Canola

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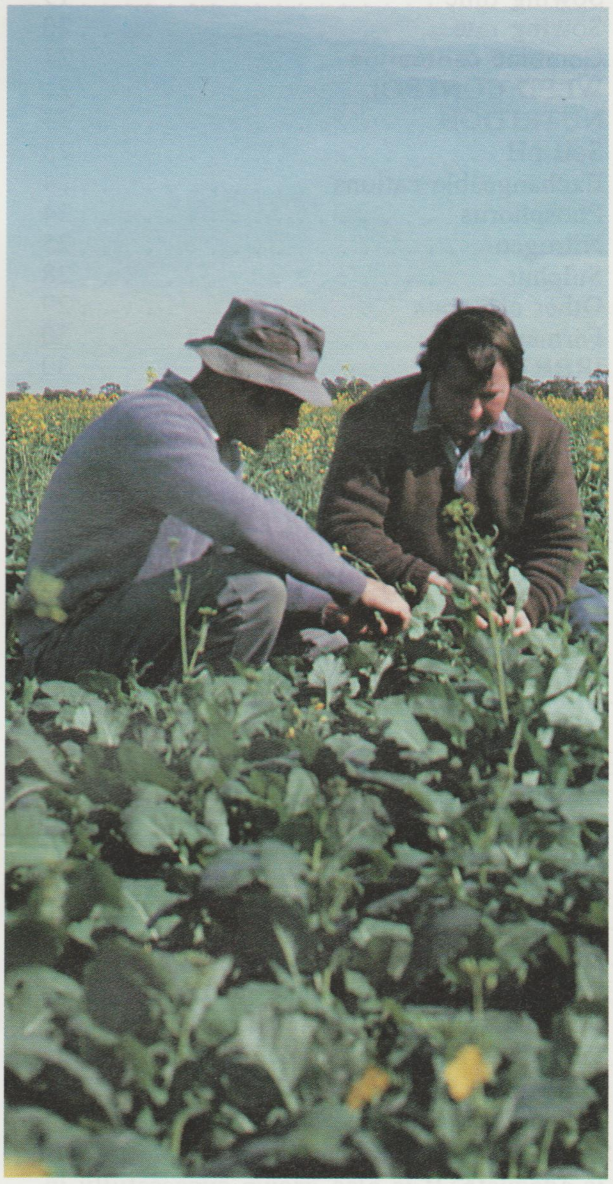

NSW Agriculture

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SYNOPSIS

Canola is a winter-growing oilseed crop adaptable to most arable areas of New South Wales with fertile soil and good drainage. Suitable soils range from the granites of the tablelands to the self-mulching clays of the north west.

Canola is consistently grown now in the better parts of the wheat belt, where rainfall is adequate. It is also grown successfully in more marginal rainfall areas, lake beds and floodplains in far western New South Wales, and under irrigation.

Growing canola is similar to growing wheat; this includes using the same machinery.

Canola production costs are higher than those for wheat as spraying is required to control insects, extra nitrogen may be necessary, and the crop may need to be windrowed just before harvesting. However, recently canola has been a more profitable crop than wheat for most growers.

Rotating canola with winter cereals and legumes is a successful strategy. Canola is sown and harvested a little earlier than wheat, so it tends to spread the workload over these busy periods. Yields from cereal crops are usually higher if canola is introduced into the rotation; this is because of better disease and weed control and because of the different growth habit of canola. Another advantage is that canola can be trucked direct from farm to crushing plant and therefore is less likely to compete with other grains for storage space.

Australian breeding programs have been successful in releasing varieties which are higher yielding, have very high quality, desirable agronomic characteristics and good resistance to blackleg disease.

Domestic demand for canola oil and meal continues to expand and there is a major export market for the seed in Japan. Potential exists for large-scale irrigation and dryland canola production in New South Wales.

Cover: Canola crops around Marrar on the southern slopes of NSW. Photo by M. Childe.

INTRODUCTION

Until 1988, canola was known as rapeseed in Australia; the word rape coming from the Latin word 'rapum' meaning turnip.

Canola belongs to the botanical family Brassicaceae, of which mustard, turnip, wild radish, cauliflower, cabbage and broccoli are also members.

Rapeseed was cultivated by ancient civilisations in Asia and the Mediterranean and its oil was used for lighting; it produces a smokeless white light.

It was recorded in India as early as 2000 BC and was grown in Europe in the 13th century. It was first grown in Canada in 1942 for use as a lubricant by the ships of the allied navies.

The use of canola for edible purposes was not fully exploited by western nations until the end of World War II. Edible oil was first extracted in Canada in 1956. Within Australia, canola was first trialed in New South Wales in 1963.

Canola was first grown commercially in 1969, following the introduction of wheat delivery quotas. The first commercial seed of the variety, Target, was imported from Canada in 1967 by Meggitt Ltd.

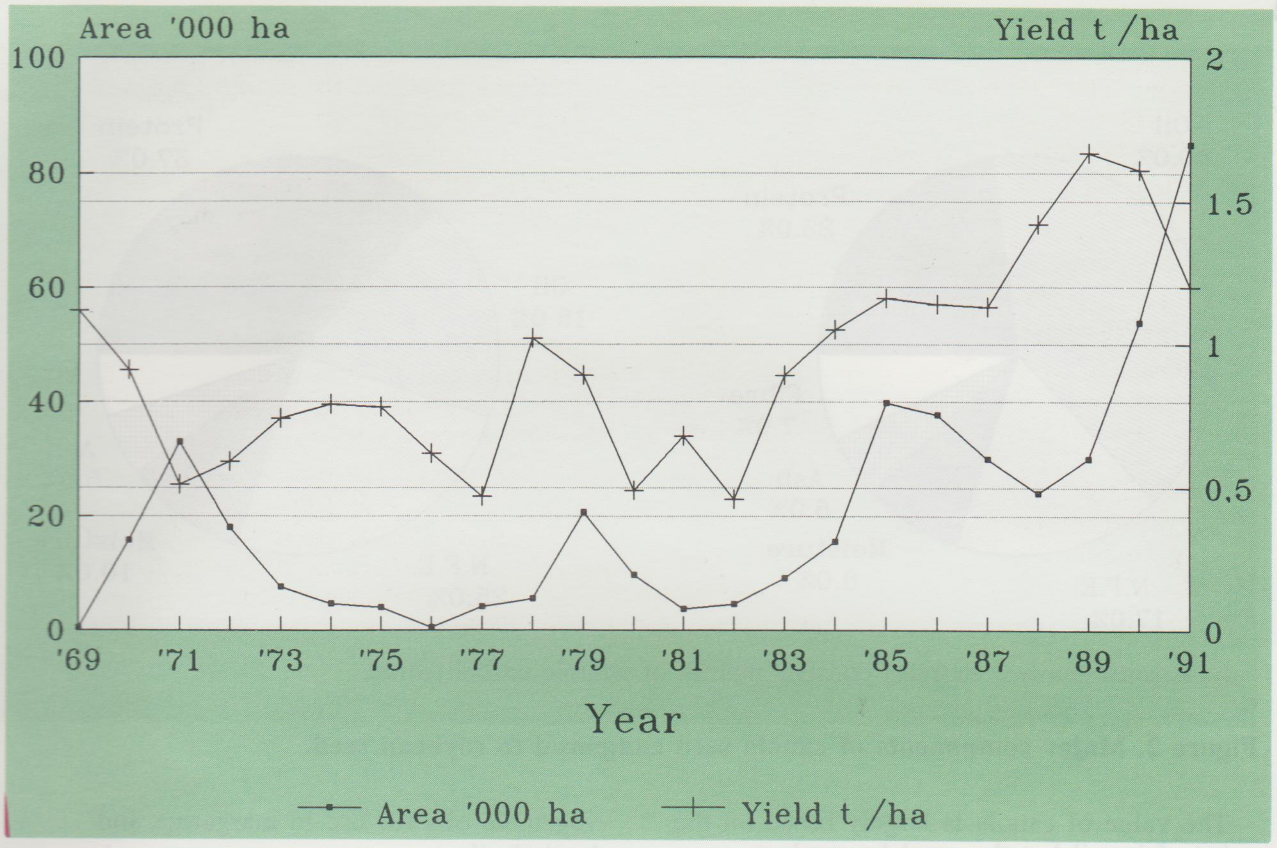


Figure 1. Canola area and yields from 1969 to 1991.

Initial enthusiasm for the crop in the early 1970s was short lived. Australian production peaked initially in 1971-72 at 87,000 ha and 55 000 tonnes, but quickly crashed when an outbreak of blackleg disease, particularly in New South Wales and Western Australia, caused widespread failure. Throughout the 1970s and early 1980s production remained in the 10,000 to 20,000 tonne range, with the exception of one or two years.

Production began to rise steadily in the late 1980s, particularly in New South Wales. The release of much higher yielding, high quality, disease resistant varieties with better agronomic features, coincided with a growing recognition of the value of canola in wheat rotations and this put the crop on a sound footing. In 1990, the Australian canola annual production first exceeded 100,000 tonnes and became sufficient to meet domestic demand. About 75 pc of that production came from New South Wales (see Figure 1).

World canola production is about 22 million tonnes, which is about 10 pc of world production of vegetable oilseeds. The major producing countries are Canada, China, India, EC, Poland and Sweden.

About 4.5 million tonnes of canola enter world trade annually; Canada is the major exporter (about 2 million tonnes) and Japan is the major importer (1.8 million tonnes).

Although domestic demand for canola in Australia continues to increase steadily, further increases in production are likely to generate exportable surpluses. Australian exports will find a ready market in Japan, which is anxious to find an additional supplier to Canada.

The challenge of the 1990s for New South Wales will be to develop a consistent export market by increasing the area sown to canola to at least 4 pc of the total winter crop area (approximately 100,000-150,000 ha compared to the 1991 area of about 83,000 ha).

In the five years to 1989-90, New South Wales canola production had an annual value of $12 million. The industry is growing rapidly and by 1990-91 crop value had risen to $26 million (see Table 1).

CROP USES

Canola* is used entirely for its oil and protein. About 40 pc of the seed is a monounsaturated edible oil which is becoming increasingly important in human diets. After removal of the oil by crushing, a high protein meal remains, which is a valuable source of protein in animal diets.

* The name canola represents a unique type of rapeseed whose varieties meet certain quality standards. Erucic acid must make up less than 2 pc of the total fatty acids in the oil, and the oil free and air-dried meal must contain less than 40 micromoles of total glucosinolates.

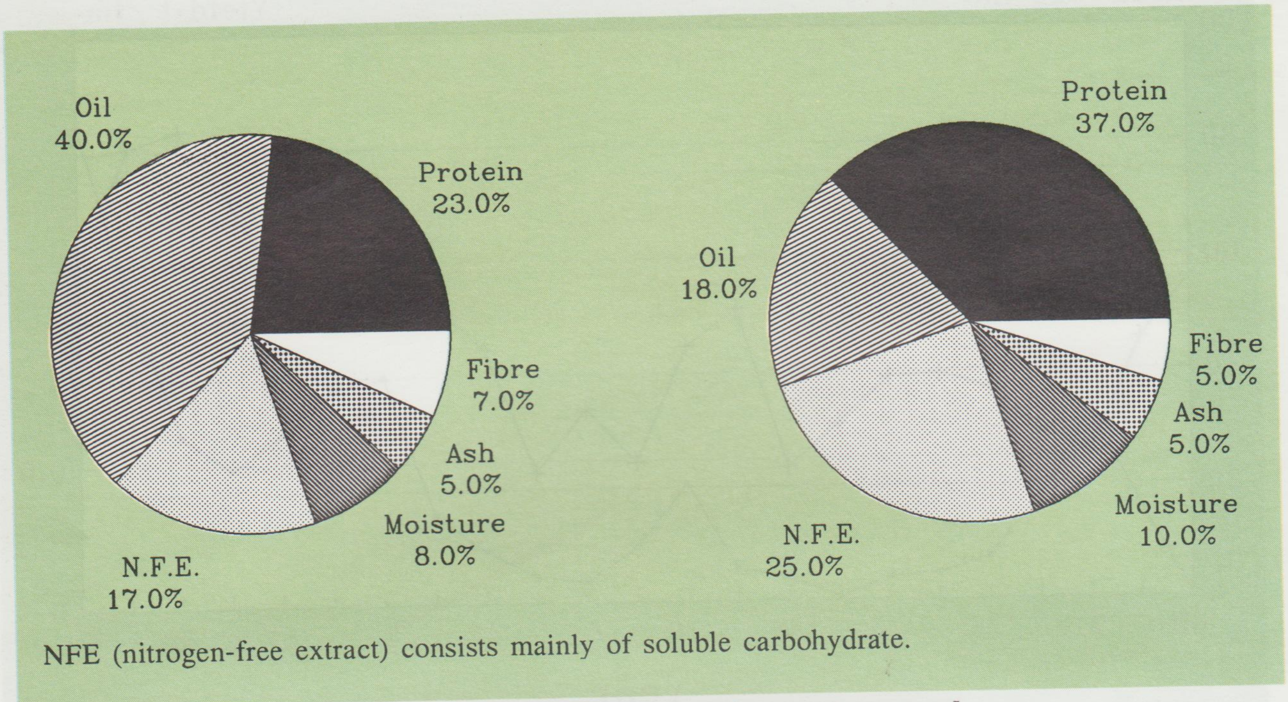


Figure 2. Major components of canola seed compared to soybean seed.

The value of canola is largely based on the price of its oil but the meal by-product compares favourably with soymeal and can be readily sold at the same price per protein unit (see Figure 2).

Oil

Canola oil is used in cooking, salad oils, shortenings and more recently, in margarine. By the end of 1991 pure canola margarine had captured 7 pc of the domestic margarine market worth $300 million annually. Pure canola oil products had a 10 pc share of the domestic bottled oil market worth $111 million annually.

Canola oil is also blended with other vegetable oils for use in margarine and bottled oils.

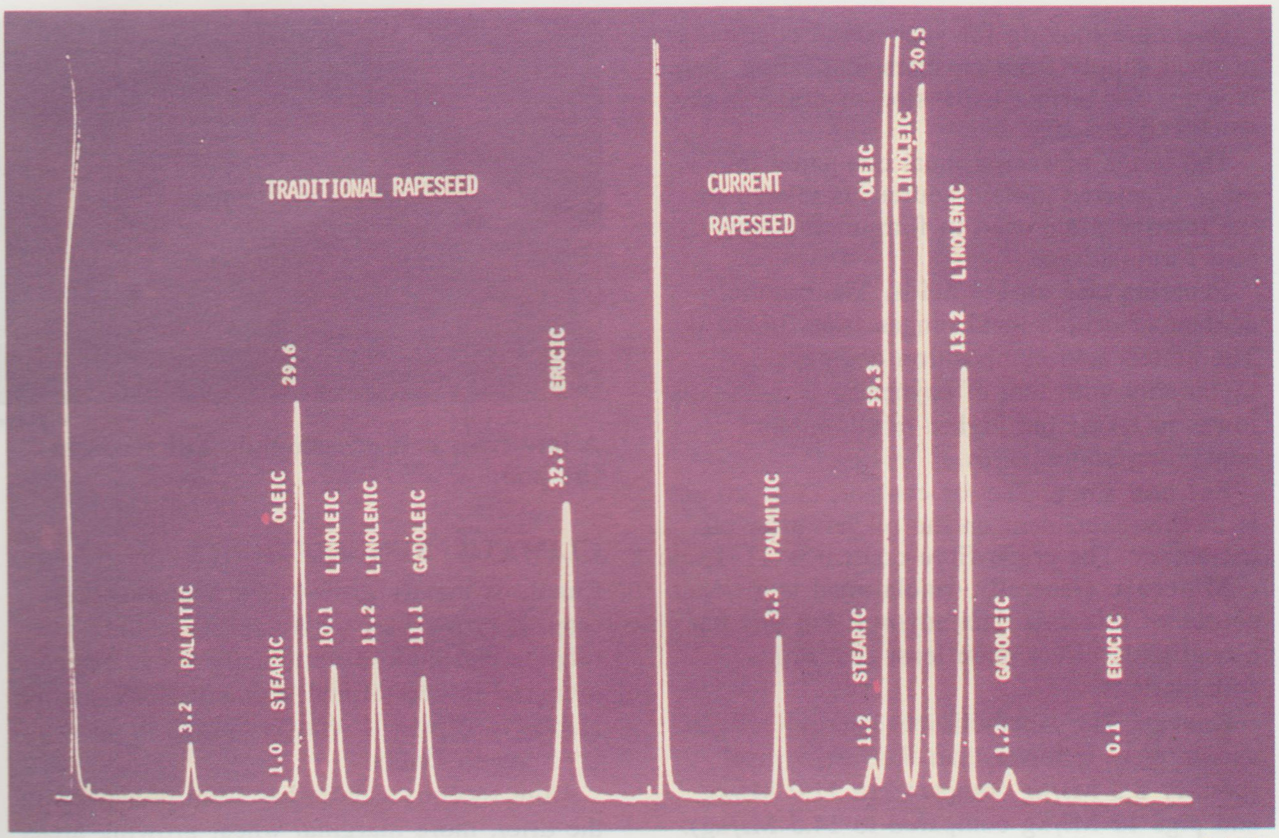
Vegetable oils consist of a mixture of fatty acids, with palmitic, oleic, linoleic and linolenic predominating. The relative proportions of these weak organic acids determine whether an oil is saturated, monounsaturated, or polyunsaturated. Oleic acid predominates in canola and olive oils, making them monounsaturated; whereas linoleic predominates in safflower, sunflower and soybean, making them polyunsaturated.

Oil from the early rapeseed varieties contained high levels of erucic acid and quite low levels of oleic and linoleic acids.

Table 1. Area, production and value of canola in New South Wales.

Year	Area '000 ha	Production '000 t	Value $ million
1985/86	40	46	14
1986/87	38	43	11
1987/88	30	34	9
1988/89	24	34	11
1989/90	33	55	15
1990/91 *	53	86	26
1991/92 #	85	105	29
Av 5 years (to 1989-90)	33	42	12

Source: Australian Bureau of Statistics
* ABARE estimate
# NSW Agriculture estimate



Plant breeders have raised the oleic and linoleic fatty acids while virtually eliminating erucic acid.

High erucic acid rapeseed oil has valuable uses as a high temperature lubricant but has been shown to cause health problems in laboratory animals when used for edible purposes. Plant breeding during the 1970s and 1980s has virtually eliminated erucic acid from Australian canola oil. The latest varieties contain levels of less than 0.5 pc.

Nutritionists now emphasise the desirability of increasing the intake of mono- and poly-unsaturated oils at the expense of animal fats in human diets. They also recommend a reduction of dietary cholesterol. This means substituting animal fats, which are highly saturated and contain cholesterol with vegetable oils which are unsaturated and do not contain cholesterol.

Among the popular vegetable oils, canola oil is well placed from a health point of view. It has the lowest level of saturated fat (6 pc) and is second only to olive oil in having the highest level of monounsaturated fat (60 pc) (see Table 2).

Meal

The meal is the portion remaining after removal of the oil and contains proteins, carbohydrates, minerals and fibre. Canola meal is used in the Australian stockfeed industry as a protein supplement (mainly in pig and poultry feeds).

Canola meal is more valuable nutritionally than sunflower meal, which it has replaced to a large extent. It is also being partly substituted for soymeal in many animal rations.

Table 2. Major fatty acids in some common vegetable oils.

		Typical oil fatty acid composition					
		Rapeseed	Canola	Olive	Sunflower	Soybean	Cottonseed
Saturated	Palmitic	3	4	10	6	10	22
Mono-unsaturated	Oleic	21	61	80	26	24	20
	Erucic	40	tr	-	-	tr	-
Poly-unsaturated	Linoleic	13	21	8	66	55	54
	Linolenic	7	9	-	tr	8	-

tr= trace

Users are looking for year round continuity of meal supply from crushers, indicating there is scope for further expansion of usage in the stockfeed industry.

The usage of canola meal compared to other vegetable protein sources is related to the relative price used in formulating least cost formulations.

Proteins and amino acids. The protein content of canola meal ranges from 36-39 pc. The amino acid composition compares favourably with that of soybeans; it is slightly lower in lysine but higher in all sulphur containing amino acids.

Fat and fibre. The fat content, (1.5-2.0 pc) is largely dependent on the oil left after oil extraction. The crude fibre content is 11-13 pc.

Minerals. Generally canola meal is a richer source of minerals than soymeal but this has a negligible effect upon least cost ratio formulations.

Energy. The metabolisable energy (ME) of canola meal is lower than that of soymeal (poultry 8.5 MJ/kg compared to 11.0 MJ/kg and pigs 12 MJ/kg compared to 14.5 MJ/kg). This is because canola meal has a low available carbohydrate content and a relatively high crude fibre content. Presently this restricts its use to 10-15 pc of pig and poultry rations.

Glucosinolates. High levels of sulphur containing components called glucosinolates which are found in all cruciferous plants, limited the value of the meal from the old rapeseed varieties. They reduced feed palatability and were found to be responsible for enlarged thyroids and reduced growth rates in non ruminants. As in the case of erucic acid in oil, glucosinolate levels in current varieties have been reduced by plant breeding from greater than 100 micromoles per gram to below 20 micromoles per gram of meal (see Table 3). The meal is now very acceptable as an alternative to soybean meal and other protein supplements.

Maintenance or improvement in protein and low glucosinolate levels will be essential to increase the demand for canola meal.

R. Colton

A late frost can occasionally kill seeds in the pod.

CLIMATIC REQUIREMENTS

Canola is mainly grown as a winter-spring crop. It grows best where spring rainfall is reliable and high. Traditionally it has been favoured in central and southern NSW—from Dubbo to Cowra to Wagga Wagga to West Wyalong to Dubbo.

More recently canola has been pioneered in the drier, more marginal wheat growing areas and on the north western slopes. In the early 1980s it was also planted in spring and grown into summer in higher tableland areas (above 800 m) and trialed as an alternative crop on the north and south coasts.

Canola is not as drought tolerant as cereal crops. It needs good winter rainfall or conserved subsoil moisture (80 cm to 1 m) to grow without restriction until the end of flowering. Spring rainfall (September-October) is then needed to reach maximum yield potential.

Canola is fairly frost tolerant. Damage can occur at the cotyledon stage, although it is uncommon. Seedlings affected by frosts will blacken and may die. However, resowing due to frost damage is very rare. Plants become frost tolerant as they develop. The lower temperatures which normally occur at flowering, have not caused losses. Flower abortion can occur, but the lengthy flowering period provides adequate compensation for losses caused by minor flower abortion.

Table 3. Oil, protein and quality of current varieties 1987-89.

Variety	Oil content %	Protein content %	Erucic acid %	Total glucosinolates %
Barossa	39.5	36.5	0.1	14
Yickadee	41.8	37.7	0.1	18
No:1 Canada*	41.2	39.0	0.6	32

* Canadian average export quality 1990/91 (Canola Digest March 1991)

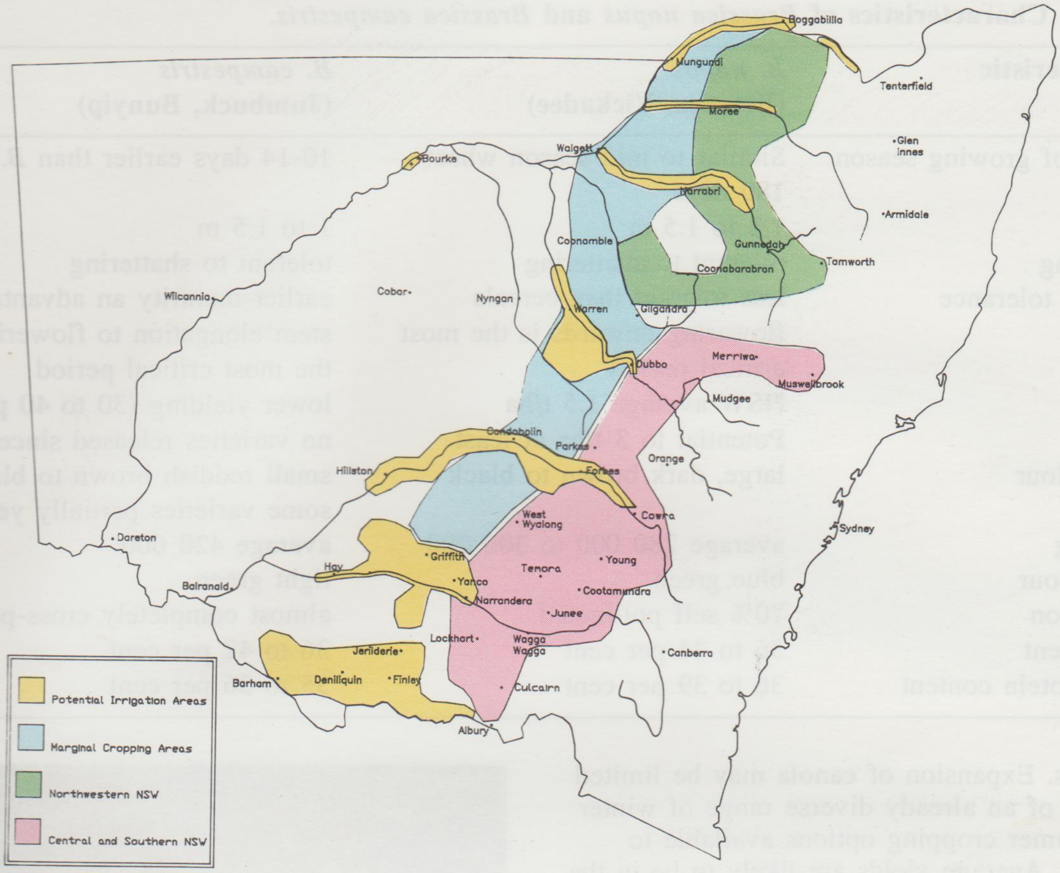


Figure 3. Major canola growing areas in New South Wales.

A late frost (when the crop has finished flowering and the seed is at the milk stage or approximately 60 pc moisture in early to mid October from April sowings) can cause major losses. The seed shrivels in the pods but its green colour is retained. In 1991, mild winter conditions hastened crop maturity on the north western plains and light frosts caused pod abortion and seed shrivelling. Very low temperatures in October on the river flats at Cowra have caused similar problems in some years. However, such late frost damage is relatively infrequent.

PRODUCTION LOCALITIES

In New South Wales there are four main production areas (see Figure 3). Each differs in cropping history, producer experience and crop management recommendations:

Irrigation

Canola has developed as an opportunity crop depending on available price for canola and other competitive crops, for example, irrigated wheat. During the 1980s it was found that canola, grown on raised beds and irrigated 2–3 times in spring, could yield more than 3.0 t/ha. Yield potential is less on border check irrigation; canola is not recommended on contour irrigation.

In practice, average yields of irrigated crops are in the range of 2.0–2.5 t/ha. It is expected that canola will develop as a prominent irrigation crop during the 1990s because of its reduced water and labour requirements compared to summer oilseed crops with similar returns.

Marginal cropping areas

Experience from 1984 to 1991 has shown that canola can be a viable crop in low rainfall areas (350–450 mm annual average rainfall). Average yield potential lies between 1.0–1.5 t/ha. Growers have utilised the fact that canola is relatively frost tolerant and therefore can be sown early to avoid hotter finishing conditions. As it is a taproot plant, it can utilise deeper subsoil moisture than cereals. Experience has shown that for canola to be a reliable crop there must be a definite cut-off date for sowing (early May); good subsoil moisture (80 cm to 1 m) must be available at this time.

Northern wheat belt

Apart from the occasional season such as 1979, northern New South Wales was not a significant canola producer during the 1970s and 1980s. However, canola is gaining more acceptance as a beneficial crop despite limited use of legume pastures in developing

Table 4. Characteristics of *Brassica napus* and *Brassica campestris*.

Characteristic	*B. napus* (Barossa, Yickadee)	*B. campestris* (Jumbuck, Bunyip)
Length of growing season	Similar to mid season wheat 180 days	10-14 days earlier than *B. napus*
Height	1.2 to 1.5 m	1 to 1.5 m
Shattering	tolerant to shattering	tolerant to shattering
Drought tolerance	less tolerant than cereals flowering onwards is the most critical period	earlier maturity an advantage stem elongation to flowering is the most critical period
Yield	NSW average 1.5 t/ha Potential to 3 t/ha at least	lower yielding (30 to 40 per cent) no varieties released since 1983
Seed colour	large, dark brown to black	small reddish brown to black some varieties partially yellow
Seeds/kg	average 280 000 to 300 000	average 420 000
Leaf colour	blue green	light green
Pollination	70% self pollinated	almost completely cross-pollinated
Oil content	36 to 44 per cent	36 to 42 per cent
Meal protein content	36 to 39 per cent	35 to 36 per cent

rotations. Expansion of canola may be limited because of an already diverse range of winter and summer cropping options available to growers. Average yields are likely to be in the range of 1.3–1.5 t/ha.

Central and southern wheat belt

The central and southern slopes have been the traditional production base for canola in New South Wales. Production began in 1969 but suffered problems due to disease, unsuitable varieties and lack of good management skills. However, it has always been recognised as an ideal crop grown straight after a pasture phase or as a second crop in the rotation following oats.

Many growers persevered with the crop over the years and developed a sound management base. Others came and left the industry only to be attracted again by the profitability and rotational benefits being gained by neighbours. After 21 years of development, canola has emerged as a profitable crop in its own right and as an ideal crop grown in rotation with cereals and legumes. Average yields are likely to be in the range of 1.5–1.8 t/ha.

THE PLANT AND HOW IT GROWS

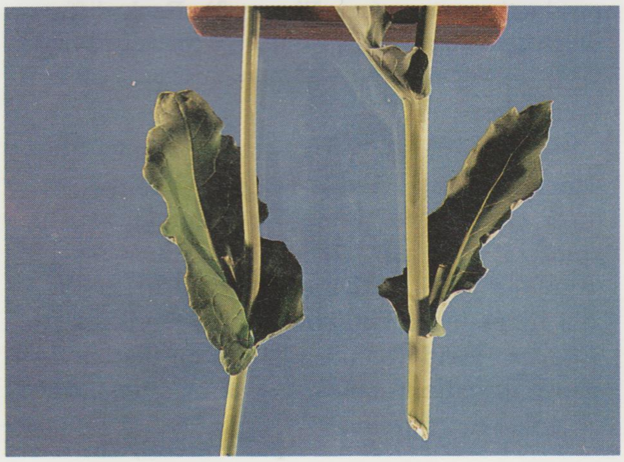
Two cruciferous species of canola have been grown commercially in Australia—the swede rape type *Brassica napus* (for example, Barossa) and the turnip rape type *Brassica campestris* (for example, Bunyip). *Brassica juncea* (brown mustard) is also grown as a minor crop in New South Wales.

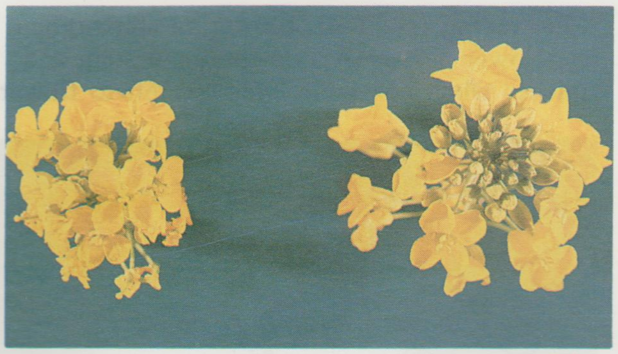
F. Tome

***B. campestris* (left) leaf colour is light green and turnip-like compared to *B. napus* which has a dark blue-green cabbage-like colour.**

The leaf sheath of *B. campestris* (left) clasps the plant's stem whereas that of *B. napus* extends only halfway around the stem.

F. Tome





F. Tome

The flower buds of *B. napus* are visible above the open flowers.

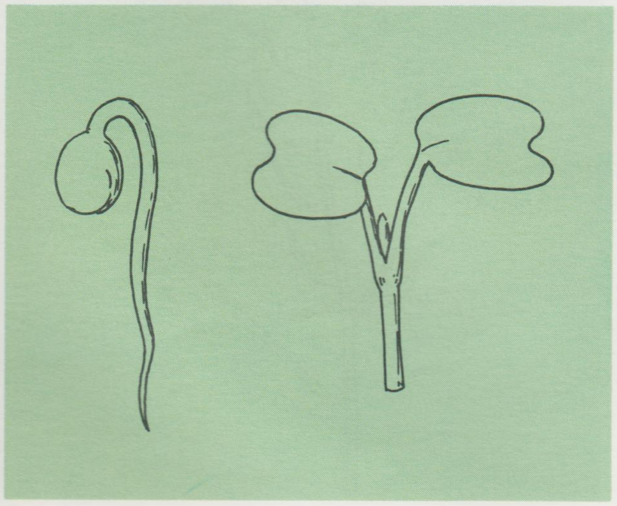
J. Sykes

Canola newly emerged, showing cotyledon leaves.

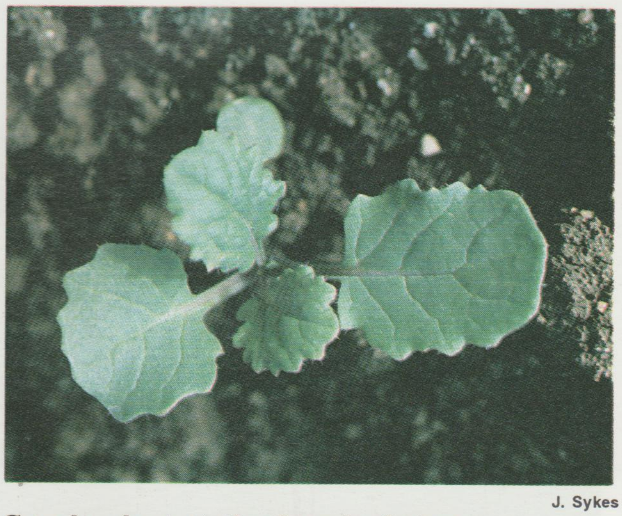
There are approximately 10 different oilseed rape types grown throughout the world; they are mainly annual and biennial variants of *B. napus* and *B. campestris.* In Canada, both species are of considerable importance; *B. napus* is the dominant species in Europe and the Indian sub-continent. Each species has an optimum set of environmental and growing conditions (see Table 4).

The life cycle of the canola plant is divided into seven principal stages. By recognising the beginning of each stage growers can be reminded of critical management decisions that have to be made at these times. Each growth stage covers the development of a stage of the plant. However, the beginning of each stage is not dependent on the preceding stage being finished (that is, growth stages overlap). The beginning of each growth stage from budding is determined by looking at the main (terminal) stem.

Germination and emergence (stage 0). Emergence occurs after the seed absorbs moisture and the root (radicle) splits the seed coat and the shoot (hypocotyl) pushes through the soil pulling the cotyledon leaves upward, in the process shedding the seed coat. When exposed to light, the cotyledons part and become green.



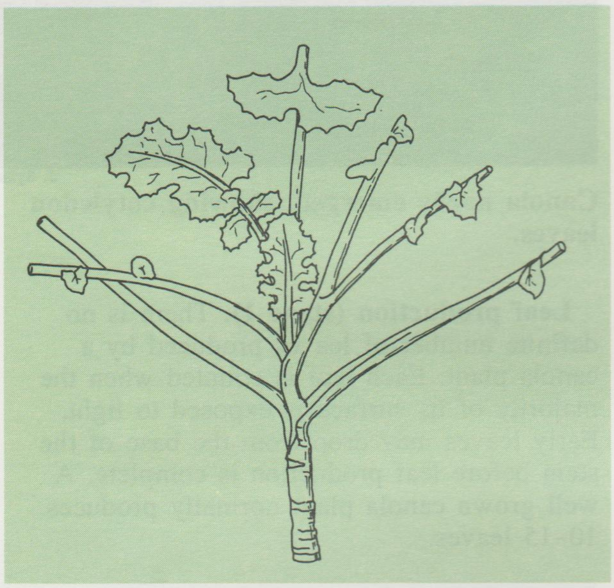
Leaf production (stage 1). There is no definite number of leaves produced by a canola plant. Each leaf is counted when the majority of its surface is exposed to light. Early leaves may drop from the base of the stem before leaf production is complete. A well grown canola plant normally produces 10–15 leaves.



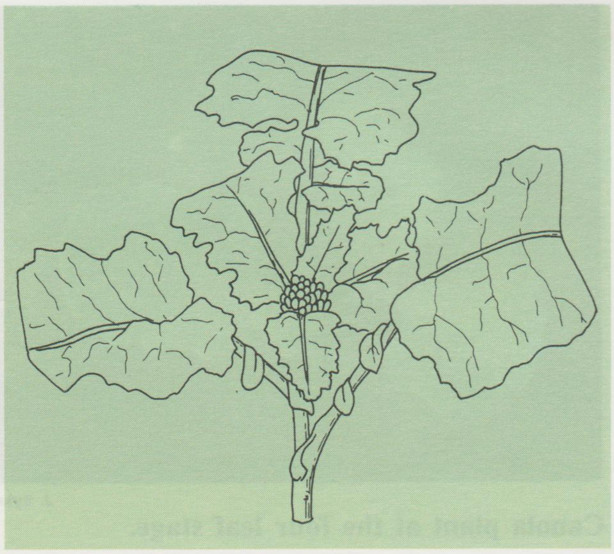
J. Sykes

Canola plant at the four leaf stage.

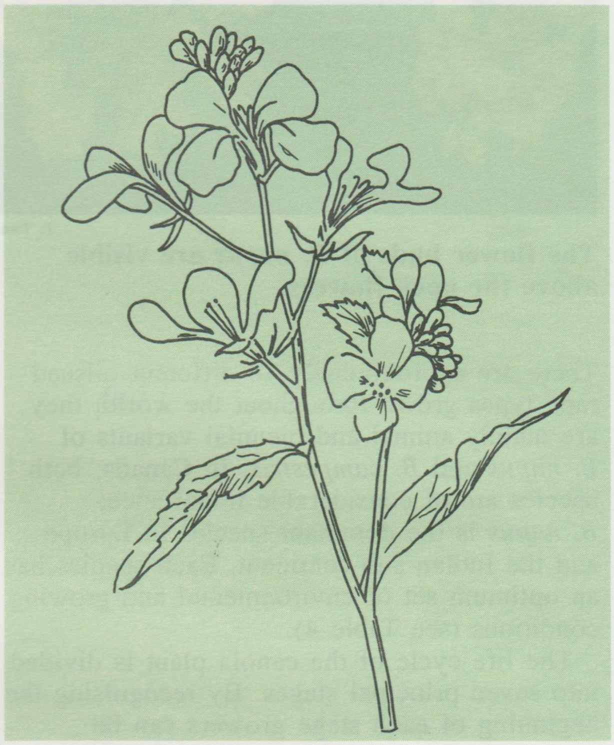
Stem extension (stage 2). Stages of stem extension are defined according to how many detectable internodes (minimum length 5-10 mm) are found on the stem. A leaf is attached to the stem at each node. Each internode is counted. Normally, a well grown canola plant produces 15-20 internodes.



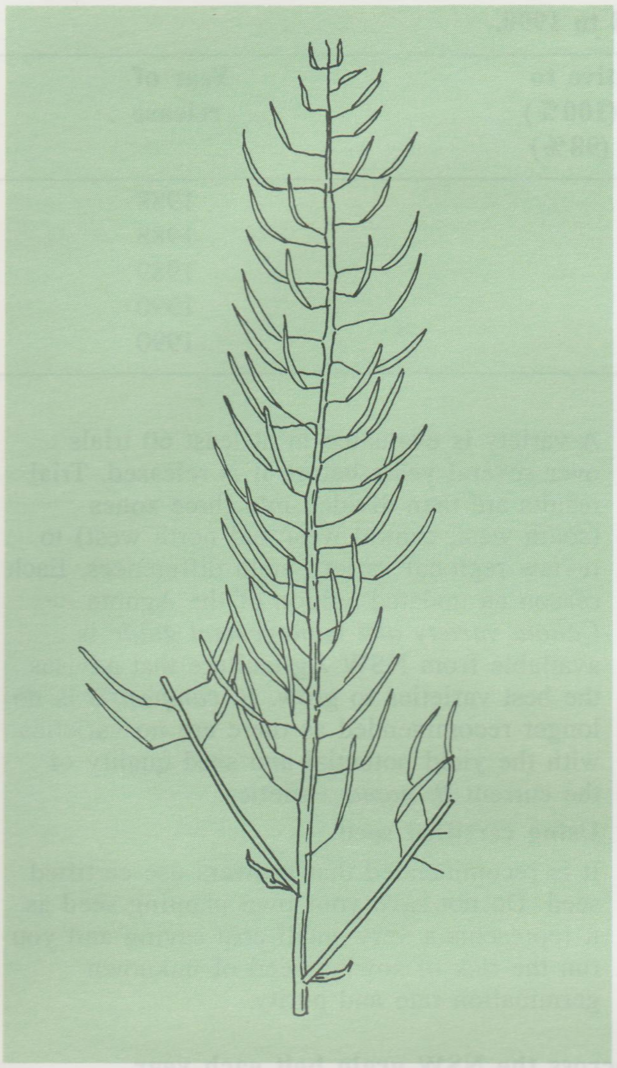
Flower bud development (stage 3). Initially flower buds remain enclosed during early stem elongation and can only be seen by peeling back young leaves. As the stem emerges they can be easily seen from above but are still not free of the leaves; this is described as the 'green bud stage'. As the stem grows, the buds become free of leaves and the lowest flower stalks extend so that the buds assume a flattened shape. The lower flower buds are the first to become yellow, signalling the 'yellowing bud stage'. Progressively more buds become yellow as the stem grows with lowest buds flowering last.



Flowering (stage 4). Flowering starts when one flower has opened on the main stem and finishes when no viable buds are left to flower.

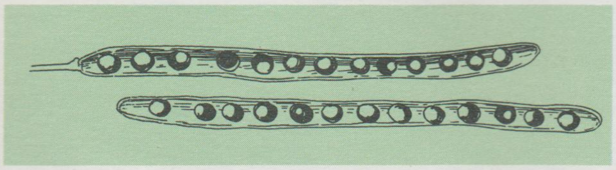


Pod development (stage 5). Podding development starts on the lowest one third of the branches on the main stem and is defined by the proportion of potential pods which have extended to more than 2 cm long.



Seed development (stage 6). Seed development is also **seen** on the lowest one third of branches on the main stem. The stages are assessed by seed colour as follows:

1. seeds present
2. most seeds translucent but full size
3. most seeds green
4. most seeds green-brown mottled
5. most seeds brown
6. most seeds dark brown
7. most seeds black but soft
8. most seeds black but hard
9. all seeds black and hard.



The growth stage when the crop is **physiologically mature** is important and one that growers should learn to recognise. It is the stage when the seeds have reached their maximum dry weight and the crop can be windrowed. At this time 40-60 pc of seeds have started to change from green to their mature colour (growth stage 6.4 to 6.5). At this time, seed moisture content is 35-40 pc and most seeds are firm enough to roll between the thumb and forefinger without being squashed. It is a period of rapid change as all seeds can develop from translucent to black over a 12-day period. It is important not to windrow too early; windrowing before physiological maturity will reduce yields by 3-4 pc for each day too early, due to incomplete seed development. Oil content will also be reduced.

Canola can be harvested when the moisture content of black seed is 9 pc.

VARIETIES AND SEED QUALITY

Both *Brassica napus* (Target) and *B. campestris* (Arlo) species were grown in the early years; *B. napus* in the more favoured areas and *B. campestris* in the drier, shorter season areas. By the late 1970s the industry in New South Wales was based mainly on *B. campestris* varieties (Span). They were favoured over *B. napus* varieties because of their earlier maturity and tolerance to pod shattering. However, both species lacked high oil and meal quality and were susceptible to blackleg disease. The popularity of *B. campestris* continued in the 1980s with the release of Jumbuck and Bunyip in New South Wales. These varieties introduced tolerance to blackleg and improved oil quality.

A series of *B. napus* varieties with tolerance to blackleg and with improved oil and meal quality was released from Victoria (Marnoo) and Western Australia (for example, Wesroona and Wesbrook) during the early 1980s, but they never really became popular with New South Wales growers.

High quality canola varieties became available in 1988 with the release of Maluka and Shiralee from NSW Agriculture's canola breeding program at Wagga Wagga. These were the first varieties to combine canola quality with blackleg resistance and high yields (see Table 5). They also resulted in a complete swing to *B. napus* varieties in New South Wales. The other significant development on the variety front was the release of the first hybrid canola, Hyola 30, by Pacific Seeds in 1988.

The 1990 release of Barossa and Yickadee marked a significant turning point in the Australian canola industry. Growers responded to the availability of improved varieties that combined high yield potential, improved standability, shattering tolerance and better oil and meal quality. The area and status of canola improved and it became the dominant winter oilseed crop grown in New South Wales.

Table 5. Canola variety yield improvement 1988 to 1990.

Variety	Yield relative to Wesbrook (100%) Marnoo (98%)	Year of release
Shiralee	116	1988
Maluka	117	1988
Eureka	122	1989
Yickadee	123	1990
Barossa	128	1990

Further improvement will come from maintaining an emphasis on yield and blackleg resistance while improving oil content and protein levels. Government and private breeding programs aim at introducing earlier maturity, reduced height and improved vigour into new varieties.

Choosing a variety

Improved varieties will continue to become available during the 1990s. Recommendations will change as new varieties are evaluated. About 25 variety evaluation trials are conducted each year within commercial dryland and irrigated paddocks throughout New South Wales. Trials are conducted by NSW Agriculture staff to compare new lines with recommended varieties and the most promising lines from other breeding programs.

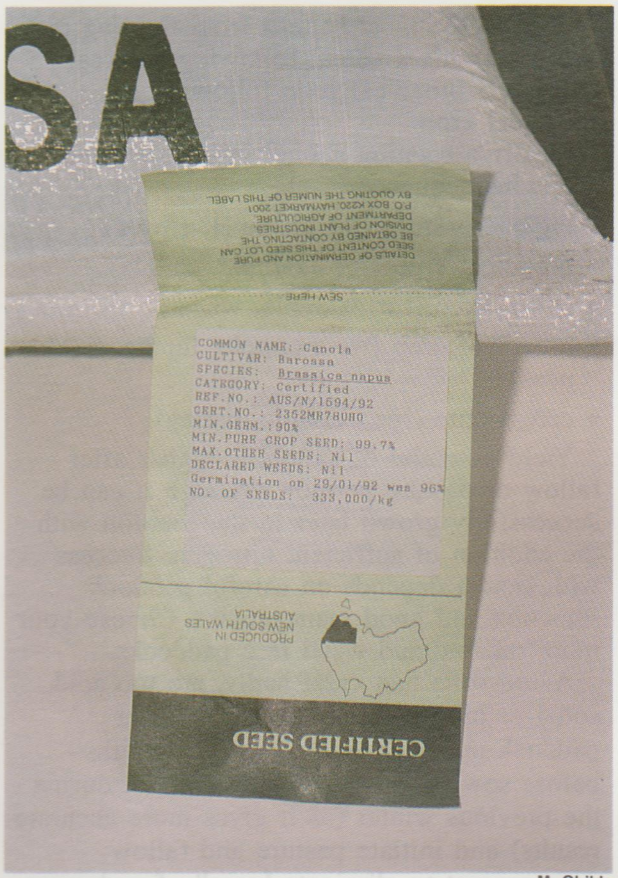
A variety is evaluated in at least 60 trials over several years before it is released. Trial results are then divided into three zones (south west, central west and north west) to review regional variety yield differences. Each season an updated edition of the Agnote *Canola variety and management guide* is available from NSW Agriculture that advises the best varieties to grow. *B. campestris* is no longer recommended as there are no varieties with the yield potential and seed quality of the current *B. napus* varieties.

Using certified seed

It is recommended that growers use certified seed. Do not save your own planting seed as it represents a very small cost saving and you run the risk of sowing seed of unknown germination rate and purity.

New varieties are tested at some 25 trial sites across the NSW grain belt each year.

R. Colton



M. Childe

Green (domestic) certification tag showing the sticky label attached. The sticky label contains vital information which allows the seed source to be identified and lists germination, purity and weed seed content.

Bag of canola seed showing the green certification tag but without the sticky label attached. Without the sticky label, the seed does not comply with the NSW Seed Certification Rules or the NSW Seeds Act 1982.

M. Childe

Other negative factors are: oil and meal quality deterioration as successive generations are grown from the original seed lot; and nuisance value of cleaning small amounts of carry-over seed.

Growers gain more from delivering all their grain to buyers and buying new seed that has been produced in a well organised seed certification program. With certified seed, you are guaranteed to get the varieties that you ask for, and there is little or no risk of importing prohibited weed seed (such as wild radish) onto the farm. This is due to careful paddock inspection and the seed testing program conducted by the Seed Section of NSW Agriculture. New South Wales certified seed meets international standards for purity and seed quality. A small proportion (royalty) of the cost of seed you buy (made available through Plant Variety Rights legislation) is directed back into the breeding program to help fund the development of new varieties. This arrangement began with the varieties Barossa and Yickadee.

CROP ROTATION

Canola is a profitable companion crop when grown in rotation with cereal and legume crops. The downturn in 1990 grain prices re-emphasised the need that each grower must plan and develop a long term rotation management system that suits the whole farm and individual paddock circumstance. Rotation systems require an approach that is flexible, integrated and continuous.

The inclusion of canola in rotations will:

- Lift the yields of following cereal crops by enabling them to extract deeper subsoil moisture, as a result of the deeper rooting habit of canola.
- Reduce the incidence of root diseases in cereals as it does not host the same diseases which affect winter cereals. This results in higher yields in following cereal crops.

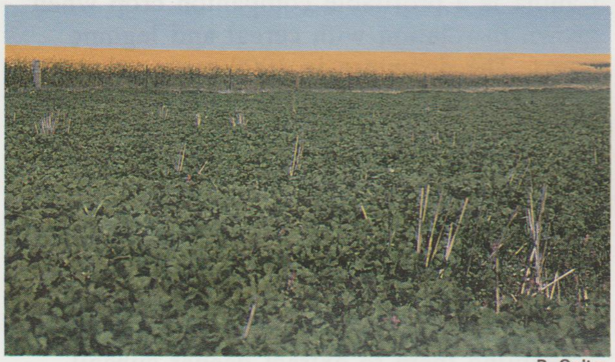
Canola leaves the soil soft and friable, allowing the following crop to be direct drilled very easily and cheaply.

F. McRae

- Avoid the repeated use of the same herbicide. Changing crops and herbicides reduces the potential for herbicide resistance to develop in weeds and residues to accumulate in the soil. It also results in better control of weeds.
- Improve soil structure as canola is a taprooted plant which 'conditions' the soil and allows direct drilling of a following cereal crop into a more friable topsoil.
- Lengthen the time available to use machinery and labour because of its earlier sowing and harvest than wheat.

These benefits can result in a more profitable and sustainable farming operation by:

- producing higher yielding, more profitable cereal crops
- more diversified sources of income;
- better use of machinery and labour because of earlier sowing and harvesting than wheat;
- prompt delivery to crusher reduces competition with wheat and other grains for on-farm and other grain storage.



R. Colton

Growing canola after sub clover and following with a winter cereal is a winning crop sequence. The clover feeds both crops with nitrgoen. The canola breaks the cereal disease cycles and its deep taproots give the cereal access to deeper soil moisture, resulting in higher yields.

A patchwork of canola, cereals, grain legumes and clover-based pastures in the Temora district—a sound basis for profitable rotations.

F. McRae

To gain the most benefit from rotating crops avoid growing a cereal following a cereal crop, or a broadleaf crop following a broadleaf crop.

Ideally a rotation should incorporate the following sequence of crops:

- legume pasture (for example, clover)
- broadleaf crop (for example, canola)
- cereal crop (for example, wheat)
- broadleaf crop (for example, lupins, field peas)
- cereal crop (for example, barley)

Yield potential of canola is higher after fallow or pasture periods although it can be successfully grown later in the rotation with the addition of sufficient nitrogen. Success with canola depends on careful paddock selection and good management. Choose your more reliable and weed free paddocks.

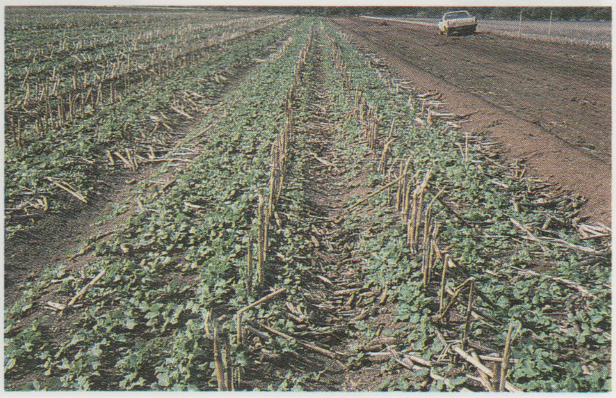
Avoid soils that crust badly, are too acid, sodic or prone to waterlogging. Begin paddock management at least 12 months before sowing. It is better to soil test during the previous winter (as it gives more accurate results) and initiate pasture and fallow management to eliminate broadleaf and grass weeds, and establishment pests such as red legged earthmites.

Following summer crops

Grain sorghum and cotton growers on alkaline soils in northern New South Wales have reported low yields and poor growth following canola, particularly on the Liverpool Plains. This is possibly due to depletion of soil microorganisms (VAM). They are friendly soil fungi (mycorrhizae) which assist the uptake of phosphorus and zinc which would otherwise be unavailable to the crop. Canola does not rely on these fungi to help in its uptake of phosphorus and zinc.

Canola can be grown successfully in rotation with summer crops in southern NSW. Seen here: direct drilled into maize stubble and watered up on permanent beds near Hay.

J. Muir



When canola is grown after a long fallow there is a reduction of (VAM) fungi and insufficient numbers are available for following dependent crops such as grain sorghum or cotton. To avoid this problem, follow canola with a short-fallow crop such as wheat, and not VAM dependent crops such as legumes or long-fallow crops such as sorghum and cotton. Additionally, be careful when growing canola on these soils if they have been heavily cropped and have had little applied fertiliser. It is probable that phosphorus, zinc, nitrogen and sulphur fertilisers will be needed much earlier in the rotation than they would if only wheat was being grown.

PADDOCK SELECTION

There are three major considerations when selecting a paddock to grow canola in rotation with other crops. They are: soil type, potential disease problems, and broadleaf weeds.

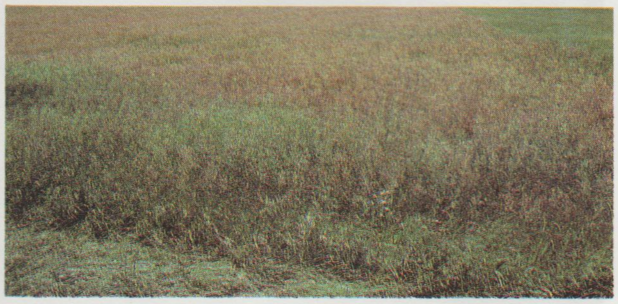
Soil types

Canola generally grows best on highly fertile soils. In mixed livestock and cropping areas, it is ideally grown straight after pasture. High yields can also be obtained after a fallow or later in the rotation when nitrogen fertility has been reduced by cropping, provided adequate nitrogen fertiliser is used. Canola will not perform well on cropped-out country. Generally the best wheat growing soils will produce the best canola crops. Paddocks which have a uniform soil type will have a more uniform sowing depth and more uniform crop ripening. Avoid growing canola where there are the following problems:

- **Hardpans.** Although canola is a taprooted plant it is not strong enough to penetrate most hard pans. Paddocks should be checked 12 months in advance by using backhoe pits or some similar method to visually assess a suspected problem, and to determine the depth of working or ripping that may be required.
- **Waterlogging.** This can be caused by the accumulation of surface runoff. It often results from sodic clay subsoil of low permeability. The latter problem can be identified from a simple soil testing procedure (dispersion test) backed up by laboratory chemical analysis. These soils should be avoided unless they have a good depth of well drained topsoil which allows adequate root growth, even after heavy rainfall.
- **Crusting.** The surface of a soil can crust after rainfall and reduce plant establishment if it is poorly structured and has low organic matter levels, or if it is a sodic clay that disperses. A return to pasture or the use of gypsum on sodic clay soils must be considered before sowing canola.
- **Acidity.** Canola is susceptible to low pH and aluminium. If you expect pH (calcium chloride) levels to be below 5.0, have the canola paddock soil tested during the previous winter. Where a pH level of less than 4.7 is combined with exchangeable aluminium levels above 3 pc, canola should not be grown. Look for early indications that acidity may be a problem, for example lucerne will not successfully grow, or triticale or oats grow better than wheat. Consider using lime as a preventative action when the topsoil pH starts to drop below 5.0. For more information see 'Nutrition'.

Poorly drained soil produces poor canola yields.

R. Colton



Disease potential

Blackleg is an important consideration when selecting a paddock. Although variety tolerance to the damaging stem canker form of the disease has been greatly improved in recent years it must be complemented by management that does not put undue pressure on this tolerance.

The disease is carried over from year to year on infected canola stubble. It is vital when managing paddocks to make sure old stubble has totally broken down and disappeared before sowing canola.

Ideally canola should not be grown within four years in the same paddock. The old recommendation not to grow canola next to last year's canola stubble, or where prevailing winds are likely to blow spores from other stubble areas, has been eased. While the recommendation is still desirable it is no longer practical on many farms as the canola area increases.

Another disease, sclerotinia (*S. sclerotiorium*) has been an intermittent problem in most canola areas, particularly central and southern New South Wales. It has a wide host range of broadleaf plants and weeds, for example, lupins, chickpeas, field peas, beans, capeweed, and sunflower. Growing canola after any of these crops or

weeds can increase the risk of this disease, especially under irrigation or in higher rainfall areas.

For more information, see 'Diseases'.

Weeds

There are four brassica weeds that should be eliminated from canola paddocks. They are:

- charlock (*Sinapis arvensis*)
- wild radish (*Raphanus raphanistrum*)
- wild or mediterranean turnip (*Brassica tournefortii*)
- wild cabbage or Hare's ear (*Conringa orientalis*).

These weeds can jeopardise the international reputation of Australian canola quality. All have a similar seed size to canola and cannot be easily removed from seed samples. These weed seeds contain approximately 50 times more erucic acid in the oil and approximately 10 times more glucosinolates than found in canola.

Growers must be able to recognise and eliminate these weeds before paddocks are sown to canola. Alternatively, do not sow canola in these paddocks.

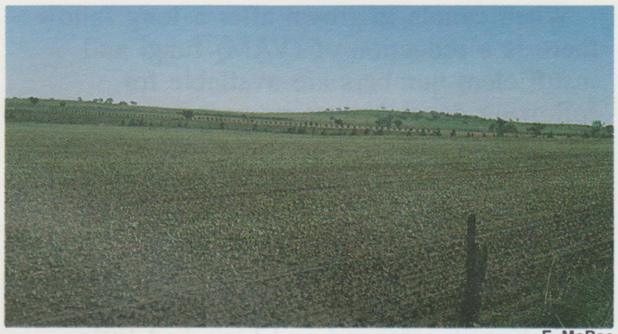
Other problem brassica weeds have a smaller seed size than canola and are usually removed during harvesting. They are shepherd's purse (*Capsella bursa pastoris*), turnip weed (*Rapistrum rugosum*) and the mustards (*Sisymbrium spp.*). However, these weeds reduce yield through competition. There are no post-emergent herbicides currently available to control any brassica weeds in canola. They should be controlled during fallows, before sowing using cultivation or knockdown herbicides or during other stages of the rotation.

CROP ESTABLISHMENT

A uniform plant stand is the most important factor in achieving above average canola yields. Management must focus on the fact that canola is a small seed and must be sown into very good moisture at an even and shallow depth. For new growers, who are used to a more robust cereal seed, it is most important to perfect the skills and machinery options to ensure reliable establishment every time.

Successful uniform establishment is linked to profitability through:

- higher yields from quick and uniformly emerging seedlings;
- improving the ability of canola to compete with weeds in the first six weeks;
- even growth for insect control;
- more even ripening (fewer late green heads) and improved timing of harvest.



F. McRae

Uniform plant establishment is the first step towards high yields.

Seedbed preparation

The seedbed should be fine, level, well consolidated and moist near the surface. Avoid sowing into a loose or 'fluffy' soil that does not have a firm base of soil at sowing depth. If this is not available, the small seed of canola cannot absorb enough moisture from the loose drying soil so a reduced and staggered germination can result (often taking over six weeks).

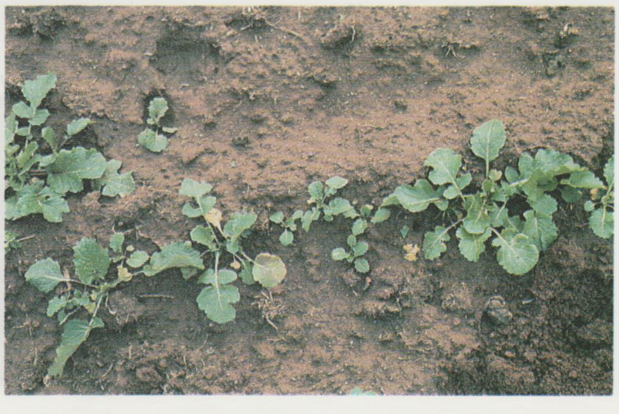
Once a cultivation sequence is planned and initiated (initial cultivations may need to be deep to break up hard pans), the seedbed depth can be successively reduced to ensure the last cultivations (usually herbicide incorporation) do not exceed the desired sowing depth of 3–5 cm. It is worthwhile after herbicide incorporation to consider rolling to firm the seedbed further.

Like wheat, canola will benefit from long fallow and stored subsoil moisture, particularly in marginal cropping areas and on the northern slopes where winter and spring rainfall is unreliable. Manage fallows efficiently to ensure that 80 cm to 1 m of subsoil moisture will be available to the crop before sowing commences.

Finalise seedbed preparation by the end of March or early April in all production localities (particularly in drier western areas)

Seed drilled into moisture to a uniform shallow depth is unlikely to suffer from the staggered germination seen here.

R. Colton



J. Kneipp

Conserve soil structure and soil moisture by substituting knockdown herbicides for cultivation.

to allow sowing to commence on the first opportunity rain that occurs in early to mid April. To achieve this, it may be necessary to incorporate pre-emergent herbicides into dry soil and to break down larger soil clods mechanically (using a roller or length of heavy railway line) to obtain a fine seedbed. If soil structure is damaged, the taprooted canola plant helps repair the soil during the growing season leaving it with a friable surface structure which is easy to direct sow a following cereal crop into.

Substituting the final cultivation before sowing with a knockdown herbicide enables better moisture retention and sowing with minimum soil disturbance. It also ensures the best weed kill of potential problem broadleaf weeds.

Canola can be established successfully using direct drilling and zero tillage techniques but good weed control is essential.

Sowing method

It is preferable to drill canola into the soil rather than drop it on the soil surface and then harrow it in as drilled seed is more likely to be in contact with moisture and germinate more uniformly.

Seed is best sown in 15-20 cm rows, through a grain box of standard wheat sowing equipment. When the soil surface is dry, drilling the seed will give a more uniform establishment than using a bandseeder. The combine should be in good condition and the level adjusted (from side to side, front to back, and tyne to tyne) to ensure sowing at a uniform depth. Ensure there are no leakages between seed and fertiliser boxes as they can alter seed rates, or that combine lids are not left open during operation as unwanted dust can accumulate. Regulate ground speed to avoid tyne bounce as it causes an uneven sowing depth. A maximum speed of 8-10 km/h is suggested for most soils.

Extend the points of sowing tynes to penetrate the compacted area left by the tractor and combine tyres that precede.

The seedbox on most newer combines can be calibrated to the recommended low seed rate. When this is not possible, canola can be readily mixed with fertiliser. Either mix with a low rate of phosphorus fertiliser, usually 2:1 (fertiliser:seed), and sow through the grain box, or mix canola into the sowing fertiliser and sow through the fertiliser box.

Seed can be layered between each bag of fertiliser to ensure good mixing takes place.

Canola must be sown on the day of mixing and not left to stand overnight. Establishment can be significantly reduced if seed is mixed with a compound fertiliser containing nitrogen or if more than 20 kg of nitrogen is sown per hectare down the same spout as the seed. In each case, fertiliser may affect seed viability.

Broadcasting seed through the combine small seed box is unreliable and usually results in staggered germination, especially during the warm, drying conditions early in the sowing season. As well, broadcast seed takes longer to reach the fertiliser band and is often slower to establish.

R. Colton

Bandseeders have been successful in the more reliable winter rainfall areas.

Bandseeders ensure a reasonably shallow sowing but if moisture is not close to the soil surface, seed will be sown into dry soil and will not germinate.

F. McRae

Confine broadcasting to pasture establishment where a quick uniform emergence is not critical. Bandseeding is a better alternative and is recommended for higher rainfall areas where sowing is often later and more likely to be followed by rainfall.

Trail light harrows or mesh to level the seedbed and help compact moist soil around the seed. Avoid heavy harrows with long tynes as they can disturb the seed. A rubber tyred roller will further compact the soil around the seed. This is normally a decision made on the day with the knowledge that soil crusting could be increased if rain occurs soon after.

In marginal rainfall areas, drilling seed to a pre-determined depth is the only sowing method recommended. Depending on soil type and moisture, growers can use a range of machinery refinements to place seed more accurately.

In the heavier northern soil types, depending upon depth of soil moisture, growers have had success with moisture seeking points, press wheels, rubber tyred rollers, rod weeders and trailing cultipackers.

In the lighter sandier soils in the western Riverina, moisture seeking points in conjunction with 'V' press wheels, give an excellent result.

Take care when sowing into wet soils to avoid a smearing action by the moisture seeking points, which could result in a reduced plant stand. Alternatively growers have used the distribution mechanism of the small seedbox and extended the distribution tubes down to the base of the back cultivation tynes. This places seed in 35-cm rows which is quite satisfactory where few weeds are expected.

Coil packers (seen here trailing behind an airseeder), or other types of roller, firm the moist soil around the seed to ensure a more even establishment.

F. McRae

Airseeders have been used successfully to sow canola but are not as precise or even in sowing depth. Crop establishment surveys have shown that only 50-60 pc of seed sown establishes. This must be taken into account when selecting a seeding rate.

When using an airseeder, replace the 15 cm wide points with 10 cm wide points to minimise soil moisture loss and maintain a level seedbed. Most airseeders can be calibrated to sow canola. If not, seed can be mixed with a small quantity of fertiliser (2:1). If a seedbox is available for pasture seed it can also be used to dispense canola seed and a tube used to relay it to the main box for distribution to the sowing tynes.

In the north west, many equipment modifications have been made to enhance the establishment of summer crops into heavy clay soils. These techniques can be used to establish canola. One such technique is deep furrow planting which allows seeding into subsurface moisture through the dry surface soil. This technique uses heavy duty hoe assemblies with relatively narrow points that penetrate through the dry subsoil into the moisture below. Seed is placed 1.5-2.5 cm into moist soil. The moist soil is then firmed around the seed by a packer wheel. Loose dry soil is thrown aside into the inter-row spaces, so that the developing seedlings come up in the furrow.

Thoroughly clean out the seeder after sowing to prevent seed residue from contaminating other crops sown later.

A checklist for sowing equipment:

- accurate calibration for seeding rates;
- avoid seed/super mixes that contain nitrogen;
- even wear of points for accurate seed placement;
- narrow points to reduce ridging;
- front and rear rows of tynes level;
- do not sow too fast because of shallow depth and avoid seed bounce;
- level ridges behind the seeder: heavy harrows maybe too severe and finger harrows too light.

Two other sowing methods have been trialed recently which reduce sowing delays caused by unseasonably wet or dry conditions. They are dry sowing and aerial sowing.

Dry sowing. Dry sowing is used in more reliable eastern production districts when paddocks have been fully prepared for canola but little or no rain is received by mid May. Seed is drilled, or broadcast and harrowed, into the dry soil to a shallow depth to await

F. McRae

Dry sowing can be successful provided weeds can be managed and favourable weather follows sowing.

germinating rain. Because of the lack of pre-sowing rain to germinate weeds, they must be controlled in other ways: paddocks should have had prior weed treatment such as spray topping, fallowing or trifluralin incorporation or weeds must be capable of control using post-emergence herbicides. Dry sowing can be successful provided these guidelines are followed but success will depend on favourable conditions following sowing.

Aerial sowing. Aerial sowing is used when opening rain has delayed sowing and soils are too wet to carry sowing equipment. It has been developed as a successful sowing technique for fertile heavy clay soils in southern New South Wales which remain very wet after small rainfall events. It must be well planned; and pre-emergent herbicide and fertiliser (phosphorus and nitrogen) must be applied early or before the start of suitable sowing times. Establishment is slower and plants are more susceptible to competition from weeds and insects in the first 8–10 weeks. It is recommended to harrow after seeding if the soil has been flattened and compacted by rain, and the seed is not likely to be protected by soil clods.

Sowing depth

Soil temperature and the availability of surface moisture influences sowing depth. Canola is a small seed and it is not as easy to establish as cereals.

Drill seed to a shallow, even depth of 2–4 cm on most soil types. Although seeds are small, the seedlings grow vigorously and will normally germinate satisfactorily from this depth.

Early in the season you can sow seeds deeper as temperatures are higher and the seedbed will dry out quicker and possibly deeper. This applies particularly to marginal western areas and self mulching clays of the northwest where it is better to 'chase' the firm, moist base of soil and avoid sowing into the loose topsoil which will dry quickly.

On self mulching clays, sow at 5–6 cm. However, if you are forced to delay sowing because the topsoil is too wet and soil temperatures are cool, aim for a shallower sowing.

Sowing time

Central and southern wheat belt (including irrigation). Varieties having maturity similar to Barossa should be sown from mid April to mid May in the main wheat belt. The preferred sowing time is from mid to late April. Research shows that it is preferable to sow earlier rather than later; this may be undertaken with confidence because all recommended varieties stand well and are not likely to lodge in high fertility paddocks. Late sowings predispose the crops to lower yield and oil content. Crops grow very slowly during cold and overcast winter weather and can fail to reach the desirable full ground cover by budding. Later sowings also predispose the crop to more stressful periods of hot, dry weather during grain fill. Experience suggests yields start to decline from mid May onwards. When sowing after this date, you can expect a 10 pc yield reduction for every week late. In higher rainfall areas (more than 500 mm a year) sowing can take place until early June. Paddocks sown late must be well prepared and planned for canola. Do not sow poorly drained paddocks after early May.

Marginal areas. In the drier western cropping areas (350–450 mm annual average rainfall) sow canola so flowering finishes by the end of September to avoid as much heat and moisture stress as possible. The optimum sowing time for varieties of Barossa maturity is April 10 to 20. The aim is not to miss any sowing rain around this period.

Crops sown after mid May are usually lower yielding.

R. Colton

It is critical that growers have a definite cut-off date. If the autumn break has not occurred by the last week of April, you need to be flexible and switch to another winter crop that is more suited to sowing from early May onwards.

Occasionally, when late autumn and winter temperatures are much milder than usual, crops sown before mid April flower and begin to fill pods in July and August. While flowering plants can tolerate frost, developing seeds can be damaged by heavy frosts which can occur in August. The risk of this kind of frost damage is quite low and should not deter growers from early planting in marginal areas. The extra seed and oil achieved in almost all seasons greatly outweigh the occasional loss from frost.

Northern wheatbelt. Canola is normally sown earlier than other winter crops. Its inclusion in a rotation increases optimum sowing time available to sow winter crops. The highest seed and oil yields are likely to come from April sowings with mid to late April being optimum for varieties of Barossa maturity. Sowings can be made from the second week of April and can be extended to mid May with little penalty. When sowings are delayed beyond mid May, yields begin to decline and the sowing time clashes with that of other crops.

Coastal areas and tablelands. Sow during May in coastal areas but be prepared to sow up to mid June if earlier sowing is not possible (for example, where canola is part of a double cropping program). In tableland areas above 800 m sow crops in August and September and grow them into summer. Spring sowings avoid the very cold winter when a slow growing crop can be overtaken by weeds.

In general sowing at the optimum time pays off in a number of ways:

- Seed and oil yields are higher because the crop finishes under cooler, moister, slow maturing conditions. A premium is paid for oil content above 40 pc.
- In the wheat belt, canola sowing and harvesting are kept well ahead of the busy wheat periods.
- Early sown crops grow quicker initially and so compete better with winter weeds.
- Early sown crops normally have less problems with insect pests, such as aphids, in spring.

Frosts that occur during September when the crop is flowering are not a problem as the 4-6 week flowering period compensates for any flower abortion.

Sowing rate

Uniformity of plant population is more important than having an ideal population. Canola is a very flexible crop in that variations in seeding rate or plant population over relatively wide ranges, normally have very little effect on the final yield.

When the plant population is low, individual plants will grow larger, bear bigger stems, branch more profusely and produce more pods, which generally extend lower on the plant.

As plant population increases, each plant produces less dry weight, thinner stems, fewer branches, fewer pods and less seeds per plant due to increased plant competition. However, under similar seasonal conditions the larger number of plants compensates with seed yields per unit area similar to those in lower plant populations.

The recommended seeding rate for *B. napus* canola is 3-4 kg/ha. Within the recommended plant population range, it is better to have too many canola plants than too few.

It is advisable to sow a heavier seed rate (an extra 1-1.5 kg/ha) when the seedbed condition is not ideal, when sowing late, when aerial sowing into heavy clay soils or stubble residues, when sowing dry, when using airseeders or when the crop is irrigated-up in border check irrigation.

Growers should carry out plant population counts within 6 weeks of emergence to review the success of the sowing operation and to help decide whether the seed rate or equipment needs to be modified for the next crop. Use a tenth metre square and count as many sites as possible (minimum of 20).

Ideal plant populations are (plants per square metre):

Central and southern wheatbelt	50-75
Irrigation	50-75
Northern wheat belt	30-50
Marginal areas	30-50

At less than 15 plants per square metre, the crop is likely to be patchy and lower yielding. However, before abandoning a crop always double check with an experienced agronomist or grower because plants can compensate remarkably well and the yield level may be as good as a later sown crop.

Typically, about 40-60 pc of sown seeds establish as plants. However, if conditions are really favourable, establishment can be as high as 80 pc.

Check the seed size every year as it can vary depending on how well the seed crop finished in spring. For *B. napus* varieties, the range lies between 250,000-350,000 seeds per kilogram.

Table 6. **The number of plants established per square metre from different sowing rates and establishment percentages.**

Sowing rate kg/ha	Establishment percentage		
	40	60	80
3	34	51	69
4	46	69	91
5	57	86	114

Recommended sowing rates in this Agfact are based on an average seed size of 280 000-300 000 seeds per kilogram (see Table 6).

Combine calibration

To calibrate the desired sowing rate use the following guidelines:

- Check calibration procedure in the combine manual and review the use of reduction gears.
- Work on 60 pc field emergence of purchased seed, that is 3.5 kg/ha should establish 60 plants per square metre.
- Base the calibration on a 100th of a hectare quantities, that is:

  20 run (3.5 m) combine needs to travel 28.6 m (17.5 cm row spacing)
  24 run (4.2 m) combine needs to travel 23.8 m
  30 run (5.25 m) combine needs to travel 19.0 m

- Initially calibrate in the shed. Use plastic foolscap protector bags and wire or plastic bands to attach and catch the seed from the delivery hoses across one third of the machine rows. If treated seed is to be planted, use treated seed for calibration as it flows slower than untreated seed. For example:

  24 run combine - travel 23.8 m, weigh seed from 8 runs
  12 g x 3 = 36/24 runs (1/100th/ha)
  = 36 x 100
  = 3600 g or 3.6 kg

- Recheck combine in a paddock and calibrate while it is still catching seed. This will account for all vibration and shakeout factors not normally experienced with cereals to help avoid too high a seeding rate and a lack of seed to finish the area. A further check can be made in the paddock by dividing seed used by hectares sown.
- Use silastic or cloth to fill any gaps in the lids between the seed and fertiliser boxes. Spilled granular fertiliser can inhibit seed flow. Avoid getting dust in the grain box by not opening combine lids during operation. This also alters the seed rate.

WEED CONTROL

It is vital to have a good knowledge of which broadleaf and grass weeds are likely to germinate in the paddock selected to grow canola. Four problem brassica weeds must be avoided (see 'Paddock selection') while some harder to kill weeds such as silver grass, wireweed and fumitory cannot be controlled with post-emergent herbicides. It is best to avoid problem weed paddocks. Good crop rotation practices will make it easier to manage weeds. In recent years, pastures have been manipulated at the end of their phase (winter cleaning, spray topping, grazing) to increase the legume dominance before cropping and eliminate weeds.

Canola seedlings are very susceptible to weed competition in the first few weeks after emergence; effective weed control during this period is vital. The crop canopy usually closes 6-8 weeks after emergence and from then on canola becomes an excellent weed competitor.

Pre-emergent herbicides are available for grass weed control in canola. Trifluralin is the most commonly used pre-emergent herbicide as it has the ability to control a wide spectrum of weeds including ryegrass, phalaris, silver grass and wireweed. It also has a good suppression effect on fumitory and wild oats.

Trifluralin, can be applied at rates up to twice that recommended in wheat. At low rates it can be applied within a day of sowing canola, while at high rates it is recommended you wait a week before sowing.

Research has shown trifluralin can reduce early growth of emerging canola plants if crops remain stressed over a prolonged period (more than 7 weeks after sowing).

However, its advantages in weed control will normally compensate for any early damage caused by inadvertent application practices.

The best results when using trifluralin will be obtained where there are low trash levels, the soil has good tilth (not cloddy) and two cultivations are used for incorporation, the second as a cross working. If these conditions cannot be met some benefits can be obtained by using the highest recommended rates.

R. Colton

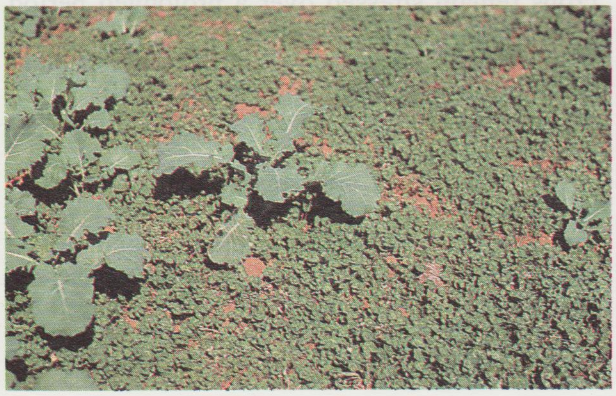
Pre- and post-emergent herbicides are available to control most annual grasses in canola.

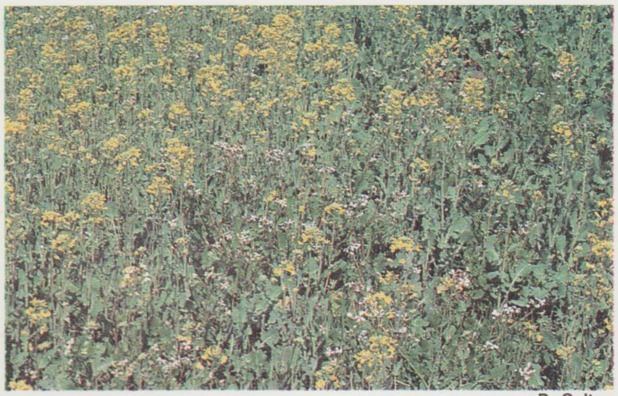
A specific pre-emergent herbicide can be used where wild oat is a major problem, particularly in northern New South Wales. If not, volunteer cereals and grasses can be controlled with post-emergent grass herbicides. Remember, it is better to control young weeds and rely on the smothering ability of canola to control later germinations.

In marginal growing areas, because of unreliable rainfall, it is recommended to use only post-emergent grass herbicides. Use of pre-emergent herbicides can cause loss of valuable soil moisture and reduce alternative crop options if a late break occurs. Alternatively, trifluralin can be split applied to ensure the rate does not exceed that recommended on cereals. If trifluralin is applied onto dry soil, use maximum water rates (100 L/ha) to ensure the chemical is accurately applied to the soil surface.

Subterranean clover can act as a weed when canola is sown immediately after pasture. If not controlled it can reduce yield by 20–25 pc.

F. McRae





R. Colton

Paddocks must be selected to avoid brassica weeds. Wild radish plants (white flowers) can be seen here in canola.

Pod pieces containing wild radish seed in harvested canola. Do not grow canola in radish-infested paddocks.

F. McRae

The problem broadleaf weeds—capeweed, thistles (except advanced variegated) and subterranean clover, medics—can be controlled with a post-emergent broadleaf herbicide. When applied, early skeleton weed and variegated thistle can be suppressed. There is no herbicide available to control problem brassica weeds.

Canola is highly susceptible to hormone herbicides. Take care when spraying adjacent cereal crops to avoid spray drift. However, canola's susceptibility to hormones is very useful when removing volunteer plants from subsequent cereal crops.

Canola is also extremely susceptible to low concentrations of the widely used residual herbicides in the sulfonylurea family. These include the cereal herbicides Glean®, Logran® and Ally®. Do not plant canola after a cereal crop treated with these herbicides until a minimum period of months has elapsed. This period is greatest on soils that have a pH above 7.0. Growers should consult the plant-back information on the label of these herbicides.

C. Duff

Crop damage from a boom sprayer which was not properly cleaned after spraying a sulfonylurea cereal herbicide.

Thoroughly clean all traces of these cereal herbicides from spray equipment before it is used on canola. Check the clean-up procedure on the label of each herbicide as they vary.

Herbicides

A table of herbicides recommended for weed control in canola is included in the annual NSW Agriculture publication *Weed control in winter crops*. The publication is available from NSW Agriculture District Agronomists and retailers.

NUTRITION

Canola has a higher requirement for the major nutrients nitrogen, phosphorus and sulphur than cereals and other crops. Canola crops will not produce high yields unless there are adequate quantities of all three (as well as other major and minor elements) to supply plants with balanced nutrition. An example of this need for balance has been the way in which higher rates of nitrogen and phosphorus have induced sulphur deficiencies in crops on the central and southern slopes.

A knowledge of soil and paddock history (see 'Paddock selection') will help you to decide which rates and types of fertiliser to use.

A soil sample taken from the topsoil (depth of cultivated layer) to determine the chemical status of the soil will also help. A soil test will also indicate possible problems such as low pH and high exchangeable aluminium levels, and will be the basis for decisions that improve soil fertility or ameliorate problem conditions.

Growers should become familiar with two terms which are used in soil test reports. These are soil pH and soil cation exchange capacity.

Soil pH

A soil test carried out the previous winter to growing canola will provide the most reliable pH figure. It will show if the soil is alkaline, neutral or acid. Successful canola crops have been grown on soil from pH ($CaCl_2$) 8.0 (alkaline) to 5.0 (acid). High pH or alkaline soils are more typical on the northern slopes (deep cracking grey or brown clays) and often need additional zinc. Low pH or acid soils are more typical on the higher rainfall southern wheatbelt areas (soils normally derived from granite or sandstone) and can contain toxic amounts of aluminium or manganese.

Canola growth and yield is reduced significantly if there is aluminium in the soil. The crop will not respond to available nutrients and there will often be patches (where aluminium levels are highest) of stunted, single stem plants whose roots are concentrated in the top 5–10 cm of the topsoil. The problem is accentuated by late sowings and a decline in organic matter when canola is sown after a long cropping history.

Manganese toxicity is a less frequent problem but patches of crop can develop bright yellow margins on the leaves.

F. McRae

Lime can be applied in the year before the canola is grown and incorporated into the soil during fallowing and seedbed preparation.

The addition of 2.5 t/ha of lime (right) resulted in a major yield increase for this Temora grower.

F. McRae

R. Colton

Toxic levels of aluminium produce patches of stunted growth.

R. Colton

Plants affected by aluminium are spindly with shallow roots (left) compared to a normal plant.

Manganese toxicity produces distinctive bright yellow leaf margins.

R. Colton

In this situation it is recommended that growers prevent the soil pH from dropping below 4.8–5.0 and therefore reduce any aluminium available to the plant by lime application. Paddocks with a pH less than 4.5 should be avoided or treated with lime. For further recommendations read Agfact AC.15, *Liming materials* and Agfact P1.4.1, *Liming problem acid soils.*

Exchangeable cations

Exchangeable cation levels indicate the capacity of the soil to hold and exchange cations, the positively charged ions of the elements calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and aluminium (Al). The sum of these cations is used to approximate the cation exchange capacity (CEC). Soils that have a low cation exchange capacity, that is 2–5 cmol (+)/kg are often acid to depth (frequently there is a pale subsurface layer) and unsuitable for canola. Better soils indicated by a higher CEC, that is 10 to 15 cmol (+)/kg can still develop surface soil acidity but are generally suitable for canola.

Phosphorus

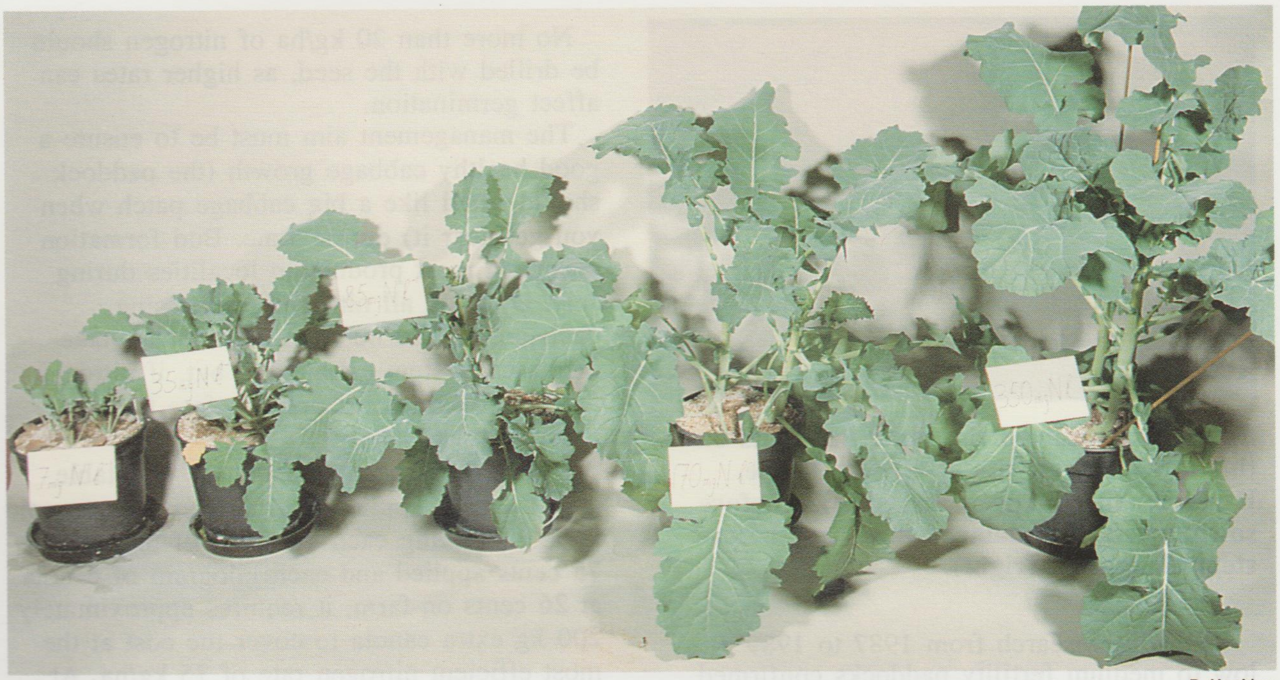
Canola responds to phosphorus if soil residual levels are low to moderate. Canola has a slightly higher requirement for phosphorus than wheat. A maintenance application of 20 kg/ha of phosphorus will be required if a

R. Colton

On a low phosphorus soil at Trangie an application of 20 kg/ha (left) contrasts with a nil application.

Phosphorus deficiency, showing a dull purple flush which appears on the older leaves first. Symptoms can be confused with those of nitrogen deficiency. Growth can be drastically reduced without any symptoms showing.

P. Hocking



P. Hocking

Canola is very responsive to nitrogen.

grain yield of 2.5 t/ha is sought, that is 8 kg/ha of phosphorus for every tonne of canola you expect to harvest. If there is a high soil phosphorus level, it may be uneconomic to apply phosphorus.

Phosphorus is extremely immobile in the soil and when applied as fertiliser rarely moves more than 0.5–1 cm from the granule. Most soils have the ability to tie phosphorus up so it is unavailable to plants.

Carefully assess phosphorus requirement needs when soils are medium to heavy clays (particularly in rice growing areas when soils are flooded for long periods) or strongly acid (particularly if exchangeable aluminium is present). **Phosphorus applications should always be banded.** This ensures phosphorus only comes in contact with a small volume of soil so a lower percentage is tied up than would be if it was mixed through the soil.

With experience, soil tests can be a reliable guide in determining the likely response of canola to phosphorus. Virtually any company test showing less than 15 mg/kg phosphorus is considered low and a response is likely.

However, if the soil phosphorus level is high a response to phosphorus is unlikely unless the soil is acid (pH($CaCl_2$) less than 4.8) and has a low cation exchange capacity (less than 5 (cmol(+)/kg). In these situations significant yield responses have been obtained in southern New South Wales.

Nitrogen

A key to high yields is to ensure adequate nitrogen is available to the crop. Canola is ideally grown on soils high in nitrogen; for example the first or second crop following several years of legume-dominant pasture. However, paddock fertility status is often underestimated and not enough nitrogen fertiliser is added to produce high yields.

Initially nitrogen recommendations were developed from guidelines used in cereal production, and from the knowledge that canola requires more nitrogen than wheat at comparable yield levels. Canola needs between 40–50 kg of nitrogen per tonne of grain produced (30 pc more than wheat). This information has been combined with advisory and grower experience to produce Table 7.

Table 7. Nitrogen recommendations for canola in New South Wales.

	kg N/ha
Canola after dominant legume pasture	nil
Canola later in rotation	
—high rainfall (500^+ mm)	50 to 75
—low rainfall	25 to 50
Irrigation and continuous cropping	50 to 100 (split)

R. Colton

Both plots received the same nutrients on this low nitrogen site at Greenethorpe. However, the nitrogen was applied before sowing (left) but delayed until just before stem elongation (right).

Statewide research from 1987 to 1989 on low to medium fertility paddocks confirmed nitrogen recommendations for New South Wales. An average 35 pc yield increase was obtained by applying 75 kg/ha of nitrogen.

Further trials showed that the total amount of nitrogen applied was more important than the time of application. However, low to medium fertility paddocks crops do best when the majority of nitrogen is applied before sowing.

If soil nitrogen levels are high and you are concerned about excessive early growth, nitrogen can be delayed until bud formation starts.

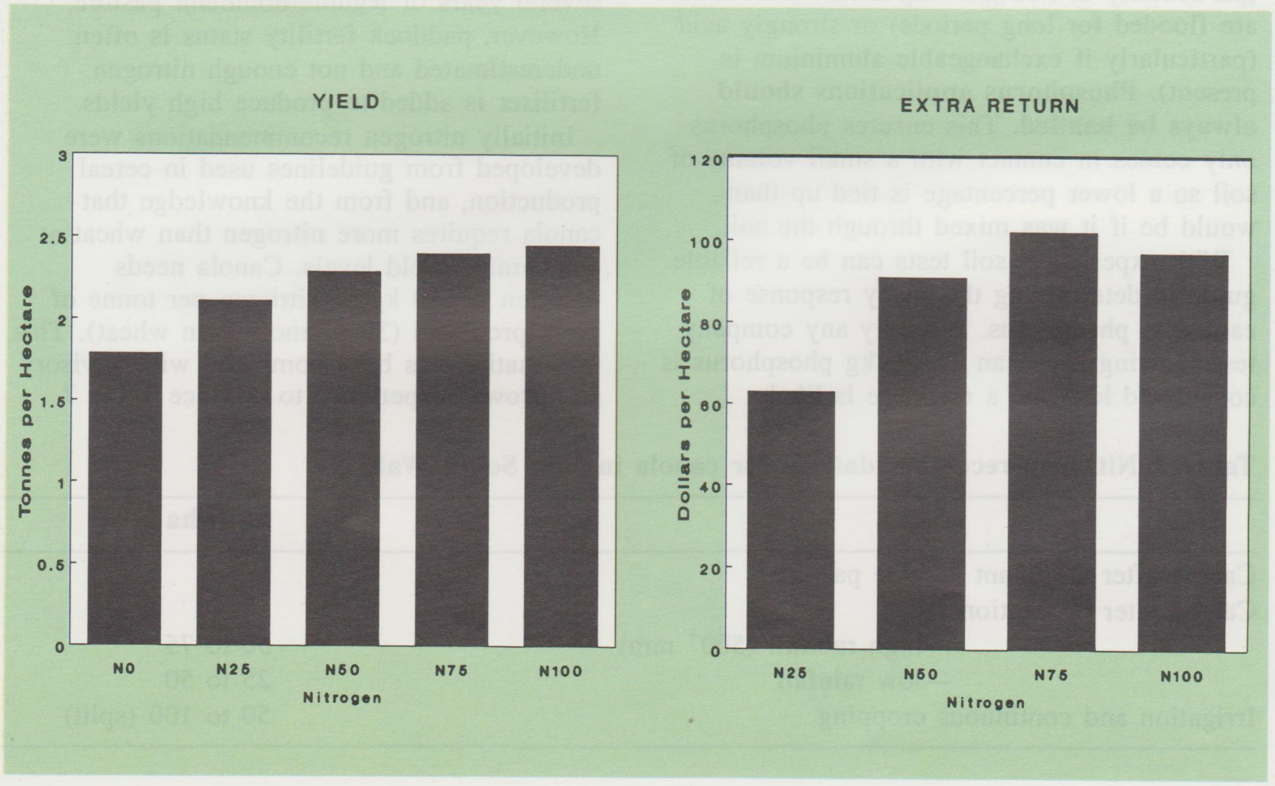
No more than 20 kg/ha of nitrogen should be drilled with the seed, as higher rates can affect germination.

The management aim must be to ensure a good healthy cabbage growth (the paddock should smell like a big cabbage patch when you get near it) during June. Bud formation occurs in most production localities during July. By then, all nitrogen topdressing decisions should be finalised. Plant uptake increases at stem elongation, but, if nitrogen deficiency symptoms occur before this time, topdress immediately.

Applying nitrogen to canola is profitable and it can be applied confidently. For example in 1991, pricing each kilogram of nitrogen at 75 cents applied and each kilogram of canola at 26 cents on-farm, it requires approximately 200 kg extra canola to cover the cost at the most efficient nitrogen rate of 75 kg/ha. At this rate, yield increases averaged 600 kg extra canola in the trials (see Figure 4). Oil content remained similar at least up to the 75 kg/ha nitrogen rate after which it tended to drop slowly. This is consistent with overseas information that shows only rates above 100 kg/ha nitrogen reduce the oil percentage.

If you are not confident in your ability to assess the need for nitrogen, test strips are a good standby. Just after the crop is up, measure a 10 by 10 metre square and apply 1.5 kg of urea. Keep the plot 20 metres off

Figure 4. Extra seed yield and extra dollar return from added nitrogen.



fencelines and assess for colour and vigour changes after rainfall. The more deficient the crop, the sooner a result is seen. Topdressing should take place immediately.

Generally there has been no difference in yield response between nitrogen sources—urea, anhydrous ammonia, ammonium nitrate or Easy-N®. Growers should always check prices before purchase by comparing the cost of one kilogram of nitrogen from each source.

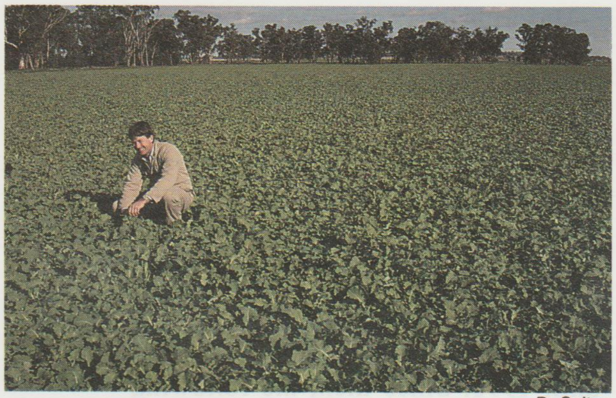
Urea is normally chosen because it has a high analysis (less handling required), is cost competitive, and does not affect soil pH. It can be readily incorporated into soil before sowing or topdressed through a combine. In theory nitrogen can be lost as ammonia gas to the atmosphere when topdressed, particularly on alkaline soils. However, topdressed urea has shown good results in central and southern New South Wales, presumably because soils tend to be acid and low winter temperatures slow down the loss process.

Topdressed urea is most successful when it is washed into the soil profile by rainfall soon after application or it dissolves when applied to moist soil during overcast weather. Be cautious and do not topdress urea onto very dry and dusty topsoils.

Urea can be readily topdressed onto plants. The fertiliser prills (granules) will not damage the plants, as they run off the plants and onto the ground if the leaves are not wet with dew. It is also important not to overlap or leave gaps during topdressing as crop maturity differences can occur. If crops are topdressed with a combine during the vegetative stage, they recover well from wheel marks and no damage is evident.

Although urea is a preferred nitrogen source to add to irrigation water, the canola crop is often too advanced for efficient uptake by the time the first irrigation is necessary (usually in August/September). A urea solution is also satisfactory to use as a foliar spray but only low rates of actual nitrogen can be applied.

Nitrogen deficiency symptoms. The nitrogen content of a canola plant (expressed as a percentage of dry matter) is highest at the rosette stage. Deficiency symptoms are therefore often expressed early in the vegetative stage. Generally, the older leaves become pale green to yellow, and may develop red, pink or purple colours. The plant is stunted and ground cover is difficult to obtain in the first 8–10 weeks after sowing. Once stem elongation commences, a deficiency is then characterised by a thin main stem and restricted branching. This results in a thin and open crop. Flowering will occur over a shorter period, reducing the number of pods.

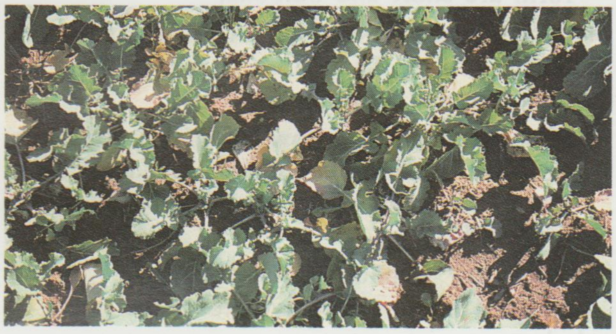


R. Colton

The density and uniform dark green colour of this crop indicates that it is not nitrogen deficient.

Pale green plants with erect leaves, some of which are yellow and pink, and poor crop vigour suggest nitrogen deficiency.

J. Sykes

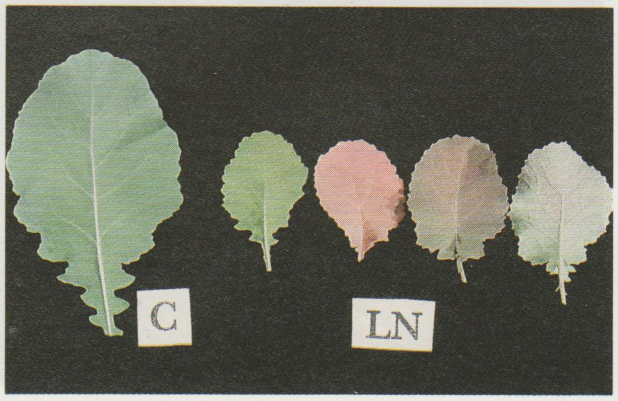


J. Sykes

Older leaves turn yellow, red, pink or purple on nitrogen deficient plants.

Compared to a healthy leaf (left), nitrogen deficient leaves are smaller and more upright on the plant.

P. Hocking



Unfortunately, some visual symptoms are shared with other nutrient deficiencies (for example, phosphorus and sulphur).

Sulphur

Canola needs more sulphur than wheat or legume crops. At 2 t/ha yield levels, canola removes about 20 kg of sulphur per hectare in the grain, compared with 4 kg/ha for wheat and 8 kg/ha for lupins. Sulphur deficiency was noted in 1988 and 1989 but did not occur on a wide, or economically significant, scale until 1990. Since then, the following deficiency symptoms have been recorded:

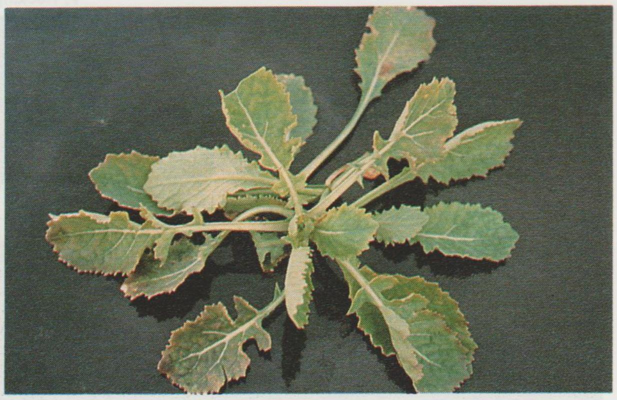
- pale mottled leaves in plants from early rosette to stem elongation. The leaves may be cupped, with a purple margin (very deficient crops);
- pale yellow to cream flowers;
- poor pod set and pod abortion. Pods that do form are short and bulbous;
- during pod set, stems of affected plants are purple-brown. They ripen to a brown rather than a straw colour;
- affected plants are slow to ripen, continuing to flower until moisture runs out, after the rest of the crop has dried off sufficiently for windrowing.

Note: low sulphur levels will cause yield loss, even if the above symptoms are not obvious.

Most sulphur is held in the soil's organic matter; low organic matter soils have low reserves. Additionally, there has been a tendency towards using 'high-analysis' fertilisers which add very little sulphur to soils. In some years, seasonal conditions can cause low mineralisation rates; for example, dry conditions in summer and autumn before sowing can reduce mineralisation, or wet conditions during winter can cause leaching of sulphur.

Sulphur deficient rosette stage plants have pale mottled leaves which may be cupped and have purple margins.

H. Burns



H. Burns

Sulphur deficient plants exhibit pale yellow flowers (right).

The thin pale flowered crop in the foreground is sulphur deficient and yielded 430 kg/ha. The dense bright flowered crop at the rear had 13 kg/ha of sulphur applied and yielded 1200 kg/ha.

H. Burns

In the longer term it is likely that many canola paddocks will become sulphur deficient, particularly the well drained loam soils in central and southern wheatbelt areas that have been heavily cropped, and the high phosphate basaltic soils in the northern wheatbelt.

All paddocks sown to canola should receive 20 kg/ha of sulphur in the available sulphate form. On lighter soils with a history of deficiency symptoms, increase rates to 30 kg/ha.

Sulphur can be applied before sowing (gypsum), at sowing (single superphosphate) or topdressed during the vegetative stages (sulphate of ammonia). Where the higher rates are needed, the most economic way is to apply gypsum during the pre-sowing period.

Do not underestimate crop requirements. Sulphur deficiency has occurred in paddocks which have been topdressed in the pasture phase with single superphosphate. Sulphur deficiency can be induced in paddocks with high yield potential where plenty of phosphorus and nitrogen has been used.

Other elements

Boron. A deficiency seems possible in the tablelands and southern slopes area, particularly where the soils are derived from granite, sandstone rocks and conglomerate parent materials. Canola is classified as a susceptible plant but to date only rare occurrences have been observed. Symptoms of deficiency (low flower and pod numbers) are more likely during periods of low moisture availability or where liming has reduced the availability of boron and its uptake by plants. Look for symptoms and use tissue testing to confirm suspicions. If there is a deficiency, apply 1-3 kg/ha of boron.

P. Hocking

Boron deficiency showing convex cupping, pale mottling, and reddening and yellowing of leaves.

High clay content soils and heavily limed soils usually need higher rates than acid and sandy soils. Boronated fertilisers before sowing is the commonest way to apply boron to the soil. For foliar application or boron mixed in insecticides, fungicides or herbicides Solubor® is most commonly used (see Agfact AC.14, *Boron in agriculture*).

Molybdenum (Mo). This element enables the plant to use nitrates taken up from the soil. A deficiency can occur when soil acidity falls below pH ($CaCl_2$)5.5. It can be avoided by applying molybdenum at a rate of 50 grams of actual molybdenum per hectare once every 5 years. The most common application methods are:

- 150 grams/ha of the soluble form sodium molybdate (39 pc Mo) sprayed onto the soil surface. Molybdenum is compatible with pre-emergent herbicides and can be thoroughly incorporated into the soil before sowing;
- 75 grams/ha of molybdenum trioxide (66 pc Mo). This can be mixed with the seed or fertiliser at sowing.

It is not usual to use factory mixed molybdenum and phosphorus because molybdenum rates are lower than required when using normal phosphorus rates. For more complete recommendations see Agfact AC.4, *Molybdenum deficiency in plants*.

Zinc. There are few reports of zinc deficiency in canola but growers should be cautious, especially in the following situations:

- when soils are alkaline, pH ($CaCl_2$) greater than 7, and have a high phosphorus level or are fallowed for a long period;
- following landforming where alkaline subsoil is exposed.

If growers are aware of these situations, incorporate zinc into the soil before sowing canola. Zinc can be broadcast at rates of 10-20 kg of zinc per hectare. These rates have been shown to give residual activity for 5 or more years on the heavy soils of the Liverpool Plains in northern New South Wales. Zinc oxide is the cheapest and most concentrated zinc form but it is usually broadcast with fertiliser for even application. Only consider foliar sprays as a stop-gap measure and apply before symptoms are obvious soon after crop emergence. For soil and foliar zinc application methods see Agfact AC.16, *Zinc deficiency in field crops*.

Withertop is caused by mild calcium deficiency induced by a period of very rapid growth in spring. It is of minor importance.

R. Colton

Farmer trials

Farmers should conduct their own trials to assess nutrient needs. Visual assessment can be misleading, therefore make trial evaluations on harvested yield. Trial a measured area in the paddock (wider than the header) that can be harvested and weighed in bulk or alternatively seek help from your NSW Agriculture District Agronomist or company representative who has mobile weighing equipment.

IRRIGATION

Canola has developed as a commercial irrigation crop since the mid 1980s. Irrigated production is expected to expand during the 1990s as the availability of strong stemmed, high yielding varieties has reduced the management problems experienced with earlier varieties. Similar yields (3 t/ha plus) can now be expected from canola compared to more labour intensive and higher water consuming summer oilseed crops.

Canola will yield better on high fertility fallow paddocks, particularly in self mulching grey clay soils. Canola should not be considered if paddocks are not landformed and lasered to a uniform grade so as to allow efficient watering.

Raised beds are the preferred irrigation method. Raised beds allows the crop to be irrigated-up without soil crusting, and be fully irrigated to schedule in spring. The plant's anchorage is less likely to be weakened at ground level as irrigation water soaks through the soil.

Paddock lay-out must allow the crop to be irrigated and drained within 12 to 15 hours. Border check irrigation is acceptable when paddock slopes are steeper than 1:1500, but preferably 1:750 to 1:1000.

Contour bay irrigation is usually not suitable as individual bays drain too slowly.

Yields of up to 3 t/ha can be achieved under irrigation on permanent beds.

R. Colton

R. Colton

Maintain some moisture reserve in the soil to cope with a sudden heatwave during grain fill when a sprinkler system may be unable to meet crop demand quickly enough.

Spray irrigation is suitable if enough water can be applied during the later spring period when the evaporation rate increases.

The management of irrigated canola and high rainfall grown canola crops is similar in most aspects (read previous sections). However, the following management information is related entirely to irrigated canola production.

Raised bed system

The suitability of soils needs to be carefully assessed for this technique. The selection of bed width should be dependent upon the soil's ability to absorb water (sub) and the wheel spacing of the equipment to be used. Once a bed has been formed, under no circumstances should a tractor or implement ride upon it so as to keep it free from compaction and over time allow better subbing as the structure improves.

Bed width varies according to soil types; it is normally 1.5–2 m. The latter has been used where row cropping equipment is set at a traditional 95–100 cm row spacing. Beds are produced by simply removing every second lister and connecting two heavy bed-forming chains. Take care when selecting a bed width for red brown earth soils or non self-mulching grey soils as moisture will not sub to the centre if the beds are too wide.

It will be necessary to modify the undercarriage of a combine to sow and apply fertiliser. Narrow precision planting boots can be mounted on diamond tool bars and fitted under a 6 m or 28 run combine; these boots are more suitable for sowing dry and irrigating up than sowing directly into pre-irrigation moisture. Otherwise moisture seeking points are better to place the seed on an undisturbed moisture base. Plant spacing can be flexible, and if necessary, rows can be placed closer to the edge of beds if moisture is unlikely to penetrate to the middle.

J. Muir

On beds, adapt row spacing to suit planting machinery and soil type.

Bedshaping equipment has given way to ring rollers that are made with heavy cast iron rings independent of a main axle to allow them to adjust to the curve of the bed. The implement is cheap to use and principally breaks down clods and firms up the bed. Depending on soil conditions, it is utilised prior to chemical spraying and before sowing.

Pre-irrigation and establishment

On raised beds, shallow sowing and irrigating-up in April is the preferred method of establishment. On border check paddocks, which are usually red loams, irrigate in late March/early April and sow the seed into moisture as quickly as possible, preferrably after April 10. Alternatively, pre-irrigate in February, especially where broadleaf weeds are a problem. Cultivate after herbicide application and leave the paddock in readiness to sow after rainfall.

Where broadleaf weeds are not a problem, canola can be irrigated up with reasonable success in early to mid April.

Crops are much slower to establish after irrigating up and an early sowing time is critical to take advantage of warmer soil temperatures. The risk factor in irrigating late is a wet winter and the crop being waterlogged in June, July or August. This risk factor will have to be carefully evaluated by each grower.

If irrigating-up on the flat, it is best to use a disc opener when sowing. On drying, the soil will fracture along the sowing line, leaving a pathway for seedling emergence. Always sow up and down in the direction of the border check instead of around and around, as this will aid drainage throughout the year.

Spring irrigation

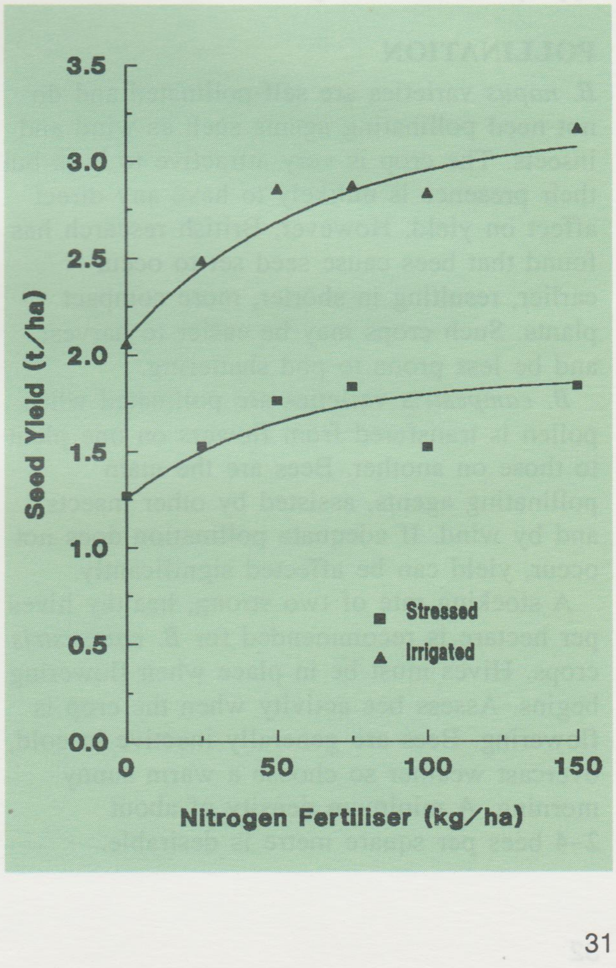
Spring moisture requirements of canola are different to those of wheat.

Canola is less tolerant of waterlogging (usually caused by a combination of irrigation and rain) than wheat in the period from flowering to maturity. Its peak water use is from stem elongation until the end of grain filling (about 25 days after the end of flowering) when any stress will result in yield loss. However, its quick early root development allows for a more efficient use of water early in spring.

Unless there has been a substantial winter rainfall (soil profile is wet to 60–80 cm), it is advisable to start irrigation in August. Any earlier (July) is dangerous because it pre-disposes the crop to cold wet soil conditions if further rain is received.

Timing of the first irrigation is critical. A minimum of two, and possibly three irrigations is needed to finish the crop. It is important to ensure the first irrigation is applied as the soil moisture content reaches the refill point. This time is likely to coincide with the critical flowering period during which a missed irrigation can reduce yield by 50 pc (see Figure 5). If only one irrigation is possible, apply it to ensure that moisture is available during flowering (late August–September).

Figure 5. Relationship between moisture stress during flowering and applied nitrogen on canola grain yield. (Data from work at Condobolin Research Station by A. Bernardi.)



Irrigation scheduling

Many farmers plant more area than they can water adequately in peak conditions. Either they underestimate peak water requirements, or they are optimistic on weather conditions. To time irrigations precisely, the irrigation supply system must have the capacity to deliver sufficient water. The planted area must be matched to the supply rate by calculating water requirements during peak conditions.

Growers should use a locally developed and tested irrigation scheduling system to aid their irrigation management decisions. Two practical systems are available for canola, based on either the measurement of weather conditions or soil water.

NSW Agriculture provides a weather based water use information service called Water Watch in some irrigation areas of New South Wales. This information can be related to any type of crop and used in a manual water balance calculation system.

The most common soil water based system involves taking moisture readings with a neutron moisture meter (neutron probe) and processing the data with computer software. Initially most irrigators using this system contract with agricultural consultants who specialise in this type of service.

NSW Agriculture has specialist irrigation staff available to assist growers on the use of appropriate scheduling aids.

POLLINATION

B. napus varieties are self-pollinated and do not need pollinating agents such as wind and insects. The crop is very attractive to bees but their presence is unlikely to have any direct affect on yield. However, British research has found that bees cause seed set to occur earlier, resulting in shorter, more compact plants. Such crops may be easier to harvest and be less prone to pod shattering.

B. campestris varieties are pollinated when pollen is transfered from flowers on one plant to those on another. Bees are the main pollinating agents, assisted by other insects and by wind. If adequate pollination does not occur, yield can be affected significantly.

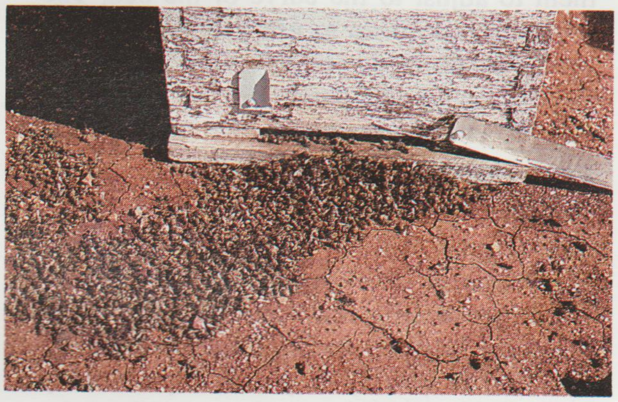
A stocking rate of two strong, healthy hives per hectare is recommended for *B. campestris* crops. Hives must be in place when flowering begins. Assess bee activity when the crop is flowering. Bees are generally inactive in cold, overcast weather so choose a warm sunny morning. A minimum density of about 2-4 bees per square metre is desirable.

R. Colton

Canola is a valuable food source for honey bees but they are not important pollinating agents in *Brassica napus*.

When spraying insect pests, take care to avoid harming bees foraging in the crop.

R. Colton



Insecticides and bees

Honeybees find canola very attractive and will travel several kilometres to work a canola crop. It is often necessary to apply an insecticide to control pests during flowering when the bees are most active. Insecticides can kill bees, and special precautions are necessary to avoid serious bee losses.

Insecticides can be less damaging to bees if the correct chemical is chosen and is applied correctly. Some insecticides have a fairly short residual toxicity to bees (10 hours or less), and can be safely applied at sunset after most of the bees have returned to the hive for the day. By morning it is safe for the bees to return.

Some other insecticides remain toxic to bees for several days after application and are never safe to apply to a flowering crop. If one of these chemicals must be used, remove the hives from the area and do not return them until the crop is safe again. Also remove hives if an insecticide with a short residual toxicity has to be applied at a time other than late in the evening.

Give as much notice as possible to bee keepers and notify your neighbours of your intention to spray and the chemical to be used. This will enable bees on your property or neighbouring properties to be moved, if necessary, to minimise bee losses. For further information see Agfact P5.2.4, *Rapeseed pollination*, and Agfact A.8.9.7, *Pesticides affecting beekeeping and crop pollination.*

WINDROWING

Windrowing is cutting the crop and placing it in rows on the cut stubble. This hastens the drying rate of the crop; reduces the possibility of seed losses from wind and hail; and ensures even ripening. After the crop cures to a uniform moisture content of 9 pc (usually 5-7 days) it can then be harvested with minimal seed loss.

The windrows are easily picked up by standard crop lifters on an open front header. Special pick-up attachments replacing the usual header front can also be used. These can be fitted to most headers, including power take off (PTO) machines with detachable comb fronts.

Most canola crops are direct headed in the northern areas as earlier maturing crops ripen more evenly and harvest can be quickly completed. The improved shatter tolerance of the new varieties has increased the trend to direct head crops in southern and central areas. However there remain distinct advantages of windrowing canola:

- It allows earlier harvest (8-10 days) because seed matures more evenly. This is particularly important in paddocks where maturity is uneven (higher rainfall areas) and/or where growers have a long harvest period ahead with cereals and other crops.
- It insures the owner from hail loss and excessive wind damage.
- It gives growers more flexibility with large areas as the timing of harvest is not as critical.
- Shatter losses are reduced during the harvest operation.
- Unlike direct harvesting, the windrowing operation can be run around the clock, if necessary, to assist with the harvesting of large areas.
- It will mechanically kill weeds allowing a cleaner sample and reduce the time available for insect pests to cause damage to crops.

Types of windrowers

Windrowers can be either self-propelled or PTO (power take off) driven. The draper belt style of windrower is superior to the auger style in reducing canola cut crop damage.

T. Amos

A self-propelled, draper-style windrower.

A PTO driven, draper-style windrower.

T. Amos

Self-propelled machines are more suited to irrigated crops or in undulating country or country that requires windrowers to be highly manoeuvrable, but their high cost may restrict their purchase.

Essential features of a windrower

- Sufficient depth (front and back) of the table or platform to handle the cut crop. This would need to be at least 1.1 m.
- A large throat opening 1.0-1.3 m which is at least as wide as the distance between the draper belts.
- A vertical clearance of up to 1 m under the window opening to allow large windrows to pass through without interference.
- The throat opening should be free of projections that may catch or bunch the windrow as it passes through the machine. **Note:** Avoid bunching as it leads to both harvesting and drying problems.
- The windrower should have ample reel and table adjustments to handle the range of crop conditions experienced with canola. The major problem is the amount of material in heavy crops that has to be forced through the window.
- The divider must be capable of separating heavy and tangled crops.

Size of a windrower

The width of the windrower will depend on the bulk of the material in the crop, and the ability of the windrower to feed the cut crop through the machine. Wider machines are more appropriate in areas where yields are normally lower, whereas narrower machines are more effective in heavy dryland and irrigated crops.

The cut may be as small as 3.5 m with self-propelled windrowers. Pull-type windrowers need a clearance to allow for the tractor on the next round which requires a width of approximately 4.6 m.

The harvesting capacity of the header is also important. The smaller capacity headers need a maximum cut width of about 5.5 m in most conditions. The larger headers, and in particular, hydrostatic drive and axial flow machines, can handle cuts of up to 7.6 m in the windrow.

Attachments

Difficult crop conditions may require windrowers to be fitted with specialised attachments to assist with the feeding of the crop. These include the following.

Vertical knife. This knife is similar to the sickle bar knife of the windrower, but it is in a vertical position on the divider end of the windrower. In a down or tabled crop, the vertical knife operates far more efficiently than a cone or looped steel rod divider. This knife will assist in the division of the crop and help reduce the 'bunching' problems associated with tangled crops and give a clean edge to the uncut crop.

There are several styles of vertical knives which include systems using one stationery and one reciprocating knife; the double knife with two moving blades; and chain driven knives where the knife travels in one direction driven by a chain attached to a link. The latter gives a wide profile and hence there are problems forcing the divider through the crop.

Replacing the crop divider with a vertical cutter bar improves separation, particularly in lodged and tangled crops.

T. Amos

I. Amos

A revolving belt fitted to the top of the opening helps the cut material to flow evenly from the machine.

Another system, based on a rotating saw principle, tends to create a shatter problem.

The double knife system appears to be the best suited for all crop conditions as it reduces the shatter loss on the drier crops.

Vertical knives can be either hydraulically or mechanically driven.

The mechanical drive is more appropriate if smaller tractors are used which have only two sets of remote hydraulics to control the table height and reel height.

Throat drapers. Window openings that catch the cut crop and cause 'bunching' are a major problem in heavy canola crops. The 'bunching' of windrows does not allow the even drying or feeding of the windrow into the harvester.

The fitting of blocks to raise the frame height of the windrower opening will help with the under-frame clearance but this makes the draper belt at a steeper angle and can cause problems with the feeding of the cut crop along the draper and later, into the header.

The fitting of a mechanically driven drum or belt that revolves around the top of the frame opening helps to reduce 'bunching' by forcing the crop through the opening.

The top draper also assists in heavy crops by pushing the exposed heads down, packing them into the windrow and reducing the chance of windrow shatter due to strong winds.

When to windrow

Canola is usually ready to windrow about 25 days after the end of flowering. It may be ready sooner if finishing conditions are hot, or take longer if they are mild. The end of flowering is defined as the time when only about 10 pc of plants have any flowers left on them. Being able to roughly predict when the crop will be ready to windrow allows you to plan ahead, particularly if you are using a contractor.

R. Colton

Only 10 per cent of plants have any flowers left. This crop will be ready to windrow in about 25 days.

L. Banks

Regularly shell out 10 to 20 randomly chosen pods to monitor seed colour change.

A crop is ready to windrow when 40 to 60 per cent of the seeds have changed colour from green to their mature colour.

R. Colton

Start sampling pods at random through the crop each day to monitor seed colour change from about 15 days after the end of flowering. The crop is ready to windrow when 40-60 pc of seeds in pods have changed colour from green to their mature colour of brown or black and all seeds are firm when rolled between the thumb and forefinger. Maturity varies between the top and bottom of the plant, therefore it is important to obtain a representative sample.

A canola crop is likely to remain at a suitable stage for windrowing for only about 3-4 days, as the crop dries out quickly.

F. McRae

Aim to produce a smooth and continuous windrow which will dry uniformly and feed evenly into the header. Bunching (as seen above) is a header driver's nightmare.

Completing the windrowing operation successfully in this limited period requires careful planning and reliable, well-adjusted equipment with sufficient capacity to handle the area of crop.

There will be losses if windrowing is done outside the recommended period. A 10 pc yield loss and a lower oil content are the likely outcome of being a couple of days too early. Pods will shatter readily if windrowing is too late, particularly on hot, dry days. Losses from windrowing too late can be reduced by windrowing at night or when humidity is high after rain or dew.

Operations and settings

Cut the crop just under the pods to reduce the amount of crop passing through the throat, without missing any of the lower pods.

The reel height in most cases should be just at the top of the crop to hold the plants gently against the knife with the rotation speed slightly faster than the ground speed.

The middle range belt speed on most windrowers is very suitable for canola as the cut crop becomes slightly tangled and easier to pick up at harvest. The need to create a formed windrow is not as critical in a cereal crop.

Owner or contract windrow

Traditionally windrowing has been carried out by contractors but in recent years more growers have taken the option of buying their own windrower and contracting for neighbours. However, hiring a competent contractor has advantages in that there are no running or maintenance costs or labour requirements and a competent operator should do a quality job. The major disadvantage is the risk of not having the contractor there when the crop is ready.

Generally a windrower has the capacity to cut approximately 5 ha/hour; 500-600 ha per windrower is the maximum area that should be contracted in one harvest period (7-10 days). Ideally, a windrower should be shared between 2 or 3 growers to minimise capital investment. To date when a windrower is depreciated over 10 years it will cost slightly more to own a machine than to contract. However, the windrowing is more likely to be completed on time and the machine can be used on other crops (for example, barley, oats, lupins etc).

CHEMICAL DESICCATION

Chemical desiccation (drying) can be used as an alternative to windrowing. It was previously only recommended for *B. campestris* varieties but with improved shattering tolerance of *B. napus* varieties, desiccation can be regarded as a harvest aid for both types.

Desiccation has been successful in central and southern areas where crops have tabled or lodged early on high fertility, alluvial river soils and weeds have grown through the crop. It has also been successful in undulating areas where crops were maturing unevenly or where windrowing machinery was unavailable.

Diquat is the main chemical used worldwide. This desiccant has no detrimental effects on seed or oil quality, or on seed germination. It has a contact action, hence complete coverage of the plants is required. An experienced pilot must be employed to ensure uniform coverage through correct droplet size (250-400 microns), water volume (20-30 L/ha) and addition of the most appropriate crop oil. Avoid spray drift onto adjacent crops, pasture and trees (for example, pepper trees).

The desiccant is applied when 70-80 pc of seeds have changed colour—a slightly later stage than for windrowing. The desiccating action is rapid and the crop will normally be ready to harvest 7-10 days after treatment, when 9 pc seed moisture content is reached.

An accurate moisture meter is needed to identify when to start harvest. (Service moisture meters every winter and calibrate them before harvest).

Split application time if large areas are desiccated as 60-80 ha is considered the maximum for one header in the time available. There is some commercial experience with *B. napus* varieties suggesting that desiccation reduces seed loss during harvest as seed is retained better in pods. The cost of treatment in 1991 was the same as windrowing.

Desiccation should be considered as a 'special purpose' management aid when problems with windrowing or direct heading are anticipated.

HARVESTING WINDROWED CROPS

When to harvest

Under normal conditions a windrowed canola crop is usually ready to harvest about 5-10 days after cutting. Seed moisture content should be 9 pc. A good moisture meter is essential to ensure correct timing.

Header type

Open front headers are suitable for picking up windrows.

Comb front headers require pick up attachments to lift the crop into the header. These attachments may also be used on open front headers. They replace the existing comb front and consist of a replacement front usually shorter than the original, with a table auger similar to the open front. The windrow is picked up using either a rubberised draper belt, an aluminium draper fitted with fingers or a drum type.

R. Colton

Large capacity, open front headers are capable of handling more than one windrow, depending on windrow size.

Crop lifters are fitted to every third finger. The rest of the cutter bar may be covered with folded tin to avoid taking in second-cut stubble.

F. McRae

T. Amos

Pick-up fronts, such as this rubberised draper type, can be fitted to headers with open or detachable closed fronts.

For canola the rubber belt type is preferred with rubber or synthetic fingers as the gentle action helps to reduce shatter losses. The aluminium type is more suited to bunched windrows.

The speed of the pick up must be matched to the forward speed and a variable speed hydraulic drive is preferred.

DIRECT HARVESTED CROPS

When to harvest

A canola crop is ripe when all the pods are dry and rattle when shaken. The seeds of *B. napus* varieties are dark brown to black in colour when they are ripe. The stems may still be partly green at this stage.

The bottom pods on the plant ripen first and at harvest a few of the small top pods may still be slightly green. These will pass through the header unthreshed.

Start harvesting when the seed moisture has fallen to 9 pc or less (9 pc is the maximum moisture level for receival into crusher storage). At about 10 pc moisture and above, seed can heat rapidly on hot days, particularly if there is a proportion of immature seed and admixture.

Seed losses from shattering will be much lower in the cooler part of the day or at night, when humidity is higher. As a rough guide, do not start canola harvesting until about 3 hours after the relative humidity drops to 70 pc in the morning and stop about 4 hours after it returns to 70 pc in the afternoon or night. Night harvesting is preferred during periods of very hot weather. Canola can usually be harvested when conditions are too damp for cereals and harvesting can recommence much sooner after rain than with cereals. However, seed moisture level must be monitored to make sure the 9 pc level is not exceeded.

J. Muir

An open front header, with finger reel, suitable for direct harvesting heavy irrigated crops.

Header type

Depending on the area to be direct harvested, have a number of machines on standby to harvest the crop without delay as soon as seed moisture reaches 9 pc as the crop becomes very susceptible to shattering losses as it dries out.

Open front machines are the most suitable for direct harvesting, and with minimal adjustments, will limit crop losses and ensure an acceptable seed sample.

Comb front machines have been used to direct harvest canola but difficulties often occur resulting in heavy seed losses. The large bulk of material to be handled, relative to cereal crops, and the potential for pods to shatter on entry make canola very difficult to handle. Comb front headers lack the capacity and range of adjustments of open front machines, and should only be considered for direct heading canola in areas where shorter, lighter crops are expected.

If a comb front header is used, widen the finger spacings to about 13 mm and raise the rear comb spiral and adjust it back to provide more clearance.

Header settings

Reel. A normal bat reel is usually satisfactory, but in heavy lodged crops a finger reel is desirable. When direct heading canola the reel speed and height should be set so as to gently assist the crop into the machine. A reel which is set too low or too fast will cause excessive shattering at the cutter bar.

Front auger and elevator. Adjust the table auger as high as possible. If the adjustment is insufficient to give 8-10 cm clearance, it may be necessary to slot the adjustment holes.

The front elevator carries a much bigger volume than is normal in cereals and should be checked for tension and freedom to float.

Drum and concave. Canola is not a difficult crop to thresh. In fact, under normal conditions most of the seed threshes out in the front or in the elevators.

Drum speed should be about 60 pc of that used for cereals. Set at 650–700 rpm for small diameter (46 cm) cylinders, and 450–600 rpm for large diameter (61 cm) cylinders. Excessive drum speed causes seed cracking and skinning and excessive smashing of pods and stems, which may then be difficult to remove from the sample.

The concave should be wide open (40–50 mm at the front). A wide setting is important when harvesting windrows.

Riddles. Top: adjustable frogmouth top riddle, 3–6 mm open; or standard, 10–13 mm top lip riddle.

Bottom: adjustable frogmouth bottom riddle, 2–4 mm open; or 4 mm round hole or lip riddle. The old one-eighth inch round hole riddle is ideal, but its metric equivalent (3 mm) is too small, especially for *B. napus* varieties.

Closely monitor returns to the drum. A well set header will have almost no returns. If too much is returning it will be 'skinned', releasing oil which leads to build up of gum throughout the threshing, cleaning and grain tank areas. High drum speed and a too closely set concave can cause similar problems.

Wind. The fan should be set at half to three-quarter speed. Where wind is controlled by shutters these should be less than half open.

Walkers. If straw baffles are fitted over the walkers these should be lifted as high as possible to allow a smooth flow of straw.

Rotary screen. The rotary screen will need to be blanked off to prevent grain being collected in the 'seconds' box. A piece of closely woven hessian or sugar bag material wrapped around the screen and stitched to fit tightly will direct grain into the main grain tank.

Sample. The best sample will be made when humidity is high, for example at night or soon after rain. During high daytime temperatures (over 30°C) smashed pod pieces will tend to contaminate the sample, but because of its light weight a small percentage of such admixture is acceptable. Often during the hottest part of the day skinning of the seed will start to occur and the problem cannot be corrected by further adjustments. It then becomes necessary to stop harvesting for a couple of hours until the temperature falls.

Speed of travel. Work rate will vary considerably depending on crop conditions and header type. As a guide, a 6.7 m open front machine picking up two 3-metre cut windrows in a 1.5–2 t/ha crop will travel at 4–7 kilometres per hour and harvest about 2 hectares per hour.

The same machine direct harvesting a standing 1.25 t/ha crop would travel up to 20 pc slower.

GRAIN LOSSES

Grain losses can occur up to the point of harvest due to pod shattering. Losses can also occur out of the front and back of the header if adjustments are not correct, and from leakage through small holes in the machine.

Because of the very small seed size, it is essential to seal all holes and cracks, especially in the table and front elevator and in the grain tank. The most suitable materials to use are a roll of 50 mm plastic tape and a tube of silicon rubber sealing compound.

A standard grain monitor, suitably adjusted, is satisfactory for canola. A loss of 1 kg/ha seed on the ground is indicated by 23 seeds of *B. napus* and 42 seeds of *B. campestris* per square metre.

GRAIN DRYING

Grain drying is not normally necessary in New South Wales. However, where seed is harvested above 10 pc moisture it should be dried as soon as possible to avoid seed heating and possible spontaneous combustion. The seed size of canola requires the installation of fine screening to prevent seed from passing through the drying bin. The drying capacity will be substantially lower for canola than for cereals.

When drying canola seed containing up to 16 pc moisture, temperatures of up to 70°C can be used without damaging the oil quality. To maintain seed viability, keep drying temperature at or below 60°C. (For more information see Agfact P5.2.10, *Drying oilseeds—safe temperatures*.)

MARKETING

Market opportunities for canola have increased significantly since the late 1980s because of the significant gains made in both oil and meal quality.

New markets for canola products have opened up and have potentially increased canola's share of oil and meal markets.

Canola is sold into a deregulated market and the responsibility of finding an acceptable price and arranging a buyer rests with the grower.

Domestic demand

The potential use of canola meal has increased considerably since the introduction of low glucosinolate varieties. The meal has started to replace soybean meal which is still being imported into Australia.

As well, canola meal is considered to be a superior product to sunflower meals and pulses, and a premium is paid above its protein level, due mainly to higher lysine and energy levels and improved digestibility.

Meal consumption, largely through pig and poultry feeds, has increased in parallel with domestic production of canola.

Maintenance of high protein levels and low glucosinolates will be essential to ensure further growth in demand for canola meal.

Canola oil underwent an image change in the late 1980s with the introduction of improved varieties. Originally the oil was only used in vegetable oil blends. Now it is recognised as a product very low in saturated fats with additional health properties due to its monounsaturated fatty acid make up. This has improved the demand of canola in bottled oil and margarine which is now positively marketed within Australia and overseas.

The domestic demand for canola in the eastern states in 1991 was about 130,000 tonnes of seed.

Export

Japan is a major importer of canola seed, with annual imports of about 1.8 million tonnes in recent years. Japan's needs are met almost exclusively by Canada, the world's major exporter. Japanese crushers are anxious to seek alternative sources of canola to reduce their dependence on a single supplier.

Compared to Canada, Australia has the advantages of lower sea freight, different harvest timing and a product of at least equal quality.

Australian canola is quite acceptable in Japan. Small cargoes were successfully exported there from New South Wales in 1986 and 1987.

Prospects for future exports are excellent. However, we must become a consistent exporter of seed if we are to gain the reputation of being a reliable supplier.

Pricing

Australia's oilseed production is insignificant in terms of global oilseed production so the prices paid to Australian farmers for oilseeds are determined very largely by world supply and demand factors. Australia is a nett importer of oilseeds, mainly soybeans and palm oil.

Different oilseeds can substitute for one another to some extent but because each has different oil and meal quality, and oil and meal is often present in different proportions in each oilseed, complete substitutions are often not possible. These factors complicate the market and make comparisons difficult.

Although there are no perfect substitutes soybeans are considered the 'benchmark' for trading and prices internationally. (Soybeans are the most important oilseed internationally, making up about 70 pc of world oilseed trade.)

Import parity price will set the ceiling on domestic prices, just as export parity will establish the floor. Typically, domestic trading for canola was \$10–15/t above export parity in the late 1980s when local production did not meet Australian demand.

Develop a market strategy

Growers must pay attention to the long term forecasts being offered by market analysts before canola is sown each year. It is important to develop an opinion about the market—whether the trend is stable, or likely to rise or fall.

Look at the potential area you have available to grow canola. Planning must have a degree of flexibility to take into account the vagaries of seasonal conditions.

Complete gross margin budgets and take into account the potential for improved yields from a following wheat crop. Estimate your direct cost requirements and overhead costs that go towards maintaining machinery and land values. Your total cost of production per tonne will determine the minimum price you can afford to accept and the relative profit you are likely to receive once a price is accepted.

From the time of sowing, it is advisable to monitor the weekly price of canola on graph paper. At the same time ensure you have developed 2 or 3 sources of independent market advice:

- ensure you have a strong selling contact who will immediately pass on important price changes (these can occur over a 24 hour period);
- organise independent information that keeps you in touch with market trends on a weekly basis (newsletters etc). If prices change obtain further information from market sources;
- let your likely industry selling point know of your cropping intentions and ask to be contacted by their field representative or agent after sowing.

Options for selling grain

Part of the strategy is deciding when to sell grain. Canola is not normally stored on-farm after harvest. It is usually bought off the header and stored at local delivery silos or trucked directly to the crushing plant.

A fixed tonnage contract is used if growers decide to forward sell some time before harvest. This locks the grower into delivering

a fixed quantity and quality of grain by a specified date. The advantage is that the grower has the option of locking into a profit at a known and acceptable price during the growing season.

Usually a number of contracts are taken out progressively as you become more confident of your crop yield.

Alternatively, a harvest cash price is always available for grain sold off the header. By then you are quite sure how much grain you have for sale but the price on the day must be accepted.

In the past a guaranteed minimum price (GMP) has been provided by crushers as a service to an emerging industry. A GMP contract stipulated a minimum price to be paid per tonne for all grain harvested from an agreed area. The final price paid, which was often higher than the guaranteed minimum, depended on when the grain was actually sold to the buyer. A GMP contract provided a low risk option for growers who could then budget using a minimum price. However, crushing companies do not favour buying grain 6 months in advance and accordingly set low prices which do not reflect true market values.

With any market strategy the grower must feel comfortable with the risks he takes. Each grower must develop his own strategy, but it is important that marketing be given equal status compared to other technical decisions. The aim is to ensure that a major proportion of the crop is sold on the high side of the market. Forward selling a portion of the crop during the season is a good way to avoid having to accept a lower price at harvest time.

Delivery standards are as follows:

Moisture content. Nine per cent maximum (oven dry basis). A penalty of 2 pc of the price for each 1 pc moisture above allowed level operates. Growers normally have little trouble achieving a moisture level of 9 pc; in fact many crops are as low as 6 pc when harvested. Seed should not be stored at 10 pc moisture or above, as severe heating is likely.

Oil content. Forty per cent is standard, with 1.5 pc premium or deduction for each 1 pc above or below standard.

Impurities. Seed is rejectable at over 4 pc (by weight) impurity. A one-for-one penalty operates up to 4 pc, and two-for-one penalty operates above 4 pc if the seed is accepted. Impurities include weed seeds, stem and seed pieces, and very small shrivelled canola seeds. Most growers achieve a fairly clean sample and few are penalised for impurities.

Test weight. Test weight (bushel weight) is not used as a delivery standard but is useful for calculating the weight and volume of seed. Canola test weight is more variable than cereal test weights. The recognised figure is 62.5 kilograms per hectalitre, the same as for barley.

Broken seed. Seed is rejectable if it contains over 7 pc broken seed. There is a 0.5 pc price penalty for each 1 pc broken seed above this level. Broken seed consists of hulls, kernels and seed pieces normally resulting from mechanical damage.

Damaged seed. Three per cent of seed may be damaged without penalty but it will only be rejected if over 40 pc is damaged. A half-for-one penalty operates above the 3 pc level. Seed is 'damaged' if it is affected by heat, frost, sprouting or other weather damage.

STUBBLE DISPOSAL

There is little grazing value in canola stubble itself, but any seed lost before or during harvest which germinates with summer rain can provide worthwhile feed.

Dispose of stubble as soon as possible after harvest to minimise disease spread. Canola stubble does not burn as readily as cereals; usually the standing stubble between the header trash windrows remains unburnt and is left to stand if a cereal crop is to follow. This standing material rarely presents a

F. McRae

Typical burning pattern of canola stubble.

A fast harrowing smashes and spreads canola stubble

F. McRae

problem at sowing, even where the following crop is being direct drilled.

Dry canola stubble is very brittle and is easily smashed up and spread by a fast harrowing so that it can pass through standard sowing equipment. This approach can be used following a poor burn or on a light stubble where a burn is not attempted.

GRAZING AND HAY

Canola has been grazed or baled for hay during drought times because of its likely failure to produce grain. There is a potential risk of toxicity if canola forage or hay is fed to stock, although the risk is considered to be relatively small. When grazing canola stands:

- do not place hungry stock on canola;
- observe stock regularly and remove immediately if unusual behaviour is observed;
- take special care in dull, rainy weather or following heavy frosts.

Canola hay

Canola, cut and baled soon after flowering, can produce good quality hay. Tests have shown it to have considerably better feeding value than average quality cereal hay. Crude protein (approximately 13 pc) and metabolisable energy (approximately 9 pc) levels are adequate to maintain lactating ewes or cows, and to grow out weaners. However, limit the amount to that which is necessary to satisfy roughage requirements (20 pc of lactation diets).

PESTS

A number of insects and mites can damage canola crops. Most are usually of only limited importance. Some, such as the redlegged earth mite, blue oat mite, cutworms, aphids, heliothis caterpillars and Rutherglen bug, cause severe and widespread losses in some years.

Significant damage is most likely to occur during establishment and from flowering until maturity. Growers should be prepared to treat each year, at or soon after sowing, to control mites and budget for an aerial spray between flowering/podding and maturity.

Cultural control of establishment pests

Canola crops often follow a pasture phase. Pasture is the natural habitat of some establishment pests, including redlegged earth mite, blue oat mite and false wireworms. They can be reduced by a period of fallow between cultivation of the pasture and sowing of the crop.

Early ploughing and the maintenance of a clean fallow by occasional cultivations is often beneficial. Weedy fallows can promote build up of the pests or provide shelter for them.

Many weeds are food plants for insect pests. Large populations may develop or shelter in grassy or weedy headlands and later move into adjacent crops. Clean cultivation of headlands during summer and autumn stops pests from breeding or sheltering there.

ESTABLISHMENT PESTS

Redlegged earth mite (*Halotydeus destructor*) and blue oat mite (*Penthaleus major*).

Both mites feed, by a rasping and sucking action, on the cotyledons and leaves of seedlings. Heavily infested plants have mottled and then whitened cotyledons and leaves. Very severely damaged plants die and severely damaged plants usually remain stunted and weak. Sometimes the seedlings are killed before they emerge.

Feeding is normally from late afternoon until early morning, but continues during the daytime in calm, overcast weather.

A. Philby

Mites attack seedlings as soon as, or even before, they emerge, weakening or even killing them.

Red legged earth mite. Actual length 1 mm. Silvery patches indicate mite damage.

R. Colton

· Pests was contributed by G. J. Goodyer, Entomology Branch, BCRI.

The mites are very active and when disturbed on a plant will drop or descend to the ground and quickly hide in the soil or under vegetation.

The two mites are similar in appearance in all their life stages and they both prefer light, sandy or loamy, well drained soils. They also often occur in association in crops and pastures on the tablelands, slopes and plains of the southern half of New South Wales. Redlegged earth mite is, however, usually responsible for most of the damage to canola crops in the southern and central inland, whilst blue oat mite causes all of the damage in the northern inland.

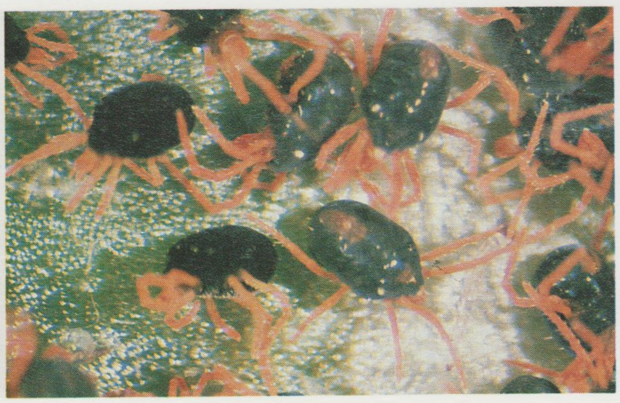
Both adult mites are eight-legged, oval shaped and about 1 mm long. Redlegged earth mites have somewhat flattened black bodies and pinkish orange legs and mouthparts; blue oat mites have rounded, dark brown or black bodies, bright red or bright pinkish red legs and mouthparts, and a red streak in the centre of the lower back.

Control the previous spring. Both mites oversummer as eggs. These *aestivating* eggs are produced in mid-late spring by the final generation adults and do not hatch until favourable conditions of temperature and moisture occur in the following mid autumn to early winter.

The size of the oversummering egg population can be greatly reduced by treating mite-infested pasture paddocks with a systemic (foliage-absorbed) insecticide during August or early September, the year before sowing. Spraying for mite control, however, needs to be a separate operation—after winter cleaning (July to early August) and before spray topping (late September to October). If this management procedure is not carried out, canola sown into pasture paddocks is at risk.

Red legged earth mites have black bodies (left), while blue oat mites have blue-black bodies with a red streak on their backs (right). Both are about 1 mm long.

D. James



I. Mack

A perimeter spray could have prevented the plant losses which mites caused around the edges of this crop.

Control at sowing. The mites must be detected early for control to be effective. The paddocks, headlands, fencelines and adjoining areas should be checked for mites before sowing and sprayed, if necessary, at or soon after sowing.

Protect emerging and establishing crops by:

- checking carefully for mites at 2–3 day intervals, especially along fencelines and in adjacent pasture paddocks. You will need a magnifying glass to see the early stages when inspecting bare ground;
- sowing insecticide-treated seed into previously cropped or low risk paddocks;
- perimeter spraying low risk paddocks with either the higher rate of endosulfan within the paddock or with a systemic insecticide onto weedy fencelines or adjacent pasture;
- boomspraying the soil surface of previous pasture or high risk paddocks with the lower rate of endosulfan immediately after sowing.

Cutworms (*Agrotis* spp.)

Cutworm caterpillars are sporadic but often serious pests. They either climb the seedlings and young plants and eat the leaves, or cut the stems near ground level and eat the top growth.

A cutworm caterpillar feeding on young canola seedlings.

J. Sykes

L. Turton

Cutworm caterpillars at different stages of development. Length 40 to 50 mm when fully grown.

Large patches of the crop may be damaged if caterpillars are numerous during establishment. Sometimes the young plants are partly drawn into the ground. They usually feed in the evening and at night.

Inspect emerging and establishing crops in the evening or at night for cutworms. The caterpillars are 40-50 mm long when fully grown and grey-green, dark grey or nearly black often with dark spots on the back and sides of the body. Treat promptly when they are feeding. Spot spraying may be all that is needed.

False wireworms (family Tenebrionidae)

The larvae sometimes stunt or kill the seedlings by feeding on their roots and underground stems. Damage may be only light thinning of the crop or may be the development of large bare patches.

Examine the soil for false wireworms **before sowing** because treatment after sowing is not practicable. The larvae are usually found at the junction of the loose, drier cultivated soil and the undisturbed moister soil below. They have hard, round, smooth, yellow-brown or blackish bodies with pointed upturned tails or a pair of raised spinelike processes on the end segment. They are 8-40 mm long when fully grown.

A false wireworm (about 40 mm long) with the remains of a canola seedling.

J. Sykes

False wireworms can be controlled by clean cultivating paddocks and headlands during summer and autumn. The oversummering beetles must eat to live and in the absence of shelter and food plants, they either die or disperse to more suitable areas.

Vegetable weevil (*Listroderes dificis*)

The larvae and adults feed on the leaves of the seedlings. They usually feed in the evening and at night and shelter by day in the soil near affected plants. Damage can be severe if the larvae or adults are numerous and seedling growth is impaired by adverse weather.

Check emerging crops in the evening or at night for larvae and adults. Infestation is often confined to the edge of the crop so border spraying may be all that is needed. Treat in the evening or at night.

The legless larvae are about 13 mm long when fully grown with curved green, yellow-green or cream bodies and dark heads. Adult weevils are about 8 mm long and dull greyish brown with prominent snouts. They have a V-shaped, pale mark near the middle of the back and a small pointed process towards the rear of each wingcase.

The vegetable weevil can be controlled by bare fallowing infested paddocks in late spring and summer and eliminating weeds and grasses from headlands. The oversummering weevils must eat to live and in the absence of shelter and food plants either die or disperse to more suitable areas.

Larva of vegetable weevil. About 13 mm long when fully grown.

L. Turton

Brown pasture looper (*Clampa arietaria*)

The late stage caterpillars sometimes move, armylike, into young crops and severely defoliate the plants. Capeweed is a preferred food plant and infestations are likely to be confined to areas around the edges of crops, or within crops, near patches of this weed. Spot or perimeter spraying is usually all that is required.

L. Turton

Brown pasture looper. Length 35 to 40 mm when fully grown.

The caterpillars crawl with a looping motion and are 35–40 mm long when fully grown. They have yellow-brown heads and are grey to dark brown with a pale stripe down each side of the back and a row of reddish spots along each side of the body.

FLOWERING, MATURITY PESTS

Cabbage aphid (*Brevicoryne brassicae*); turnip aphid (*Lipaphis erysimi*) and green peach aphid (*Myzus persicae*)

Infestation is most common during flowering to podding. Dense clusters feeding on the upper stems, flower heads and developing seedheads can seriously reduce pod set, pod fill, seed quality and viability.

Check crops at least twice weekly during flowering and podding to observe changes in aphid numbers on flower heads. Initially only small groups of plants scattered through the crop may be affected. The rate of increase and spread of aphids within the crop varies greatly. Sometimes infestations can develop very rapidly.

Cabbage aphids (2 to 2.5 mm long). Typically aphids form a dense cluster near the top of the plant. The lady beetle is an aphid predator.

R. Colton

Treatment is warranted if a 25 mm length of the stem of the flower head **of most plants** is covered with aphids and biological control agents (lacewings, ladybirds, larvae of hoverflies, tiny parasitic wasps and fungal diseases etc) are not very active. Check plants in a large number of sites at random to determine the extent and severity of the infestation.

Experienced growers in southern New South Wales have found that early sown crops often escape infestation because they flower before aphid build-up occurs. Spraying has only been necessary in one year out of six or seven. In northern areas, milder winter and spring weather may induce early aphid build-up and necessitate more frequent spraying.

Cabbage moth (*Plutella xylostella*)

The caterpillars make clear, membranous 'windows' and small holes in the leaves and also graze on the stems and pods. Severe defoliation and pod grazing during flowering, pod formation and pod filling reduces seed yield. Sometimes large numbers of caterpillars may develop on the foliage after flowering without causing harm, but then move to the pods and cause damage in a short time.

Examine crops regularly from flowering and podding until windrowing, for caterpillars and their damage. Check at a number of sites to determine the severity and extent of the infestation. Sometimes damaging populations can develop very rapidly.

The caterpillars are 10–13 mm long when fully grown and have slender pale green bodies that taper towards each end. They wriggle violently when disturbed on a plant and may drop to the ground or hang suspended by a silken strand.

Cabbage moth caterpillar (actual length 10 to 13 mm) and typical leaf damage.

R. Colton

R. Colton

Heliothis caterpillar and pod damage in canola.

L. Turton

Corn earworm moth resting with forewings slightly parted. The pale patch, or the two pale spots in the dark outer margin of the hindwing, is exposed.

Heliothis caterpillars (Family Noctuidae); corn earworm (*Helicoverpa armigera*); native budworm (*H. punctigera*)

Heliothis caterpillars, especially caterpillars of the native budworm, can extensively damage canola crops in some seasons. Infestation can occur at anytime from flowering and podding until the seedheads have dried off after windrowing; it is most common during flowering to podding. Caterpillars less than 10 mm long normally feed only on the foliage, but caterpillars longer than 10 mm also chew holes in the pods and eat the seeds. Loss of foliage usually does not matter, but heavy damage to the pods severely reduces the yield.

In spring 1991, heliothis caterpillars were abnormally abundant in flowering to podding canola crops in many areas. Investigations indicated that this was probably due to the combined effect of two or more of the following factors—concurrent drought conditions, concurrent heavy aphid infestation and absence of more attractive nearby crops (for example, grain legumes) to divert the egg laying moths away from canola.

Heavy aphid infestation and hot, dry weather appear to favour heliothis infestation because the egg laying moths are attracted to the aphid honeydew as an alternative or additional source of food to flower nectar.

The aphids also provide an alternative prey for predators that would otherwise feed upon the heliothis eggs and small caterpillars; the hot, dry weather is detrimental to the wasps which parasitise the eggs and young larvae.

Examine crops at regular intervals from flowering to podding for moths and young caterpillars.

Moth activity alone cannot be taken as a guide for spraying. Base spray timing on careful observation of the extent of caterpillar infestation in the crop.

Check plants in a large number of sites at random for caterpillars and their damage to the pods. Sweep the borders of dense crops with a butterfly net or shake plants in thinner crops over a white fertiliser bag or plastic tray.

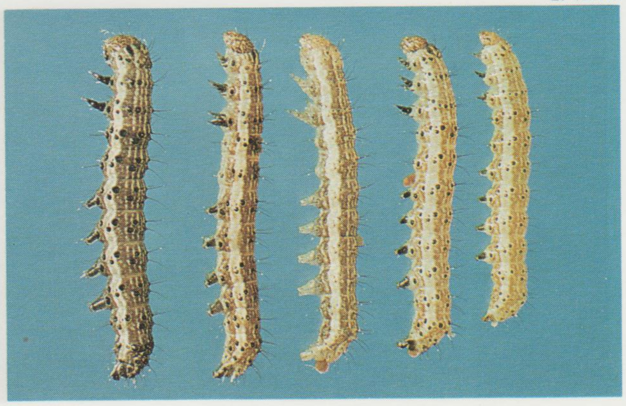
Newly hatched heliothis caterpillars are 1-1.5 mm long with dark heads and dark-spotted, whitish bodies.

Native budworm moth resting with the forewings slightly parted. The outer margin of the hindwing is uniformly dark.

L. Turton

Partly grown heliothis caterpillars. Length 10 to 20 mm.

L. Turton



Young caterpillars are 10–20 mm long and pale yellow, greenish or brownish with dark heads, conspicuous upper body hairs and often narrow, dark stripes along the back and sides of the body.

In spring 1991, the caterpillar population in some crops exceeded 150 per square metre, and 20–40 per square metre was fairly common. Direct observations made by several NSW Agriculture District Agronomists indicated that the former treatment guidance figure was inappropriate and could be increased significantly. Based upon the spring 1991 experience the new treatment guidance figure is 5–10, 10-mm long pod-feeding caterpillars per square metre; that is, treat if pod boring commences and there is an average of between 5–10, 10-mm long caterpillars per square metre.

For further information on heliothis caterpillars see Agfact AE48, *Heliothis caterpillars*.

Seed bugs (Family Lygaeldae); grey cluster bug (*Nysius clevelandensis*) and Rutherglen bug (*N. vinitor*)

The Rutherglen bug is usually the most important pest. It will attack crops at any time from flowering and podding until the seedheads have dried off after windrowing. The adults and nymphs suck sap from the leaves, stems, flowers and developing and ripening pods and seeds. Heavy or prolonged infestation can severely reduce pod set, pod fill, seed quality and viability.

Regularly check for adult and nymphal bugs at a large number of sites in the crop from the start of flowering until windrowing. Infestation is most likely during hot dry weather and damaging populations can build up rapidly. Treatment is warranted if there is an average of 10 or more adults or 20 or more nymphs per plant and the crop is moisture stressed. If necessary, spray before windrowing to prevent damage in windrowed crops.

Rutherglen bugs feed on the pods, reducing the weight and oil content of the seeds.

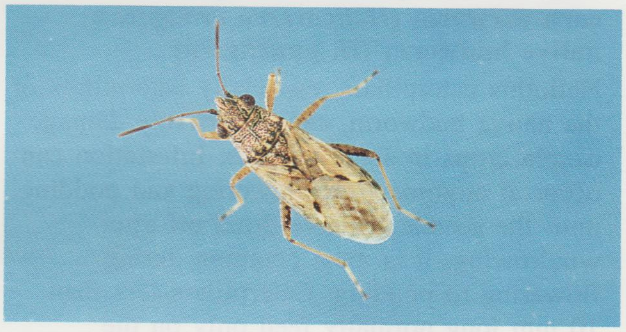
R. Colton

R. Colton

Rutherglen bug nymphs can cause similiar damage to that caused by adults.

Rutherglen bug adult. Length about 5 mm.

L. Turton



Adult bugs are about 5 mm long, narrow bodied and grey-brown with prominent black eyes. Nymphal bugs are reddish brown, somewhat pear shaped and wingless.

Plague thrips (*Thrips imaginis*)

The adults and nymphs frequently occur in very large numbers in the flower heads and mainly feed on the stems, flower petals and pollen. They do not affect pollination, pod set or pod fill, but some pods may be distorted.

Adult plague thrips are slender, about 1 mm long and brownish with two pairs of narrow, fringed wings. The nymphs are smaller, yellow or orange-yellow and wingless.

Canola pods distorted by plague thrips. Only the odd plant is affected.

L. Turton

R. Colton

Mice will climb plants and feed on the seeds and pods, or whole pods may be cut off and dropped to the ground.

Insecticides

Recommendations change regularly. For currently recommended control measures obtain a copy of the bulletin *Insect control in winter crops* available at your nearest NSW Agriculture office.

DISEASES

Blackleg

Blackleg, caused by the fungus *Leptosphaeria maculans*, is the most common and most serious disease of canola in New South Wales. The disease is so serious that in all production areas susceptible varieties can no longer be grown profitably.

The disease is carried over from season to season by survival of the fungus on canola stubble and trash. Brassica weeds and volunteer canola plants may also be important in the build-up and spread of the disease.

Autumn rain causes a massive release of spores from infected stubble. These spores are carried on prevailing winds, to infect nearby seedling crops.

Blackleg leaf lesion (usually about 1 cm across) containing numerous pinpoint-size black spots.

R. Colton

R. Colton

Blackleg basal stem canker. Plants rot off at ground level and fall over. Numerous pinpoint-size black spots are usually visible.

Most spores travel no more than 300 m, but some can travel several kilometres. The fungus spreads within a crop from plant to plant by water splash.

The disease is favoured by the cool moist climate of the tablelands and slopes of central and southern areas. Cool showery weather, which frequently occurs during winter and spring, favours infection and spread of the disease in growing crops.

Blackleg may attack canola plants at all growth stages. A heavy infection soon after germination will kill plants in the seedling and rosette stages. At first, leaves show a red, purple or yellow discolouration followed by the plants later rotting off at ground level.

Infection of older plants occurs on leaves, stems, inflorescences and developing pods. Light grey lesions (damaged areas) containing numerous black spots develop. These small black spots are spore cases of the fungus which give rise to millions of airborne spores which initiate fresh infections.

Older plants frequently become infected at the base of the stem, leading to cankering (decay) at ground level. This impedes and cuts off sap movement in the plant so that in severe cases the stem breaks off at ground level. At best, cankered plants may produce some shrivelled seeds.

Canker, which results from earlier infection, may not be apparent until early spring. It is the most damaging form of the disease. Current blackleg resistant varieties develop leaf spots but do not develop cankers to any degree.

Growing resistant varieties is the only satisfactory answer to blackleg. However, since the fungus has the ability to produce genetically different spores each season, additional precautions are necessary to minimise losses and delay a breakdown of varietal resistance.

Canola should not be grown on the same ground more than once in 4 years. While this recommendation has been broken (reduced to 2 or 3 years) in recent years as growers strive for maximum returns from cropping, you should try to stick to it wherever possible. Varietal tolerance will be put under more pressure as the canola industry expands. It is in the interests of all growers when selecting or managing paddocks to make sure old stubble has totally broken down and disappeared before sowing canola again. As well it is desirable not to grow canola next to last year's stubble, or where prevailing winds are likely to blow spores from other stubble areas if at all practical.

Avoid spilling seed at sowing and harvest along farm tracks and around silos. Control volunteer plants and brassica weeds in pastures, other crops and on waste ground. These good hygiene practices will reduce the amount of disease inoculum available to infect subsequent crops.

Alternaria leaf spot

The disease alternaria leaf spot is caused in canola by the fungus *Alternaria brassicae*. It can cause serious yield loss in wet seasons when spring weather remains wet and/or humid through to crop maturity—on average, about 1 year in 7 or 10.

R. Colton

Alternaria leaf spot—brown target-like spots usually about 1 cm across.

Alternaria pod spot. Heavy pod infection causes seeds to shrivel.

R. Colton

The main source of infection in crops is windborne spores blown in from alternative weed hosts, particularly cruciferous weeds such as wild mustards and turnips.

Infected crop residues are also an important source of spores. Infected planting seed is a much less significant source but it can introduce the disease into clean paddocks and may cause a seedling blight if weather conditions are favourable.

The disease first appears as dark target-like round spots on the lower leaves in winter. When wet humid weather continues through spring the disease spreads up the stems and onto the pods. If the infection is heavy, pods become covered with spots, causing them to dry-off prematurely and the seeds to shrivel. Pods shatter more readily and crops mature unevenly.

Disease severity is influenced more by prevailing spring weather than by any other factor. However, the choice of variety and planting date are important.

Strong standing *B. napus* varieties are not only less susceptible to the disease, but they mature later and warmer weather may limit disease activity.

The quicker maturing *B. campestris* varieties, particularly when early sown, mature in mid spring when disease activity is greatest.

- Purchase seed known to be from a clean crop or treated with a fungicide. Do not save planting seed from infected crops.
- Practice crop rotation. Select paddocks which are isolated from last year's stubble.
- Control cruciferous weeds in and around canola paddocks.
- Avoid planting too early in more favoured rainfall areas.
- Crop protection with fungicide sprays, as practised in Europe, is very expensive and unlikely to become economical in Australia.
- Breeding resistant varieties is being investigated, but success is a long way off.

White rust or staghead

White rust, caused by the fungus *Albugo candida*, is more common on shepherd's purse than on canola.

However, the strain which attacks shepherd's purse is not capable of attacking canola. It is a disease of minor importance, but a few infected heads tend to look spectacular in a crop.

It is more common in *B. campestris* and occurs in some varieties more than others.

Whitish cream pustules may form on leaves, stems, flower heads, or pods. Systemic infection results in distortion and enlargement of the flower head so that it resembles a stag's head.

Yield loss is directly proportional to the percentage of stems with staghead, and rarely exceeds 2-3 pc.

Sclerotinia stem rot

Cool, humid conditions which occur in dense canola crops in wet springs favour the development of stem rots caused by *Sclerotinia* spp. fungi. The disease white mould (*S. sclerotiorum*) is more common in all production localities and causes occasional yield losses in crops.

These diseases may affect the plant at the base of the stem or higher up. They can be recognised by the white fluffy external growth on the stem, in which numerous black bodies (sclerotia) are found. Wilting occurs above the point of attack. In a severe attack widespread lodging can occur. This was evident in some crops on the southern slopes in 1986.

The disease is carried over both on infected seed and in the soil in the form of small black fruiting bodies (sclerotia).

Sclerotinia stem rot. Note bleached centre section of the stem.

R. Colton

R. Colton

Sclerotinia affected stems usually contain black fungal fruiting bodies.

Lodged crops which enclose relatively stationary, cool and humid air enhance sclerotial germination. The sclerotia grow at the soil surface into small mushroom like structures (apothecia) from which millions of airborne spores are released. Having landed on a plant, the fungus uses falling petals and other floral parts as a nutrient source. It is thought airborne spores can travel 2-5 km. Airborne spores are short lived, dying within 12-24 hours. As many falling petals become caught at the locations where leaves and branches arise from the main stem, most infections also start there.

There are no known sources of plant resistance to sclerotinia. In Canada and the United Kingdom fungicides are sometimes used at flowering. However, a prediction system is used and growers treat in advance of injury—an insurance approach. In Australia the following is appropriate:

- A crop rotation of at least 4 years with non susceptible crops. The host range of *S. sclerotiorum* extends to about 400 species of mostly broadleaf plants and weeds (for example, lupins, field peas, beans, capeweed, Datura, volunteer broadleaf plants, and most vegetable crops). Grasses and cereals are immune to this disease. Check the likelihood of infection from neighbouring paddocks and any alternative crops sown in rotation must remain weed free.

- Use disease free seed. Check the level of sclerotes in the seed and reject seed where levels are excessive. If necessary investigate seed treatment using a fungicide.
- Deep ploughing of stubble may give partial control. The apothecial stalks usually cannot elongate more than 15 cm, however, dormant sclerotes could be brought up at subsequent cultivations.

Phytophthora root rot

This disease is caused by the fungus *Phytophthora megasperma* var. *megasperma.* It is the same soil borne pathogen which attacks the vegetable crucifers but is different from the ones which attack soybean, lucerne and safflower.

The disease was first recorded in New South Wales on canola in 1982 in a flood irrigated crop on heavy black soil in the Lachlan Valley.

The disease is favoured by slow draining heavy soils and is more likely to show up when canola is grown on these soils, especially under flood irrigation.

The disease is usually first noticed when plants begin to die. Dead plants occur either individually or in patches (the patches often coinciding with low lying areas). Plants pull up easily and exhibit dark discolouration and decay of the roots.

Phytophthora root rot. Plant roots are discoloured and decayed.

R. Colton

Root rot losses can be minimised by selecting soils with good surface and internal drainage.

Select irrigation fields which have been landformed or have very uniform grades. Ensure that water can be brought on and drained off quickly so as to avoid waterlogging.

Downy mildew

Downy mildew is caused by the fungus *Peronospora parasitica.* The disease occurs sporadically, rarely causing significant yield loss. It is favoured by the cool moist conditions of winter, when yellow-brown angular lesions develop on the leaves. White mealy growth can be seen on the lower leaf surfaces.

The disease is rarely seen beyond the rosette stage. The crop normally grows away from it with the onset of warmer weather at the end of winter.

Downy mildew. Yellow-brown angular lesions on the leaf upper surfaces correspond with patches of white mealy growth on the lower surfaces.

R. Colton

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FURTHER INFORMATION

For more localised information, consult your local NSW Agriculture District Agronomist.

More information on canola and related topics is contained in the following NSW Agriculture publications:

Agfact P1.4.1 *Liming problem acid soils*
Agfact P5.2.10 *Drying oilseeds—safe temperatures*
Agfact A8.9.7 *Pesticides affecting beekeeping and crop pollination*
Agfact AE.41 *Rutherglen bugs*
Agfact AE.48 *Heliothis caterpillars*
Agfact AC.4 *Molybdenum deficiency in plants*
Agfact AC.14 *Boron in agriculture*
Agfact AC.15 *Liming materials*
Agfact AC.16 *Zinc deficiency in field crops*
Annual bulletin *Weed control in winter crops*
Annual bulletin *Insect control in winter crops*
Annual agnote *Canola variety and management guide*

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