Oilseeds WA

Growing Western Canola

An overview of canola production in Western Australia

GRDC Grains Research & Development Corporation

Department of Agriculture
Government of Western Australia

MAY 2006

Growing Western Canola
May 2006

Important Disclaimer

In relying on or using this document or any advice or information expressly or impliedly contained within it, you accept all risks and responsibility for losses, damages, costs and other consequences resulting directly or indirectly to you or any other person from your doing so. It is for you to obtain your own advice and conduct your own investigations and assessments of any proposals that you may be considering in light of your own circumstances. Further, The Oilseeds Industry Association of WA, the Chief Executive Officer of the Department of Agriculture, GRDC, the authors, the publisher and their officers, employees and agents: Exclude all liability of any kind whatsoever to any person arising directly or indirectly from reliance on or the use of this document or any advice or information expressly or impliedly contained within it by you or any other person.

ISBN 0-9758168-0-2

Publisher: Oilseeds Industry Association of Western Australia
Suite 5, 110 Robinson Avenue,
Belmont WA, 6104
Australia

This booklet is based on the experience and hard work of the Western Australian Department of Agriculture, growers, independent and company agronomists and many others over the past three decades or longer. To list them all would certainly result in omissions.

Editors: John Duff of Oilseeds WA, David Sermon of ConsultAg, Graham Walton, Peter Mangano, Chris Newman and Kevin Walden of the Department of Agriculture, Martin Barbetti of the University of Western Australia, Bevan Addison of Elders Ltd, David Eksteen of United Farmers, Eddy Pol of CSBP and Brian Leach of John Duff & Associates.

The advice of these and many other scientists, agronomists and organisations not listed here is also acknowledged and appreciated.

Cover photo courtesy Jon Slee, Riverland Oilseeds.

Back cover photos (top to bottom):

Jon Slee, Chairman, Oilseeds WA, examines canola.

Brad and Jeremy Wood up to their armpits in canola at Kendenup.

Harvesting a swathed row at Kendenup.

The black grain goes into a weigh trailer in 2005.

Special thanks to the following organisations:

GRDC Grains Research & Development Corporation

Department of Agriculture Government of Western Australia

Elders

Contents

1 Introduction

The aim of this booklet is to provide an overview guide to canola production in Western Australia. In 2006 it is part of a package that includes *High, Medium and Low Rainfall Zone Updates* and *The Canola Ute Guide* (Top Crop Australia and GRDC).

We have not attempted to replicate everything available on canola production but to simply provide a summary of the last 30 years experience of canola production in WA. Sources of further information provided in this booklet are listed in section 11. Growers are advised to seek further detailed advice from locally experienced, qualified agronomists.

1.1 What's in a name?

Canola varieties grown in Western Australia belong to the *Brassica napus* species. The Brassica genus includes cabbage; cauliflowers and brussels sprouts and is part of the larger mustard plant family. Since canola was introduced into Australia, plant breeders have bred many new varieties. *B.juncea* varieties are currently being trialled throughout Australia.

*Canola's name is derived from **Can**ada and **ol**eic **a**cid, which spells canola.*

The official definition of canola is:

…an oil that must contain less than 2% erucic acid, and the solid component of the seed must contain less than 30 micromoles of any one or any mixture of 3-butenyl glucosinolate, 4-pentenyl glucosinolate, 2-hydroxy-3-butenyl glucosinolate, and 2-hydroxy-4-pentenyl glucosinolate per gram of air-dry, oil-free solid.

What is canola grain?

Canola is an oilseed that yields high food quality oil. Canola grain is crushed to yield around 40 to 50% vegetable oil and residual canola meal. Canola is Australia's major oilseed crop.

Canola oil can be used in most applications where vegetable oils are used including margarines, cooking oils and salad dressings. Canola oil is considered healthy because it is low in saturated fat, high in monounsaturates, has a desirable balance of omega fatty acids and is a good source of vitamin E.

Canola meal is the highly important co-product of canola left behind after the seed is crushed and the oil extracted. It is a high quality source of protein for animal feeds. It has an excellent amino acid profile and is rich in vitamins and essential minerals. It is palatable and non-toxic. Canola meal can also be used as an organic fertiliser.

History

Commercial seed was first imported into Australia in 1967. (*Canola the first thirty years*: AOF Website). Canola, firstly known as Rapeseed (var. *rapa*, common name "Polish Rape") was initially grown in WA in 1969. In 1971, 30,000 hectares were planted. Unfortunately, the crop was decimated by the fungal disease known as blackleg and as a result no rapeseed crops were grown in WA from 1973 to the mid-1980s. The crop "re-emerged" as canola and armed with blackleg resistance in the late 1980's.

The reintroduction was made possible by Dr Narendra Roy, a Department of Agriculture Western Australia (DAWA) Canola Breeder and others (eg. Dr Noel Thurling) who bred blackleg resistant canola and varieties suited to the lower Great Southern and parts of the South Coast. In 1988 an early maturing variety Maluka suited to the area south and west of the Great Southern Railway and along the South Coast to Esperance was introduced from NSW.

The crop became increasingly more popular through the 1990's, climaxing in a 1 million tonne crop from 900,000 hectares in the 1999/2000 season. Since then various factors including price have contributed to a reduction to around 400,000 ha planted per year in WA. In 2003/2004 a second highest state delivery of 610,000 tonne was achieved and in 2004/2005, despite a relatively low rainfall year, 490,000 tonne.

A critical factor behind the increase in area of canola in WA was the highly effective weed control that Triazine Tolerant (TT) varieties achieved.

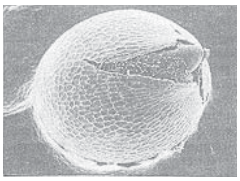
Canola faces a number of ongoing threats to yield including the major threat of blackleg. In 2003 highly successful, high yielding, high oil varieties that base their resistance on the sylvestris gene succumbed to pressure from mutated strains of blackleg fungi in South Australia and Victoria. These varieties accounted for an estimated 70% of the crop in 2003.

1.2 Growth stages of the canola plant

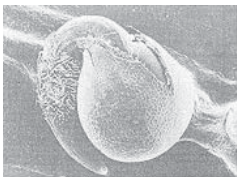
The length of each stage of canola is greatly influenced by temperature, moisture, light, nutrition and variety. The vegetative stages, or days from seeding to first flower, depend on variety, seeding date and growing conditions.

Germination and emergence

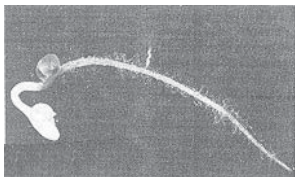
Germination involves water absorption leading to splitting of the seed coat and emergence of the root tip. The new stem begins as two heart-shaped cotyledons. Because canola has a relatively small seed, the new seedling is very dependent on sunlight and available nutrients as it first emerges. Unlike cereal seedlings the growing point of canola is above the soil between the two cotyledons. This exposed growing tip makes canola seedlings susceptible to sand blasting and insect attack.



17 hours



24 hours



48 hours

Germination (Photos courtesy N J Campbell, University of Alberta).

Leaf production

The seedling develops its first true leaf 4 to 8 days after emergence. The plant quickly establishes a rosette with larger, older leaves at the base and younger leaves in the centre. Rapid leaf development is important for the early and full use of sunlight. The larger the leaf area index, the more dry matter and higher crop yield it can produce.

Two leaf stage (Photo courtesy Canola Council of Canada).

Stem extensions

Stem extension has begun when the distance between two leaves on the stem is greater than the width of the stem itself. Tall varieties will have a longer internode length than short varieties. It is during this stage that the plant demand for nutrients begins to increase dramatically, in particular for calcium and potassium which are required for cell wall structures.

Bud initiation

Longer days and rising air temperatures trigger bud formation. A cluster of flower buds appears in the centre of the rosette. Maximum leaf area is usually reached near the start of flowering and then begins to decline with the loss of bottom leaves. The upper leaves are the major source of food for the rapid development and growth of a large leaf area. A larger leaf area after flowering increases pod set, seed growth and oil content.

Bud initiation (Photo courtesy David Sermon, ConsultAg).

Flowering

Flowering begins with the opening of the lowest bud on the main stem and continues upward. Pollen is shed and dispersed by both wind and insects, even though canola is about 70 to 80% self-pollinated. The young pod becomes visible in the centre of the flower a day after the petals drop. During flowering, branches continue to grow longer as buds open into flowers and as flowers develop into pods. In this way the first buds to open become the pods lowest on the main stem or secondary branches. Canola plants initiate more buds than are able to develop into productive pods.

Canola flowering (Photo courtesy Jon Slee, Riverland Oilseeds).

The abortion of pods is a natural occurrence. If unfavourable growing conditions (i.e. critical maximum temperature is 30°C), or damage at early flowering causes abortion, the plant can compensate by developing buds which otherwise would have been aborted. By mid-flower, when lower pods have started elongating, the stem has become the major source of food for plant growth (with a reduced amount from the declining leaf area). There is competition between flowers and pods for food supply. The earliest developed pods have an advantage over the later formed ones. A decrease in food supply during pod development results in fewer flowers and fewer pods retained to maturity. Pods will be smaller with fewer, lighter seeds, especially in the later secondary branches and tops of branches.

Canola varieties are either determinant or indeterminate. **Determinate Growth** occurs when the axis (central stem), is limited by the development of the floral reproductive structure, and therefore does not grow or lengthen indefinitely. For plants with **Indeterminate Growth** the axis (central stem) is not limited by the development of a reproductive structure and therefore growth continues indefinitely or until limited by abiotic stress, for example lack of moisture or temperature effect, which prevents plant growth continuing.

Pod development

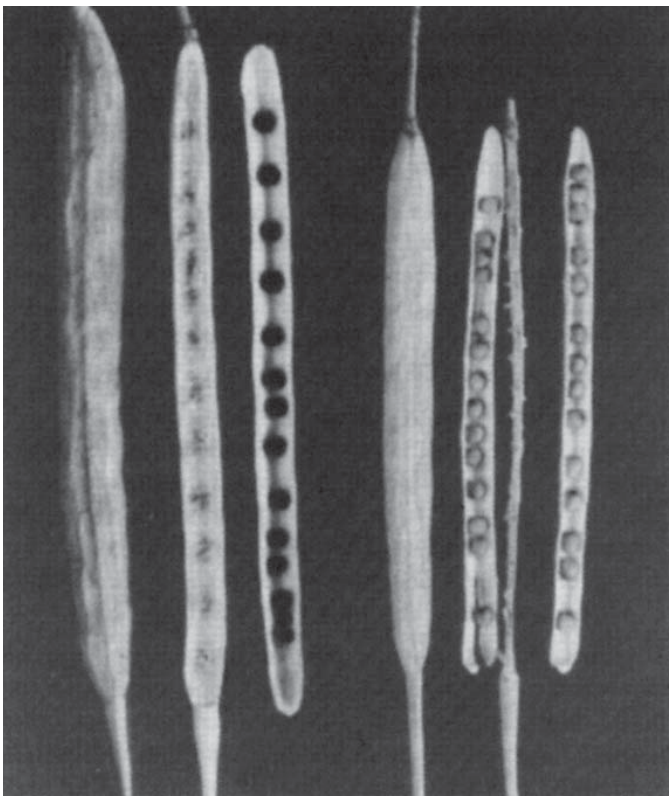
In the first phase of seed development, the seed coat expands until the seed is almost full size. The seed at this stage resembles a 'water filled' balloon. The seed's embryo grows rapidly to fill the space previously occupied by fluid. Seed weight increases as proteins and carbohydrates are laid down in the seed (in that order). Immature seeds, when filled, contain about 40% moisture. Seed filling is followed by a maturing or ripening stage characterised by seed coat colour changes. Ripening begins with petals falling from the last formed flower on the main stem. Oil is the last component developed in the seed.

Brad Wood of Kendenup inspects pod development (Photo courtesy John Duff, Oilseeds WA).

Seed development

At this stage the older pods at the base of the flowering branches are well formed with firm seeds in many of the pods. When 30 to 40% of the seeds on a plant have begun to show a colour change to black or brown, seeds in the last formed pods are all in the last stages of filling, and the average seed moisture is about 30 to 35%. In canola, the seed accounts for about 15 to 35% of the total dry matter produced. It has a lower harvest index than cereals where the seed can account for 40% of the total dry matter.

Mature pods are easily split along the centre membrane and the seed lost. Because of this factor most canola crops are swathed before harvest to minimise loss from pod shatter.



Seed pods (Photo courtesy Canola Growers Manual, Canola Council of Canada).

2 Deciding to grow canola

2.1 Benefits of growing canola

Canola is a crop that can provide maximum profit from higher levels of management and inputs. It is relatively easy to grow, provided a few simple rules are adhered to.

It is an excellent break crop for cereals, where diseases such as Take-all and Rhizoctonia inhibit yield. For the higher rainfall districts of the state it allows pasture paddocks to be cropped, without the need for severe pasture manipulation to control grass and *Vulpia* weeds and root diseases, especially following the introduction of herbicide tolerant canola varieties.

The move towards phase cropping in WA provides canola with an important role at the beginning of the cropping phase to set up a clean paddock for the following cereal crop. The net effect is that long-term gross margins are raised as average profit from cropping enterprises is increased.

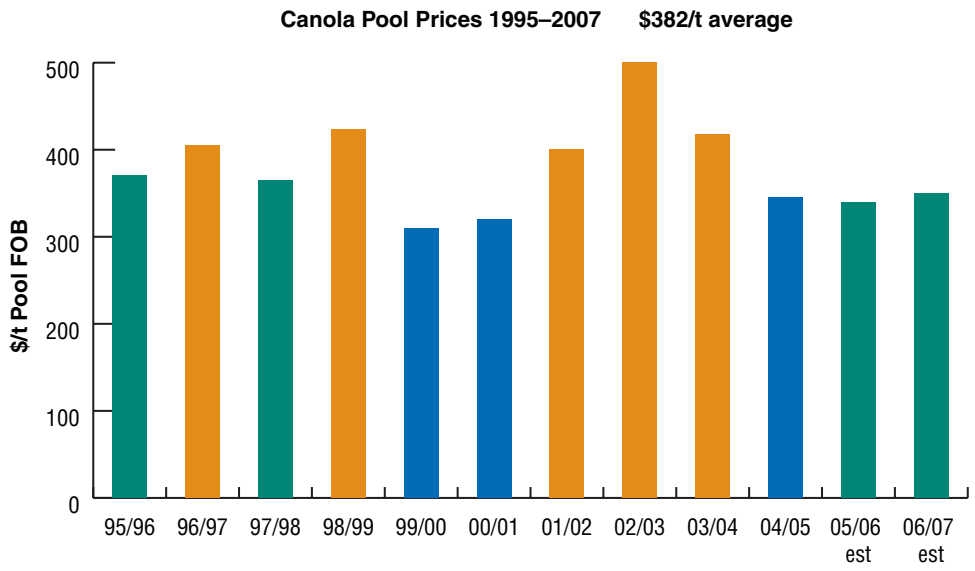
The exact benefit of canola preceding cereal crops is difficult to quantify. The removal of herbicide resistant ryegrass can account for up to 20% yield gains in the following cereal crop. If canola makes up 10% of a 1000-hectare cropping program, this benefit could be worth between $15 and $20 per hectare, resulting in an increased profit of $20,000 each year.

Key benefits of canola in the rotation:

- Reduces weed seeds bank.
- Improves long-term gross margins.
- Increases flexibility in the system.
- Permits better management of wheat and barley quality.
- Reduces cereal diseases and summer weeds.
- Provides for wider rotation of herbicide groups and sub groups.

2.2 Profitability

Chart 1. Historical price of canola



Price and markets are critical to agricultural profitability and canola is no exception. Table 1 allows a quick assessment of price risk. Costs used to create the gross margin are based on a medium rainfall scenario. Growers can alter the scenario by using their own cost of production data and multiplying price by tonnes/ha.

Table 1. Possible Gross Margin vs Yield

	POSSIBLE GROSS MARGIN $/ha					
Price/mt	**$320**	**$340**	**$360**	**$380**	**$400**	**$420**
Yield mt/ha						
0.4	–141.12	–133.15	–125.19	–177.23	–109.27	–101.31
0.6	–85.78	–73.84	–61.90	–49.95	–38.01	–26.01
0.8	–30.45	–14.52	1.4	17.32	33.25	49.17
1.0	24.89	44.79	64.70	84.60	104.51	124.41
1.2	80.22	104.11	127.99	151.88	175.76	199.65
1.4	135.56	163.42	191.29	219.16	247.02	274.89
1.6	190.89	222.74	254.59	286.43	318.28	350.13
1.8	246.23	282.06	317.88	317.88	389.54	425.37

2.3 Agronomic risk

Agronomic factors that determine successful canola growing are usually; paddock selection, weed control, fertiliser strategy, blackleg management, variety selection, seeding date, seeding depth, insect control and timeliness of swathing and harvest.

Canola is considered a high risk-high input/high management crop as it has:

- A high demand for disease, pest and weed monitoring and control.
- Higher nutrition requirements than cereals.
- Seasonal, district and variety specific nutrition strategies.
- Frost susceptibility.

Risks are generally considered lower in the high rainfall zone. However, newer shorter season varieties are reducing risk in the medium to low rainfall districts.

2.4 Where does it fit in your farming system?

Considerations include longer-term rotations, recent seasonal conditions and your preferred level of risk.

Key points to consider

- Your risk profile.
- Canola's role in your rotations.
- The predicted seasonal outlook.
- Your cropping program's degree of flexibility.
- Your ability to adjust your cropping program as the season rolls out.*

*Cut canola from the cropping program if soil moisture is too low or the season starts too late especially in low rainfall districts.

2.5 Preparation and paddock selection

Blackleg and other disease pressure is a major factor in paddock and variety decisions. Choose a paddock that has not had canola grown in it for at least four years that is well separated in time as well as distance from previous crops whether they are yours or your neighbours. Blackleg is not as critical in the medium and low rainfall zones, especially in the Northern Region, as it is in southern areas with rainfall greater than 425 mm p.a.

Key points to consider

Select Paddocks with:

- No canola for last four years.
- That did not have a triazine (Atrazine or Simazine) applied in previous year.
- At least 500m from previous (2 years) canola crops including neighbours.
- Reduce canola stubble residues in adjacent paddocks if separation is not feasible.
- Soils with deeper profiles.
- Sound fertiliser history.
- Avoid frost prone areas if possible.

2.6 Compaction and deep ripping

Canola is very responsive to cultivation immediately below the level of the seed. In DAWA constraints trials conducted in 2003 ripping gave an average yield boost of 11% across the wheatbelt. Ripping costs may range from $30 to $50/ha, but a typical canola response will more than double this investment. Benefits are also likely to carry over to following crops.

Sand plain paddocks which have not been ripped for more than four years should be deep ripped or at least have a shallow rip of 20 cm. When deep ripping prior to seeding canola, allow time for the seedbed to settle or lightly roll it before seeding. This will help avoid sowing too deeply and reduce moisture loss.

3 Varieties

3.1 Selection and development

Varieties were initially selected for production per hectare and percentage oil traits. A recent exciting trend is the development of varieties for a wider range of traits including their ability to grow in drier areas, fatty acid profiles and potential industrial uses. These varieties may open up new markets and provide new value adding opportunities.

Early, mid and late season varieties better suited to WA have been bred in WA and the eastern states in recent years. Growers and agronomists are advised to investigate the agronomic benefits and requirements of new varieties as they are released to the market. A source of independent advice on varieties is available from GRDCs National Variety Testing Program (NVT).

3.2 Blackleg resistance

Blackleg is considered the most serious canola disease in Australia. Hence resistance to blackleg is a prime selection criterion for new varieties.

Recently, breeders have reverted to releasing varieties with polygenetic resistance to blackleg due to the breakdown of resistance to blackleg in South Australia and Victoria in 2003 by certain varieties. These varieties had their resistance to blackleg based on a single dominant gene originating from *Brassica rapa ssp. Sylvestris*. The blackleg fungus is continually evolving into new strains, hence the need to continue breeding new varieties with increased resistance in order to not only combat the blackleg threat but also improve the crop.

Varieties are rated for blackleg resistance and ranked on a scale by both the CAA (Canola Association of Australia) and DAWA. The CAA scale is based on percentage plant survival while the DAWA scale also includes the level of stem canker infections in surviving plants.

Each year CAA and DAWA publish their resistance ratings for commercially available varieties. Growers and agronomists are advised to consult these scales and to always select a variety with the highest disease resistance rating, especially in high blackleg threat districts and paddocks. In 2005 and 2006 they were reprinted in the Oilseeds WA seasonal updates.

3.3 Varietal types

Conventional

Conventional varieties have no specific herbicide tolerance. Many successful crops have been grown by sowing these varieties in relatively weed free situations.

Triazine Tolerance (TT)

More than 90% of canola varieties grown in WA are triazine tolerant (TT varieties). TT varieties have a generally accepted 5–10% lower yield potential than conventional varieties in weed free situations when sown at the same time. This gap has narrowed with the release of higher yielding TT varieties better suited to WA conditions.

Imidazolinone Tolerant (IT)

First bred conventionally by Cyanamid (now BASF licensed to Nufarm in Australia) to be tolerant of Imidazolinone, a Group B herbicide. In drier conditions and very low organic matter (OM), imidazolinone (a residual herbicide) can carry over in the ground to the following year affecting the next cereal crop.

Clearfield (registered TM of BASF) production system varieties, designated CL, have been bred to tolerate imidazolinone. The Clearfield production system has been promoted as a total production package however there is no need to buy seed and herbicide together anymore. Imidazolinone herbicides include On Duty®.

Hybrid

Hybrid varieties are the result of cross breeding of two pure inbred lines of canola specially selected to increase yield. Yield increases can be significant. As hybrid varieties do not generally produce fertile seed, new seed is required for each crop. Retaining seed will reduce quality, genetic purity and vigour.

High Oleic, Low Linolenic (HOLL)

High Oleic, Low Linolenic oil content (HOLL) varieties have been bred and are being grown for speciality use in the fast food industry.

Industrial

Rapeseed oil is too high in erucic acid to qualify as canola. It can be used for industrial applications such as biodiesel, plastics, lubricants, lacquers and detergents. Recent trials of Indian mustard and other specialty oilseeds have kindled interest in industrial oils in WA.

Transgenic (GM)

Transgenic or genetically modified (GM) varieties have received very high levels of publicity. Roundup Ready Canola (Monsanto) and In-Vigour (Bayer Crop Science) have been considered for release in Australia. All Australian State Governments currently prohibit the commercial growing of GM varieties, making Australia a non-GM canola producer.

3.4 Variety selection

Variety selection can be critical to successful canola crops. Variety selection considerations include:

1. Relative yield and oil performance relevant to your district to maximise return ($/ha).
2. Will the variety grow and mature uniformly within your anticipated growing season.
3. Does it have strong polygenetic resistance to blackleg?
4. Harvest method required.

Each year new varieties are released to the WA market. These varieties have made a significant difference to the quality of crops in recent years.

Oilseeds WA, the National Variety Testing Program (ACAS/GRDC), DAWA and others have tested the performance of different varieties across WA. Independent or company agronomists, seed companies and DAWA provide advice on varieties.

Seed quality

Seed that has poor germination and low establishment is the most expensive seed. The best results are generally attained from sowing quality assured seed. If you retain your own seed, then use seed from last season that has been tested for vigour and germination prior to sowing.

Quality assured seed is required to meet specified standards such as being grown in controlled/inspected paddocks and has been tested for germination, weeds and other foreign seeds. If you intend retaining your own seed, then it should be graded heavily to maximise seed size and tested for germination and weed seeds. Many growers store their seed in bags or Bulka-Bags to minimise viability losses due to heat.

Seed size

Research has shown that seed size has a significant effect on the vigour and germination of canola. Seed should be greater than 1.7 mm in diameter. The longer seed is stored the more variation in maturity and quality that is expected, therefore, germination testing is advised for retained seed.

Seed sellers may display the number of seeds per kg on canola seed bags. This data can be used to calculate the seeding rate where a certain establishment plant density is targeted. Less than 100% germination and survival needs to be assumed due to disease, insects, waterlogging and other factors.

Canola varieties generally range from around 250,000 to 320,000 seeds/kg. At these densities a 5 kg/ha sowing rate will provide around 140–160 seeds per square metre. If assuming an establishment efficiency of 50% then 70 to 80 seedlings/m^2 should result.

4 Establishment

4.1 Uniform, vigorous crop establishment—key to successful canola

Early plant establishment is greatly influenced by the firmness, moisture content and temperature of the seed bed before and after sowing. Soil textures, depth of seeding, seed quality, fertiliser placement with respect to seed, chemical seed treatment, insects and diseases at the time of seeding are also critical factors in establishing a uniform plant stand with high yield potential.

Modifying establishment factors has relatively little effect on input costs but a large effect on yield.

4.2 Sowing depth

Canola seed sown to a depth of 12–25 mm into a firm, moist seedbed germinates rapidly with a high percentage emergence. On sandy soils, or in environments where the topsoil dries quickly, planting can be slightly deeper, around 30 mm. Large seed will assist when sowing deeper.

Local studies show that increasing seeding depth to 50–75 mm results in poor emergence; reduced root, seedling and plant growth; increased seedling disease; and reduced yields. Canola seeds do not have sufficient stored energy to push their cotyledons to the surface from the depth at which cereals are normally sown.

If sufficient moisture is not available at 50 mm soil depth, then a common practice is to sow at a shallow depth (dry seeding) and wait for further rain. When dry seeding, delay spraying triazines until after rainfall.

4.3 Equipment

Canola can be seeded satisfactorily with a range of equipment. The seeder must do the following:

- Open a furrow into sufficient moisture.
- Place the seed at a uniform depth on a firm seedbed.
- Accurately meter the seed in each run.
- Cover the seed with the right depth of soil.
- Pack the soil around the seeds.

A disc seeder or 'knife point and press wheel' machine fulfils the above requirements whereas a 'full cut finger harrow' combine rarely meets all of them.

Press Wheel trailing seeder (Photo courtesy Wade Longmuir, ConsultAg).

Canola performs better in deep, well drained soils. It is beneficial to deep rip hard pan soils particularly after a long term pasture phase. Canola, like wheat, is very responsive to deep ripped soils.

It is important to achieve good seed to soil contact to maximise germination. This can be attained through several methods including a home made levelling bar or in case of heavy stubble, tyre rollers. These methods reduce or avoid cloddiness in heavier soils.

Use a knife point where fertiliser can be banded below or along side the seed within 4 cm. Before placing seed into the knife opening, use a closer plate to firm the soil back down. Drop the seed on the firm and moist soil and cover with loose soil using a press wheel, a chain or light harrow which does not disturb the seed. Retain stubble—but don't incorporate it for best canola germination. Reduce stubble by raking and burning if seeding equipment cannot manage stubble; or dry seed canola at higher seeding rates.

4.4 Seeding rate

Due to canola having an ability to grow extra branches to fill spaces in the crop a wide variation in seedling density, within limits, does not necessarily affect final yield, especially in high rainfall districts. Local studies demonstrate that populations ranging from 60 to 200 plants/m^2 can result in similar yields. Local trials at Merredin have shown that optimal plant numbers range between 50 to 90 plants/m^2.

When dry sowing, a rate of 4 to 6 kg/ha is suggested.

Seeding Rate Calculator

The *Thousand Seed Weight* (the weight of 1000 seeds in grams [**g**]) can be used to quickly calculate seeding rates in kg/ha.

$$\textit{Thousand Seed Weight}\ \mathbf{g} \times \frac{\textit{Target plant population/m}^2}{100} = \textit{Seeding rate in}\ \mathbf{kg/ha}$$

Example

Where 1000 seeds weigh three (3) grams (g)

3g x 80 plants/m^2/100 = Seeding Rate of **2.4 kg/ha**

Another option

Is to use the seed count per kilogram where provided on the seed bag label. For example if you have a known seed count of 250,000 seeds/kg and sow at 4kg/ha you will plant 1,000,000 seeds/ha or 100 seeds/m^2.

Adjustment to allow for germination percentage and seedling mortality rate

To allow for germination and mortality divide the seeding rate in kg/ha by the percentage factors for germination and mortality following seeding to calculate an adjusted seeding rate.

Example

2.4 kg/ha of seed with a 90% germination test result means:

2.4 kg/ha is divided by 0.90

which determines that a seeding rate of 2.67 kg/ha is required.

To also allow for seedling loss following planting:

2.67 kg/ha with an in-field survival rate of say, 80% means that:

2.67 kg/ha is divided by 0.80

resulting in the higher seeding rate of 3.34 kg/ha.

Seeding Oilseeds WA variety demonstration trial, Williams 2005.
(Photo courtesy Wade Longmuir, ConsultAg.)

4.5 Plant density and row spacing

Maximum seedling emergence is important, as canola seedlings are small and prone to insect and wind damage.

If the target seedling density is not reached it is suggested that the whole seeding system is reviewed instead of just increasing seeding rate. If establishment is poor or seedling damage is high, reseeding is rarely profitable, as a late emergence of the new crop will probably still result in low yield and oil content at harvest. There is often a second germination of seed from the original seeding that will fill in the gaps.

Rule of thumb:

A canola population between 50–70 plants/m^2 (assessed 30 days after emergence) in an even distribution should result in maximum yield. In a one metre row a minimum of 5 plants needs to be established, based on 7 inch row spacing.

Even seed distribution and therefore plant distribution will help optimise nutrient uptake and provide better competition against weeds. This is particularly true in the shorter growing season in medium and low rainfall zones.

Row spacing is important for trash clearance, and trash is important for moisture conservation. Design your seeder to provide maximum trash clearance with minimum row spacing adjustment.

Canola yields are affected by row spacing. For every inch increase in row spacing above 7 inches the yield can decline by up to 2%. However, this can be compensated for by reduction in weed seed disturbance and increased moisture conservation that wider row spacing can generate. Precision seeding does pay off. Row spacings between 6 and 12 inches will in most situations generate a fairly even spread of plants to maximise yield. Wider row spacings in excess of 20 inches have been shown to be detrimental to yield in most cases.

Local trial data should provide a better indicator to growers. Studies in 2002 (Elders, Crop Updates 2004) confirmed previous DAWA results that, "**a seeding rate of 4 to 6 kg/ha at row spacings of 8 inches**", provided the best results.

4.6 Time of seeding

Studies from 1997 through to 1999 showed that canola has a very significant response to time of sowing. As a general rule of thumb, canola in the low rainfall zone will suffer a yield loss of around 5% for every week's delay in seeding from the beginning of April and beyond the end of May.

Last date to sow canola

Oil content can be seriously affected by a delay in seeding throughout the low rainfall zone. A strong correlation between average rainfall post anthesis (start of flowering) and oil content of canola has been found. Average daily mean temperatures during the pod maturation stage also influence the final oil content.

A rough rule of thumb for the last date to sow is shown in Table 2.

Table 2. Last date to sow—a rough rule of thumb

Rainfall Zone	Date
High	June 21
Medium	June 1
Low	May 7

Dates need to be slightly earlier in the year for the Northern Region. In the low rainfall zone test for retained soil moisture if summer rainfall has occurred. Generally, 80 mm of summer rainfall should be sufficient to warrant sowing in the low rainfall zone.

5 Nutrition

5.1 Profit and nutrition

Profitable canola production depends a great deal on optimum and balanced plant nutrition. This section is general in nature as varying soil types, rainfall zones, seasons, varieties, rotations, fertiliser history and other factors will determine optimum fertiliser strategies. Detailed advice from your adviser(s) is recommended.

As is the case with all crops, the key to making the most from your fertiliser dollar lies in identifying (through observation, sampling, testing and recording) the most limiting nutrients in each paddock, in each season and then applying the optimum fertiliser rates. Rates are also influenced by achievable yield potential.

Comparing canola fertiliser needs to those of wheat

Research on wheat nutrition by the Department of Agriculture provides guidance for canola fertiliser decisions. From wheat research the following rules of thumb can be used to compare canola fertiliser needs to those of wheat:

- Where nitrogen is not limited canola will yield approximately half that of wheat (t/ha).
- Wheat response (kg/ha) to applied N is approximately double that of canola.
- Canola appears better at extracting phosphorous and trace elements from the soil than wheat. However it is recommended that phosphorus applications for canola equal that applied to wheat in the same situation. If in the year of production less P is applied than for wheat the following crop will require more P to replace the extra P extracted by canola.
- It is more critical when growing canola to ensure K levels are adequate.
- Canola has a higher sulfur requirement, especially in high nitrogen situations.
- Canola is more sensitive to low pH.
- Canola is less responsive to trace elements.

5.2 Soil nutrient content

Variations in soil nutrient levels occur from year to year and may also vary within paddocks. Paddocks should be regularly soil tested for nutrient status. Take soil test or plant tissue test samples from the poor and good areas of a paddock to determine the limiting nutrients.

The most commonly deficient nutrients in Western Australian soils are nitrogen and phosphorus. Potassium deficiencies are likely to occur on sandy soils and possibly on some duplex soils of the Great Southern. Increased yield response on header trails or swath rows, especially those that are burnt, are often an indicator of potash deficiencies or low soil pH levels.

Soils with low to moderate levels of organic matter are likely to be deficient in sulfur for canola.

Calcium and magnesium are generally not in short supply for crop growth in Western Australia although “induced” calcium deficiency in canola is becoming more common in dry soils and on deep sandy soils of high rainfall districts. Generally the application of lime and/or gypsum supplies adequate calcium requirements.

5.3 Fertiliser priorities and strategies

In practice nitrogen and sulfur deficiencies represent the vast majority of nutritional problems encountered in canola.

While there will be some exceptions the nutrients to be applied to canola in most situations can be prioritised in value for money order as listed below:

1. nitrogen, sulfur
2. phosphate
3. potassium
4. calcium, magnesium and trace elements.

However, this will change according to the most limiting nutrient at a particular site. For example, where there is a deficiency of potassium as shown by soil test; potash must be applied as the first priority or the investment in N, S & P will be wasted.

Points to consider

1. Excess nitrogen occurring later on during crop growth can reduce oil content and increase grain protein. This is most likely to occur when nitrogen supply is excess to requirements for the actual yield achieved. This can occur if simply too much nitrogen is available to the crop (eg. high rate of urea application on a long term clover pasture) or some other factor has limited the yield (eg. late sowing, sulfur deficiency, insect damage, dry spring).
2. In most situations, time of sowing and environmental factors such as high temperatures during pod fill, have a greater impact on oil concentration than nitrogen.
3. Excess rates of other nutrients do not appear to reduce oil content.

Fertiliser strategy

1. **Apply nitrogen within 8 weeks of seeding.**
   For maximum effect nitrogen needs to be available to the canola plant at the beginning of stem elongation. There is no consistent benefit in delaying nitrogen application beyond this stage. It may be a realistic option to apply all nitrogen at seeding in low rainfall districts with little risk of leaching loss especially for short season varieties, however delaying applications allows yield potential to be better assessed prior to applying additional nitrogen. In areas of high leaching risk 30–60% of N should be applied at seeding with the balance at 4–6 weeks, or possibly, split 4 & 8 weeks after seeding.

2. **Ensure that sulfur is in a form that is readily available to the plant.**
   Plant roots take up S as sulfate. Common sources are compound fertilisers high in sulfur (eg. Agstar and Allstar), sulfate of ammonia products and gypsum. Elemental sulfur is only effective when it is in a fine powdered form, and then mostly not until spring when warm conditions allow soil bacteria to oxidise S and release sulfate.

3. **Fertiliser toxicity is a very real risk when high rates of nitrogen are drilled close to the seed.**
   The risks increase when seeding with knife points, sowing into dry soil and using wider row spacing. In practice, 20–25 kg N/ha with the seed is safe when sowing into moist soil with full cut points. For knife points on 180 mm spacings 15 kg N/ha is a maximum which should be further reduced if soil moisture is marginal or using wider row spacings. Try to minimise the amount of N in close proximity to the seed.

4. **Regular soil testing is strongly recommended to further refine the decision for individual situations.**

5. **K compounded products give a good starter level of K.**

5.4 Nitrogen

Nitrogen is a very important nutrient for canola growth and high yields. It is important in the production of many compounds in the plant, including protein and chlorophyll. A shortage of nitrogen results in very pale plants. Nitrogen is an important component of protein in canola meal but excess N can reduce the oil content of the grain.

Nitrogen is also very mobile in the plant. During a period of deficiency, nitrogen is remobilised in older leaves and moved to the younger growing tissue of the canola plant. As a result, deficiency symptoms first show in the oldest leaves.

Table 3. Best Bet Guide to N fertiliser for canola following different phases in the rotation and rainfalls

	Rainfall zone		
	Low < 330 mm	Medium 330–460 mm	High 460–600 mm
Yield potential (t/ha)	0.8 – 1.2	1.2 – 1.8	1.8 – 2.5
Previous phase	Rate of nitrogen (kg N/ha)		
Cereal	30 – 60	50 – 80	80 – 110
Legume or pasture	20 – 40	30 – 50	50 – 80

Canola is not as likely to 'hay off' as are cereals when too much nitrogen has been applied therefore fertilise canola according to the crops potential and soil nitrogen status.

Nitrogen Deficiency (Photo courtesy David Sermon, ConsultAg).

Placement and timing

Nitrogen's ability to increase canola yields can be significantly affected by the method of placement and time of application.

Rates of nitrogen that would normally cause little or no damage to wheat or barley can cause severe reduction in germination and emergence of canola when placed with the seed. Urea based fertilisers are particularly damaging at emergence due to ammonia toxicity and should not be placed with the seed.

However, compound fertilisers containing both phosphorus and nitrogen can be placed with the seed. Applying phosphorus fertiliser in the same operation will reduce the cost. Side-band placement is the best method of applying fertilisers containing nitrogen (30 kg N/ha) in paddocks with little risk of leaching. However, at high rates of nitrogen, a 2.5 centimetre separation of seed and fertiliser bands may not be sufficient to prevent harmful effects.

Be aware that leaching losses could be severe if nitrogen is applied in the nitrate form. The ammonium form of nitrogen is more stable as it binds to the soil colloids.

Canola plants take up a large proportion of their nitrogen in the growth stages before flowering. This helps establish the number of branches, flowers and eventually pods. Nitrogen must be available early when it is needed most.

Rainfall immediately after broadcasting additional nitrogen will incorporate the nitrogen into the soil and move the fertiliser safely into the root zone. Be aware that urea is more subject to volatile losses at high temperatures, high soil pH, wind, low organic matter and intermediate humidity than other nitrogen sources.

Broadcasting granular fertiliser or spraying liquid nitrogen after the crop has emerged may cause damage if the foliage is wet.

Yield potential for canola is established during stem elongation and the budding stage, so all nitrogen should be applied before this stage of growth (8 to 10 weeks) after seeding.

Inadequate nitrogen or poor timing of application is a major reason why many canola crops set a low, or fail to reach, yield potential. Insufficient nitrogen also reduces returns on other investments in a canola crop, including other nutrients.

Use of liquid N fertiliser may increase flexibility of timing and provide better seasonal management of N levels.

Application options

- In heavier soils in low rainfall districts, all nitrogen can be applied at seeding. In medium to high rainfall areas where there is a greater risk of waterlogging and hence losses of nitrogen through denitrification, growers would be advised to consider splitting their nitrogen applications pre- and post-emergent. Broadcast or band N before, or at seeding, so that the seeder will bury most of the nitrogen. Further N could be applied if the season becomes favourable and yield potential is higher.
- On deeper sandy soil it is better to split the application with 60% of N at seeding, then broadcasting the balance four to six weeks after emergence, before stem elongation.
- In the lower rainfall districts, additional nitrogen can be added if the crop has a high yield potential, but again, applied four to six weeks after emergence.
- Under waterlogged conditions liquid fertilisers, such as UAN (eg. Flexi N), appear to be more readily absorbed by the canola plant, providing more rapid recovery. Growers in 2005 were able to stimulate growth, which resulted in good yields, through the strategic use of liquid fertilisers. The quick response is most likely due to the form of N applied.
- It is vital not to delay all second applications until the stem elongation stage. Do not allow canola to run out of available nitrogen.

5.5 Phosphorus

Soil phosphorus occurs in both organic and inorganic forms. Canola roots absorb only inorganic phosphorus present in the soil solution.

Phosphorus plays an important role in energy storage and use. Lack of phosphorus restricts root growth. This results in poorly developed root systems; spindly, thin stems with few branches and small narrow leaves. Severe phosphorus deficiency may cause a dark bluish colouration of leaves, often accompanied with purple or reddish colourations.

Phosphorous Deficiency

(Photo courtesy David Sermon, ConsultAg).

Placement and timing

Phosphorus should be placed close (within 2–3 cm) to the seed to obtain an early boost to growth. Canola has the ability to start absorbing banded phosphorus in large amounts at an early growth stage. Canola generally absorbs more total phosphorus than cereals and it is also a very effective scavenger for soil phosphorus. The phosphorus requirement of canola is usually met by sowing the seed with an appropriate rate of an NPS-based fertiliser, determined by soil sample analysis.

Canadian research shows that the yield response of canola to both nitrogen and phosphorus fertiliser is nearly double the response of canola to nitrogen alone and around eleven times that of phosphorus alone.

5.6 Sulfur

Canola has a higher sulfur requirement than cereals as it is crucial to the synthesis of oil and proteins. Sulfur is also required for the formation of chlorophyll, vegetative growth and total dry matter production. The required nitrogen:sulfur ratios for canola are lower than for wheat so available sulfur needs to be considered when applying nitrogen.

Most sulfur in soil is contained in organic matter as proteins, amino acids and other compounds not immediately available to plants. Plants can only use sulfur in the sulfate form. Two common sources of sulfur are gypsum and ammonium sulfate. Gypsum is a good source of sulfur (16–18%) because unlike sulfate of ammonia it does not cause acidification of the soil. During the cool wet months of July and August, sulfur mineralisation is low (due to low soil micro-organism activity) and root exploration of the soil volume is low. This can result in the plants being unable to access sufficient sulfur, resulting in temporary deficiency symptoms showing in patches. Later when the soil warms up there is sufficient sulfur mineralisation to provide enough of the mineral to the growing plant.

Sulfur deficiency (Photo courtesy Graham Walton, DAWA).

Potassium deficiency (Photo courtesy DAWA).

Sulfur deficiency in canola crops is more common on deep sandplain soils and where leaching has moved residual sulfur from the root zone. Paddocks with a history of low sulfur fertiliser application are also a risk. Sulfur-deficient symptoms can be detected at all stages of growth. Unlike nitrogen and phosphorus, sulfur is not mobile in the plant, and therefore, new leaves, flowers and pods at the top of the branches are more likely to be deficient in sulfur than older leaves and pods.

Soil disturbance at sowing helps to increase available sulfur as organic matter breaks down, releasing useable sulfate. A strong trend towards direct drill and no-till may explain why there is increasing occurrence of sulfur deficiency in canola in some districts.

Maximum responses to sulfur fertiliser in trials occurred at rates of 10 to 20 kg/ha on soils which were very deficient in sulfur.

5.7 Potassium

Adequate supply of potassium (K) provides plants with increased disease and drought tolerance, and increased starch production. Canola crops take up large amounts of K during growth, but only a small proportion of this is accumulated in the seed. Few responses to potassium fertiliser in seed or oil yield have been recorded. Deficiencies are more likely to show up in following cereal crops, in the high rainfall districts, on sandy surfaced soils where the depth to gravel or clay is more than 40–50 cm and soil potassium test is below 50 ppm.

K should not be placed with seed due to toxicity from the salt load affecting emergence.

5.8 Calcium, magnesium and micronutrients

Calcium (Ca) and magnesium (Mg) are generally not required to be applied for canola crop growth in Western Australia. Ca is less mobile in dry soils, and therefore, under dry conditions Ca deficiency symptoms may be seen during the rapid growth stages of stem extension and flowering.

Canola requires a supply of all essential micronutrients to produce a healthy crop.

There is a limited amount of information on micronutrient responses in canola throughout Western Australia. Until further trial data can establish what effect they have on oil and yield, growers are advised to apply micronutrients as they would for wheat in a similar situation.

Trace element responses in canola are rare in WA. Confirm any suspected deficiencies with a tissue test before purchasing foliar trace element sprays.

5.9 Soil conditions

Soil acidity and aluminium toxicity

Canola has a similar tolerance to soil acidity as barley. Canola's preferred pH range is above 4.5. Canola will tolerate alkaline soils with a pH of up to 8.3 before serious yield reduction occurs.

On strongly acid soils plant root growth may be affected directly by the toxicity of hydrogen ions or by high levels of aluminium, which becomes increasingly soluble at pH below 4.5. Aluminium toxicity can cause foliar injury due to reduced uptake of nutrients and/or pathogen attack which are more pronounced in aluminium toxic, acid soils. Nutrients such as P and N are generally less available in acid soils due to lower microbial activity and chemical reactions of iron and aluminium with P to form insoluble compounds.

Soil tests for pH are recommended before growing canola and can be undertaken in late summer with the soil fertility test. Surface soil samples (0–10 cm) should be taken along with deeper samples (10–20 cm, and 20–30 cm) to check for sub-soil acidity.

Growers should have a good understanding of their soil pH values across the property and should be considering liming (apply 1–2 t lime/ha) if the pH is below 4.5, particularly where canola is part of the rotation.

Results from two trials in the Lakes district in 1997 showed consistent positive yield responses to lime application (DAWA). Canola responded to lime only one year after application at two sites, while responses in wheat yield can often take two or more years depending on the conditions.

Salinity

In the absence of waterlogging canola is considered moderately salt tolerant at a level similar to barley.

6 Integrated Pest Management (IPM)

6.1 IPM strategy for canola

Pests including weeds, insects and diseases can severely limit the yield of canola. Integrated Pest Management (IPM) uses multiple tools for pest control. The aim of IPM is to achieve safe, cost-effective pest management that enhances the viability of the farm. The tools are chemical, cultural, mechanical and biological.

Four steps involved in implementing an IPM program are:

1. **Prevention**
   Practices that reduce the severity of pest infestation or prevent pest build-up.
2. **Monitoring and forecasting**
   Determining what pests are present and what action is required.
3. **Intervention**
   Actions to reduce the economic crop damage from pests.
4. **Record keeping**
   Maintaining a field record system for effective planning.

Underpinning all four of these steps is the grower's/agronomist's ability to accurately identify pests (refer to *Canola Ute Guide* or websites listed on the last pages for photographic assistance). By knowing the pest and its life cycle, growers can use IPM strategies that exploit weaknesses in pest lifecycles to achieve the most effective control. Timing is critical, especially in lower rainfall districts as the seasons are relatively short.

In canola, IPM judiciously utilises clean healthy vigorous seed, crop rotations, resistant varieties, an understanding of life-cycles and population dynamics, economic injury levels and economic thresholds for the judicious use of crop protection chemicals. The outcome sought from IPM is to minimise the impact of pests while maximising returns and protecting the farm environment for the long term.

7 Weeds

Weeds in canola significantly depress yields and if not controlled can be the major limiting factor to production. Early work on canola focused on weed management strategies including the breeding of herbicide tolerant canola varieties such as triazine tolerant (TT) varieties which now account for an estimated 90% of canola grown in WA.

The control of all weeds at knockdown time is essential for the establishment of conventional canola varieties following early April rains. Two knockdowns may be possible in many districts. Where tank mixes are used plant back periods must be taken into account as some incur longer seeding delays than others (eg. dicamba mixed with a knockdown).

Transplants are the most expensive weeds to control, in terms of herbicide costs and yield loss. Conventional canola varieties face many problem weeds, which are either difficult to control or unable to be controlled with current herbicides. Silvergrass, radish, capeweed and turnip devastate many early sown conventional canola crops. The only herbicides registered for conventional canola are grass selectives and Lontrel for limited broadleaf control.

Reduce early weed competition. Don't use canola as the solution to a serious weed problem paddock! It should only be used in conjunction with other herbicide resistance management strategies. If the season permits, always apply a knockdown.

7.1 Weed control in TT canola

The rapid rate of adoption of canola in Western Australia has been due mainly to triazine tolerant (TT) varieties. Although triazine tolerant varieties may be less efficient (5 to 10% yield penalty) than conventional varieties, better weed control and earlier sowing counterbalances the lower yield potential of TT canola in weed prone paddocks.

Triazine herbicides Atrazine and Simazine require good soil moisture to be activated. TT canola is the only crop grown in Western Australia that can tolerate high levels of Atrazine applied at the seedling stage.

Atrazine is taken up by weeds through roots and leaves and can be used as a knockdown on small weeds. The main benefit of Atrazine application is that it can be used after the emergence of TT canola without causing any damage. Weed control in TT canola is entirely different to weed control in crops like lupins, field peas, etc., where the application of Atrazine or Simazine is restricted to pre-emergent use only.

Where time of sowing is critical, TT canola gives growers the very real flexibility to sow on opening rains without compromising weed control.

Simazine works very effectively on germinating weeds as they absorb the herbicide through their root systems. It has very limited foliar activity. Hence, lack of adequate soil moisture often results in poor weed control in the low rainfall zone.

Spraying, Wittenoom Hills 2002. (Photo courtesy Quenten Knight, Precision Agronomics.)

Table 4. Label use of triazine in canola for WA

Weeds	Situation	Rate
Annual ryegrass Barley grass Capeweed Charlock Corn cromwell Double-gee Fumitories Geraniums Ivy-leaf speedwell London rocket Mustards Oats Paterson's curse Shepherd's purse Soursob Turnip weed Wild radish Wild turnip Winter grass Suppression of: Clovers and medics, wireweed and annual grasses.	**Single application:**	
	Pre-emergent Atrazine or Simazine or combination of both. **OR** **Post-emergent** up to 4–6 leaf stage, (i.e. Within 4–5 weeks of crop emergence) Atrazine only	1000–2000 gai/ha **OR** 500–1000 gai/ha
	Split application:	
	Pre-emergent Atrazine or Simazine or combination of both. **AND** **Post-emergent** up to 4–6 leaf stage, (i.e. Within 4–5 weeks of crop emergence) Atrazine only.	500–1000 gai/ha **AND** 500–1000 gai/ha

Triazines belong to the Group C family of herbicide.

TT canola practicalities

- Simazine is not currently required in the weed control program for TT canola in WA. Atrazine has the same weed control range as Simazine when applied at the pre-emergent stage and also has a unique attribute in that it can also be used as a foliar herbicide.
- When you seed with a 'full cut', spray 1 kg of Atrazine per hectare (ai/ha) before sowing to incorporate the herbicide. At this time Atrazine can be tank mixed with knockdown herbicides. Be aware of compatibility of different herbicides.
- Spray Atrazine immediately after seeding if you use knifepoints. Atrazine utilises the soil moisture of the soil particles that have been turned onto the surface.
- Postpone post-sowing Atrazine application until the soil surface becomes wet or spray just before a rain.
- Use a mineral-based oil additive of 1% if some weeds have already emerged on the paddock. The advantage of a post-sowing application is the even cover of herbicide and the knockdown of small weeds.
- Soils with low pH alter the residual effect of triazines. The lower the soil pH the shorter the life span and consequently the poorer the performance of triazines.
- Apply Atrazine at a rate of 1 kg per hectare (ai) with oil additives in the sensitive stages of the weeds (up to 2–4 leaf stages of broad leaf weeds and up to the 1–2 leaf stage of grass weeds).
- Use a high water volume with a minimum of 50 L/ha. Use an additive with an oil when you mix grass selectives with Atrazine according to the label recommendations of the grass selective. Compatibility of crop oils may vary. Consult the product labels.
- A smooth soil surface and compact seedbed make the germination of both canola and weeds even and allows better timing.
- Time is crucial in the case of post-emergent application of Atrazine. Ryegrass needs to be sprayed at no later than the 2 leaf stage for effective kill using Atrazine.

Early planning for weed control

Grow TT canola in paddocks where the weed burden is too great for conventional canola.

Atrazine will control all the common weeds in Western Australia except old man dock and sorrel. It is particularly effective on double-gee and silver grass, and will do a good job on the brassicas and other broad-leaved weeds and grasses. Do not rely upon Atrazine only for weed control in TT canola crops. You should also implement good knockdown chemical control whenever the season allows.

Pre-seeding strategies for controlling emerged weeds before a canola crop (using knockdown herbicides) are similar to those for most other crops. In very weedy paddocks, delay seeding until at least one germination of weeds has been controlled by a knockdown. This may require the use of an earlier maturing variety. In drier areas, weeds have a far greater impact on canola yield than delayed sowing.

Pre-seeding weed control is especially important in paddocks with a heavy burden of resistant ryegrass. Aim to reduce ryegrass numbers as much as possible before they are exposed to Atrazine. There will then be a much lower chance of Atrazine-resistant individuals being present and beginning to contaminate the paddock.

Knockdown control is also important in seasons when summer or autumn weeds germinate. Although Atrazine is a very effective herbicide, do not expect it to control large transplants, especially transplants that are stressed by low moisture or from cultivation disturbance. Spray these plants with an adequate rate of glyphosate before seeding.

Timing of Atrazine for optimum weed control

Triazines work most effectively when weeds are small, before they have developed extensive root systems. Control at this stage can result in the greatest yield benefit. Thus the herbicide should be applied just before or just after seeding.

Although the best result can be achieved by incorporating Atrazine with a full cultivation at seeding, the preferred timing with minimum tillage seeders is immediately post seeding. In this way Atrazine is evenly distributed across the seed bed rather than being pushed out of the seed row where weeds could still emerge. By applying Atrazine post seeding, where using no-till seeders, the chemical will remain on the surface until sufficient rain falls to leach it into the root zone. However, in most situations it will be slightly less effective than if it were incorporated.

If a knockdown herbicide application has left the paddock essentially weed-free at seeding, delay the Atrazine application until the first weed seedlings appear. This will be three to four weeks after seeding. Applied post-emergent, with oil, this Atrazine application should be particularly effective.

Make a second application of Atrazine (plus oil) at the 4 to 5 leaf stage of the crop if a second flush of weeds, particularly radish, emerges. The paddock should remain free of weeds as the canola canopy closes over and smothers further germination.

Handy hint

*If **dry sowing** canola then attempt to apply Atrazine on or immediately after the opening rains. This way your options are still open if the rains are delayed beyond the end of May.*

Rates of Atrazine for weed control

A rate of 2 L/ha of flowable product (500 gai/L) should control most weeds when they are small. For post-emergent applications, the addition of 1% spraying oil will greatly improve leaf penetration and efficacy. Limiting the amount that is applied in any one season also helps delay the onset of resistance in weeds.

Table 5. Example product rates

Product type	500g – 1 kg active/ha rate	1 – 2 kg active/ha rate
500 g/L active (liquid formulation) Gesaprim 500 SC Gesatop 500 SC	1–2 litres product per ha	2–4 litres product per ha
900 g/kg active (granule formulation) Gesaprim Granules 900WG Gesatop Granules 900WG	555 g–1.1 kg of product per ha	1.1–2.2 kg product per ha

The canola industry operates under a full label issued by the Australian Pesticides & Veterinary Medicines Authority (APVMA) (formerly NRA) to the Canola Association of Australia and Syngenta. Syngenta manufactures and markets GESAPRIM 600 SC as a pre-emergence and post-emergence herbicide (600 gai/kg Atrazine) which will selectively control weeds and grasses in TT canola varieties.

The APVMA released its Atrazine Review Draft report for comment in 2005. The report provides a finding that active constituents (registrations) are to be affirmed, however existing labels instructions are deemed inadequate and approved labels are to be amended. Growers (or grower organisations) should watch for the resultant label changes.

For the industry to retain the use of Atrazine, adherence to the label directions is critical. Full details of the label can be obtained from the Syngenta website: www.syngenta.com.au.

An extract of the main components of the label (2004) is printed below as a guide only and not as a replacement for being fully aware of the current instructions.

Extract from APVMA Triazine label issued for canola (16 Nov 2004)

Subject to proposed changes in 2005

The maximum rate of atrazine application on all crops except plantation forestry is limited to an amount of product equivalent to 3 kg a.i. atrazine/ha per year. DO NOT exceed this limit, especially when applying an atrazine herbicide post-emergence, where an atrazine herbicide has been applied pre-emergence. Always apply the product to an even, unridged seedbed.

Integrated Weed Management Strategy for TT Canola

An Integrated Weed Management Strategy for TT Canola (the Strategy) has been developed by Syngenta with the assistance and agreement of the Canola Association of Australia. It is advised that consultation on IWM be undertaken with an accredited agronomist prior to use of GESAPRIM 600 SC on TT Canola.

To minimise herbicide resistance:

- Avoid dry sowing in heavily weed infested paddocks. Wait for weed germination after the opening rains in weedy paddocks.
- DO NOT use GESAPRIM or Gesatop if the area to be treated had a triazine herbicide applied last season.
- DO NOT use Group C herbicides in consecutive years.
- Watch for escapes, especially in paddocks with a long history of Group C herbicide use.

Important: Use may not control canola escapes or weedy canola relatives if triazine tolerant. Syngenta, the Canola Association of Australia, neighbouring land managers and growers should be notified of suspected incidents of resistance.

To avoid Triazine carry-over:

On acid soils (pH less than 6.5)—The maximum rate of GESAPRIM or Gesatop or a combination of the two products to be applied to the crop during the growing season is 3.3 L/ ha.

On alkaline soils (pH greater than 6.5)—The maximum rate of GESAPRIM or Gesatop or a combination of the two products to be applied to the crop during the growing season is 1.7 L/ha.

Post-emergence use-It is recommended that GESAPRIM only be used, and at rates of 1.7 L/ha or less, on both acid or alkaline soils.

DO NOT mix, load or apply this product within 20 m of any well, sink hole, intermittent or perennial stream.

DO NOT apply to TT Canola by aircraft. Apply only with a low boom sprayer with a 60 m buffer zone downwind of treated fields to natural or impounded lakes or dams, and a 20 m buffer zone for any well, sink hole, intermittent or perennial stream. Apply only to areas where run-off is unlikely to occur or where run-off may be captured by farm earthworks.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS

DO NOT apply under weather conditions, or from spraying equipment, that may cause spray to drift onto nearby susceptible plants/crops, cropping lands or pastures.

DO NOT apply or drain or flush equipment on or near desirable trees or other plants or on areas where their roots may extend or in locations where the chemical may be washed or moved into contact with their roots.

DO NOT plant crops other than those recommended on this label for at least 6 months following treatments at rates up to 2 L/ha and for 18 months following treatments of 2 to 5 L/ha.

PROTECTION OF LIVESTOCK

Where treating native pasture, keep stock off for 14 days while GESAPRIM 600 SC takes effect.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT

DO NOT apply this product within 60 m of natural or impounded lakes or dams.

DO NOT use in channels and drains.

DO NOT apply under meteorological conditions or from spraying equipment which could be expected to cause drift of this product or spray mix onto adjacent areas, particularly wetlands, waterbodies or watercourses.

DO NOT contaminate streams, rivers or waterways with the chemical or used containers. This product is very highly toxic to algae and aquatic macrophytes.

STORAGE AND DISPOSAL

Store in the closed, original container in a cool, well ventilated area. DO NOT store for prolonged periods in direct sunlight.

Restraints:

DO NOT apply to waterlogged soil.

DO NOT apply if heavy rains or storms that are likely to cause run-off are forecast within 2 days of application.

DO NOT irrigate to the point of run-off for at least 2 days after application.

Industry stewardship

Growers who apply triazines in excess of the above permit requirement risk legal action by the APVMA and put at risk future availability of triazine herbicides for use in Australia. Where triazine use has been extensive on a farm, growers are advised to rotate Atrazine with trifluralin and grass selective herbicides to minimise split applications of Atrazine in the one season.

7.2 Weed control in conventional canola

Conventional canola relies on traditional grass selective herbicides (group A) and Lontrel (group I), the only broad leaf herbicide that can be used in conventional canola. Weed control is based on pre-sowing knockdown treatments combined with grass selectives in the crop and maintaining a crop plant density sufficient to compete against weeds. Trifluralin (group D) is well tolerated by canola and is now used widely as a pre-plant. The biggest threats to conventional canola are radish, turnip, silver grass, waterweeds and herbicide resistant ryegrass.

Waterweeds in canola now have a registered product for control; metalachlor (group K). This will control toad rush very effectively and adequately suppress other waterweeds. Application is post-seeding, pre-emergent and it can be tank mixed with bifenthrin for ease of use.

7.3 Spray considerations

Adjuvants are very important in increasing the efficacy of post-emergent herbicides. When using tank mixes it is important to use the correct adjuvant. The use of large volume herbicides such as glyphosate and Atrazine together with insecticides and spray oils leaves little space for water when spray volumes are 30 L/ha or less. Higher volumes of 50 L/ha are needed and will also generally increase efficacy of the herbicides used.

Failure to fully mix water volumes and pesticides will cause boom blockages. Try and use high quality spray oils with good adjuvant levels to reduce the risk of blockage with multiple chemical mixes.

Boom hygiene

Spray equipment hygiene is critical to avoid chemical damage in crops. SU (Logran, Glean, Ally, Broadstrike, etc.) contamination of tanks is a potential problem at extremely low rates. For example, 20 mg/ha Logran can devastate plant density and drastically reduce yield. Booms, tanks and lines need to be cleaned and soaked overnight with chlorine after using the above herbicides.

SU Damage in new established canola crop 2005 (Photo courtesy Craig Topham, Agrarian Management).

SU Damage on a canola plant 2005 (Photo courtesy Craig Topham, Agrarian Management).

The key factor to decontaminating a boom spray is taking the time to do it properly. The need often occurs during busy spray periods. Shortcuts often result in problems. When decontaminating, especially after the use of pre-emergent herbicides, it is necessary to take as much time as possible.

To assist in preventing contamination problems the following guidelines for decontaminating boom sprays are suggested. Be aware that every boom spray is different and particular attention may need to be paid to specific components where pesticides may accumulate.

Aerial spraying of canola, July 2005. (Photo courtesy Craig Topham, Agrarian Managament.)

Guidelines to reduce boom spray contamination

(This is a guide only. Growers should establish a strategy that best suits their equipment, facilities and farming system)

1. Decontamination should be carried out as soon as possible after the last application of a potentially damaging pesticide before spraying canola. Do not allow excess chemical to sit in the tank or lines.
2. Following any pesticide application, a boom spray should be thoroughly washed with water to remove all excess solution. Pay particular attention to components of the spray system where excess solution may accumulate (eg. bypass lines, fill lines, flush out taps). Be aware that with many new boom sprays, particularly those with many boom sections, it can often take 50–100 L of water to flush out a single line.
3. After washing with water the boom spray should be cleaned out with a suitable industrial grade detergent. There are a number of these specifically suited to boom sprays (eg. Nufarm's "Tank and Equipment Cleaner"). All traces of detergent should also be washed from the system.
4. Following the first three procedures a suitable decontamination agent should be used. Chlorine for SU's (Logran, Glean and Ally) and washing powder for Eclipse and Broadstrike. These agents should be washed through the entire system and allowed to stand for a reasonable period of 2–3 hours, or overnight if possible, to allow the decontaminating agent to neutralise all remaining pesticide.
5. The boom spray should then be thoroughly washed to remove all traces of decontamination agents. After this is done all filters, nozzle bodies, tanks and bypass lines should be removed and checked for any pesticide residue. If you have been using insoluble pesticides (eg. Trifluralin) then you should find no trace of these after decontaminating. If you do then potentially you will have traces of damaging herbicides as well.
6. As a final precaution it is advisable to then spray either a non susceptible crop (eg. grass selective onto wheat) or a reduced impact crop (eg. insecticide onto pasture) with a solvent based pesticide (eg. grass selective or insecticide) to remove any final residues. Ensure that the boom spray is fully flushed with water before filling to spray canola.

While this sounds like a very involved, time consuming procedure many growers have developed efficient methods that minimise the risk of boom spray contamination damage and spraying downtime. Most growers who have suffered chemical damaged canola believe the time taken is worth the effort.

8 Insects

Canola is very susceptible to insect attack.

Redlegged earth mites (RLEM) can severely damage a canola crop and substantially reduce eventual yield in the first 6–8 weeks after sowing. Mites, such as bryobia (commonly known as the clover mite), balaustium mite, slugs and snails are becoming a more significant pest in higher rainfall districts. Weevils can be very damaging in southern districts. In the middle of the season aphids can build up to high numbers in parts of a crop and cause considerable localised damage. Towards the end of the season, native budworm and diamondback moth (DBM) numbers can increase throughout a crop and cause significant damage, particularly DBM in the Northern Agricultural Region.

8.1 Seedling pests

Seedling pests can be controlled in most cases before they begin to seriously attack emerging crops by applying the IPM principles of prevention, monitoring and forecasting (critical for RLEM), intervention and record keeping.

Seed dressings as well as a suite of effective residual, systemic and direct contact sprays for insect control are available. All require good product knowledge, effective concentrations, timeliness of application and to be part of an integrated plan (eg. with TIMERITE® for RLEM) to be cost effective.

One of these products is Gaucho® 600 Flowable Seed Dressing by Bayer Crop Science (Active Ingredient **imidacloprid**). This insecticide offers early season control of sucking pests such as RLEM and blue oat mite. Gaucho is the only product from the chloronicotinyls insecticide group registered for canola. Gaucho is absorbed by the new plant from germination.

Key Points:

- It is critical to monitor for insects every two days during emergence.
- The *Crop Insects: The Ute Guide* 2005 edition (available from the Department of Agriculture) will assist to identify insects.
- Record any changes in plant numbers.
- After full emergence, check inspection points twice a week until four weeks after emergence.
- Control seedling pests before they begin to seriously attack an emerging crop.

8.2 Redlegged earth mite (RLEM)

(Halotydeus Destructor)

Adult mites are about the size of a pinhead (up to 1 mm) with velvety black bodies and eight bright orange-red legs. These gregarious mites are often found clumped together in large numbers which disperse quickly when disturbed.

Redlegged earth mite on lupin cotyledon (left) and bryobia and RLEM (right) together on leaf.

(Photos courtesy of David Pfeiffer (LH pic) and DAWA).

Life cycle

Mites hatch from over-summering eggs in autumn when adequate moisture and low temperatures occur. Eggs produced through the season are thin-walled and hatch immediately. Several generations may develop over winter and spring. As pastures begin to senesce, the mites produce thick-walled eggs which resist drying over summer and carry the mite through to the next season. Damaging numbers of RLEM may be found in annual pastures at the break of the season. Large numbers will be found in pastures that were "under-grazed" and unsprayed during last spring, with fewer in well grazed short pastures (less than 2 t/ha feed on offer).

Damage

RLEM can severely damage a canola crop early in the season which will result in significant loss of yield. Mites rupture cells on the surface of leaves and feed on exuding sap; affected leaves look silvered. Mite damage to seedlings is more severe if plant growth is slowed. This could be caused by cold and/or waterlogging and low seedling density after a false break. Capeweed increases the reproductive potential of RLEM.

Control

Control of RLEM is essential in canola. Treating seed with a systemic insecticide before sowing protects seedlings from attack from moderate numbers of RLEM. Post-emergent sprays are also effective. Use systemic chemicals if more than 60% of plants have emerged. If few plants have come up and cotyledons are damaged as they emerge it is more effective to use a contact insecticide.

Mite control in dense spring pastures may require higher rates of insecticide than are effective on seedlings in autumn. Hard spring grazing of pasture reduces RLEM damage and the carry-over of populations into next autumn.

Mites are more likely to be in greater numbers in canola crops that follow a pasture rotation. The eggs of RLEM survive the summer in a capsule, which is actually the dead body of a female. The eggs hatch following rainfall and a drop in temperature. The mites will move only a few centimetres in their lifetime, therefore, it is highly beneficial to control RLEM in the pasture phase with TIMERITE®. This is a program developed by CSIRO and communicated by Australian Wool Innovations that advises the optimum date to spray for RLEM on any property in Australia.

You can obtain the TIMERITE® optimum spray date for your property from the Australian Wool Innovation Limited Helpline on 1800 070 099. Alternatively, you can type the latitude and longitude of your property into the TIMERITE® website at www.timerite.com.au. Once you have the date, it should not change from year to year.

In conjunction with TIMERITE®, Gaucho® (registered for RLEM control) can be applied in a coating on canola seed; with or without fungicide; for example, Canola Cote™. Gaucho is effective on RLEM in low numbers.

Under high pressure (uncontrolled pasture) a long term residual product like Talstar® is recommended. Talstar should preferably be sprayed before emergence as the mite can attack the emerging seedlings before they reach the soil surface. It can also be applied in a tank mix with Atrazine immediately after sowing. However, applying high rates of chemical to bare ground will not be as effective as the chemical applied to green plant material before the crop is sown.

Bare earth sprays are not effective for bryobia (clover mite) or balaustium mite control. It is therefore important to correctly identify the species of mite.

8.3 Bryobia or clover mite *(Bryobia Praetiosa)*

The common name for bryobia mite is clover mite (CSIRO). Adult mites are slightly smaller than a pin head with a dark grey plump round body and pale red-orange legs. The front pair of legs on clover mite are very long and held out in front of the body like a pair of feelers. Under high magnification the body shape appears flat on the top and rounded underneath with a flange around the sides. They are easily confused with RLEM and are difficult to separate without the use of a hand lens. RLEM are not usually present in early autumn as they have a cold temperature requirement before hatching.

Bryobia mite/clover mite (Photo courtesy DAWA).

Bryobia damage (Photo courtesy DAWA).

Life cycle

Clover mites are active in late spring, summer and autumn. Eggs are present over winter, and hatch as conditions dry and warm up in spring and early summer. Winter eggs are usually laid in batches, while eggs over the dry period are laid singly on backs of leaves of host plants. Newly hatched nymphs have six legs and are bright red, but turn dark grey in a few days. They moult to an 8-legged nymph, then again to become a third stage nymph, before finally moulting to the adult stage. It usually takes a month to reach the young adult stage and there are several generations per year.

Damage

Reports of clover mite damage have increased since 1995, before which they were considered a minor and sporadic pest in some southern districts. Damaging mite populations have since been recorded in the central and some northern cropping zones. The use of minimum tillage, earlier sowing times and tolerance to some insecticides may have led to the increased importance of this pest.

Crops most at risk are those planted into paddocks with a history of summer and early autumn weeds. Conditions conducive to clover mite numbers increasing are summer rains, sufficient to germinate weeds and warm dry conditions persisting after crop emergence that allow the mites to multiply. Clover mites cannot tolerate cold, wet weather but can persist into June following warm autumn conditions.

When in high numbers, clover mites can cause severe damage to emerging canola crops. They can be a problem, particularly for early sown canola crops because their development is enhanced at higher temperatures. They feed on the tops of leaves by stabbing into the surface cells with their sharp mouth parts and sucking out sap resulting in whitish grey spots giving leaves a stippled wilted look.

Control

Early control of summer weeds in paddocks that are to be cropped will prevent the build up of clover mite populations. Weeds present in paddocks prior to cropping should be checked

to determine the numbers of clover mites present. If they are found in large numbers then the incorporation of an appropriate insecticide, with herbicide immediately prior to sowing, is a more effective control strategy than spraying when the crop is emerging.

The insecticide bifenthrin is registered at 200 mL/ha for control of clover mite in canola. It should be applied with a total spray water volume of 50–200 L/ha onto bare soil post sowing and pre-emergence of canola.

8.4 Balaustium mite *(Balaustium Medicagoense)*

The balaustium mite has a greyish/red body, red legs and looks similar in appearance to the RLEM. If viewed under a magnifying glass or microscope, short stout hairs can be seen covering the body. The adult balaustium mite grows to almost twice the size of a redlegged earth mite (RLEM).

Balaustium mite (Photo courtesy DAWA).

Balaustium cupping damage (Photo courtesy DAWA).

Life cycle

Balaustium mite requires rainfall before over-summering eggs can hatch. Newly hatched nymphs have six legs and are an orange colour. Development from egg to adult takes about 5–6 weeks. Several generations can occur each year.

Damage

Reports indicate that crops sown into paddocks that were under pasture last year, with high levels of broad leaf weeds, especially capeweed, will be most at risk. Although balaustium mites are seen in pastures and occasionally crops it was not until 1997 that reports were received of them being an economic pest. Reports of severe damage are rare but a few properties west of Ravensthorpe and some in the Esperance district have had cereal, lupin and canola crops severely bleached and wilted to the point of death from this pest. Mite numbers from 20 to 50 per seedlings were recorded on barley at the 3 leaf stage. Mites feed on the leaves of plants by probing into the surface cells with their mouth parts, and sucking out sap.

Control

In most situations crops will not require spraying as balaustium mites will cause little or no damage. Early control of summer weeds in paddocks that are to be cropped will prevent the build up of mite populations. Weeds present in paddocks prior to cropping should be checked to determine the numbers of balaustium mites present. If they are found in very large numbers then the incorporation of insecticide with herbicide immediately prior to sowing is a more effective control strategy than spraying when the crop is emerging.

No chemicals are currently registered for control of balaustium mite. The mite is difficult to kill with high rates of dimethoate, omethoate, chlorpyrifos and phosmet having been found ineffective. Farmer trials have shown high rates of synthetic pyrethroids, similar to those used to control weevils, can be effective.

8.5 Beetles including vegetable weevil

(Listroderes Difficilis)

There are several beetles found in canola in WA. Of particular importance is the vegetable weevil. Two other weevils often confused with the vegetable weevil are the desiantha weevil and the small lucerne weevil.

The adult vegetable weevil has a typical weevil snout and is dull grey-brown, 10 mm long, with two small white blazes on its back. They are hard to see but can be found hiding under objects like sticks, cowpats and soil clods. Larvae are yellow to green with a flattened slug-like body and a small brown head. They are often found under leaves.

Small lucerne weevil (top left), vegetable weevil (right), and desiantha weevil (lower left). (Photo courtesy DAWA).

Vegetable weevil (Photo courtesy DAWA).

Small lucerne weevil (Photo courtesy Brooks Grain).

Life cycle

Vegetable weevil eggs are laid in autumn and develop into larvae in winter. Capeweed is the favoured host plant. These larvae live for one to two months before pupating. Adults emerge from the pupae and feed until summer, when they hibernate under debris or tree bark until the following autumn when they become active again.

Damage

Vegetable weevil can invade canola paddocks from the edges, moving from adjacent paddocks growing capeweed. The symptoms of vegetable weevil attack on canola plants include crescent shaped bites missing from cotyledons and leaves, giving a serrated edge to the leaf. Plants can be eaten to the ground.

Control

Weevil may be controlled, to some extent, prior to sowing by decreasing the amount of capeweed in paddocks. This may be achieved by either heavy grazing or herbicide application in paddocks destined for canola in the year before cropping canola or early in the cropping season.

If a weevil problem is anticipated in a paddock, an insecticide can be applied with a knock-down spray. If weevils invade a canola paddock from the edges a border spray at crop emergence will help control them before they move throughout the crop. Desiantha and small lucerne weevils are not controlled by border sprays because, unlike the vegetable weevil, they tend not to migrate into canola paddocks from the edges. Spraying with synthetic pyrethroids (SPs) (Dominex or Fastac) can give good results if they are applied to green plant material. Control can be difficult to achieve if little or no green plant material is

present, with repeat sprays and higher rates of some chemicals needed. These chemicals will also control balaustium mite, redlegged earth mite and bronzed field beetle adults.

There are no effective insecticide treatments for bronzed field beetle larvae. Paddocks in southern areas with plenty of trash, especially following pasture or lupins, are at most risk from bronzed field beetle larvae. They are dark brown, mainly soil dwelling, with upturned spines on the end of their body. They can feed on canola seedlings near ground level and when in high numbers can cause significant crop damage. The level of damage can be decreased by identifying paddocks where the beetle is present prior to seeding and using a higher seeding rate.

8.6 Aphids *(Various Species)*

Canola aphids are varying shades of grey-green and are commonly seen clustered together on plant stems. Adults may or may not have wings. The most common species attacking canola are the cabbage aphid, the green peach aphid and the turnip aphid.

Aphids

(Photo courtesy DAWA).

Life cycle

Canola aphids have numerous generations throughout the year and survive during the off season on alternative host plants.

Damage

Aphids attack canola before and during flowering. Attack at this time can cause deformation or loss of reproductive parts, with a subsequent reduction in grain yield.

Aphids tend to be more of a problem in medium and low rainfall districts. In high rainfall districts some canola varieties are able to compensate for aphid feeding and recover from the damage caused by moderate aphid infestations during flowering. This compensation is less likely in low rainfall environments of WA.

Control

As a guideline, control should be implemented if a threshold of one in five randomly selected flowering spikes are infested with clusters of aphids. Perimeter crop spraying of early aphid infestations can sometimes be effective and may reduce the rate at which aphids progress into a crop. Pirimicarb is effective against aphids whilst being relatively safe for bees.

Parasites and predators can reduce aphid numbers, but they would need to be in great abundance to reduce numbers to a level where an insecticide treatment is not required.

Before applying an insecticide, check the weather forecast as heavy rainfall can reduce aphid numbers considerably and can also reduce the effectiveness of an insecticide treatment applied just prior to the event.

8.7 Native budworm *(Helicoverpa Punctigera)*

The native budworm (NBW) is a major pest of lupins, pulses and canola.

Life cycle

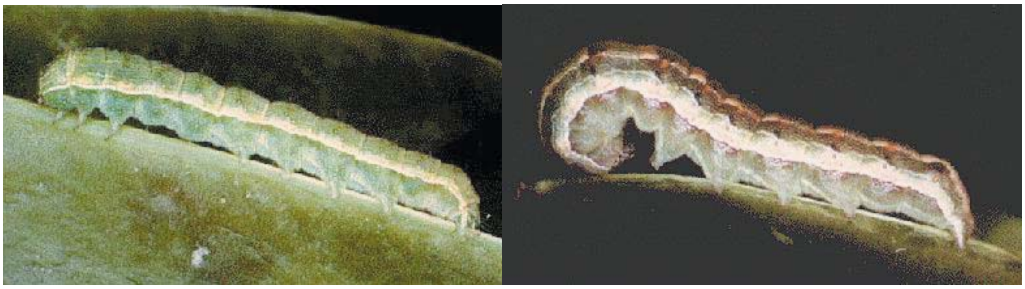
NBW usually completes only one generation in canola crops. Moths fly into crops and lay eggs in late winter and early spring. The larvae feed on leaves and fruiting bodies and complete their development just prior to harvest. They pupate in the ground at the base of plants and most emerge as moths two weeks later. Given that conditions are usually dry at this time, female moths will not mature but will disperse, sometimes over very large distances to environments that will enable breeding to continue.

Small native budworm grubs can be incorrectly identified in canola crops as diamondback moth (DBM) grubs. This is an important issue because there are different spraying thresholds, insecticide recommendations and methods of application for the two pests,

Damage

Canola in northern and eastern cropping areas of WA where NBW moths are known to have migrated in high numbers will be most at risk. Refer to weekly issues of PestFax (available at www.agric.wa.gov.au or e-mail to PestFax@agric.wa.gov.au) during August for moth numbers caught in pheromone traps.

Canola pods only become attractive to NBW caterpillars as crops near maturity with leaf fall and early drying off of some pods. NBW grubs of all sizes are capable of causing damage with larger grubs causing the most damage. Calculations of economic threshold numbers are available in the Department of Agriculture farmnote "Management of native budworm in pulse and canola crops in the south-west of Western Australia" No. 15/2001. Refer to the Summary Chart for Control at the end of this section for control suggestions.



Budworm (Photo courtesy Don Herbison-Evans, University of Sydney).

8.8 Slugs and snails *(Various Species)*

Damage

Slugs and snails become active with the break of the season. Slugs surviving from the previous season do the most damage, eating two or three times their weight daily. Slug activity is encouraged in paddocks where there has been no tillage. Retained stubble creates a micro-climate conducive to the survival and development of the slug. Paddocks after pasture in a high rainfall zone are also prone to slug damage. Slugs may move into crops from neighbouring bush or pastures.

Monitoring

Monitoring is highly recommended in areas where slugs are known to be active. Paddocks with potential slug problems can be identified before seeding by building slug traps in the paddocks. This can be achieved by digging a pit approximately 10cm (four inches) in diameter and 15cm (six inches) deep covered with a board coated with aluminium foil on the upper surface to reflect the sun's heat. In dry conditions the pit needs to be kept moist. The trap works by providing a cool, humid refuge from the sun for the slugs. As a rule of thumb, you can expect problems in the paddock if you find one to five slugs per trap. Since slugs are nocturnal, sampling should be done in the evening or when the weather is cloudy. Metaldehyde bait can be placed in the trap to attract slugs from some distance away.

Slug (Photo courtesy Neil Harris, Dovuro Seeds).

Alternatively lay lines of slug pellets with a rabbit baiter after soaking autumn rains. In infested areas slugs are attracted to the freshly turned soil and pellets placed in the furrow. If slugs are likely to be a potential problem, large numbers will be found dead or dying in the furrows or nearby.

A third alternative is to place carpet squares or hessian bags on the soil surface, with pellets under them. If after a few days, several slugs can be found under and around each square/bag, this suggests their numbers are great enough to subsequently damage the emerging canola crop.

While the crop is germinating trapping to gauge slug numbers should continue.

Control

Management options are limited to baits and cultural practices. If there is a large number of slugs present, then a combination of cultural practices and baits may be needed.

Metaldehyde baits can attract slugs from up to one metre away and kill them. The primary mode of action is dehydration by stimulating excessive mucus production. During wet conditions, slugs can sometimes absorb enough moisture to compensate for water loss in mucus production and recover. Therefore, during wet conditions a combination of Methiocarb and Metaldehyde may be needed. Iron phosphate is another bait product available to growers, although research has shown some inconsistency in its performance. Spreading Mesurol granules (containing Methiocarb) is another option which works best on a smooth, flat surface with low stubble residue.

The key to controlling slugs is to identify their presence early in the season (May/June) and apply treatments immediately after germinating rains, even before seedlings have emerged. This will allow treatment before slug numbers build up and before a large amount of green material is present, providing an alternative food source for the slugs.

The best results are achieved with multiple bait applications rather than a single application at a high rate. The pellets lose their effectiveness after a few nights as they may become covered by soil during rain or decay after wetting. It is always advisable to reapply baits after heavy or prolonged rainfall.

8.9 Diamondback moth (DBM) *(Plutella Xylostella)*

(Previously known as cabbage moth.)

DBM grubs can be found in canola crops throughout the Wheatbelt of Western Australia. They first appear in crops in very low numbers in early winter and can pass through three to five generations over the growing season—the rate of development increasing with warmer temperatures. In years with mild winter conditions, numbers can increase to high levels and cause major yield losses, particularly in the Northern Region. Crops need to be monitored in winter to check for the presence of DBM grubs and monitored more frequently in spring to determine whether an insecticide treatment is required. The grubs can be difficult to control and often more than one application of an insecticide is needed.

DBM has been confused with the native budworm (otherwise known as Heliothis) which can infest crops in early spring. The two pests can be distinguished from one another with respect to colour, size, shape and behaviour. The native budworm grub has light coloured stripes along its body and can grow up to three times the size of a DBM grub. The native budworm grubs are cylindrical and move relatively slowly compared with DBM grubs that are pale yellowish-green to green, tapered at both ends and wriggle violently and often drop from the plant, suspended by a silken thread, when disturbed. An adult native budworm moth is approximately 20mm long, dart shaped when resting and a light faun colour. A DBM moth is 8–10mm long, folds its wings over its body, forming a tent-like shape and is a dark brown colour.

Life cycle

DBM has four stages in its life cycle; egg, caterpillar (grub), pupa and adult moth. The time it takes to complete the life cycle is dependent on temperature—the development rate increasing as temperatures rise. At 15°C, the entire life cycle takes 47 days, whereas at 28°C, the life cycle is completed in 14 days.

Female moths lay eggs within one day after emerging and continue to lay for up to 10 days. Caterpillars hatch from the eggs and begin feeding immediately. The newly hatched caterpillars (known as first instars) are only 2mm long and burrow into the leaf tissue to feed. They emerge after a couple of days and spend the remainder of their time feeding on the leaf surface. The grubs grow through four instars in about 10 to 21 days, depending upon food quality and temperature, reaching 12mm in length. The forth instar grubs spin white mesh cocoons on leaves, stems and seed-pods in which they pupate. The pupae start out light green but turn brown as they mature and in approximately a week adult moths emerge.

During the growing season, DBM can complete the life cycle several times and numbers can increase quite dramatically, depending on temperatures and rainfall.

During the growing season adult moths do not usually move very far in the crop and it is thought that very few of the moths produced in a crop will fly out of the crop. Female moths will mate and lay most of their eggs within metres of where they were produced and over the growing season three to five generations can be completed. Consequently, by the

DBM grub (Photo courtesy DAWA).

DBM damage (Photo courtesy DAWA).

beginning of spring adjacent crops can have significantly different numbers of DBM grubs, depending on the size of the initial breeding populations in early winter.

At the end of the growing season adult moths will begin to leave crops when they begin to dry off. Prevailing winds may carry these moths hundreds of kilometres to alternative breeding sites. It is thought that the moths initially infesting canola crops in WA during late autumn and early winter fly long distances from alternative breeding sites.

Damage

The level of damage varies greatly and depends upon the number of grubs and the time they spend in the crop. The grubs can eat irregular holes (shot holes) in the leaves and at high densities, they may eat all the leaf material, sometimes leaving only the veins (which bleach white in colour). The grubs can also eat the flowers. When the leaves begin to senesce, the grubs can feed on the surface of pods but very rarely do they enter the pods to feed on the seeds. The reduction in crop yield resulting from DBM infestations appears to be largely the result of the grubs feeding on the leaves.

Control

It is important to determine at an early stage whether DBM grubs are in your crop so that future crop assessments can be planned and control measures implemented before the crop is damaged.

DBM grubs can be developing in canola crops soon after crops emerge. However, it usually takes several weeks before they are easily detected. Grub numbers often build up quickly when crops are stressed. The first signs of DBM activity are holes or parts missing off the edge of leaves. The quickest way to determine the presence of DBM grubs is to use an insect net and sweep the net across the top of the crop, in front of you as you walk through the crop. It is best to check your crop in several places.

To determine whether it is worth controlling a DBM infestation, the cost of implementing the control measures should be compared to the potential yield loss. If the potential yield loss is greater, the control measures should be implemented. The potential yield loss can be predicted based on the number of grubs in the crop, their size, and the differences in their numbers among sampling occasions.

The only way to effectively determine the number of DBM grubs in a canola crop is to use an insect net to collect the grubs. The net is passed across the crop so that the top of the plants just fill the net. The net is passed across two metres of crop from left to right, a stride is taken then the net is passed from right to left. This constitutes two sweeps. A sample is made up of 10 sweeps. Each time the crop is assessed, at least three to ten such samples should be taken (depending on the number of grubs collected) from different parts of the crop and the numbers recorded.

The intensity and frequency of assessment should be as follows:

1. If on average up to **10 grubs per 10 sweeps** are collected, continue to assess the number of grubs in the crop by taking **3 samples once a week**.
2. If on average between **10 and 50 grubs per 10 sweeps** are collected, continue to assess the number of grubs in the crop by taking between **5 and 10 samples *once* a week**.
3. If on average greater than **50 grubs per 10 sweeps** are collected, continue to assess the number of grubs in the crop by taking between **5 and 10 samples *twice* a week**.
4. If on average greater than **150 grubs per 10 sweeps** are collected, **implement control measures**.

The number of samples per assessment is increased when more grubs are collected, to increase the precision of the estimate of grub numbers as they approach the spraying threshold.

The number of assessments per week increases from one to two when the average number of grubs per 10 sweeps exceeds 50 because, given the right conditions at this stage, numbers could increase rapidly towards the spraying threshold. A high proportion of small grubs (less than 3mm) in the sample often means the population may increase further.

Regular assessments of the number of grubs in the crop are required as the numbers can fluctuate and are just as likely to decrease as they are to increase at any stage throughout the growing season. Cool, wet and windy conditions may reduce numbers. But numbers may also decline when weather conditions are fine and mild due to an outbreak of a fungal disease.

Two to three days after the application of an insecticide the number of grubs remaining should be assessed using the methods given above. It often takes more than one spray to reduce the numbers to an acceptable level. An overall 80% reduction in numbers is achievable given two applications of one of the registered insecticides listed below.

8.10 Bees

Bees can be beneficial to canola as pollinators. When applying insecticide such as cypermethrin, primor or dimethoate during flowering, spray in the evening when bees are least likely to be foraging, and ensure that neighbours have no beehives in the vicinity.

8.11 Summary charts for insect control

Rates given are in mL/ha (unless otherwise stated) of EC formulated insecticides and are provided as a general guide. Chemical labels must be read and withholding periods observed before using chemicals.

Table 6. Chemical names

Chemical Name	Trade Name(s)
Information source–Infopest *Read chemical label before use—information below is only a guide. List may not be complete. Check with your retailer.	
alphacypermethrin 100 g/L	Alpha-cypermethrin, Alpha Duop, Alphamax100, Alpha100, Alphasip Duo, Alpha-Cyp100 Duo, Alpha-Scud Elite, Astound Duo, Buzzard, Centaur, Dictate Duo, Dominex 100, Dominex Duo, Fastac Duo, Ken-Tac 100, Unialphacyper
beta-cyfluthrin 25g/L	Bulldock Duo
bifenthrin 100 g/L	Arrow, Bifen, Bifenthrin, Bisect, Discret, Rage, Talstar, Tal-Ken, Venom, Webzone.
chlorpyrifos 500 g/L	Agricultural Insecticide, Bar 500, Chlorpyrifos 500, Chlorpyrimax 500, Chlorfos,. Fortune, Generifos, Lorsban 500, Strike-Out, Pest controller, Profos, Kesban, Voodoo.
cypermethrin 200 g/L	Cypermethrin 200 EC, Cypershield, Scud, Sonic.
Cypermethrin 250 g/L	Cypermax 250, Cypermethrin 250
deltamethrin 27.5 g/L	Assign, Delta Shield, D-Sect, Decis Options, Ballistic, Deltamethrin Duo.
dimethoate 400 g/L	Dimethoate 400, Rogor, Saboteur, Stalk, Dimethoate, Romethoate, Unidine 400.
endosulfan 350 g/L	Endosulfan 350 EC, Endosan, Thiodan—SEE PERMIT FOR USE RESTRICTIONS
esfenvalerate 50 g/L	Sumi-Alpha Flex Insecticide.
fipronil 500 g/L	Cosmos seed dressing RLEM–400mL/100Kg seed
gama-cyhalothrin 150 g/L	Trojan
imidacloprid 600 g/L	Gaucho 600 seed dressing. Treated seed is effective for about 4 weeks on RLEM and 2 weeks on L.F. Probably not effective on bryobia mites.
imidacloprid 180 g/L	Hombre, Zorro.
lambda-cyhalothin 250g/L	Karate with Zeon Tech, Matador with Zeon Tech
methidathion 400 g/L	Supracide 400, Suprathion 400EC.
omethoate 290 g/L	Le-mat 290 SL.
pirimicarb 500 g/L	Pirimicarb, Aphidex 500, Pirimicarb 500, Pirimor WG Aphicide.

Table 7. Insecticides for insect control

Pest	Insecticide	Rate/ha	Remarks
Redlegged earth mite *(Halotydeus destructor)*	alphacypermethrin 100 g/L	50–100	Can be used on bare ground
	beta-cyfluthrin 25 g/L	200	
	beta-cypermethrin 100 g/L	60–90	
	bifenthrin 100 g/L	50–100	Bare ground treatment.
	chlorpyrifos 500 g/L	140–300	
	cypermethrin 200 g/L	50–75	
	dimethoate 400 g/L	55–85	
	gamma-cyhalothrin 150 g/L	8	
	lambda-cyhalothrin 250 g/L	9	
	methidathion 400 g/L	200	Can be used on bare ground
	omethoate 290 g/L	100	
	Seed treatments		
	dimethoate		
	fipronil 500 g/L	Refer to labels for rates	
	imidacloprid 600 g/L		
	omethoate 580 g/L		
Cutworm *(Agrotis spp.)*	Bt (k)	1400	Apply as soon as pest is noticed.
	chlorpyrifos 500g/L	700–900	
	deltramethrin 27.5 g/L	200	
	esenvalerate 50 g/L	70	
Brown pasture looper *(Ciampa arietaria)*	bifenthrin 100 g/L	50–100	Larvae may migrate from capeweed.
	deltamethrin 5.5 g/L ULV	2500	
	esfenvalerate 50 g/L	70	
Vegetable weevil *(Listroderes difficilis)*	alphacypermethrin 100 g/L	400	Adults are difficult to kill. Early and repeated border sprays may be sufficient.
	bifenthrin 100 g/L	100–200	
	chlorpyrifos 500g/L	800	
Aphids *(various species)*	dimethoate400 g/L	800	Infestations may increase or decrease rapidly with changing weather conditions
	endosulfan 350 g/L	2100	
	pirimicarb 500 g/kg	500–1000	Lower rates may be effective.
	Seed Dressing		
	imidacloprid	See label	
Diamondback moth *(Plutella xylostella)*	alphacypermethrin100	400	These chemicals can also control cabbage centre grub and cabbage white butterfly
	Bt (k)	1400	
	endosulfan 350 g/L	2100	
	esfenvalerate 50 g/L	250	
	gammacyhalothrin 150	20	
	lambdacyhalothrin 250	24	
	methomyl 225 g/L	1000	
Native budworm *(Helicoverpa punctigera)*	Bt (k)	1400	Small larvae may be controlled at lower rates of some chemicals.
	deltamethrin 27.5 g/L	500	
	methomyl 225 g/L	500–2000	
Rutherglen bugs *(Nysius vinitor)*	Endosulfan 350 g/L	2100	A clean sample can often be obtained by harvesting at night. Success of insecticide spraying cannot be guaranteed since adult bugs often re-invade the crop. Only recommended for severe infestations.
	gammacyhalothrin 150	30	
	lambdacyhalothrin 250	36	
	Maldison 1150 g/L	500	

9 Diseases

The major diseases of canola in WA so far experienced are blackleg, Sclerotinia, downy mildew, white leaf spot, clubroot, Beet Western Yellows (BWY) and cauliflower mosaic viruses.

9.1 Blackleg

Description and symptoms

Blackleg is the most serious disease of canola in Western Australia. Recent annual losses due to blackleg are estimated to be more than $20 million per annum. While it is particularly a threat in the higher rainfall southern districts it occurs in all districts. Blackleg is caused by the fungus *Leptosphaeria maculans.*

The fungus can invade the plant in each growing phase. Lesions occur on leaves and pods but the most serious symptom is found on the crown of the stem, called a stem canker. Badly affected plants are ring barked at ground level by cankers causing plants to lodge, hence the name blackleg. Less severely affected plants remain standing, but pods fail to fill because their sap flow is restricted and seed is pinched. This results in reduced yield, oil percentage and higher admixture.

Blackleg leaf lesions

(Photo courtesy Heather Cosgriff, Pacific Seeds).

Blackleg on leaf

(Photo courtesy David Sermon, ConsultAg).

In the early 1970's blackleg wiped out the first attempt at a canola industry in Australia. It did not re-emerge as a successful crop until the 1990's when blackleg resistance had been bred into varieties. In 2003, blackleg significantly overcame the resistance afforded by the *B.rapa.ssp sylvestris* derived major gene resistance used in some varieties, causing a move back to polygenic resistant varieties in 2004 and 2005.

Life cycle

Blackleg survives on canola stubble, producing fruiting bodies that contain enormous quantities of spores ready to be airborne and capable of travelling several kilometres. These fruiting bodies can easily be seen with the naked eye. The date of spore maturity depends on summer/autumn rainfall and temperature. Early rainfall results in early spore maturity and may lead to increased disease severity. In the autumn and winter, rainfall triggers spore release from the fruiting bodies on the stubble. Within two weeks of spores landing on canola cotyledons and young leaves, clearly visible lesions develop. Within the lesion, more fruiting bodies that release rain-splashed spores are produced. Once the lesion has formed, the fungus grows within the plant's vascular system to the crown where it causes a canker. Severe canker will sever the roots from the stem, whereas a less severe infection will result in internal infection of the crown, restricting water and nutrient flows within the plant.

Several factors contribute towards development of the disease. Seasonal conditions, as with any crop disease, have a major influence on the level of disease. While the major source of primary inoculum is the infested residues, the inoculum is also carried over by infected seeds. However, the impact of carry-over of inoculum on the seeds is very low when compared with the inoculum carry-over on residues. Rains in late autumn and throughout winter stimulate the release of blackleg spores from canola residues present on the surface of paddocks. Blackleg is spread primarily by wind, with the heaviest spore fall out normally occurring within 500 metres of any canola residue. Each year canola residue continues to produce blackleg spores at a diminishing rate until the stubble has completely broken down.

In WA this breakdown could take up to 4 years, hence the recommendations are for long rotations—a minimum of 4 years between canola crops.

Damage

Blackleg can attack the crop at any stage, but early seedling infections are most critical in terms of the development of severe stem cankers and yield loss. Blackleg infection on canola seedlings will cause a constriction in the stem just below the first leaves but above the ground.

Canola seedlings of all varieties are susceptible to blackleg until they achieve a degree of adult plant resistance, usually at about the six leaf stage. Hence even the higher resistance rated varieties can suffer prior to the onset of adult resistance. The resistance level rating applies only to adult plants.

Heavy seedling losses can occur under very high disease pressure and in environments favourable to blackleg development, for example, where canola varieties up to WA Blackleg Canker Rating score 7 are planted on top of, or immediately downwind of last year's or the previous season's canola crop. In 2003 up to 90% yield loss was observed in canola crops due to blackleg on the Eyre Peninsula, where varieties containing the sylvestris gene-based resistance succumbed to a new race of the disease.

In some areas, for example, in the Northern Agricultural Regions, growers' experience over the past few years has shown that very early sown crops (eg. before early May) are much less severely affected by blackleg. This is because the early seedling growth phase has been completed before the onset of heavy ascospore showers.

The blackleg fungus can attack all aerial parts of the plant. While leaf infection is the most obvious symptom, high levels of leaf infection do not necessarily indicate that major losses will occur from blackleg. It is the less obvious infection in the crown region (junction of root base and stem) that causes the largest seed yield losses from blackleg.

Control and management

There are a number of detailed guides for managing blackleg recently published. They include *Australian Blackleg Guide* (CAA), *Managing Blackleg* (DAWA) and *Managing Blackleg and Sclerotinia in Canola* (GRDC/TOPCROP).

There are five main management practices for control of blackleg.

1. Select varieties with the highest polygenetic based resistance commensurate with your estimated level of risk.
2. Employ a four year minimum rotation for canola.
3. Burn or bury canola residues within 500m of the current canola paddock if a buffer of at least 500m cannot be provided.
4. Consider a fungicide in high risk situations. Two fungicides registered for canola are Impact in Furrow® and the systemic fungicide Jockey® which is applied as a seed dressing to protect against blackleg. Maxim XL® also offers suppression and may assist in low risk areas with early infections.
5. Refer to *Blackleg Sporacle Easy* (available from DAWA's pest fax service or from the DAWA website) which provides a prediction of the maximum spore release period in different regions so that growers may time seeding to avoid that period where possible.

Blackleg resistance ratings

Canola varieties may be rated for resistance to blackleg by either the Canola Association of Australia (CAA) or DAWA. An explanation of each organisation's rating scale is shown in the table below.

Table 8. Resistance rating scales

CAA Blackleg Resistance Ratings	DAWA Blackleg Resistance Ratings
Scale 1–9	Scale 0–9
3 Poor	0–2 = highly susceptible
4 Moderately poor	3–4 = moderately susceptible
5 Intermediate resistance	5–6 = moderately resistant
6 Moderately good	7–8 = resistant
7 Good	8 + = highly resistant
8 Very good	
9 Excellent	

Blackleg damage

(Photo courtesy Martin Barbetti, UWA)

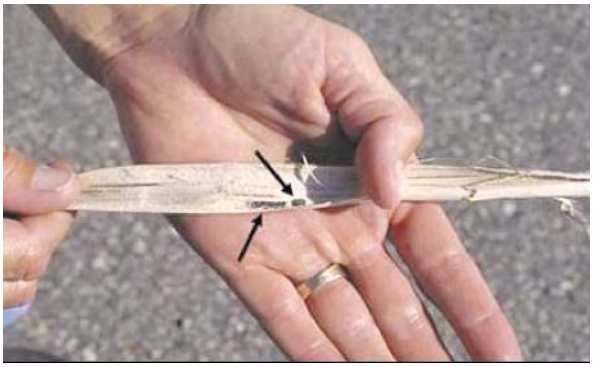
9.2 Sclerotinia stem rot

Description and symptoms

Sclerotinia stem rot is caused by the fungus *Sclerotinia sclerotiorum*. Symptoms appear as bleached greyish white or brownish white fluffy fungal growth covering portions of the canola stem sometimes just above the soil level. However infection frequently occurs even as high as 30 to 45 centimetres above the soil level.

Advanced infection will have black irregular shaped sclerotia on the inside of the affected and bleached parts of the stem. Stems can be carefully split to observe the black sclerotes within. The disease causes plants to wilt and ripen prematurely, with severe infection resulting in lodging and heavy yield losses.

It is favoured by damp, warm conditions during flowering.



Above: The black fruiting bodies (sclerotia) of Sclerotinia inside of affected stems (Photo courtesy Neil Harris, Dovuro Seeds).

Left: Sclerotinia fruiting bodies that release airborne ascospores in late winter/early spring to infect flowering crops (Photo courtesy Tamrika Hind-Lanoiselet, NSW Agriculture).

Right: Severely affected plant showing bleaching and development of sclerotia outside the stem (Photo courtesy Tamrika Hind-Lanoiselet, NSW Agriculture).

Life cycle

Sclerotinia survives as sclerotia (hard, dark resting bodies) in the soil for many years.

During cool moist weather sclerotia near the surface germinate and produce small, cream, mushroom-like bodies called apothecia, containing many ascospores. These are carried by the wind to nearby crops. Mists, dews and fogs provide enough moisture for infection.

Spores infect canola during flowering through dead flower petals falling on the leaves. Normally the spore must first germinate on, then infect, dead or dying plant material such as dead leaves or fallen flower petals caught in between the stems and leaves before it invades the stem through the leaf to create an infection in the stem. Infections high on the stems result in contamination of the seed with sclerotia.

Damage

In some countries Sclerotinia stem rot is the most important disease of canola. It is widespread in Western Australia, but generally not very severe, except in the coastal districts of the northern region where it was evident in 2004. It was commonly found in 2004 in Northampton, Mingenew, Hyden, Salmon Gums and other Great Southern Locations.

Control and management

At present it is considered uneconomic to directly control Sclerotinia with fungicides. Rotation and management of infected trash are currently the best strategies.

Leave canola out of the rotation for as long as possible (at least three years) to allow diseased residues and sclerotia to decompose, to reduce the risk of subsequent infections.

Include species unaffected by Sclerotinia in rotations, such as cereals. Leave out species such as lupins and peas, which are very susceptible, in severely affected areas.

Use canola seed that is free of sclerotial contamination.

Deep ploughing of infected stubbles may reduce carryover to subsequent crops, since deep burial, greater than 15 cm, hinders sclerotial germination and development of apothecia.

Currently there is very little resistance to Sclerotinia in commercial varieties. No fungicides are registered for control of Sclerotinia in WA. Some fungicides are registered outside Australia for application between the 20–30% flowering stage.

9.3 Downy mildew

Until recent years, downy mildew was a sporadically occurring disease caused by the fungus *Peronospora parasitica* that only rarely caused significant yield loss. However, from 1998 onwards, downy mildew has been widespread on seedlings, and in some cases it appears to have severely retarded seedling growth and vigour. This disease is usually most evident under cool moist conditions with the crop normally growing away from it as the weather warms up in spring.

Downy mildew produces yellow blotches on the upper leaf surface and white mealy growth on the underside of the leaf. It is rarely a serious problem past the seedling stage of the crop.

Downy Mildew (Photo courtesy Martin Barbetti, UWA).

9.4 Club root

Description and symptoms

Clubroot is caused by the soil borne fungus *Plasmodiophora brassicae*. The disease occurs worldwide and only affects plants in the Cruciferae family including canola, mustard, cabbage, cauliflower, brussels sprout and broccoli. Internationally, clubroot can cause yield losses of up to 50% in canola and it is considered a serious disease in Britain, Canada, Czechoslovakia, France, Germany and Sweden.

Clubroot is widespread and causes significant yield losses in Australian vegetable brassicas. The Australian oilseed industry has been somewhat protected from clubroot. This is because the major production areas for vegetable and oilseed brassicas are usually separated from one another, posing a very low risk for the fungus to spread from vegetable to oilseed brassicas. In addition, most Australian pathotypes of clubroot are only able to cause disease in the warmer months, with the exception of pathotypes in Tasmania and some parts of New South Wales where disease is observed year round. There have been sporadic reports of this disease on canola crops in WA in most seasons, but particularly in the past three seasons.

In 2003, two confirmed cases of clubroot were found on white mustard (*Sinapis alba L.*) in New South Wales. This is concerning, as both of these cases were severe and occurred in areas that were distant from vegetable growing areas and during the cooler winter months. Australian oilseed growers should now be on the lookout for symptoms resembling clubroot. Ensure plants suspected of having clubroot are sent to a plant pathologist for correct identification. Swollen, galled roots are the most typical symptom of infected plants. This ranges from tiny nodules, to large, club-shaped outgrowths that may involve most of the root system.

The galls are at first firm and white but become soft and greyish brown as they mature and decay. Affected roots have an impaired ability to assimilate water and nutrients, therefore severely affected plants can be stunted and wilt under moisture stress. The two severely infected white mustard fields in NSW also had leaf symptoms that resembled extreme nutrient deficiencies.

9.5 White leaf spot

Description and symptoms

White leaf spot disease can be found in most canola crops, but is not usually a cause of large yield losses. White leaf spot is caused by the fungus *Pseudocercosporella capsellae*.

White Leaf Spot

(Photo courtesy Tim Tresize, Agrarian Managment July 05.)

Life cycle

The fungus survives on residues of infected plants. Under favourable autumn and winter conditions it produces wind-borne conidia, which mainly cause leaf lesions. It has been commonly observed in the Esperance district on volunteer canola.

In turn, the conidia produced in these lesions are carried by wind and rain to cause secondary spread of the disease. White leaf spot is also spread from infected seeds and from pieces of infected debris present with the seed.

Optimum temperatures for infection are 13–18°C, but high moisture levels are necessary for disease development. The disease usually develops after periods of high rainfall.

Nitrogen deficient crops seem to be more severely affected by the disease.

Control and management

Undertake crop rotation and good hygiene practices as listed for blackleg.

Leave canola out of the rotation for at least three years.

In recent years, some growers have successfully reduced this break period, but there is increased risk from this practice. If the seedling stage of crop development coincides with heavy airborne spore discharges from nearby stubbles, even adult plants can suffer substantial damage.

In high risk situations and where erosion risk is minimal, destroy crop residues after harvest and graze stubbles heavily to reduce fungus carry over.

9.6 Viruses in canola

Description and Symptoms

Two viruses, **Beet Western Yellows** (BWYV) and **Cauliflower Mosaic Viruses** (CaMV) cause insidious diseases of canola crops in Western Australia. A third virus is also occasionally found in canola crops in the state, **Turnip Mosaic Virus** (TuMV).

The symptoms of BWYV are difficult to observe on late-infected canola plants in the paddock. However, early infection causes obvious symptoms of plant dwarfing, and reddening or purpling of lower leaves. These symptoms are easily confused with nutritional disorders.

Life cycle

BWYV is persistently aphid-transmitted. CaMV and TuMV are non-persistently aphid-transmitted. Seed transmission in canola has not been investigated and is possible for TuMV. BWYV is spread in canola by the green peach aphid while the other two are spread by several aphids, including turnip and cabbage aphids and species that do not colonise canola.

It occurs throughout the wheatbelt with crops often infected at low levels. It has a host range of around 150 plant species including wild radish which is a key alternative host that acts as the initial source of infection. Other hosts include wild turnip, field peas, faba beans, chick peas and sub clover.

Damage

The most widespread and economically important of the viruses is BWYV.

Research is still being conducted to determine the effect of these viruses on the yield of canola in WA. European work has found seed yield losses of 10–15% associated with this virus disease in canola.

Yield losses can be severe if green peach aphids arrive early in the growing period resulting in rapid infection of young plants with BWYV. In two DAWA field experiments, infection with BWYV that started early and reached 98% and 93% of plants decreased seed yield of canola by 37% and 46% respectively. Such epidemics will only develop when there is substantial rainfall in the 2–3 months before the growing season starts, as under such conditions, green peach aphids can build up in pastures and on weeds and invade young crops shortly after emergence.

Control and management

When used at the critical early infection phase (eg. applied as a seed dressing), control of green peach aphids with a newer generation insecticide such as Gaucho has proved effective in suppressing BWYV spread at the vulnerable seedling stage. Such applications have increased yields by up to 50% in situations where rapid spread of BWYV occurred in very young plants.

10 Harvesting, transport and storage

10.1 Swathing

For most of the low and medium rainfall districts, large crop areas with high yields (>1 t/ha) are better managed by swathing before harvest. The crop will dry more evenly allowing earlier harvesting, and reduce harvest losses from shattering. Insects such as DBM, budworm and aphids need to have been controlled well ahead of swathing in order to not breach withholding periods, which vary according to the chemicals used.

Swathed canola (Photo courtesy Heather Cosgriff, Pacific Seeds).

When canola has reached physiological maturity, it is ready to swath. That is when either the seed moisture content is between 30–35% or the seed colour change has reached 60–70%. Swathing at too high a moisture content, when the seed is immature, will adversely affect grain size, oil content and yield. For the eastern grainbelt in most seasons the crop will be ready to swath within 14 to 21 days from the end of flowering.

For grasses surviving a grass selective herbicide application, the use of a spray boom on the swather is proving a very effective means of crop topping ryegrass in canola. At present this operation is not registered and may need to be registered to satisfy QA requirements.

Also be aware that some commonly used grass selective herbicides have long withholding periods in canola.

Ashley Stewart alongside a swath (Photo courtesy of Quenten Knight, Precision Agronomics.)

Spray boom attached to swather (Photo courtesy David Sermon, ConsultAg).

10.2 Direct harvesting

Direct harvesting canola is an option for growers with suitable varieties, belt fronts, those who only have a small area of canola (<200 ha) or for crops close to breakeven returns to reduce further expenditure. Direct harvesting is very variety dependant due to large differences in pod shatter between varieties.

Throughout the low rainfall districts where the crop may dry out unevenly, the denser area on the valley floors could be swathed while the remainder of the crop on the hilltops could be direct headed. Direct heading is an option for salvaging small uneven areas or where not enough plants exist to retain the swathes off the ground.

The crop will be ready when the majority of pods are dry and rattle when shaken. Always test a small amount and have the moisture measured. The header must be ready for harvest once the crop has reached 8.5% moisture in the seed.

10.3 Crop topping or desiccation

This method of harvest preparation is not generally favoured due to knockdown herbicides needing to be sprayed by air.

Farmer experience has shown Reglone™ will kill all green material within two to three days; however the seed will not dry out well in the pods, resulting in high moisture content grain if attempts to harvest are too early.

When Glyphosate is applied plants die slower, however this may result in more damage if strong winds occur after desiccation. Plants are prone to damage from strong hot winds in October and November and considerable loss of grain can occur even though the crop has been desiccated.

As a general rule of thumb for most canola crops growing in the eastern grainbelt, desiccation is not justified unless it is for the control of a serious herbicide resistant weed population, although swathing can achieve a result without the risk of seed loss through shattering.

10.4 Timing of harvest

Harvest can begin when seed moisture content is below 8.5% (Ensure moisture meter is calibrated). Moisture levels in canola are lower after mid-morning and remain so well into the evening.

Harvest usually commences approximately 10 to 20 days after swathing. Direct harvesting canola without swathing usually occurs up to 30 days from the time the crop would have been ready to swath. For a crop swathed 20 days after flowering, harvest is possible approximately 5–10 days after swathing. Swathing advances harvest by about 5 days relative to direct harvest.

Seed can be graded to remove weed seed such as ryegrass and radish in the harvest sample.

Oil "Bonification" bonus or discount payments vary from acquirer to acquirer. Most cash payment terms have a cap on oil premiums. Growers should check bonification terms and conditions with each company at time of sale or delivery.

The Grain Pool Pty Ltd pays a premium or deducts a discount for each 1% oil in seed, (measured on a clean seed basis), above (bonus) or below (discount) 42% oil content in canola seed delivered into their pool. Canola with oil content below 30% is currently classed as undergrade. There is no limit to Grain Pool Pty Ltd premiums. Special segregations are required for canola below 38% oil content, which is subject to seasonal conditions and regional seed averages.

Please check with CBH before delivering grain to your local receival point.

Admixture penalties are applied for 0.0% to 3.0% at 1% pro rata basis, plus $2 per tonne for each 0.1% admixture above 2% and up to 3% (2.5% = $10.00/ tonne, 3.0% = $20.00). Canola with over 2.0% admixture may be received as CS2, and any canola > 3.0% admixture is considered undergrade.

Bonification bonuses or discount rates and admixture penalty rates should be checked each season.

10.5 Harvest losses

Harvest losses can be significant in canola if harvesting is not carefully monitored. Patience is important to minimise losses as small seed losses are easily over looked. Previous surveys have shown harvest losses to be anywhere between 40kg to 150kg/ha. A loss of 20 to 30kg/ha is considered acceptable.

Losses can be minimised by:

- Correctly setting up sieves.
- Slowing harvesting speed.
- Harvesting early in the morning and at night, especially when direct harvesting.

The easiest method of assessing the losses in canola is to use 2 litre ice cream containers. Put eight containers in the uncut crop in front of the harvester, four either side of where the harvester will go to measure the front losses, and four in the middle of the machine to measure the front plus machine losses. Then harvest the crop over the top of where the containers are placed and count the number of seeds in each container. For swathed crops just put 8 containers either side of the swathed row. Sixty (60) seeds in the area of a 2 litre ice cream container (0.022 m^2) is equivalent to a loss of 100 kg/ha.

10.6 Storage

Quality canola stores well if its moisture and temperature are properly maintained. Storage of canola on-farm below 8% moisture content should only be for a maximum period of up to two months without aeration before being marketed. Storage of retained seed is preferable in bags where plenty of air can circulate around the bags or in a small silo fitted with aeration.

Canola grain that is not stored in cool dry conditions can suffer increased fatty acid content, oil colour change, insect damage, surface crusting, mould and in extreme cases smoulder or catch fire.

10.7 Aeration and drying

Aeration in its simplest form is the forcing of ambient air through a stack of grain. Grain can be cooled and stored at a higher than normal moisture content; moisture migration is prevented by equalising the temperature throughout the stack. Cool grain also keeps insect numbers low; temperatures of 12 to 14ºC will stop them breeding.

Aeration Unit (Photo courtesy Jon Slee, Riverland Oilseed Processors).

During the storage period some drying will occur if the ingoing air has a low relative humidity (rh). Introducing air into the stack with a rh below that of the air surrounding the grain, will absorb the extra moisture and carry it out of the silo through the exhaust vents. The reverse is also true. Hence it is important that the operator makes judgements that introduce only air that best suits the storage strategy.

Grain aeration can be described as three processes: drying, cooling and maintenance. The amount of air passed through the grain is measured in litres per second per tonne and varies depending on the particular aeration strategy.

Grain under aeration will dry as air passes through the stack until equilibrium is reached. This is known as the equilibrium relative humidity, when the incoming air has the same rh as the air surrounding the grain. The volume of air passing through the grain and the rh will determine the speed of drying.

Aeration drying

An aeration drying system requires an air flow of more than 20 litres per second per tonne of grain. To achieve this volume of air you will need a very large blower or a medium sized blower and a small stack of grain. The grain will dry more efficiently in a shallow bed depth of up to three metres. This allows the faster passage of drying fronts.

Grain at 12% moisture content and a temperature of 22ºC has an equilibrium relative humidity of 55%. Selecting incoming air well below 55% will dry the grain. The speed of drying will increase if the relative humidity is considerably lower. Grain could be dried in several weeks in a standard silo with a high air flow and very low incoming relative humidity air.

Aeration cooling

Aeration cooling performs two tasks, cooling the grain and equalizing the moisture in the stack by transferring it from moist grain to dry grain.

Airflows of 2 to 4 litres per second per tonne are normal for this process. The aim is to remove heat accumulated during harvest and cool the grain quickly. This assists to protect the grain from mould development and self heating. Canola can be stored safely below 20°C with up to 9% moisture content. Higher moisture canola should be stored below 18ºC. When harvesting moist grain, aerate continuously as it is loaded for at least 48 hours to stabilise the internal temperature. Then only switch on the fan during the coolest part of the day until the target temperature is reached. In a deep bed silo (>6 metres) this process may take several weeks if ambient conditions are unfavourable.

Aeration maintenance

When stored grain has been cooled, fans are used intermittently to maintain the required temperature. The number of fan-hours per month will depend on ambient temperature and humidity. To remove the guesswork from cooling and maintenance phases it is recommended the aeration fan be connected to a controller. The standard lower cost unit operates by selecting the coolest part of the day. The more expensive units have a selection function that allows grain conditioning to a desired outcome.

Harvest benefit from aeration

Aeration is a valuable tool that can extend the harvesting window in the southern cropping areas. It will enable harvesting of crops before they become weather damaged (i.e. when they are at optimum quality but still too moist for delivery). The problem will always be the logistics of handling large amounts of seed as it is harvested.

Large aerated silos or sheds can keep the grain cool and safe but drying will be limited unless there is a very high airflow. A grain drier will bring the grain to delivery standard in a known time but the removal of moisture in an ambient air drier will be subject to the rh and temperature of the day.

Drying with heat

Drying canola with a heated air grain dryer is not without risk. Overheating of the grain will cause the destruction of the seed germ and the release of free fatty acids. Seed dried to below 6% moisture content (mc) is more vulnerable to cracking.

Generally, wetter seed (>12% mc) requires a longer drying time using a lower air temperature.

Selection of dryer type is a consideration in selecting the plenum air temperature. Seed in a batch dryer that is next to the plenum chamber will reach a temperature approaching the heat of the incoming air. For this reason the air temperature in a batch dryer, for up to 10% mc canola, should be a maximum of 40°C for seed and 65°C for crushing grain.

Continuous flow dryers can be a cross flow design, where the air from a central plenum blows directly through the grain column, or a mixed flow type where the air is blown in and exits through ducts in the grain bulk.

Cross flow dryers also have potential to overheat the seed, depending on the speed of flow through the machine. Care should be taken to ensure the temperature does not exceed 45°C for seed and 70°C for processing canola.

Mixed flow dryers are less likely to cause damage due to the mixing of the grain and shorter resident time close to the heated air ducts as it progresses though the machine. Plenum air temperatures can be slightly higher at 49°C for seed and 82°C for processing grain.

Most grain dryers are set up for handling cereal grains and contain perforated mesh. It is important to chech there is no canola loss through the mesh or that the seeds are lodging in perforations. Mixed flow dryers do not have perforated ducts and are able to accommodate all seed sizes.

11 Further reading and advice

11.1 Acknowledgements

Major references

1.	*Canola Growers' Manual*	Canola Council of Canada
2.	*Canola in Australia—the first thirty years*	AOF website
3.	*Quality of Australian Canola*	NSW Agriculture & AOF
4.	*The biology and ecology of canola*	Gene Technology Regulator
5.	*Growing Golden Canola*	DAWA
6.	*Profitable Canola Production in the Eastern Grain belt WA*	DAWA
7.	*Profitable Canola Production in the Great Southern and Lakes District*	DAWA
8.	*Profitable Canola Production in the Central Grain belt WA*	DAWA
9.	*Profitable Canola Production in the Northern Grain belt WA*	DAWA
10.	*Profitable Canola Production in the South Coast Region*	DAWA

Further reading

1.	*Canola: The Ute Guide* (Stanley and Marcroft)	Topcrop Australia/GRDC
2.	*Managing Blackleg Bulletin 4571*	DAWA
3.	*Managing Blackleg and Sclerotinia*	Topcrop Australia/GRDC
4.	*Diseases: The Back Pocket Guide*	Topcrop Australia/GRDC
5.	*Pulse and Canola—Frost Identification/GRDC*	DAWA
6.	*Crop Insects:* The Ute Guide(Western Ed.)	DAWA/GRDC
7.	*Identification and Cultural Control of Insect & Allied Pests of Canola*	DAWA
8.	*2005 and 2006 Growing Western Canola Grower Updates*	AOF website/Oilseeds WA page
9.	*Canola Grower Case Studies*	AOF website/Oilseeds WA page

Department of Agriculture Publications

Most of these publications are available electronically at: www.agric.wa.gov.au

Farmnotes

29/1995.	Sulphur deficiency in canola
10/1998.	Phosphorus requirements of canola compared with wheat
29/1994.	Fungal diseases of canola
50/2004.	Update to high rainfall (>450mm) canola production package 2004
5/1994.	Take-all disease of cereals
51/2004.	Managing the sylvestris resistance breakdown risk in canola
49/2004.	Update to medium rainfall (450–325mm) canola production package 2004
9/1995.	European earwigs threaten high-yield crops
45/2004.	Aphid management in canola crops
15/2001.	Management of native budworm in pulse and canola crops in the southwest of Western Australia
80/1993.	Managing waterlogging and inundation in crops
97/1996.	Bedstraw
1/2005.	Chemical control of insect and allied pests of canola
77/1999.	Warehouse beetle (Trogoderma variabile)
24/1999.	Measuring canola harvest losses.

Fact Sheets

16/2001.	Aster yellows and its most effective vector, the aster leafhopper Macrosteles quadrilineatus: exotic threats to Western Australia

11.2 Key contacts

Oilseeds WA (Oilseeds Industry Association of WA)

John Duff	08 9475 0753 Email: jd@consultag.com.au
Australian Oilseeds Federation	www.australianoilseeds.com
Canola Association of Australia Inc	www.canolaaustralia.com
AAAC (Australian Association of Agricultural Consultants)	www.aiast.com.au/aaac.php
Department of Agriculture WA	www.agric.wa.gov.au
ACAS National Variety Testing Database	www.acasnvt.com.au

Seed companies in WA

For more details on varieties refer to seed company websites.

Heather Cosgriff	Pacific Seeds	0429 619 103
Milton Sanders	Canola Breeders WA	0427 013 951
Neil Harris	DOVURO	0427 090 431
Tim O'Dea	PlantTech	0429 203 505
Wayne Loughrey	Pioneer Hi-Bred	0408 943 490

Input suppliers

Bevan Addison	Elders Pty Ltd.	9422 2391
Eddy Pol	AWB Landmark	9318 8150

Agronomists who specialise in canola agronomy

(who provided advice to the editors of this publication)

David Sermon	ConsultAg—Belmont	9475 0311
David Eksteen	United Farmers—Esperance	9072 1155
Craig Topham	Agrarian Management—Geraldton	9964 5191
Tim Tresize	Agrarian Management—Kojonup	9831 0175
Quenten Knight	Precision Agronomics Australia —Esperance	9072 0004
Travis Hollins	Progressive Agronomics	9047 1700
Graham Walton	Department of Agriculture	9368 3333
Brian Leach	John Duff & Associates	9475 0753

Crushers

Joe Young	Kojonup Oils	9833 6267
Jon Slee	Riverland Oilseed Processors	9531 2022

Exporters

Rob Dickie	Grain Pool of WA	9216 6000

Refiners

Ashley Palmer	Alba Edible Oils	9431 7255
Brian Evans	Goodman-Fielder	9722 3402

Notes:

Notes:

GRDC
Grains Research & Development Corporation

Oilseeds WA

Department of Agriculture
Government of Western Australia