CANOLA WEED MANAGEMENT

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SUMMARY

- Weed management is strongly influenced by crop rotation sequence. Canola planted after a pasture ley provides greater opportunities for integrated weed management programs than does canola planted in a continuous cropping sequence.
- The widespread occurrence of herbicide resistance in Australian weeds makes the weed management in continuous cropping much more problematic, since weed control is highly dependent on the very herbicides to which weeds are developing resistance. Further, the increasing incidence of shorter rotations is adding to the pressure on the development of herbicide resistance.
- The area sown to triazine tolerant varieties of canola has increased dramatically in recent years, particularly in Western Australia. However, widespread use of these varieties is likely to accelerate the development of resistance to the triazine herbicides.
- Imidazolinone tolerant (IT) canola varieties are likely to be available next year. Liberty Link®, Roundup Ready® and bromoxynil resistant varieties are expected to be released in the next few years.
- The resistance to several of these herbicides that already occurs in Australian weeds shows that these varieties are not a panacea for herbicide resistance management, but they will add significantly to the options available to farmers in respect to resistance management.

WEED SPECTRUM AND HERBICIDE RESISTANCE

While there are inevitably large numbers of weed species that affect canola production, those that feature consistently in Australia are listed in Table 5. Prior to the introduction of herbicide resistant varieties, control of key broadleaf weeds was the most important constraint to production of canola throughout southern Australia.

Table 5: Common weeds of Australian canola crops

Wild radish*	*Raphanus raphanistrum*	Vulpia*	*Vulpia* spp.
Indian hedge mustard*	*Sisymbrium orientale*	Wireweed	*Polygonum aviculare*
Annual ryegrass	*Lolium rigidum*	Toad rush	*Juncus bufonius*
Shepherds purse*	*Capsella bursa-pastoris*	Wild oat	*Avena* spp.
Wild turnip*	*Brassica tournefortii*	Spiny emex	*Emex australia*
Turnip weed*	*Rapistrum rugosum*	Fumitory	*Fumaria* spp.
Charlock*	*Sinapsis arvensis*	Buchan weed	*Hirschfeldia incana*
Musk weed*	*Myagrum perfoliatum*	Capeweed	*Arctotheca calendula*
Patterson's curse*	*Echium plantagineum*	Volunteer cereals	

* Weeds species that have been particularly important in restricting canola production prior to the introduction of TT varieties.

The degree to which such weeds have restricted the canola area is reflected in the rapid adoption of the triazine tolerant (TT) varieties across southern Australia.

Herbicide resistance in Australian weeds

Australian farmers have moved away from aggressive tillage practices because of the extreme risk of soil erosion. Few farmers use inversion tillage as is practiced in Europe, while the majority use reduced tillage methods. Significant proportions of the crops are seeded using no-till. Therefore, crop sequences and seeding techniques are highly dependent on herbicides. Repetitious use of herbicides has selected for herbicide resistant weed biotypes. Herbicide resistance now affects 22 species of Australian weeds, foremost among them being annual ryegrass. Where canola production was restricted by weeds like wild radish prior to the introduction of TT varieties, it is likely that herbicide resistant weeds will also reimpose restrictions. This could be the case with multiple and or cross-resistance in single species as well as mixed populations of resistant weed species.

Canola growers in Australia use a range of herbicides on canola crops from many herbicide groups and the number of groups will increase with the commercial production of additional herbicide resistant varieties in the next few years (Table 6).

Table 6. Current and likely future (*) herbicides in use in canola crops in Australia

Herbicide Groups	Herbicides
A	Fluazifop, Haloxyfop, Diclofop-methyl, Fluazifop/butroxydim, Sethoxydim, Quizalofop, Clethodim
B	On-Duty*
C	Simazine, Atrazine, Bromoxynil*
D	Trifluralin
I	Clopyralid
K	Metolachlor
M	Glyphosate*
N	Glufosinate ammonium*

Most populations of annual ryegrass would now be classified as susceptible to diclofop methyl, while on many farms, the ryegrass is cross-resistant to both Group A and Group B herbicides. On some farms, annual ryegrass biotypes are resistant to all selective herbicides that are currently available. The recent confirmation of glyphosate resistant annual ryegrass on several farms has shown that farmers must adopt integrated weed management (IWM) methods to protect all herbicides, not just the selective types.

While the major herbicide resistance problems in Australian weeds are with Groups A and B herbicides, resistance to Groups C, D, F, L and M herbicides have also been discovered.
Wild radish has now developed resistance to Group B, Group C and Group F herbicides. Combined with the resistance in ryegrass, this has serious implications for farmers in general but particularly to those wishing to use the IT and TT varieties.

While the majority of farmers are fully aware of the resistance problem, most still react to the development of resistance to a particular herbicide by changing to another herbicide. This is exemplified by the widespread change to trifluralin by southern

Australian farmers in response to the failure of the Group A and Group B herbicides over the last two to three seasons. This will have the inevitable consequence that trifluralin resistance will increase.

The introduction of herbicide resistant crops will immediately increase the frequency of use of the specific herbicides on weeds. It is probable that this increased exposure to the herbicides will lead to more resistance problems, particularly in the case of the TT and IT varieties.

Farmers across Australia are being encouraged to adopt integrated weed management (IWM) in order to address the resistance problem. There are two essential components to IWM, namely the rotation of herbicide groups to avoid repetitious use of the same or similar herbicides, and the avoidance of treating large numbers of weeds with a single herbicide. To achieve the second component, farmers must move away from a high dependence on herbicides for weed control.

THE IMPACT OF WEEDS IN CANOLA

Since canola is often seeded from late April through June, it is placed into cold or cooling soil. This leads to slow early growth and so crops are very susceptible to competition from weeds. Weeds such as toad rush are highly competitive for available nitrogen, which potentially reduces yield. The grass weeds (ryegrass, vulpia, brome grass and others) not only compete with the crop but they harbour cereal root diseases such as take-all (*Gaeumannomyces graminis* var. *tritici*). These root diseases affect the cereal crop that usually follows the canola.

Weed seed contamination of the canola seed in excess of limits will lead to reduced prices. This is especially the case with weeds from the family *Brassicaceae,* which lead to increased erucic acid and glucosinolates and consequent reduction in canola quality. Weed seed and other debris in the canola seed leads to direct penalties, based on the percentage present. Weed competition can affect nutrient uptake by the canola plants and thus affect yield.

WEED MANAGMENT IN DIFFERING SCENARIOS

Canola following pasture

The pasture ley system of farming was developed in Australia to allow crops to make use of nitrogen provided by legume pastures. A cropping phase of one to several years follows a period of pasture production. Growing canola in the first year after pasture has been regarded as the preferred practice. The system provides fertile, low weed density conditions for the crop. A significant bonus is that cereal root diseases are controlled for the following wheat crop, provided that grasses are controlled in the pasture. The ley pasture phase provides farmers one or more growing seasons in which weed numbers can be reduced using non-selective techniques such as grazing, winter cleaning (pasture manipulation), topping, hay making and silage production. In the spring prior to sowing, the pasture and weeds are killed using glyphosate. In a well-managed ley system, weed numbers are significantly reduced prior to planting the canola.

Invariably, trifluralin is applied prior to sowing, targeting grassy weeds and susceptible broadleaf species. Following a strong pasture phase, subterranean clover *(Trifolium subterraneum)* can often be dense enough to suppress the seedling canola crop, especially if the 4-6 week period leading up to planting is dry. Other common weeds are annual thistles and capeweed (*Arctotheca* spp.*)*. In these cases, clopyralid is used.

Finally, producers may need to treat late wild oats (*Avena* spp.*)* and other grass weeds which escaped the trifluralin or emerged late. In this case, a Group A herbicide such as fluazifop-P is used.

A common practice is to keep the canola crop as clean of weeds as possible, using the techniques outlined. This often allows the following wheat crop to be produced without selective herbicides.

The ley pasture-cropping system has a great deal of merit in terms of IWM. The system is excellent for reducing pressure on herbicides as well as managing weeds which are already resistant to herbicides. Crop and pasture phases are usually of similar length, ranging from one to 5 years. Management of herbicide resistance is straightforward in these systems. Unfortunately, the viability of the pasture ley system is closely (although not entirely) linked to livestock product prices which are currently low.

Canola in a continuous cropping sequence

A fall in livestock product prices and other factors stimulated many producers to begin continuous cropping programs. One major difference between the ley system and the continuous cropping system is that weed control is more dependent on selective herbicides and is necessarily carried out in preceding crops rather than pastures.

Weed control in these preceding crops consists of manipulating sowing time, exploiting crop competitive effects and relying heavily on selective herbicides. Weed management from pre-planting onwards is similar to the ley system, with the following significant differences:
Selection pressure for herbicide resistance is often high, especially to the Group A and Group B herbicides, because of the need to use these herbicides in the preceding crops.

Weed numbers tend to be higher as farmers do not have the range of non-selective treatments available in the pasture. This increases the risk of resistant biotypes being present in the crops when the herbicides are applied. Due to herbicide resistance, continuous crop programs may include a forage / fodder or green manure crop so that non selective weed control can be achieved.

In both the ley system and the continuous cropping system, a significant component of weed management may be achieved through crop competition, although the effectiveness will vary between environments. For example, crop competition has been effective in suppressing late germination of wild radish in Western Australia, but

less so in south eastern New South Wales where wild radish germinating ten weeks after crop sowing subsequently produced seed.

Triazine Tolerant (TT) canola

In 1999, TT canola accounted for almost 50% of the Australian crop, even though the varieties have a yield penalty relative to non-TT varieties. In the majority of cases, TT canola is chosen because the weeds present cannot be controlled in the conventional varieties. In some situations, TT canola may be chosen as part of a strategy to control annual ryegrass resistant to Group A and Group B herbicides, in order to avoid repetitious use of trifluralin. In addition, the TT varieties were initially grown without an associated best management package, although this has now been rectified. All future herbicide resistant crops will be introduced with a best management guide.

Some areas, particularly parts of the Western Australian cropping belt, have a long history of triazine herbicide use, particularly in lupins. The widespread production of TT canola and use of triazines will certainly lead to an escalation in resistant populations of weeds, particularly annual ryegrass. There is already evidence of triazine resistance in wild radish.

Imidazolinone Tolerant (IT) canola

IT canola varieties, which will soon be available to Australian growers, offer some significant benefits but there are important limitations. These varieties will be marketed along with an imidazolinone herbicide mix called "OnDuty". This has a wide spectrum of activity and does not suffer from extended plant back periods on acid soils. Unlike the TT varieties, the IT varieties carry no yield or oil penalties. The introduction of IT varieties is likely to immediately reduce the area of TT canola, which will have herbicide resistance management and environmental benefits.

Of the disadvantages, Group B herbicides are "high risk" in terms of the development of herbicide resistance. Group B herbicides (eg chlorsulfuron and triasulfuron) are already used frequently in cropping sequences. Therefore, producers will have to plan carefully on how to fit the IT varieties without increasing the frequency of Group B herbicide use. The company is developing best management packages that will help greatly in this regard. The Group B resistance problem is so severe already in some areas (particularly in Western Australia) that the IT varieties may have limited, if any, scope for use.

Liberty Link® canola

Liberty Link® varieties are currently being developed for the Australian market. At this time, there are problems with efficacy of glufosinate ammonium during the cool growing season, particularly on wild radish and annual ryegrass. This may limit the widespread application of Liberty Link® canola in some areas of southern Australia. However, when Liberty Link® is combined into hybrids the additional seedling vigour may enhance competition with weeds.

Roundup Ready® canola

Roundup Ready® canola will be available to Australian producers in the near future. Roundup has a wide spectrum of activity on weeds, has no soil residual problems (in the great majority of situations) and belongs to a low risk group in terms of herbicide resistance. Given these factors, Roundup Ready® canola will offer producers a significant alternative to other varieties, herbicide resistant or otherwise. The introduction of Roundup Ready® canola will lead to further reductions in the area of TT canola, which will be good for management of triazine resistant weeds and the environment.

A problem industry has to deal with is glyphosate resistance in annual ryegrass, for which there are currently two documented cases. If glyphosate is the only herbicide used in Roundup Ready® canola, these biotypes will survive unless some other intervention is used, such as alternative knockdown herbicides prior to sowing, cultivation at or prior to planting, and/or in-crop herbicides. Therefore, best management packages will need to include recommendations for minimising the risk of increased selection for the glyphosate resistant biotypes.

TIGHTER CROPPING ROTATIONS

In an ideal situation, a continuous cropping system in southern Australia would be: *cereal, canola, cereal, pulse, cereal, canola, cereal*. Pulse crops could be varied between lupins, peas, chickpeas etc. Such a system allows for a three year break between canola crops for disease management. It is also diverse in species, allowing for an optimum rotation of herbicide groups, a variety of planting times and harvest dates. This diversity greatly facilitates integrated weed management.

Unfortunately, variable yields, disease outbreaks and relatively poor prices for pulses have encouraged producers to drop them out of the rotation. As a result, there has been a growing trend towards tightening rotations, with the following rotation sometimes being employed: *cereal, canola, cereal, canola*. This dramatically reduces plant diversity, meaning much less opportunity to rotate herbicide groups, manipulate sowing and harvest times and other weed management measures available in a more diverse system.

In terms of weed management, tighter rotations will almost certainly lead to increased selection pressure for resistance. This may be alleviated partially when farmers have access to a range of herbicide resistant varieties. These could be alternated in the rotation, thus providing a more diverse herbicide use in the canola component.

FUTURE DIRECTIONS

Canola is set to remain a popular crop in Australia providing grain prices remain satisfactory and blackleg is controlled with varietal tolerance. However, herbicide resistance in weeds may force producers into less intensive rotations in order to manage seed banks of resistant weeds.
Weed resistance is likely to restrict the useful life of the IT and TT varieties. This is particularly the case with the IT varieties because the associated herbicides are “high

risk" for resistance development, but also because widespread resistance to these herbicides already exists.

Of all the herbicide resistant varieties, Roundup Ready® varieties offer the most to farmers due to the wide spectrum of activity of glyphosate. It seems likely that these varieties will be quickly adopted, especially where farmers have problems with the other herbicide groups. However, the potential development of glyphosate resistance in weeds also poses one of the most serious risks to our current agricultural practices. Therefore, farmers will need to use this product with extreme care.

FURTHER READING

Bowran, D. G., Hamblin, J. and Powles, S. B. (1997) Incorporation of transgenic herbicide resistant crops into integrated weed management systems. In *Commercialisation of Transgenic Crops: Risks, Benifits and Trade Considerations*. G.D. McLean, P. Waterhouse, G. Evans and M.J Gibbs (Eds), Bureau of Resource Sciences, Canberra, pp.301-312.

Powles, S. B. and Holtum J. A. M. (Eds) *Herbicide Resistance in Plants, Biology and Biochemistry.* Lewis Publishers, Boca Raton, Florida.

Mullen C. L. and Dellow J.J. (1999) Weed Control in Winter Crops 1999. NSW Agriculture, Orange, NSW.