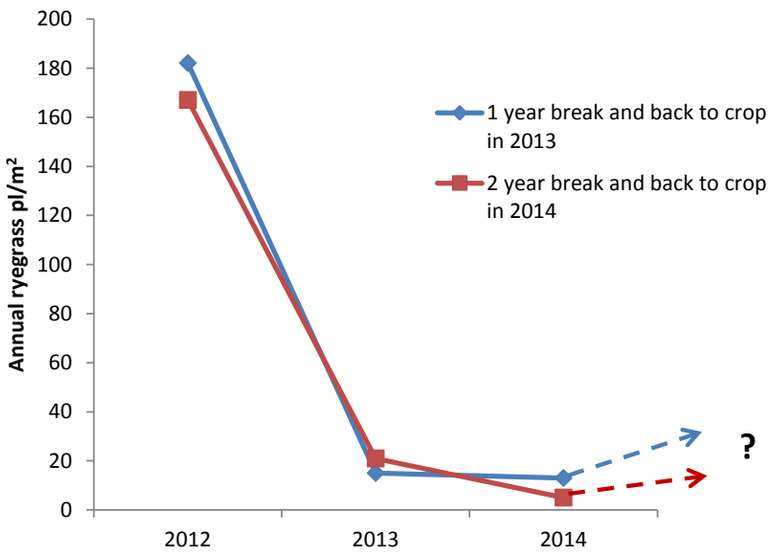

Figure 3. Change in annual ryegrass numbers (measured in June) using Balansa clover as a break crop for one year and back to crop compared to two years in the pasture break.

Focusing on results for ARG at Lake Bolac (Figure 3) suggests

that a one year fodder break crop like Balansa clover can reduce ARG by up to 85% (>160 to <25 pl/m^2) when weeds were measured in June (at crop establishment). This high level of control is coming from successful pre sowing and early in crop management, so is it the late season weeds that are causing weed numbers the following year? The first year back in crop was TT canola which appears to have maintained low weed numbers quite well. How will this line look after a second year of crop? Have we achieved enough with a one year break?

Weeds were reduced further after a second year in break crop (Balansa clover), with the same principle, stopping weed seed set using grazing and fodder conservation options. Although there are still weeds present in June after two years of a pasture break, numbers were down to five plants per square metre (Figure 3). Again, the question remains, is two years enough? Is it as good as one year or will weed numbers blow out once the traditional canola, wheat, barley rotation resumes?

Deciding on a break crop species

A range of species were tested, with different species having different growth characteristics and management options. General observations are:

- Oats and ryegrass grow rapidly and compete well early in the season as well as providing a lot of dry matter later in the season.
- Annual clovers (Persian, Arrowleaf, Balansa) have been slow to start but bulk up very quickly in spring to provide late competition and high amounts of dry matter.
- Lucerne and sub clover were slow and produced little in the first year but came back in the second and third year very quickly and provided great competition throughout the season.
- Sowing nothing and allowing weeds to grow (but managed through the season so no seed set) was included, as a low cost option that still produced feed and allowed weed control that wouldn't normally be available in a cash crop.

Different fodder species also allow different options for chemical weed control in-crop (Table 2) so a pasture species can be chosen not just on the basis of its competitiveness, biomass production or potential for N fixation, but also on the chemistry it offers. Rotating herbicide groups and modes of action is a critical part of any IWM strategy.

Table 2. Herbicide groups that can be used in different fodder species during the growing season. Refer to individual product labels for specific application instructions.

Clovers	Serradella	Oats, ryegrass	Lucerne	Peas,
A, I, F, G	A, B, G,	I, F	A,B, C,L	A, B, G

Whilst starting weed numbers were variable, all species seem to have been successful in reducing weed numbers through competition and providing an option for weed removal as fodder or green or brown manure. Figure 4 outlines the species effect on WR numbers at Inverleigh, Figure 5 targeting ARG at Lake Bolac. It is important to note that timings were targeted at the growth stage of the focus weed, so management for WR is likely to be slightly different than for ARG.

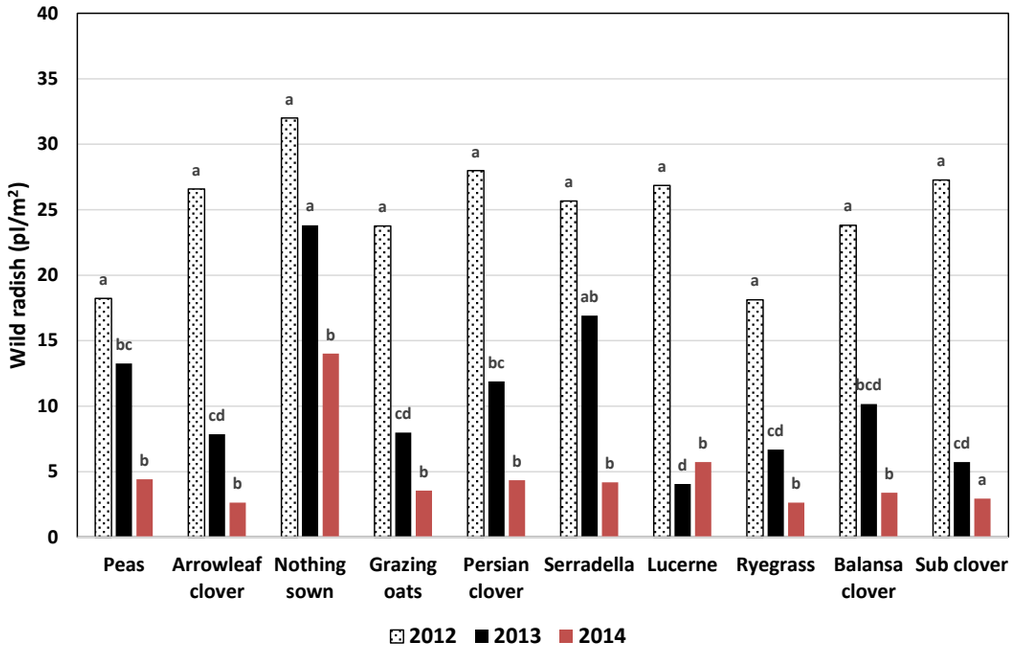

Figure 4. The change in wild radish numbers (pl/m^2) after two years of different fodder break crops at Inverleigh, Vic (weeds measured in June 2012, 2013 and 2014).

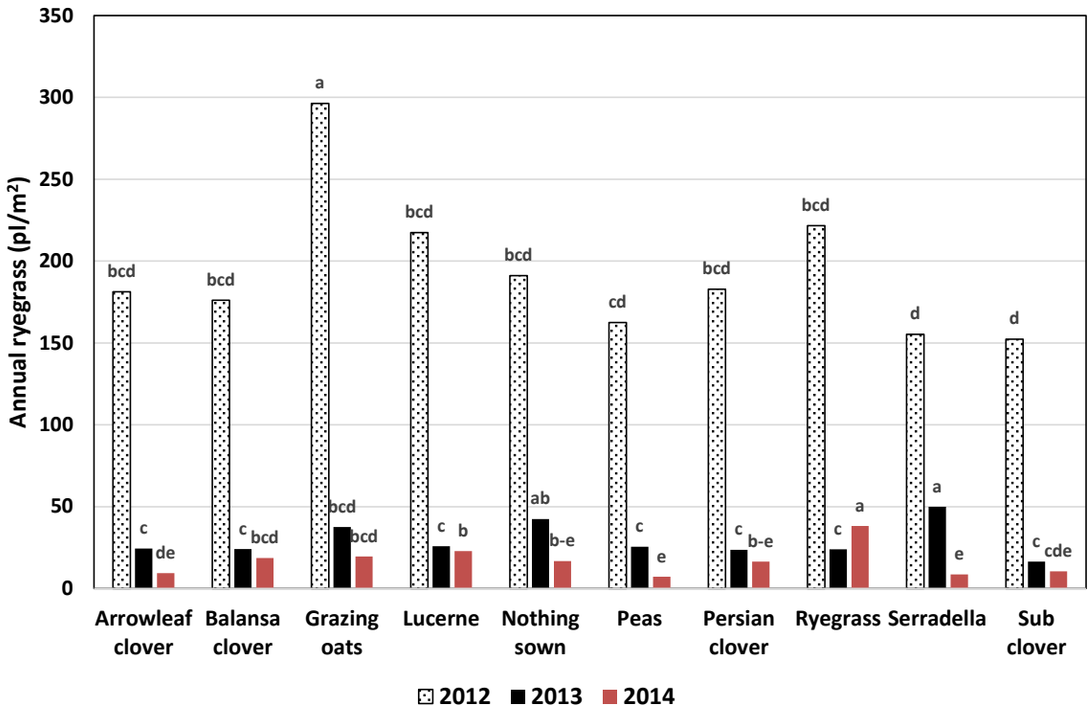

Figure 5. The change in annual ryegrass numbers (pl/m²) after two years of different fodder break crops at Lake Bolac, Vic (weeds measured in June 2012, 2013 and 2014).

Some species have the potential to fix nitrogen, whilst others are going to be desirable due to their ability to produce large amounts of dry matter throughout the season. Table 3 and 4 show the species trialled, fodder quantity reduced and the change in weed numbers at Inverleigh and Lake Bolac respectively.

Table 3. Dry matter production from different species and change in wild radish numbers at Inverleigh 2012-2014 (weeds measured in June).

Species	Dry matter 2012 (kg/ha)	Fodder removal	Change in wild radish numbers after 1 year fodder break	Dry matter 2013 (kg/ha)	Fodder removal	Change in wild radish numbers after 2 year fodder break
Annual clovers*	3330	Graze, silage	-62%	5624	Silage, hay	-87%
Sub clover	1922	Graze	-79%	6623	Hay, silage	-89%
Lucerne	1977	Graze	-85%	4281	Graze, hay	-79%
Peas	2884	Hay	-27%	2475	Silage	-75%
Oats	4755	Graze, silage	-66%	8194	Hay	-85%
Ryegrass	4421	Graze, silage	-63%	6363	Graze, hay	-85%
Nothing sown	1106	Graze	-25%	3008	Silage	-56%

*Species included Arrowleaf, Balansa and Persian clover.

Table 4. Dry matter production from different species and change in annual ryegrass (ARG) numbers at Lake Bolac 2012-2014 (weeds measured in June).

Species	Dry matter 2012 (kg/ha)	Fodder removal	Change in ARG numbers after 1 year fodder break	Dry matter 2013 (kg/ha)	Fodder removal	Change in ARG numbers after 2 year fodder break
Annual clover*	5027	Silage	-87%	5026	Graze, silage	-92%
Sub clover	2416	Graze	-89%	2463	Silage	-93%
Lucerne	1794	Graze	-88%	3035	Graze, silage	-90%
Peas	5434	Hay	-84%	6913	Hay	-96%
Oats	6110	Silage	-87%	10372	Graze, silage	-93%
Ryegrass	5272	Silage	-89%	7753	Silage, graze	-83%
Nothing sown	3138	Graze	-78%	4625	Graze	-91%

*Species included Arrowleaf, Balansa and Persian clover.

Figure 6. Weeds can provide good forage though the season. Sown ryegrass (5 t/ha dry matter) on the left compared to nothing sown (3 t/ha dry matter) on the right at Lake Bolac.

Livestock in the crop paddock – the impact of grazing on soil structure

Changes in soil structure have been measured across three trials from 2010 to 2012 to determine if grazing in winter or summer is having a negative effect on soil condition and ultimately crop yields. This is a difficult topic to research, as the natural variability in the soil and current testing method can only determine large differences in soil condition.

The findings include:

- The effects due to grazing are mainly in the surface soil (0–10 cm)
- There can be immediate changes in soil properties due to grazing, but rarely have reductions in subsequent crops been measured.
- Because compaction from livestock is shallow, it is not long lasting and is rectified by natural processes (and tillage).

Research into the impact of grazing on soil structure will continue, with the hope that more information on compaction, pore space and infiltration at certain depths can be looked at more closely.

Adding value through break crops

Moving away from continuous cropping does not have to mean sacrificing production or income from that paddock. Utilising a pasture or fodder in the short term can help solve problems in a cropping system (weeds or poor soil structure), provide an opportunity (grazing, fodder conservation or fixed nitrogen) with a vast range of options to cater for the preference of the farmer.

There are many mixed farming operations with weed problems and livestock to feed, yet are seeking the ideal break crop in the form of a harvestable grain. Why not grow fodder as the break crop?

In the year of 2015, we will focus on completion of field trials (four years of data collection on soil parameters, weeds and yield (dry matter and grain), as well as factoring in feed values, costs and gross margin to complete the picture.

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TT canola – is the break crop broken?

Comment from David Watson, Agvise Services

In the mid 1990s two coincidental events dramatically changed land use patterns in the high rainfall zone of southern Victoria. The development of broad acre raised bed farming techniques in 1995 and the release of triazine tolerant canola in 1993 meant that we could now grow a sound crop rotation with lower risk. Waterlogging and weeds could both be controlled with confidence- a new industry was about to take off and yields and gross margins could be achieved that could only be dreamt of in the past.

Rapidly a standard rotation of canola, wheat and barley was widely adopted with TT canola the lynch pin by allowing the reliable control of a large range of weeds commonly found in the south. Weeds that thrived under wet soil conditions in a long growing season environment could now be controlled.

Progressively varieties of the three crops were improved with longer season maturity and better disease resistance. Region specific agronomic knowledge and practice rapidly developed with Southern Farming Systems at the forefront of this. TT canola was fundamental to this change and in the absence of any suitable alternative break crop it is unlikely any such land use change would have taken place.

Until recent years TT canola accounted for greater than 90% of canola sown and for very good reason. Application of simazine and/or atrazine post sowing, pre emergence, allowed for the control of a broad suite of weeds for an extended period, often when paddock access in winter would have been difficult due to wet soil conditions. Further in-crop applications of group A Dim herbicides for grass control and Group I for broadleaf control meant that we could be confident that at the end of the canola phase few weeds would set seed and that we had re-set the weed clock for another rotation.

As the years progressed though chinks appeared in the armour.

- The widespread development of herbicide resistance to post emergent grass weed herbicides in cereals meant that canola had to contend with heavier weed burdens and hence the selection pressure for herbicide resistance to the canola herbicide chemistry increased.
- Spraying conditions in winter in southern Victoria are often marginal (at best) with post emergent herbicide chemistry regularly being applied late under cold conditions onto large, stressed weeds. This further increased the selection pressure for herbicide resistance.
- Our long growing season has been great for yield but also gives weeds, especially ryegrass, an opportunity to emerge long after in-crop control options have been exhausted.
- These same conditions give rise to high slug populations which often lower plant density in canola and give rise to bare areas with less crop competition leading to more weeds setting more seeds and hence even greater selection for herbicide resistance.

In recent years enhanced herbicide traits incorporated into canola such as Clearfield, Roundup Ready and Roundup/ triazine tolerant canola have endeavoured to keep pace with reducing efficiency of TT canola in containing weeds but the lack of broad scale adoption is an indication that they are not a clear solution. More recently again new herbicide registrations for use both early and late in crop have offered some encouragement that we may be able to keep the canola dependant rotation going for a bit longer. However history and common sense tell us that whilst there use may help prolong canola as our principle break crop but that time and use will rapidly compromise their efficacy.

With TT canola coming under so much pressure we need another break crop and we need it quickly. One crop would be great but again history and common sense indicate that a number of options in this space will buy us much more time, reduce risk and result in a more sustainable cropping system.

Pulses form the basis, or at very least support rotations in most other cropping areas of Australia. They frequently have slightly higher risk and lower returns but at least they provide a viable option. In southern Victoria very few pulses have been reliably successful and their adoption is limited. Recently improved varieties of faba beans and

agronomic packages to accompany them have given great hope that we can at last have a nitrogen fixing legume within our rotation. In reality though having one more broadleaf with a very similar weed control armoury will not significantly change the weed control or herbicide resistance situation. Late season use of paraquat for crop topping in faba beans is an option that is not currently available within a canola/cereal rotation. This therefore provides another control option but given that it is difficult to reliably achieve greater than 70% seed sterilisation, wide spread use of crop topping faba beans will not significantly change the weed dynamics in the rotation.

In southern Victoria our climatic conditions conspire to limit our choice of traditional break crops, reduce the efficacy of herbicides and significantly increase selection pressure for herbicide resistance. But these same forces give us rotation options that may have limited application in other areas.

Most farms have significant areas of non-arable land and livestock numbers have remained high despite increasing their cropped area in recent years. Increased stocking rate, climate variability and a need for rapid turn off of production stock mean that high producing, high quality pastures are now in greater demand than ever. High producing, short term pastures and fodder crops including legumes, brassicas, cereals and grasses offer an enormous opportunity for southern Victoria to develop new crop rotations with new weed control options that utilise short term pasture/fodder cycles to compliment TT canola which is under so much pressure.