CANOLA IN ROTATIONS

***R. Norton, J. Kirkegaard, J. Angus and T. Potter*.**

SUMMARY

- Canola is one of the most profitable crops available to grain growers in southern and western Australia and rotations have been adapted to accommodate it.
- Canola provides large yield benefits to subsequent cereal crops by providing an effective disease break.
- Canola was often grown as the first crop after pasture but now canola is often used more intensively in rotations, posing problems of herbicide use, disease carryover and increasing potential of blackleg in existing cultivars.
- The sulfur, gypsum and lime required to grow canola in many regions are providing a benefit to crops and pastures grown in rotation.

INTRODUCTION

Canola now occupies 6% of the cropped area in New South Wales, Victoria, South Australia and Western Australia. The Canola Association of Australia estimate for canola plantings in 1999 was for 360,000 ha in New South Wales, 250,000 ha in Victoria and 214,000 ha in South Australia and 900,000 ha in Western Australia. Although this is only about 10% of the area sown to wheat, canola is now 46% of the area cropped to non-cereals. In New South Wales, when growers increased the proportion of broadleaf crops in their rotations from 6% to 32%, average wheat yields increased by 50% and water use efficiency by 25%. Canola now plays an important role as a broadleaf crop in the rotation and its impact will increase as the area cropped continues to rise.

In the winter-dominant rainfall areas of Australia (between 30^{o}S and 38^{o}S), the ley farming system introduced in the 1950s consisted of cereals alternating with pastures, initially with 20-30% of the farm area under crop. With recent poor returns from grazing industries, particularly wool, a crop to pasture ratio of 1:1 has become common and some farms have eliminated livestock altogether in the 1990s. In higher rainfall regions, pasture and crop phases are commonly 3 to 5 years. The pasture leys are often based on annuals such as sub-clovers (*Trifolium subterraneum*) on the more acid soils or annual medics (e.g. *Medicago truncatula*) on alkaline soils. There is also increasing interest in using lucerne (*Medicago sativa*) and perennial grasses as the pasture ley in higher-rainfall areas.

Within the cropping phase, widely adapted canola varieties enable growers to diversify their rotations, with a balance between cereals and broadleaf crops. Canola is often the first crop following the pasture and benefits from the nitrogen fixed by legumes during the pasture phase. The subsequent crops will be wheat followed by a second wheat crop or a pulse, and then another cereal. The chosen pulse could be lupins (*e.g*. Western Australia), field peas (*e.g* western Victoria and South Australia) or, less commonly chickpea, lentil or fababean. In some regions, such as southern

New South Wales, the returns from pulses are not attractive to many growers, and alternating crops of canola and wheat are becoming more common.

From the Victorian TOPCROP database for 1994 and 1995, a survey of 114 canola crops showed that the most common preceding land uses were pulse (29%), pasture (29%), fallow (19%) or wheat (13%). In some cases the pulse was ploughed in as a green manure crop. From those data, there was little difference in mean canola yield (1.8 t/ha) between the four preceding land uses. From the same survey, 82% of canola crops were sown to wheat in the subsequent year, while only 12% of those paddocks were sown to pulses.

The development of triazine tolerant (TT) canola has opened up cropping areas previously considered unsuitable for canola by providing low cost and effective control of broadleaf weeds, especially *Brassica* weeds. However, the widespread use of TT varieties poses the risk of overuse of triazine herbicides and the selection of resistant weeds.

In a conservation farming system, retention of cereal stubble is generally accepted to improve crop production. Canola is not often sown following cereals, although this would enable better broadleaf weed control in the cereal than a pulse crop. The reluctance to sow canola in high stubble loads may be due to low soil temperatures under stubble, higher N demand with stubble retention, the presence of red-legged earthmite (*Halotydeus destructor*) or wide sowing row spacing used to facilitate stubble flow. An area of further research is to identify management and cultivar responses to stubble retention, so that canola can be grown where stubble loads are high.

CANOLA PROFITABILITY

The huge increase in canola plantings since the early 1990s has been a consequence of the profitability of canola compared to other break crops. Canola has fitted easily into the current production system, with high oilseed prices and low cereal prices generally making canola the most profitable crop in most grain winter rainfall cropping regions of Australia. Table 3 shows the comparative gross margins (gross returns less variable costs) for wheat and canola in two regions of southern Australia - the Wimmera (rainfall 425 mm) and the Victorian south-west (rainfall 600mm). Canola yields are usually 55-60% of wheat yields when grown under similar situations. However canola is usually grown on the best soils on a farm, so that the yields are often 60-70% of average wheat yields. Variable costs for canola are more than wheat, a reflection of the higher input of herbicides, pesticides and fertilizers into the canola crops.

To produce canola only limited additional capital expenditure is required. The sowing and harvest times of canola are usually earlier than wheat, which spreads the time for using existing machinery. In southern Australia, canola is commonly windrowed before harvest, and until recently, few farmers had such equipment. As the area planted increased, most farmers now have access to windrowers, either their own or through contract services.

Table 3. Gross margins for canola and wheat for two rainfall zones in southeastern Australia.

	South-west Victoria		Wimmera	
	Wheat	**Canola**	**Wheat**	**Canola**
Expected Yield (t/ha)	4.0	2.6	3.0	2.0
Net Price ($/t on farm)	153	300*	154	299*
Income	**612**	**780**	**462**	**598**
Seedbed Preparation	7	7	7	11
Seed	19	21	14	15
Fertilizer (including appl)	85	85	61	72
Pre-Sowing Herbicides	11	13	7	11
Sowing	6	6	3	3
Post-sowing herbicides	20	34	23	28
Insecticides	0	5	0	6
Windrowing	-	25	-	25
Harvesting	7	14	7	11
Insurance	7	11	5	10
Local cartage	6	-	8	-
Variable Cost	**168**	**221**	**135**	**192**
GROSS MARGIN/ha	**444**	**559**	**327**	**406**

* Assumes 44% oil content in canola.
Source: Wimmera Gross Margins 1999 (K. O'Brien, DNRE Horsham), South-West Gross Margins (L. Beattie and S. Holden, DNRE Hamilton).

As a result of its high gross margin and relative reliability, canola is now the key crop in the rotations of many farms. There has been steady adoption of canola following initial reluctance mainly due to the perception that it was difficult to establish and costly to grow. Due to the high cost, some growers prefer to grow lower cost crops, particularly after unfavourable seasons. In low rainfall areas canola is often grown only in years where the break of seasons enables early sowing.

ROTATIONAL BENEFITS OF CANOLA

The rotational benefits of *Brassica* crops in the Northern hemisphere have been recognized for some time where they were an integral component in the "Norfolk four-course rotation" and considered by many to be an excellent "cleaning" crop. Similar benefits of canola were recognized by farmers and researchers during the early years of its integration into cereal rotations in Australia. The improvement in the yield and quality of wheat grown after canola was an important factor which encouraged rapid adoption during the early 1990s.

From a survey of 226 wheat crops in 1995 across Victoria, pulses were the most common prior crop (27%) followed by canola (19%), fallow (15%) and pasture (15%). The wheat yields where canola was the previous crop were 3.9 t/ha, compared to wheat on pulse 3.1 t/ha and wheat on fallow 3.2 t/ha. Wheat following pasture or wheat on wheat were similar (2.8 t/ha). This represents a substantial yield benefit to the subsequent cereal. Similar results have been seen in 14 on-farm experiments in southern NSW where wheat after canola yielded on average 21% more, and protein content increased by 1.3% compared to wheat after wheat.

Research in Australia has sought to quantify these significant yield benefits to subsequent wheat crops and determine the mechanisms involved. Canola, like other broadleaf crops, is not a host for the major soil-borne cereal pathogens such as take-all (*Gaeumannomyces graminis*) and so provides a "break" during which the inoculum of cereal pathogens decline. In this way break-crops reduce the incidence and severity of these fungal diseases in subsequent wheat crops resulting in higher yields and quality.

The effect of canola appears to go beyond simply providing a period free from pathogen hosts. Recent studies have shown that decaying canola roots release biocidal compounds which are toxic to fungal inoculum in the soil. This "biofumigation" by canola has been shown to result in lower levels of take-all inoculum surviving after canola compared with other crops which may partly explain the superior break-crop benefits of canola. Although these biofumigation effects are of benefit to following cereals, there is some concern about the impact on beneficial organisms such as VAM (Vesicular-Arbuscular Mycorrhizal) fungi or *Rhizobia*, which may be detrimental to legume or VAM-dependant crops in the rotation by reducing the availability of phosphorus and zinc, and this is an area of on-going research.

As a consequence of its own profitability, and the effects on subsequent wheat crops, rotations that incorporate canola are the most profitable. For example, in 14 on-farm experiments in New South Wales from 1990 – 1994 the canola-wheat system had a two-year gross margin of $252 per ha compared with wheat-wheat of $163 per ha. Much of the benefit in those years did not arise from the canola itself, but from the better wheat crops which followed. In very good years, a 6 t/ha wheat crop with 13% grain protein will provide better returns than a 2.5 t/ha canola crop given average prices. In 1995 - 1996, in a pair of favourable years, the 2-year gross margin for the wheat-wheat sequence was $1000 compared with $1250 for the canola-wheat sequence.

Similar results have been reported from low rainfall areas in South Australia, where the gross margins from canola-wheat were higher than wheat-wheat. Also, canola-wheat produced similar gross margins to pulse-wheat, provided nitrogen nutrition was adequate in the crops following canola. In that environment, the increased risk of soil erosion due to the lower stubble load from pulses compared to canola can also be significant in the choice between canola and a pulse in the rotation.

Canola is also thought to have beneficial effects on soil structure. Where there is no subsoil hardpan, the large taproot provides channels that improve the rate of water infiltration and may provide access for the roots of following crops into the subsoil. The extensive fine root system in the surface also improves surface soil structure, creating more stable soil aggregates than those formed under cereals, and increasing infiltration rate. These effects are probably responsible for the common observation by farmers that canola leaves the soil more friable and easy to work. This friability and the generally low levels of residues left by the crop provides opportunities for farmers to direct-drill subsequent cereal crops. Additionally, there are usually few weeds growing in the autumn following a canola crop, so that a subsequent cereal is typically sown 1-2 weeks earlier than after other crops or a pasture, which has a consistent advantage for dryland crops in Australia.

The increased yield and protein of wheat grown after break crops not only represents increased profit, but is associated with an increase in the uptake of water and mineral N from the subsoil, reducing the risk of deep-drainage and N leaching. The deeper and healthier root systems of these more vigorous wheat crops grown after canola has been shown to use around 30-50 mm more water and 30-40 kg more N/ha from the subsoil below 1 m than wheat crops grown in monoculture.

Until the 1990's, the use of nitrogen fertiliser on dry-land cereals in southern Australia was low by international standards. Part of the reason has been the prevalence of root disease, and part has been the risk of "haying-off", the decrease in yields with excessive nitrogen in conditions of terminal drought. Canola has provided the opportunity for more reliable responses by subsequent cereals to nitrogen by reducing cereal root diseases. Canola itself seems to suffer less from haying-off than cereals, so relatively high rates of nitrogen fertiliser are applied. Even when grown after pastures, canola is normally supplied with some nitrogen fertiliser.

The good returns from canola have encouraged growers to address the problems of soil acidity with lime, or soil sodicity with gypsum. These benefits flow through to other parts of the farming system such as improved legume or pulse growth. In some parts of southern NSW, more than half the farmland has now been limed, thanks almost entirely to canola. In a similar way, the high demand for sulfur by canola has provided the impetus for growers to apply sulphate supplements, and the effects of these supplements have flowed through to assist with better legume and wheat protein yields.

FUTURE DIRECTIONS

Herbicides

Rotations with canola provide opportunities to rotate herbicides and delay the onset of herbicide resistant weeds. However, the high frequency of triazine tolerant (TT) canola represents a challenge to integrated weed control. Although TT cultivars have enabled the widespread growing of canola, especially in Western Australia, there are concerns about widespread use of triazine herbicides. There have been atrazine resistant annual ryegrass and wild radish populations identified in Western Australia. Within a rotation, the use of high rates of triazines can restrict the choice of the next crop in years where dry springs and summers occur.

The in-crop use of herbicides with long residual activity can affect the subsequent inclusion of canola into the cropping cycle. For example, the sulfonyl urea group (e.g chlorsulfuron, sulfsulfuron) used in cereal crops have a canola plant-back period of between 24 and 30 months. Similarly, some herbicides registered in pulse crops can have plant-back periods ranging from 9 months (simazine) to 24 months (flumetsulam) to 34 months (imazethapyr). The use of such herbicides can therefore have implications on crop selection and prevent canola being sown for up to three years.

The introduction of additional herbicide resistances in canola will provide farmers with alternatives to control a range of broadleaf weeds. The implications of these herbicides on cropping systems is largely uncertain, due to the weed species controlled and some pre-existing weed resistance. However, it is likely that earlier sowing and sowing dry may become options where effective in-crop weed control can be used.

Diseases

There are few diseases that are common between canola and the major field crops in Australia. *Sclerotinia* occurs sporadically and affects a range of broadleafed crops but is not hosted by cereals. *Rhizoctonia solani, Alternaria, Fusarium, Helminthosporum* and *Phoma* are widely distributed in cropping zone soils and may cause seedling damping off. Of these, *Rhizoctonia* has been identified as a significant cause of poor emergence in canola in both Western Australia and the eastern states. However, surveys in Western Australia and Victoria have shown that the isolates from canola are from different anastomosis groups to the isolates that infect wheat.

Root lesion nematodes (*Pratylenchus neglectus* and *P. thornei*) have been recorded throughout the cropping areas of southeastern Australia. *P. neglectus* has a wide host range including a some common wheat varieties, canola, chickpea and medic, and will build up where rotations have a low frequency of break crops such as fababeans, some barley cultivars or field peas. The levels of the nematodes can be monitored using a DNA probe and rotations adjusted if levels are high. The impact of *Pratylenchus* spp. on canola plantings is as yet uncertain. Canola is resistant to, but not tolerant of, stem nematode (*Ditylenchus dipsaci*) and within some areas of South Australia it is not recommended to sow canola after infected oat or bean crops.

The frequency of canola crops in rotations is increasing, particularly in the higher rainfall regions of southern New South Wales. There are now some fields where the highly profitable system of alternating crops of wheat and canola has been followed for 10-20 years. This practice defies the current recommendation, which is based on the survival of the blackleg fungus on crop residues, for a three-year break between canola crops. There is concern within the canola industry that the increased incidence of blackleg may lead to the fungus overcoming the resistance genes in the current canola varieties. Even though the mode of resistance is considered to be robust, the implications of the development of virulent strains of blackleg are severe and until further research, the industry is being urged to keep rotations wide to reduce spore loads.

FURTHER READING

Angus J.F., van Herwaarden, A.F., and Howe, G.N. (1991) Productivity and break-crop effects of winter-growing oilseeds. *Australian Journal of Experimental Agriculture* **31**, 669-677.

Kirkegaard, J.A, Gardner, P.A., Angus, J.F. and Koetz, E. (1994) Effect of Brassica break crops on the growth and yield of wheat. *Australian Journal of Agricultural Research* **45**, 529-545.

Chan, K.Y. and Heenan, D.P (1991) Differences in surface soil aggregation under six different crops. *Australian Journal of Experimental Agriculture* **31**, 683-686.

Kirkegaard J.A., Sarwar M., Wong P.T.W. and Mead A. (1998) Biofumigation by brassicas reduces take-all infection. In 'Agronomy – Growing a Greener Future', D.L. Machalk and J.E. Pratley (Eds). *9th Australian Agronomy Conference*, Charles Sturt University, Wagga Wagga, pp. 465-468.

Mead, J.A. (1992) Rotations and farming systems - the current situation. In *'Rotations and Farming Systems for Southern and Central NSW'*, G.M. Murray and D.P. Heenan (Eds), NSW Agriculture, pp.5– 0.

Potter, T.D. and Salisbury, P.A. (1993) The role of triazine resistant canola in Australia. 9*th Australian Research Assembly on Brassicas,* Wagga Wagga, pp. 87-91.