



Department of  
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# Irrigated canola in southern cropping systems



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*Promoting irrigated agriculture*



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## Acronyms used in this publication

<b>BMP</b>	Best Management Practice
<b>CIA</b>	Coleambally Irrigation Area
<b>CWFS</b>	Central West Farming Systems
<b>GRDC</b>	Grains Research and Development Corporation
<b>ICC</b>	Irrigated Cropping Council (Victoria)
<b>IREC</b>	Irrigation Research and Extension Committee
<b>MFMG</b>	MacKillop Farm Management Group
<b>MIA</b>	Murrumbidgee Irrigation Area
<b>NSW DPI</b>	New South Wales Department of Primary Industries
<b>SFS</b>	Southern Farming Systems
<b>SARDI</b>	South Australian Research and Development Institute
<b>VSAP</b>	Variety Specific Agronomy Package
<b>ML</b>	Megalitre

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# Introduction

This manual provides an outline of the best management practice principles to consider for high-yielding irrigated canola production in south-eastern Australia. It is an output of the 'Southern irrigated cereal and canola varieties achieving target yields' project (2014–17) that aimed to demonstrate an increase in irrigated cereal and canola production.

A series of research experiments were conducted to identify the optimum cereal and canola varieties and their associated agronomic management practices to maximise production in irrigated farming systems in south-eastern Australia. An overview of the project including outputs and experiment locations can be found in Appendix 1.

Organisations that have conducted research experiments for the project are NSW DPI (Murrumbidgee Valley, NSW; Murray Valley, NSW), Irrigated Cropping Council (Northern Victoria), Southern Farming Systems (Tasmania), MacKillop Farm Management Group (south-east South Australia), Central West Farming Systems (Lachlan Valley, NSW) and Ag Grow Agronomy & Research (Lachlan Valley, NSW).

Regionally relevant variety specific agronomy packages (VSAPs) containing detailed outcomes from each research location have also been produced.

The project (DAN00198) had joint investment from NSW Department of Primary Industries (NSW DPI) and the Grains Research and Development Corporation (GRDC).

## Irrigated canola production in south-eastern Australia

Canola is a valuable crop in irrigated farming systems in south-eastern Australia. The area of grain and dual purpose canola has expanded and increased gross margin profitability on high value irrigation land throughout south-eastern Australia.

Canola can significantly increase yield of the following wheat crop, primarily by acting as a break crop for weed and disease cycles, and is a profitable crop in its own right. It is an alternative to high water use crops such as rice when water allocations are low or water prices are high. It also has a sound fit in cotton farming systems following recent expansion of the cotton industry in southern NSW.

There is significant potential to increase irrigated canola production in southern NSW through better varietal selection and agronomic management. Research in dryland cropping systems has proven the positive impact of correct canola varietal selection and best practice agronomic management on grain yield and quality. However, these recommendations are not necessarily valid in irrigated cropping systems and further research is required in irrigated farming systems.

Higher and more stable yields are needed for growers to lock canola into the crop rotation. Prior to 2003 the average irrigated canola grain yield in southern NSW and northern Victoria was 2.2 t/ha with the top 20% of growers reaching 3.0 t/ha (Jones 2008). However, target yields are now commonly 4 t/ha which is achievable in favourable seasons (mild spring temperatures) when best management practices are employed. Under experimental conditions, irrigated canola crops have yielded over 5 t/ha in northern Victoria (experiment average 4.2 t/ha) (Jones 2008).

Paddock selection (suitable soil type), varietal choice (with good disease ratings), crop nutrition, irrigation management (layout and scheduling), sowing time and nutrition management are some of the key management areas for high-yielding irrigated canola crops. Crop establishment (including plant population and sowing date), weed management and soil moisture monitoring is also crucial. High yielding irrigated canola crops require a higher level of management with a commitment to higher inputs, determined by the target yield.

## Key project outcomes

Key outcomes of the irrigated canola component of the irrigated cereal and canola project include:

- Varietal selection has a highly significant effect on irrigated canola grain yield. Select varieties that are proven to consistently produce high yields in your area.
- Nitrogen management will affect grain yield and quality, and also lodging. Avoid high nitrogen levels early in the season to prevent excessive lodging.
- Plant population will affect establishment and grain yield. Irrigated canola plant populations should be between 30 and 50 plants/m<sup>2</sup> (up to 70 plants/m<sup>2</sup> in southern areas including Tasmania).

## Key management areas

<b>Paddock selection</b>	Select paddocks with good soil structure that are not hard setting and have good internal drainage.
<b>Irrigation layout</b>	Use layouts suitable for your soil type with minimal watering and drainage periods where possible.
<b>Crop sequencing</b>	Include break crops in the rotation for weed and disease management.
<b>Soil moisture at sowing</b>	Soil moisture at sowing is essential for optimal emergence and crop stand. Pre-irrigate or irrigate-up, if necessary, to ensure adequate soil moisture at sowing.
<b>Variety</b>	Select a variety that is proven to consistently reach your target yield in your region.
<b>Sowing time</b>	Sow within the recommended sowing window for your region and the variety selected (under irrigation).
<b>Establishment</b>	Aim for a plant population of 30–50 plants/m <sup>2</sup> for maximum grain yield (50–70 plants/m <sup>2</sup> in southern areas including Tasmania).
<b>Grazing</b>	Avoid overgrazing, especially at critical growth stages.
<b>Nutrition</b>	Use soil test data and target grain yield to tailor your fertiliser program. Leaf tissue testing in-crop is helpful for foliar trace element adjustments and assisting with N and K topdressing requirements.
<b>Weeds, pests &amp; diseases</b>	Control weeds, pests and diseases with break crops and pesticide application as required.
<b>Irrigation scheduling</b>	Monitor soil moisture to accurately schedule irrigation events. Avoid moisture stress and waterlogging at critical growth stages.





# Irrigation management

John Smith and Brian Dunn, NSW DPI Yanco

The greatest benefit of being able to irrigate a canola crop is that it provides the grower with a high degree of confidence that an economic return will be obtained from inputs applied. This allows growers the opportunity to increase inputs with greater assurance that higher grain yields and profits will result.

Irrigation water is one of the most limiting resources within an irrigated farm business and needs to be managed in a way that maximises return (\$/ML) within the irrigation system. Water prices for the temporary trade of water in the Murray Valley have averaged \$139/ML from 1998/99–2015/16 with a range of \$58–\$274/ML ([www.murrayirrigation.com.au](http://www.murrayirrigation.com.au)). This highlights how quickly water can become a significant cost to an irrigation enterprise, especially if used inefficiently.

Given the increasing value of irrigation water it is becoming increasingly important that the irrigation water resource be used wisely to achieve the best return to the grower. Crop productivity (t/ha) and profitability (\$/ha) have historically been used as the standard measures of crop production success, but given the increasing value of water, water productivity (t/ML) and profitability (\$/ML) are now more useful measures.

Water productivity in irrigation farming systems, defined as tonnes of product per megalitre (ML) of irrigation water, is influenced by four areas of irrigation system management:

1. Opportunity time (water on/off time) – This refers to the period of time between the soil first being covered with water and surface drainage complete leaving any remaining surface water to infiltrate into the soil.
2. Irrigation layouts/systems – Different layouts and irrigation systems are suited to different soil types and influence crops grown and yield potential. They may also influence decisions around water priorities, particularly in seasons with limited water availability.
3. Irrigation management – This depends on irrigation layout and the water budget in each season. More efficient layouts offer the opportunity for higher yield potential and better response to more irrigations allowing fully scheduled irrigated production. Limited water may dictate partial spring irrigation of crops and when combined with better layouts the return from the available water is maximised.
4. Irrigation scheduling – Soil and plant-based tools that enable better matching of soil water availability to plant requirements are useful for management of irrigation timing in fully irrigated crops which can increase water productivity.

## Opportunity time

The most important factor in the success of most irrigated crops is the length of time from when water is first applied to the soil surface to when soil surface drainage is complete. If this period is too long there is limited opportunity for remaining surface water to infiltrate into the soil and waterlogging will often occur with subsequent negative impacts on plant growth.

If the opportunity time is too short, then the amount of water applied to the bay within the flooded irrigation system will be inadequate and may lead to patchy water infiltration within the bay leading to variable crop growth and reduced yield potential. In addition to the low and variable coverage of the crop, further irrigations will need to be scheduled within the growing season to ensure that crops are not water stressed within the fully irrigated cropping system. Getting the balance between minimising opportunity time and refilling the soil profile with



sufficient plant available water is becoming more important in automated systems on lighter soil types.

The maximum opportunity time depends on soil type and irrigation layout and is important because it influences the period of waterlogging following each irrigation. Waterlogging has a cumulative effect on plant production and each waterlogging period further impacts growth and development of the crop.

Maximum opportunity time targets are:

- Overhead irrigation – system uniformity is much more important than opportunity time in overhead irrigation as water application is over a very short period of time (less than one hour)
- Border check – 6 hours
- Rice layouts (poorly-structured soils) – 10 hours, including sodic soils (with soil management practices to improve their physical fertility)
- Rice layouts (well-structured soils) – 18 hours for better draining non-swelling soils (red-brown earths).

Opportunity times greater than those listed can significantly reduce water productivity. Research conducted by NSW DPI in the Murrumbidgee Valley has shown that extending the opportunity time from 6 to 48 hours on soil with good drainage resulted in a 25% reduction in water productivity in irrigated wheat (Dunn et al. 2016). A similar or higher impact would be expected in irrigated canola with the severity of the grain yield decline determined by growth stage of the crop and duration of waterlogging. Generally, waterlogging conditions that reduce crop biomass will reduce grain yield.

A key aspect of reducing opportunity time is to improve drainage and reduce the recession time of water. Often, supply rates are adequate but excessive drainage times from the field are the problem.

## Irrigation layouts/systems

The choice of irrigation layout or system will depend on several factors including soil type and structure, topography, other crops in the rotation and economic constraints of capital improvement. Good irrigation layouts that allow fast irrigation and most importantly shorter drainage times will result in higher water productivity, grain yields and profitability.

Irrigation layouts and systems should ideally be matched to the specific soil types (Table 1). If they are not matched to soil types, water productivity may be compromised requiring greater emphasis on irrigation management to minimise the risk of waterlogging.

Table 1 Irrigation systems and the range of soil types that they are most suited to.

Irrigation system	Soil type
Overhead irrigation	Red-brown earths Sandhill soils All Tasmanian cropping soils
Border check	Red-brown earths Transitional red-brown earths Self-mulching and non-self-mulching clays
Raised beds	Self-mulching clays Red-brown earths Non-sodic transitional red-brown earths
Rice layouts	Non-self-mulching clays Red-brown earths Transitional red-brown earths

### Overhead irrigation

Overhead irrigation systems are best suited to lighter soil types with high infiltration rates or undulating topography where the cost of landforming is extremely high. Soils that disperse are generally not suited to spray irrigation systems. Overhead irrigation systems allow for high water productivity and often lower crop water use compared with flood irrigation systems, and also have less risk of waterlogging occurring.

The flexibility of water management that overhead irrigation offers also means that they allow the application of light irrigations enabling the establishment of crops on time and irrigation during dry winters when surface irrigation is too risky. The biggest disadvantage of overhead irrigation is the high cost of initial capital investment, operation and maintenance.

### Border check

Border check is a common layout often used for irrigated canola as it suits a large range of soil types. The entire soil surface is flooded which can increase the risk of waterlogging, particularly if the slope and length of runs do not match the soil type. It is important that the field can be irrigated and all surface water drained within 6 hours, or less on very heavy soils, to reduce waterlogging risk.

Border check can be utilised over a range of slopes but as the slopes become flatter the length of runs will need to be shorter so the irrigation flood and drain time of less than 6 hours can still be achieved.

### Raised beds

Raised beds allow for improved drainage and significantly reduce the risk of waterlogging and surface crusting as the entire soil surface is not covered with water. Raised beds are suitable for most soil types except light textured soils as the water subs up from the furrows into the beds due to capillary action which is most successful on heavier clay soils.

Bed width varies according to soil type with beds on red-brown earths and non-self-mulching clay soils narrower (1–1.5 m wide) while on self-mulching clay soils that sub better the beds are generally wider (1.8–2 m wide). Another major advantage of raised beds is they allow the opportunity for double cropping winter and summer crops and when established in a bankless channel layout provide maximum flexibility.

### Rice layouts

Rice irrigation layouts are usually landformed and laser levelled with rectangular bays and drainage recycle systems. Rice layouts often have adequate slopes and suitable sized irrigation structures that allow good supply of water. Drainage is generally the main problem in these layouts due to the slopes causing back-up of water in preceding bays. Opportunity times as long as 40–50 hours have been identified, resulting in waterlogging periods of 100–150 hours (4–6 days). Improved design of existing layouts and alternative layouts such as bankless channels and V bays are enabling better drainage, with appropriate design and infrastructure, with opportunity times of 10 hours, thus allowing irrigated canola to be successfully grown in rice layouts.

## Irrigation management

### Sowing and watering up

Shallow sowing and watering up is the preferred method to establish canola when grown on raised beds and on soils that have good structure that are not likely to slake or crust. Good drainage is essential for this practice to be successful. Sow and irrigate when soil temperatures are generally higher (7–30 April) to ensure establishment prior to the onset of cooler, wetter winter conditions. When watering up on border check layouts dry subsoil is a definite advantage.

### Pre-irrigation

In flood irrigated layouts, pre-watering might be used to germinate weeds for control before sowing, or to settle the seedbed. However, due to unevenness in soil types, the paddock usually dries unevenly and makes it difficult to sow seed into moisture. Pre-watering also uses more water and adds to growing costs.

### Spring irrigation

Spring irrigation of a canola crop is one of the major factors influencing grain yield. The decision of when and how often to irrigate is complex and depends on several factors including available soil moisture, rainfall, time of irrigation water availability in relation to plant development, potential yield benefit, risk of waterlogging or lodging, and returns from using the water on another crop or selling it.

A fully irrigated canola crop will require between two and four spring irrigations to achieve maximum grain yield, depending on the irrigation system being used, location, rainfall and soil water holding capacity. In a dry winter when the soil profile is dry to depth it is very important to irrigate it as soon as possible in the new irrigation season (usually early–mid August) or significant grain yield reduction will occur.

When irrigation water is limited, one irrigation applied at early flowering will give the best grain yield response and economic return in a dry season. Canola is very sensitive to moisture stress at flowering, particularly early flowering, and moisture stress during this period can dramatically reduce grain yields. Supplying adequate moisture to the crop at this time will maximise the number of pods that set seed and later irrigations will maximise seed size.

Canola is less tolerant of waterlogging in the period from flowering to maturity than most cereal crops. It is therefore very important that the opportunity time with each irrigation or large rainfall event is within the guidelines for each soil type, or reduced grain yield will occur.

### Irrigation scheduling

Scheduling when irrigations are applied to a crop is important to ensure that the crop is irrigated before moisture stress occurs but also not irrigated more frequently than required.

There are several methods available to assist with irrigation scheduling. The methods are divided into either plant based or soil based tools. Daily evapotranspiration (ET<sub>o</sub>) figures are a common plant based tool while soil capacitance probes and gypsum blocks are both soil based options. Other plant indices are being developed using plant based methods that will increase the ease of irrigation scheduling and offer the advantage of identifying in-field variability throughout the season.

The use of ET<sub>o</sub> requires growers to access weather data from the internet and keep records for each of their fields. A crop coefficient that depends on the growth stage of the crop is also required. Once familiar with using this method and the plant available water for each soil type it is easy to use and also valuable for predicting when future irrigations will be required.

There are several providers of services to install and monitor soil capacitance and gypsum blocks as well as an increasing number of data logging methods allowing the soil moisture data to be accessed in the field or in real-time from the internet. It is important that this equipment is installed in locations that are representative of the majority of the field or the results may be misleading.

Regardless of method used, it is important to monitor crop water use in order to avoid crop moisture stress. Do not allow soil water to deplete below 60% of plant available water capacity (PAWC) referred to as readily available water (RAW). The point of timely irrigation is commonly known as the 'refill point'. Plant growth and yield potential will decline considerably if soils are allowed to dry down beyond the point of RAW, which is particularly important in crops fully irrigated for maximum yield potential. Readily available water will vary across soil types (Table 2).

Table 2 Estimate of readily available water (0–60 cm) for a range a soil types.

<b>Soil texture</b>	<b>Readily available water (mm) to a depth of 60 cm</b>
Sand	24
Sandy loam	42
Clay loam	48
Medium to heavy clay	39

Successfully growing an irrigated canola crop and achieving high levels of water productivity is dependent on matching the layout with the soil type and creating bay sizes that allow ponded water to be on the field for as short as practical, preferably less than 10 hours.

Reducing the number of irrigations can often increase water productivity in irrigated canola but it is important that timing of the irrigations are planned to maximise grain yield.



# Varietal selection

**Rohan Brill**, NSW DPI Wagga Wagga and **Don McCaffery**, NSW DPI Orange

Canola has been developed and improved as a dryland oilseed, with little emphasis placed on plant varietal characteristics that suit the irrigated environment. Most company seed production is however conducted under irrigation, but for hybrids, is managed differently to a commercial crop.

This guide is targeted at irrigated canola that is grown across a wide range of environments, soil types and irrigation systems. For this reason the underlying principles will need to be adapted for each situation and especially for outside of NSW.

All canola varieties can be grown under irrigation. Currently there are over 50 varieties from which to choose. Varieties vary in yield potential, disease resistance, phenology (progression through growth stages), harvest maturity time, and other characteristics such as seedling vigour. Most canola varieties will have a market life of 3–5 years. Since 2007, between eight and 21 new varieties have been released annually and a similar number were withdrawn. Yield and disease resistance (primarily blackleg) are the two most important breeding objectives in new varieties.

Canola breeding has also developed varieties with different oil quality profiles for specific food markets, for example high oleic, low linolenic fatty acid oil profiles which currently attract a premium price. Research is also underway to bring to market a variety with high Omega-3 fatty acid oil.

Variety selection needs to best match the irrigation layout and the management objectives of the grower. For example, will the crop be grown for grain only under flood, furrow or overhead spray (centre pivot and linear move) irrigation, or as a dual-purpose crop under spray or flood irrigation for prime lamb production and for grain?

The five top features desired in a canola variety for irrigation are:

1. High yield potential with high harvest index (HI) and early to mid–early maturity
2. Strong seed and seedling vigour
3. Medium plant height with lodging resistance
4. Good disease resistance
5. Herbicide tolerance to suit the paddock weed spectrum.

## High yield potential with high harvest index

Commercial experience with irrigated canola in the main irrigation areas of southern NSW over the past two decades suggest that early to mid–early maturing varieties (Table 3) have been the highest yielding. Figure 1 and Figure 2 highlight the phenology differences of several commercially available canola varieties. Note especially the phenology differences from early sowing (12 April).

Longer maturing varieties require more water and are potentially exposed to higher spring temperatures during flowering and grain-fill. Long season varieties also have a tendency to be taller and more prone to lodging. Shorter season varieties flower rapidly which can limit grain yield potential in medium to high rainfall dryland environments but in low rainfall irrigated environments early flowering has negligible effect on yield potential as there are higher levels of solar radiation in winter.

Triazine tolerant varieties are generally lower yielding as they are inherently less efficient at converting solar radiation to biomass (see ATR Bonito in Figure 3) which limits grain yield potential. Canola varieties for irrigation need to grow sufficient biomass to achieve grain yield potential and also be able to convert the biomass into grain yield i.e. have a high harvest index. Harvest index (HI) is the ratio of harvest seed weight to the total above ground harvest biomass (seed plus whole plant dry matter). Canola commonly has a HI of about 0.27 but can range from 0.20 to 0.35. At Finley in 2016 there were only small differences between the biomass of four non-TT hybrid varieties (one TT variety was much lower) at maturity but one variety, Nuseed Diamond, had a high harvest index and hence high grain yield (Figure 3).

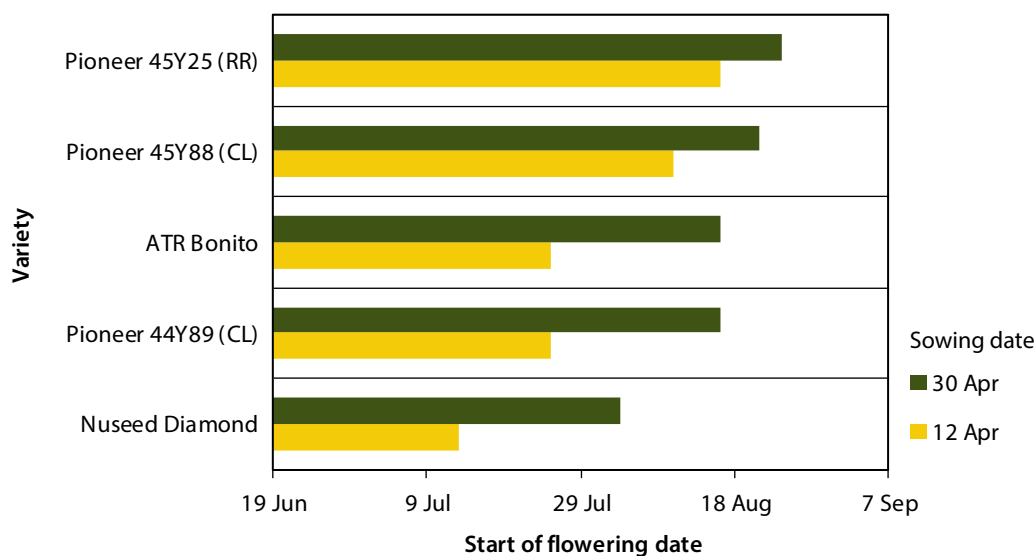


Figure 1 Start of flowering (defined as date when 50% of plants have one open flower) of five varieties sown at two sowing dates at Finley in 2016. Nuseed Diamond was 34 days faster to flowering than Pioneer® 45Y25 (RR) when sown on 12 April.



Figure 2 Canola varieties vary in their phenology. In this experiment sown on 12 April 2016 at Finley, southern NSW Nuseed Diamond (left) was quickest to flower followed by Pioneer® 44Y89 (CL) (centre) and then Pioneer® 45Y25 (RR) (right) which was slowest to flower (photo taken 22 July 2016).

## Strong seed and seedling vigour

Hybrids have been generally superior to open-pollinated (OP) varieties in irrigated situations. Part of the reason for this is stronger seedling vigour leading to better and more uniform establishment across variable soil types. Research on dryland crop establishment in central NSW in 2012 and 2013 showed that hybrid varieties had better establishment than OP varieties. This is primarily due to the larger seed size of hybrids but also partly to the 'hybrid vigour' trait.

Table 3 Selected varietal characteristics of canola varieties. Data current as of November 2017.

Variety	Marketer	Year released	Open-pollinated (OP) or hybrid	Harvest maturity #	Blackleg (September 2017)	
					Rating	Resistance group
<b>Conventional</b>						
AV-Garnet	Nuseed	2007	OP	Mid to mid-early	MS	A
Nuseed Diamond	Nuseed	2015	hybrid	Early	MR	ABF
Nuseed Quartz	Nuseed	2018	hybrid	Mid to mid-early	R	ABD
SF Brazzil	Seed Force	2013	hybrid	Very late-winter type	R-MR	BC
<b>Specialty Conventional</b>						
Victory V3002	AWB	2012	hybrid	Early-mid	MR	ABF
<b>Triazine Tolerant (TT)</b>						
ATR-Bonito	Nuseed	2014	OP	Early to early-mid	MS	A
ATR-Mako	Nuseed	2016	OP	Mid-early	MR	A
ATR-Stingray	Nuseed	2011	OP	Early	MR	C
ATR-Wahoo	Nuseed	2014	OP	Mid-late	MS	A
DG 560TT	Landmark	2016	hybrid	Mid	MR	BF
DG670TT	Landmark	2017	hybrid	Mid-late	MR	BF
Hyola 350TT	Advanta	2018	hybrid	Early	R	ABDF
Hyola 559TT	Advanta	2013	hybrid	Mid	R-MR	ABD
Hyola 650TT	Advanta	2014	hybrid	Mid-late	R	ABD
HyTTec Trophy	Nuseed	2018	hybrid	Early to early-mid	n.d.	n.d.
InVigor T4510	Bayer	2017	hybrid	Mid	MR-MS	BF
Pioneer 44T02 (TT)	Pioneer	2017	hybrid	Early-mid	R-MR	ABD
Pioneer 45T01 (TT)	Pioneer	2016	hybrid	Mid	MS	AB
SF Ignite TT	Seed Force	2017	hybrid	Mid to mid-late	MR	BF
SF Turbine TT	Seed Force	2016	hybrid	Early-mid	MR-MS	BF
<b>Specialty TT</b>						
Monola 416TT	Nuseed	2016	OP	Early-mid	MR	B
Monola 515TT	Nuseed	2015	OP	Mid	MR	Unknown
<b>Imidazolinone Tolerant (Clearfield®)</b>						
Banker CL	Heritage	2015	hybrid	Mid-late	MR-MS	A
HSHC1503CL	Heritage	2018	Hybrid	Mid to mid-early	MR	B
Hyola 575CL	Advanta	2011	hybrid	Mid to mid-early	R	BF
Hyola 970CL	Advanta	2014	hybrid	Late - winter type	R	H
Pioneer 43Y92 (CL)	Pioneer	2015	hybrid	Early	R-MR	B
Pioneer 44Y90 (CL)	Pioneer	2017	hybrid	Early-mid	R-MR	B
Pioneer 45Y91 (CL)	Pioneer	2017	hybrid	Mid	MR	B
SF Edimax CL	Seed Force	2015	hybrid	Late - winter type	R-MR	C
<b>Specialty IMI</b>						
Victory V7001CL	AWB	2016	hybrid	Late	MR	ABF
Victory V7002CL	AWB	2018	hybrid	Early-mid	n.d.	n.d.
<b>Roundup Ready®</b>						
DG 408RR	Landmark	2018	hybrid	Early-mid	MS	AC
DG 460RR	Landmark	2016	hybrid	Early-mid	MR	A
Hyola 404RR	Advanta	2011	hybrid	Early-mid	R-MR	ABD
Hyola 506RR	Advanta	2018	hybrid	Mid-early	R	ABD
IH51 RR	Bayer	2015	hybrid	Mid	MR-MS	A

Variety	Marketer	Year released	Open-pollinated (OP) or hybrid	Harvest maturity #	Blackleg (September 2017)	
					Rating	Resistance group
InVigor R 3520	Bayer	2018	hybrid	Early to early–mid	MR	Unknown
InVigor R 5520P	Bayer	2017	hybrid	Mid	MR	AC
Nuseed GT-42	Nuseed	2016	hybrid	Early to early–mid	R	ABDF
Nuseed GT-53	Nuseed	2017	hybrid	Mid	R	ABDF
Pioneer 43Y23 (RR)	Pioneer	2013	hybrid	Early	MR	B
Pioneer 44Y27 (RR)	Pioneer	2018	hybrid	Early–mid	MR	B
Pioneer 45Y25 (RR)	Pioneer	2015	hybrid	Mid	MR	BC
<b>Specialty RR</b>						
Monola G11	Nuseed	2015	hybrid	Early–mid	R–MR	ABS
Victory V5003RR	AWB	2016	hybrid	Mid	MR	A
<b>Dual Tolerance TT and RR</b>						
Bayer 3000TR	Bayer	2016	hybrid	Early–mid	MS–S	B

# The relative maturity of varieties can vary depending on location and sowing date.

Note: maturity terminology is supplied by the seed companies. A description of mid to mid–early indicates variety is slightly earlier than a true mid–maturing variety.

## Medium plant height with lodging resistance

The primary cause of lodging in canola is root lodging (poor anchorage) rather than stem lodging (though ‘tabling’ often occurs). Root lodging is exacerbated in flood irrigated crops as the soil around the crown remains soft for extended periods (following rainfall or irrigation) during pod-fill stages. The effect of lodging can be twofold:

1. Decrease in photosynthetic ability and hence biomass production
2. Grain yield loss at harvest (and reduced harvest efficiency).

Selection of varieties with medium plant height and high harvest index will reduce the risk of crop lodging. Other management factors such as seeding rate and plant population, and nitrogen management will also affect crop lodging potential.

## Good disease resistance

The main diseases of irrigated (and dryland) canola are blackleg and sclerotinia. There is little difference in varietal resistance to sclerotinia but flowering date can have a large impact on disease development. Early sown fast developing varieties that flower in early–mid winter are more likely to be exposed to wet conditions with higher potential for disease infections.

There are differences in varietal resistance to blackleg. Varieties should be rated at least moderately resistant (MR) to blackleg and growers should be aware of blackleg resistance groups and rotate canola varieties based on these groups (see <https://grdc.com.au/GRDC-FS-BlacklegManagementGuide>).

## Herbicide tolerance to suit paddock weed spectrum

One of the primary roles of canola in the crop rotation is to control problem grass weeds. Canola varieties are currently available in five herbicide tolerance groups – conventional, triazine tolerant (TT), imidazolinone tolerant (IMI or Clearfield®), Roundup Ready® (RR) and tolerance to both triazine and Roundup Ready® (RT). New technologies will be commercially available from 2019. The Monsanto TruFlex™ Roundup Ready® canola trait and Pioneer’s Optimum™ GLY trait both offer greater flexibility with a wider application window for their respective glyphosate products. Breeders have begun ‘stacking’ herbicide resistance genes so that varieties might be resistant to multiple herbicide groups in the future, but will be accompanied with strict management or stewardship programs.



The herbicide tolerance group should be chosen according to the paddock weed spectrum. Generally hybrid non-TT varieties are more vigorous and have better establishment than OP TT varieties so the advantage of being able to use triazine herbicides may be offset by reduced crop competition. For further information on weed control options for canola see the NSW DPI *Weed control in winter crops*.

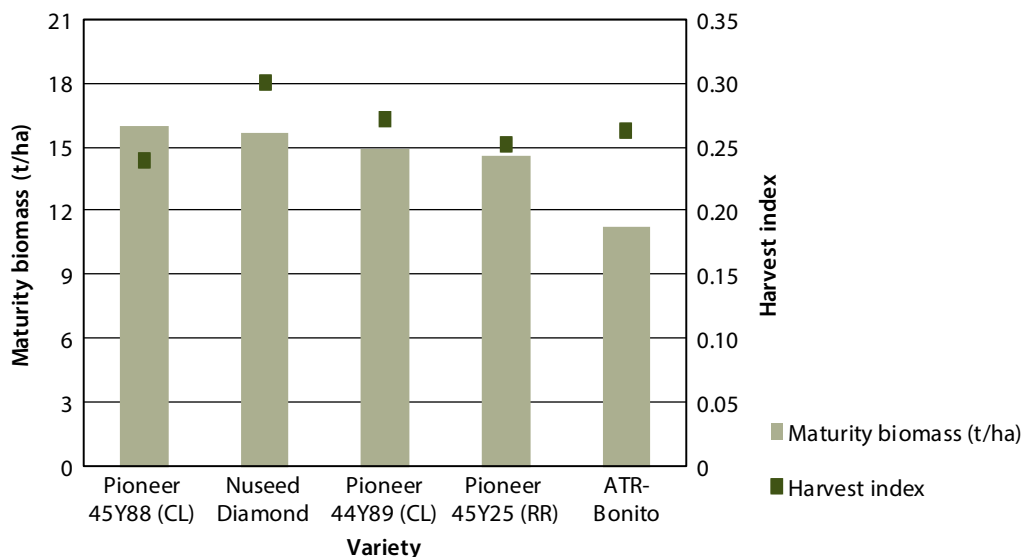


Figure 3 Maturity biomass and harvest index of five canola varieties at Finley in 2016. Varieties that grow high quantities of biomass and convert this into grain yield efficiently are best suited to irrigated canola cropping.

## Other information

### Dual purpose canola

Dual purpose (graze and grain) canola can be highly profitable with the right combination of variety and sowing date, especially in relatively cooler irrigated environments. The best suited varieties for dual purpose production are the winter types (Table 3) which can be sown anywhere from late spring to mid-autumn. Longer season spring varieties can also be grazed if sown early (into mid-autumn) but the grazing period will be shorter than for winter types. Dual purpose graze and grain varieties are proving profitable under irrigation.

### Variety testing

Recent releases of new specialty types with a premium might be just as profitable, or more profitable, than canola quality types. However, the plant type still needs to suit irrigation systems e.g. resistance to lodging.

Limited variety testing under irrigated conditions has been undertaken over the past two decades and all National Variety Trials (NVT) are conducted at dryland sites. Variety evaluation has been conducted under irrigation at Kerang in north-west Victoria over a number of years, and recently varieties have been evaluated at Leeton in the Murrumbidgee Irrigation Area (MIA), in the Coleambally Irrigation Area (CIA) and selected varieties with contrasting phenology have been evaluated at Finley in the Murray Valley of NSW.

New varieties should be evaluated alongside existing proven varieties to measure the benefit of adopting a new variety in each particular irrigated situation. State agencies publish canola variety guides each year and NVT data from dryland experiments can also be used to determine the consistency of a new variety's yield advantage over existing varieties. For up-to-date variety performance (yield and oil content) in NSW see the NSW DPI *Winter crop variety sowing guide*.

State legislation currently prevents the growing of or importation of genetically modified canola into Tasmania and South Australia, thereby limiting variety choice.



# Crop establishment

**Don McCaffery**, NSW DPI Orange and **Rohan Brill**, NSW DPI Wagga Wagga

Uniform and even establishment is the single most important factor for setting up an irrigated canola crop for high yield potential. Given the wide range of soil types, irrigation systems and environments where canola is irrigated, this chapter should not be viewed as a fool-proof recipe for success, but many of the principles can be adapted to individual situations.

Irrigated canola yields best in moderate to highly fertile self-mulching grey or brown soils (vertosols). These soils are generally the best for irrigated winter cropping, and for non-rice summer cropping. The red-brown earth and the transitional red-brown earth soils are generally not as high yielding as the grey self-mulching soils due to physical and chemical characteristics in the soil profile. Irrigation development and the use of laser landforming have changed the characteristics of most irrigation soils from their natural state.

## Paddock selection

Select paddocks with good soil structure and no subsoil constraints such as plough pans and soil acidity, or eliminate these constraints prior to sowing. Soil acidity should be ameliorated 6–12 months before sowing canola as lime must be thoroughly incorporated and needs time to react with the soil to change pH. Gypsum on the other hand should be applied to sodic surface soils closer to sowing as its effect on sodicity is more immediate. Retaining crop residue will also help to reduce surface soil dispersion, slaking and crusting. On sodic soils, gypsum application might be required every 3–4 years. As a general rule, canola should yield about 50–55% of wheat e.g. a paddock that consistently produces 7 t/ha of wheat has the potential to produce 3.5–3.8 t/ha of canola.

## Seedbed preparation

Canola is suited to either sowing into a cultivated seedbed, or as a direct drill crop where seedbed soil structure is good. Sow canola into a seedbed that has a firm base so that seed does not get buried too deep after rainfall or when irrigated.

## Sowing

The type of sowing method will depend on the irrigation system being used. Canola seed is small by comparison with other winter crops. It has epigeal germination, where the cotyledons must emerge above the ground, making it more difficult for germinating canola to push its cotyledons through soil compared to hypogeal germination crops such as wheat, field peas and chickpeas. For this reason seed should be sown no deeper than 10–15 mm in most circumstances, especially when dry sowing and relying on irrigation (or rainfall) for emergence.

The choice of sowing equipment will be based on what has worked best in the past across the range of soil types on the farm and conditions at the time of sowing. There have been many comparisons of disc and tyned seeders in dryland cropping, with each showing advantages in specific situations. Press wheels are best avoided on flood irrigated layouts as they contribute to hard-setting and surface sealing in all soil types (Figure 4). Soils are more likely to crack along the sowing line as the soil dries following disc sowing and watering up.

Growers have successfully established canola using a number of different methods. In flood irrigated layouts, pre-watering might be used to germinate weeds for control before sowing, or to settle the seedbed. However, due to unevenness in soil types, the paddock usually dries unevenly and makes it difficult to sow seed into moisture. Pre-watering also uses more water and adds to growing costs.

## Dry sow and water up

### Flood systems

In flood and furrow (bed) irrigation systems dry sowing and watering up is a common technique. In flood irrigated layouts soils will ideally have good structure and not be prone to slaking and crusting and drainage should be sufficient to avoid lengthy periods of waterlogging (see Irrigation management chapter). Some waterlogging is inevitable at the drainage end of these types of layouts (Figure 4). In cultivated paddocks large clods can be broken down by use of ridged or flexi rollers, or other implements, which firm the seedbed so that seed does not settle too deeply after watering up (Figure 5; Figure 6). In these situations seed is either sown with tyned or disc seeders, or broadcast on top of the soil ahead of watering. Aim to have seed covered by no more than 5–10 mm of soil after irrigating (Figure 7).



Figure 4 Establishing canola by broadcast sowing is contrasted in these two bankless channel flood irrigated bays at Darlington Point that have different soil type and structure, and drainage characteristics. The seedbed on the right was waterlogged for too long.



Figure 5 Producing a firm seedbed with good surface soil structure was the key to successful establishment from broadcast sowing and watering-up on this border check layout at Kerang (Image source: Damian Jones, ICC).



Figure 6 Emptied rice rollers have been used to break and compress clods, providing a firm seedbed in preparation for sowing before watering up at Coleambally. Note the shape of the furrows and ridges has largely remained intact meaning only a small amount of soil has covered the seed.



Figure 7 Early sowing (20 April) at Griffith was the key to getting this crop away to a quick start in a bankless channel system, lessening the risk of prolonged wet soil and slower establishment conditions typical of late autumn (Image source: Iva Quarisa, IREC).

### **Furrow irrigated bed systems**

In bed layouts seed can be sown to about 10–15 mm, a little deeper than in flood layouts (Figure 8). Disc seeders are more accurate than tined implements in placing seed more uniformly at shallow depths. The biggest risk with very shallow sowing is high autumn temperatures that dry the surface soil out too quickly for the newly germinated canola seed. One technique that has been used to manage this risk is to use the fertiliser box as a second seed box and to sow a proportion of the seed shallow (10 mm) and a proportion deeper (20–30 mm).



Figure 8 Raised bed systems are reliable for canola establishment when sowing dry and watering up on well-structured soils. The crop on the left (Griffith) was sown 10 mm deep into a prepared seedbed with a disc seeder and the crop on the right (Coleambally) had the seed broadcast into a 12 month maize fallow and lightly rolled with a flexi-roller. Each system used a light covering device (bars/chains or finger harrows).

### Overhead linear move irrigation

Linear move and centre pivot irrigators are used on a wide range of soil types so general principles vary (Figure 9). For soil that is not prone to hard-setting it is possible to sow seed shallow into dry soil then irrigate with at least 15 mm to germinate and establish crops. On hard-setting soils with low organic matter it might be better to either water prior to sowing with 15–30 mm or water after sowing with multiple smaller rates of irrigation. High rates of irrigation on hard-setting soils can cause saturation and dispersion of soil which then dries in an unstructured crust and restricts establishment. Self-mulching vertosols are less prone to crusting than red-brown earth soils but take higher rates of water to wet the seedbed.



Figure 9 It is important to match the amount of water to the soil surface characteristics when sowing dry and watering to establish the crop. Here, cereal stubble was removed by baling which left the root residue intact before sowing directly into the seedbed with a tyned seeder (Image source: Geoff McLeod, Finley NSW).

## Sowing seed

Hybrids generally have stronger seedling vigour than open-pollinated varieties – a desirable trait for many irrigation soil types that are higher in clay content than dryland soils. Stronger seedling vigour is mainly due to larger seed size but also to the hybrid trait. If farmer-retained seed of open-pollinated varieties is to be sown it should be graded to a seed size of >2 mm diameter to enhance establishment rates. Retained-seed should be laboratory tested for germination and vigour. A germination percentage of >95% is preferred. Anything less than

90% might indicate a seedling vigour problem; it is possible to have high germination but low vigour.

Seed should be treated with a protective fungicide and insecticide. It is essential to treat seed with a residual insecticide to protect young canola seedlings from direct feeding damage from aphids, earth mites and other pests and also to protect plants against possible transmission of *Turnip yellows virus* (previously named *Beet western yellows virus*) by the green peach aphid. Young canola seedlings are a target for aphid feeding if they become moisture stressed in warm autumn temperatures.

## Fertiliser at sowing

The nutrient demand of irrigated canola is high but care needs to be taken to avoid negative effects of both phosphorus and nitrogen on canola emergence. The combination of high phosphorus (P) rates and low seedbed utilisation can reduce canola emergence. Ideally seed should be separated from P fertiliser (Figure 10).



Figure 10 Twenty kg/ha of phosphorus (as triple super) applied with seed (left) compared to application split between two boots (right) using an Ausplow DBS parallelogram.

Nitrogen (N) fertiliser rates applied with seed should be kept to a minimum. If N is required at sowing, separating the seed from N is recommended for rates up to 25 kg N/ha. Broadcasting nitrogen before sowing at rates above 25 kg N/ha is safer than applying nitrogen in the seed furrow (even with vertical separation between seed and fertiliser). Broadcasting nitrogen before sowing at very high rates (200 kg N/ha) can reduce establishment, as can broadcasting N after sowing in front of irrigation as the fertiliser can wash into sowing furrows.

Sulfur (S) fertiliser may also be required on certain soil types. Soil tests to a depth of 150 cm have shown that sulfur levels in soils in central and north-western NSW are higher than assumed as much of the sulfur is available below the standard soil testing depth of 60 cm. This should be taken into consideration provided there is confidence that roots can access this deeper sulfur. The cheapest form of sulfur is gypsum (calcium sulfate), usually spread at a minimum rate of 400 kg/ha. Higher rates can be used to improve surface soil structure. Fine ammonium sulfate can be broadcast just before sowing with narrower spread passes and the more expensive granular ammonium sulfate can be spread either before or after sowing on wider passes. Like urea, ammonium sulfate should only be applied at low rates within the seed furrow. A third option for applying S is to use single super which contains both P and S. This can be applied at sowing but with separation to avoid the negative effects of P on establishment.

## Sowing date, target plant population and row spacing

### Sowing date

The sowing date decision is often a compromise between a number of factors including the variety's phenology, the optimum flowering period for the environment, availability of irrigation water and the irrigation system and establishment method. Canola can generally be sown seven days earlier in areas south of the Murrumbidgee Valley. Crops that are sown dry and watered up in flood irrigated layouts can also be sown earlier as establishment is slower (by seven days) in a seedbed that has been cooled and containing less oxygen after the irrigation.

Sowing in early–mid April in the Murray Valley of NSW and northern Victoria and mid–late April in the Murrumbidgee and Lachlan valleys will maximise yield potential. Flowering should be targeted to start before the onset of spring heat which often means that early–mid season varieties are the most reliable. Flowering can commence earlier in these western environments than in eastern dryland environments as the risk of frost is often lower and incoming solar radiation (energy for crop growth) in winter is higher.

In southern irrigated regions such as Tasmania and south-east South Australia where irrigated canola is mostly sown as a dual purpose crop, sowing of winter varieties can commence anywhere from spring onwards. Winter varieties require a period of cold temperature to initiate floral development so will not flower when growing through warm spring and summer conditions.

Current research is aiming to determine the optimum time for canola to start flowering across a range of environments that best fits acceptable frost risk and later season risk of heat and moisture stress. Sowing dates can then be determined for varieties of differing phenologies so that flowering occurs during the period with the least risk. Frost risk in irrigated canola is generally lower than in dryland regions, due in part to a more western warmer environment and partly due to higher soil moisture in the irrigated clay soils.

### Plant population

Irrigated canola crops should be sown at a sowing rate to achieve between 30 and 50 plants/m<sup>2</sup>. Higher plant populations have been shown to increase lodging risk, especially in flood irrigation systems. Lower plant populations (<30 plants/m<sup>2</sup>) can be targeted when sowing early, however establishment rates might also be lower from early sowing. An even plant population of 30 plants/m<sup>2</sup> or more is more important than targeting a specific plant population. Plant population targets for dual purpose crops are up to 25% higher and are aimed to grow more dry matter for grazing.

Sowing rates can be calculated using the following formula:

$$\text{sowing rate (kg/ha)} = \frac{\text{target plant population (per m}^2\text{)}}{(\text{seeds per kg}/10,000) \times \text{establishment \%} \times \text{germination \%}}$$

#### Example:

$$\begin{aligned} \text{sowing rate (kg/ha)} &= \frac{40 \text{ plants per m}^2}{(250,000/10,000) \times 60\% \times 95\%} \\ &= 2.8 \text{ kg/ha} \end{aligned}$$

Note: Establishment and germination should be entered as a decimal e.g. 80% = 0.8.

Establishment % can vary widely depending on a number of factors. A common establishment is 50–60% but could vary from a low of 20% to 80% or more.

A sowing rate calculator is available at <https://www.agric.wa.gov.au/canola/canola-seeding-rate-calculator-0>.

### **Row spacing**

A row spacing of 18–30 cm is best for irrigated canola. Hybrids can be sown on a wider row spacing than open-pollinated varieties because they develop ground cover much quicker and compete better with germinating weeds. Row spacings wider than 50 cm can increase lodging risk as there are usually more plants within the row with thinner stems and less root anchorage. Wide rows also increase the concentration of fertiliser in the seed row which can reduce establishment rates.





# Crop nutrition

Tony Napier, NSW DPI Yanco

A higher level of nutrient management is required for high yielding irrigated canola. Nitrogen (N) influences almost all components of plant growth including root growth, leaf growth, flower number and chlorophyll production. Insufficient N will reduce crop dry matter and flower numbers resulting in lower yields compared with an adequately fertilised crop. Oil content is largely influenced by moisture and heat stress but varietal type and nitrogen management can also affect grain oil content.

High yielding irrigated canola crops with high oil content (above 42%) require adequate nitrogen levels for the target yield. To achieve a 4 t/ha canola crop, approximately 14 t/ha biomass is required with a harvest index of 0.28.

Canola dry matter production and thus plant nitrogen requirement is relatively low during the early emergence and rosette stages, prior to the commencement of stem elongation and branch initiation. Branches arise from buds in the axils of the leaves (mainly the upper leaves) and develop 1–4 leaves and a flower bud. Once this stage commences, the plant's rate of vegetative growth increases in order to build the main structure of the plant.

Once 'bud visible' commences, the crop will go through a rapid growth period until the end of flowering. Nitrogen topdressing needs to provide enough nitrogen for maximum plant growth during this period. If all the nitrogen fertiliser is applied at sowing, achieving the target yield is unlikely. When targeting a maximum grain yield, it is recommended that some nitrogen needs to be delayed and applied as a top-dressing before the crop starts flowering.



Figure 11 Irrigated canola experiments evaluating sowing date at Leeton in 2015 (Image source: Tony Napier, NSW DPI).

## Determining a target yield

The target yield is required to calculate an accurate nitrogen budget for irrigated canola. When targeting a high yield, all management factors must be taken into account, including varietal selection, sowing time and irrigation scheduling.

After sowing, the crop needs to be regularly monitored to ensure the target yield is still achievable. Establishing the desired plant population is a key factor in achieving a high yield. The general recommended plant population for maximum irrigated canola yields is 30–50 plants/m<sup>2</sup>. Research has shown that crops with an evenly distributed plant population of 20 plants/m<sup>2</sup> can still achieve very high yields. When the plant population falls below this, consider lowering the yield target.

Sowing time also needs to be considered when determining a target yield. In the irrigated regions of southern NSW and northern Victoria, sowing generally occurs during April to minimise the risk of early winter waterlogging, and high temperatures causing heat damage during flowering/early podding. See the Crop establishment chapter for detailed information on crop establishment and sowing times.

Low and uncertain irrigation water availability is a common factor limiting irrigated canola grain yields. A high yielding canola crop will need about 5.0 ML/ha (from rain or irrigation) to avoid any moisture stress throughout the growing season. Achieving a grain yield of 4 t/ha with 5 ML/ha of water would give a water use efficiency (WUE), or water productivity, of 8 kg/ha/mm. Growers will also need to consider lowering yield expectations if irrigation water supply becomes limited. See the Irrigation management chapter for more information on irrigation management.



Figure 12 Irrigated canola experiments in northern Victoria (Image source: Damian Jones, ICC).

## Preparing a nitrogen budget

Every tonne of canola grain produced requires about 75 kg N/ha (depending on nitrogen uptake efficiency). Therefore, a 4 t/ha canola crop requires a total of 300 kg N/ha. The nitrogen will come from three sources – nitrogen already in the soil at sowing (pre-sowing soil test), nitrogen mineralised during the growing season and nitrogen applied as fertiliser (Table 4).

A pre-sowing soil test (0–60 cm) should be conducted to determine the amount of nitrogen in the soil at sowing. Soil tests need to be conducted early enough to have the results back before sowing. Soil nitrogen levels can vary considerably depending on cropping history and could range from 20–200 kg N/ha with levels commonly in the range of 40–80 kg N/ha.

The amount of nitrogen mineralised during the season also varies but not as much as the level of nitrogen at sowing. The mineralisation rate is influenced by crop rotation, the level of organic carbon and available soil moisture. In irrigated canola crops the amount of nitrogen mineralised can range from 50 kg N/ha in soils with low organic carbon to 100 kg N/ha in soils with high organic carbon.

As stated earlier, nitrogen uptake is relatively low in the early growth stages of an irrigated canola crop. The general recommendation for a high yielding irrigated canola crop is to apply a portion of the nitrogen fertiliser at or before sowing and the rest by topdressing after the crop has established. Applying all of the nitrogen fertiliser at sowing can increase the risk of excess foliage, crop lodging before maturity, and result in more leaf and stem disease. Tasmanian canola growers tend to minimise their nitrogen application rate at sowing and increase pre-flowering topdressing rate to avoid high nitrogen losses from high winter rainfall.

If the crop is healthy and has a uniform plant population of greater than 20 plants/m<sup>2</sup>, maximum yields can still be achieved and high nitrogen topdressing rates should be applied. If establishment is poor and the plant population is below 15 plants/m<sup>2</sup>, a yield of 4 t/ha is unlikely and nitrogen topdressing rates will need to be lowered accordingly.

Develop a water budget at the beginning of the season and review before topdressing as this will help with decisions on yield targets and crop inputs. If irrigation allocations are low or uncertain, nitrogen topdressing rates will need to be reassessed. When nitrogen is topdressed, it should be applied just before an irrigation or rainfall to improve nitrogen uptake efficiency and to minimise losses through volatilisation. A rainfall of 10 mm is enough to wash topdressed fertiliser into the soil.

Table 4 An example nitrogen budget for a high yielding canola crop in a typical irrigated cropping system of southern NSW.

Target yield – 4 t/ha	Nitrogen (N)
Mineral nitrogen in soil at sowing	50 kg/ha
Fertiliser at sowing – DAP 150 kg/ha	27 kg/ha
Estimated mineralisation during the season	50 kg/ha
First nitrogen fertiliser application – Urea 150 kg/ha	69 kg/ha
Second nitrogen fertiliser application – Urea 250 kg/ha	115 kg/ha
<b>Total</b>	<b>311 kg N/ha</b>

An irrigated canola crop with a yield target of 4 t/ha requires a total of approximately 310 kg N/ha throughout the growing season. If 50 kg N/ha is present in the soil before sowing and a further 50 kg N/ha will become available from mineralisation during the season, 210 kg N/ha must be applied as fertiliser to reach the target yield.

A base application of DAP provides early nitrogen for the canola seedlings and all the phosphorus requirements for the 4 t/ha target. If possible, the DAP should not be sown with the seed but banded close by to avoid negative effects on establishment. The timing of the nitrogen fertiliser (urea) will vary between depending on location, paddock history, climate zone and soil type. The first application of nitrogen (urea) is often applied at sowing in southern NSW. If high rates of nitrogen are applied at sowing, it is essential that the N is separated from the seed (see chapter on 'Crop establishment' for more detail). Where winter types are grown as a dual-purpose crop, N application should be managed to replenish the crop after grazing(s) but avoid large applications during the colder, wetter winter months where slow growth and waterlogging are likely. The second nitrogen application is normally applied around the 'bud visible' (green bud) stage and before the crop reaches flowering.

## Fertiliser efficiency and nitrogen losses

Nitrogen topdressing can be inefficient with an average recovery of only 50%. Recovery can be as low as 20% or as high as 80% depending on application method and the crop environment. Losses due to volatilisation are usually minimal when topdressing is applied at the bud visible stage due to cooler weather at that time. To improve nitrogen uptake efficiency, it is recommended that topdressing is applied just before an irrigation or rainfall.

## Phosphorus and Sulfur

When preparing a nitrogen budget, other nutrient requirements of the crop such as phosphorus (P) and sulfur (S) should be considered. Adequate phosphorus is essential for healthy plant growth and P deficiency can significantly reduce canola grain yield. The full amount of P required for the target yield should be banded near (but separated from) the seed at sowing to avoid 'fertiliser burn' that can reduce establishment.

Sulfur is equally important for oil and protein synthesis and vegetative growth. Sulfur can be applied pre-sowing, at sowing or topdressed during the vegetative stage. Applying gypsum before sowing is one of the most economical ways to supply the required amount of S.

The general requirement for canola is 8 kg/ha of phosphorus and 10 kg/ha of sulfur for every tonne of canola grain produced. Therefore, for a target yield of 4 t/ha the crop will need 32 kg P/ha and 40 kg S/ha. Gypsum (calcium sulfate) is the cheapest form of sulfur with rates of 400 kg/ha adequate for a 4 t/ha canola crop. If using single super, an application of 400 kg/ha before sowing will provide all of the phosphorus and sulfur requirements for a high yielding canola crop.

## Other elements

Potassium (K) is important for improved disease, frost and drought resistance. Although the plants take up potassium during growth, most is left behind in the stubble as opposed to being removed in the grain and as a result potassium deficiencies are uncommon.

Zinc (Zn) deficiency can occur in strongly alkaline soils especially after long fallow periods. Zn should be incorporated into the soil before sowing when required.

Molybdenum (Mo) deficiency can occur in acid soils (below  $\text{pH}_{\text{Ca}} 5.5$ ) and should be applied every five years.

Boron (B) deficiency and toxicity can affect canola e.g. continuous cropping in southern NSW has resulted in low soil B levels but the acid sodic soils of the Wimmera and Mallee regions of Victoria can have high B levels. A tissue test can confirm B deficiency.

Calcium (Ca) and Magnesium (Mg) deficiencies are rarely experienced due to regular lime or gypsum applications that provide Ca, and the levels of Mg in the subsoil are inherently adequate (Paul Parker 2009).



# Disease management

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The two most important diseases of canola in Australia are blackleg and sclerotinia stem rot. Both diseases are capable of causing serious yield losses when conditions are favourable, however there are a range of disease management strategies that can be implemented by growers.

## Blackleg

Blackleg, caused by the pathogen *Leptosphaeria maculans*, is the most damaging disease of canola and juncea-canola in Australia. In southern NSW this disease is a major concern for growers, mainly due to the high intensity of canola production in the region. In northern NSW the level of blackleg observed in commercial crops has been significantly lower where production of the crop is not as concentrated.

### Irrigated canola

Irrigation of canola will not significantly increase the risk of blackleg. Canola is most susceptible to blackleg infection at the seedling stage, when canola is likely to be irrigated. Overhead irrigation may increase spread of the disease up the crop canopy by providing droplet splash and leaf wetness however monitoring of the timing of irrigations can manage this. Flood irrigation presents the lowest risk option as there is no droplet splash onto foliage or leaf wetness.

Other factors, such as distance from old canola stubble and intensity of canola production (crop rotation) are likely to be more important determinants of disease severity than irrigation alone.

### Symptoms of blackleg

Blackleg most commonly causes distinct lesions on the cotyledons and leaves of canola plants early in the growing season. The lesions are generally pale grey with a dark border and develop distinct pycnidia within the lesion. These appear as 'pepper like' spots within the lesion.

The blackleg fungus then grows without symptoms through the vascular tissues to the crown where it causes a necrosis resulting in a crown canker at the base of the plant. The crown canker appears as a dry rot at ground level and causes plants to lodge. This crown canker causes yield loss as it restricts water and nutrient uptake by the plant. Blackleg can occur on all plant parts but leaf lesions and crown cankers are the most commonly observed symptoms.

### How do we best manage blackleg?

The most effective approach to reduce the impact of blackleg is to use an integrated strategy that utilises cultivar resistance, cultural control and the strategic use of fungicides. The most effective management practices that can reduce the impact of blackleg include:

1. Sowing canola cultivars with appropriate levels of blackleg resistance – This is particularly important in districts with a high intensity of canola production. Plant resistance is the first line of defence against blackleg.
2. Avoid canola stubble, especially from the previous season's crop – The distance from last season's canola stubble will largely determine the severity of blackleg in this season's canola crop. Where possible, a distance of at least 500 m will significantly reduce the disease pressure from blackleg on this season's crop. Spores of the blackleg pathogen are released

from old canola stubble onto emerging canola crops. The greater the distance from this inoculum source the better.

3. Apply seed dressing or fungicide-amended fertiliser – Application of a fungicide seed dressing or use of fungicide amended fertiliser will provide extra protection from blackleg in the critical early growth stages of crop emergence and establishment. In high blackleg pressure situations this is very important.
4. Foliar fungicides – In certain situations it may be economical to apply a foliar fungicide to extend the length of protection from blackleg, such as if disease severity is very high and if genetic resistance is inadequate or has been overcome by the fungus. Results of field experiments indicate that use of a fungicide seed dressing in combination with the application of a foliar fungicide gives good levels of protection. Timing is crucial, with an application at the 4–6 leaf growth stage found to be significant in decreasing blackleg infection. However, the benefits are only found in those canola cultivars with a low level of resistance to blackleg and in situations of high disease pressure.
5. Canola resistance groups – The blackleg fungus has a high propensity to overcome resistance in *Brassica napus* (canola) cultivars as it is sexually reproducing, resulting in enormously diverse populations. Therefore, the fungal population evolves very rapidly and responds quickly to selection pressures such as wide-scale sowing of cultivars with specific resistance genes. This will lead to resistance being overcome when cultivars of the same resistance gene are sown for three or more years. However, we can use the fungal life traits to manipulate the fungal population. By changing cultivars with different sources of resistance, the selection pressure on the fungal population is constantly changing. All canola cultivars and National Variety Trials (NVT) lines have been classified for blackleg resistance genes and placed into resistance groups. This now allows growers to change or rotate canola cultivars every 2–3 years and prevents the build-up of individual strains that can overcome resistance. By changing canola cultivars at least every three years to a cultivar containing different resistance genes, you are likely to reduce yield losses and reduce the probability of resistance breakdown occurring.

## Sclerotinia

Sclerotinia is caused by the fungal pathogen *Sclerotinia sclerotiorum*. This fungus can infect over 300 plant species, mostly broadleaf plants including many crop, pasture and weed species. This includes plants like canola, lupin, chickpea, sunflower, lucerne, cape weed and shepherds purse.

### How does the disease develop?

The complexity of the disease cycle of sclerotinia stem rot results in disease outbreaks being sporadic compared with other diseases. There are several key stages that must be synchronised and completed in order for plant infection to occur. Weather conditions must be suitable for the pathogen at each stage. These stages of development include:

1. Airborne spores of the fungus are released from apothecia (small, golf tee shaped structures 5–10 mm in diameter) that germinate from sclerotia in the soil. For this to occur, prolonged moist soil conditions in combination with moderate temperatures of 15–25 °C are considered ideal. Most sclerotia will remain viable for up to 3–4 years then survival slowly declines.
2. Spores of the sclerotinia pathogen cannot infect canola leaves and stems directly. They require petals as a food source for spores to germinate, grow and colonise the petal. When the infected petal eventually drops, it may become lodged onto a leaf, within a leaf axil or at branch junctions along the stem. If conditions are moist the fungus grows out of the petal and invades healthy plant stem tissue which will result in a stem lesion and production of further sclerotia within the stem which will be returned to the soil after harvest.
3. Sclerotia also have the ability to germinate in the soil, produce mycelium and directly infect canola plants in close proximity, causing a basal infection.

4. **Weather conditions during flowering play a major role in determining the development of the disease.** The presence of moisture during flowering and petal fall will determine if sclerotinia develops. Dry conditions during this time can quickly prevent development of the disease, hence even if flower petals are infected, dry conditions during petal fall will prevent stem infection development.

### Irrigated canola

As opposed to blackleg, the development of sclerotinia stem rot can be influenced by irrigation practices. As the disease relies on periods of leaf wetness within the canopy to develop, irrigation practices that provide prolonged periods of leaf wetness, particularly during flowering could increase disease risk. Flood irrigation presents the lowest risk, while overhead irrigation could potentially create conditions conducive to disease. The risk of sclerotinia stem rot development should be considered with the indicators listed below. If the risk is considered great enough then foliar fungicides could be applied to combat disease development at 20–30% bloom.

A plan can be developed whereby watering (particularly in the case of overhead irrigation) and foliar fungicide application can be coordinated. Where there is a risk of sclerotinia development, watering during flowering should be conducted following a foliar fungicide application when the lower leaves and stems have fungicide protection. Keep in mind that it is prolonged leaf wetness periods of at least 48 hours that trigger sclerotinia development. Short irrigation events on warm days are unlikely to cause a disease outbreak.

### What are the indicators that sclerotinia stem rot could be a problem?

1. Spring rainfall and irrigation – Epidemics of sclerotinia stem rot generally occur in districts with reliable spring rainfall and long flowering periods. Consider rainfall predictions for spring and the canola crop growth stage. Irrigation events (particularly overhead) that result in prolonged periods of leaf wetness (at least 48 hours) may trigger a disease outbreak. Flood irrigation is preferable and presents a lower disease risk.
2. Frequency of sclerotinia outbreaks – Use the past frequency of sclerotinia stem rot outbreaks in the district as a guide to the likelihood of a sclerotinia outbreak. Paddocks with a recent history of sclerotinia are a good indicator of potential risk, as well as those paddocks that are adjacent. Also consider the frequency of canola in the paddock. Canola is a very good host for the disease and can quickly build up levels of soil-borne sclerotia.
3. Commencement of flowering – The commencement of flowering can determine the severity of a sclerotinia outbreak. Spore release, petal infection and stem infection have a better chance of occurring when conditions are wet for extended periods, especially for more than 48 hours. Canola crops which flower in mid winter, when conditions are cooler and wetter, are more prone to disease development.

### If I had sclerotinia in my canola crop last year, what should I do this season?

There are a number of steps that can be taken to reduce the risk of sclerotinia:

1. Sow canola seed that is free of sclerotia – This applies to growers retaining seed on-farm for sowing. Consider grading seed to remove sclerotia that would otherwise be sown with the seed and infect this season's crop.
2. Rotate canola crops – Continual wheat–canola rotations are excellent for building up levels of viable sclerotia in the soil. A 12-month break from canola is not effective at reducing sclerotia survival. Consider other low risk crops break crops such as cereals, field pea or faba bean.
3. Follow recommended sowing dates and rates for your district and **be aware of the maturity rating of the variety and time of sowing** – Early flowering crops are more prone to developing sclerotinia stem rot by increasing opportunities for infected petals to lodge in a wet crop canopy. In addition, early sown crops will most likely develop bulky crop canopies which retain moisture and increase the likelihood of infection. Wider row spacings can also

help by increasing air flow through the crop canopy to some degree and delaying the onset of canopy closure.

4. Consider the use of a foliar fungicide – Weigh up yield potential, disease risk and costs of fungicide application when deciding to apply a foliar fungicide.
5. Timing of foliar fungicide and irrigation – If disease risk is considered high enough to warrant a foliar fungicide application, this should be timed before an irrigation event. Ideally a foliar fungicide application is timed when the crop reaches 20–30% bloom to protect early flowers and penetrate the lower crop canopy.
6. Monitor crops for disease development and identify the type of stem infection – Main stem infections cause the most yield loss and indicate infection events early in the growing season. Lateral branch infections cause lower levels of yield loss and indicate infection events later in the growing season.

### Use of foliar fungicides

At this time there are no commercial canola cultivars available on the Australian market with resistance to sclerotinia stem rot. Management of the disease relies on the use of cultural and chemical methods of control. Foliar fungicides should be considered in those districts which are at a high risk of disease development (e.g. where the disease frequently occurs, has a long flowering period, is fully irrigated, receives reliable spring rainfall). There are several foliar fungicides currently registered for use in Australia to manage sclerotinia stem rot.

Points to consider when using a foliar fungicide to manage sclerotinia stem rot include:

1. The most yield loss from sclerotinia occurs from early infection events. Early infection is likely to result in premature ripening of plants and produce little or no yield.
2. Plants become susceptible to infection once flowering commences. Research in Australia and Canada has shown that an application of foliar fungicide around the 20–30% bloom stage (20% bloom is 14–16 flowers on the main stem, 30% bloom is approximately 20 flowers on the main stem) can be effective in significantly reducing the level of sclerotinia stem infection. Most registered products can be applied up to the 50% bloom (full bloom) stage.
3. The objective of the fungicide application is to prevent early infection of petals while ensuring that fungicide also penetrates into the lower crop canopy to protect potential infection sites (such as lower leaves, leaf axils and stems). Timing of fungicide application is critical.
4. A foliar fungicide application is most effective when applied before an infection event (e.g. before a rainfall event during flowering). These fungicides are best applied as protectants and have no curative activity.
5. In general, foliar fungicides offer a period of protection of up to three weeks. After this time the protectant activity of the fungicide is compromised. In some crops development of lateral branch infections later in the season is not uncommon if conditions favourable for the disease continue. The greatest yield loss occurs when the main stem becomes infected, especially early. Lateral branch infection does cause yield loss, but at a much reduced level.
6. Use high water rates and fine droplet sizes for good canopy penetration and coverage.

Consult the GRDC Factsheet *Managing Sclerotinia Stem Rot in Canola* for further information. This publication is available from the GRDC website ([www.grdc.com.au](http://www.grdc.com.au)).





# Insect management

Jo Holloway, NSW DPI Wagga Wagga

Insect pests found in irrigated canola are the same as those that attack dryland canola. However, irrigated canola crops may be less prone to attack, or vulnerable to damage, due to the plants being less stressed through lack of moisture. Water-stressed plants are known to emit volatiles which can draw insects to them leading to greater feeding damage. Furthermore, damage, particularly from sucking pests such as aphids that remove fluids from plant cells, is exacerbated when water supply is limited.

Canola is attacked by a wide range of pests and is a favoured host of many pest groups. The crop is most at risk of economic damage during the establishment and flowering/podding stages. While canola does have reasonable compensatory abilities to respond to plant damage, it also has fragile seedlings that can easily be severely damaged and do not recover. Other contributing factors that may exacerbate pest damage include climate, soil type, moisture availability, nutrients and sowing depth. These all influence germination rate and seedling emergence and, consequently, the ability of young plants to outgrow and compensate for any damage caused by pests.

## Primary pests of irrigated canola

In irrigated canola, the most common insects that can cause severe damage include:

### Earth mites and lucerne flea

- Redlegged (Figure 13) and blue oat mites are the most common mite attackers of canola
- Balaustium mites appear to be an emerging problem in some regions
- Lucerne flea (Figure 14), a springtail, can also appear in large numbers and cause extensive damage during crop establishment
- The mites and lucerne flea lacerate leaf cells and suck sap leaving distinguishable damage marks
- The high risk period is during establishment of crops following pasture.

### Aphids

- Cabbage (Figure 15), turnip and green peach aphids (Figure 16) are the primary species found in canola
- The aphids pierce the leaves and suck sap
- The amount of damage caused by direct injury is related to aphid abundance and duration of infestation
- The aphids act as a vector for viruses such as *turnip yellows virus* (TuYV), formerly known as *beet western yellows virus* (BWYV). Virus damage is more extensive from earlier infection
- A high risk situation is seasons with late summer/autumn rainfall and warm growing conditions.



Figure 13 Redlegged earth mites (RLEM) and damage to a canola leaf (Image source: DAFWA).



Figure 14 Lucerne flea feeding on canola (Image source: PIRSA).



Figure 15 A cabbage aphid colony in podding canola (Image source: PIRSA).



Figure 16 Green peach aphid (winged and non-winged forms) on the underside of a canola leaf (Image source: Don McCaffery, NSW DPI).

### Caterpillars

- Heliothis (Figure 17) and diamondback moth (DBM) (Figure 18) are the primary caterpillar pests
- Caterpillars generally present in crops every year but economic damage only occurs periodically during seasons of abnormally high moth abundance
- Heliothis bore into the seedpods and eat the seeds, and if left unchecked, in some seasons may have a severe impact on yield
- DBM larvae may defoliate leaves and surface graze on seedpods when the crop is drying out causing yield reductions
- A high risk situation for DBM is seasons with a 'green bridge' caused by late summer/autumn rainfall and warm growing conditions.
- Cutworms occasionally cause serious damage during establishment. They usually feed at night and have been known to affect large patches of crop.



Figure 17 A heliothis caterpillar (Image source: DAFWA).



Figure 18 A diamondback moth (DBM) caterpillar and damage to a canola leaf (Image source: cesar Australia).

### Slugs, earwigs, millipedes, slaters, wireworms and false wireworms

- These pests feed on germinating seeds and emerging plants
- Slugs are more prevalent in high rainfall regions
- Identification of slug species is important for effective management as different species have different feeding habits and ecology
- Feeding damage from slugs can result in failure of seedling emergence, plants eaten off at ground level and irregular shaped pieces removed from leaves due to their rasping action
- Earwigs, millipedes and slaters are an emerging problem thought to be related to increased stubble retention, but very little is known about their ecology
- Some earwig, millipede and slater species appear to switch from predatory behaviour to feeding on plants which may cause damage to crops during establishment. The reason for this feeding switch is unknown, but is currently being investigated
- Crops sown with minimal soil disturbance and high stubble loads may be at risk of damage from earwigs, millipedes and slaters (Figure 19)
- Incidence of wireworm and false wireworm is increasing with increasing use of minimum tillage and short fallow periods.



Figure 19 A European earwig nest (Image source: cesar Australia).

## Key factors of good pest management

### 1. Identification

It is important to ensure you know the species you are dealing with. Different species may have different tolerances to pesticides (e.g. lucerne flea are more tolerant than redlegged earth mites) or require different chemistry (certain insecticides are effective against heliothis, but not DBM) while other species may not even be pests but predators.

Identification also provides knowledge of the ecology and life cycle of the pest. This can assist in knowing when and where to target sampling. Furthermore, certain insecticide based control methods may work for one pest but not for another e.g. Timerite® (IPM tool for growers) targets redlegged earth mites but is not effective against blue oat mites.

Take advantage of resources such as PestFacts South-eastern (website: <http://cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern>) for alerts and information on pests that are likely to be present and how to deal with them.

## 2. Monitoring

Frequent, accurate and timely crop monitoring maximises the chances of effective and timely pest control. Ensure samples are taken from a number of random sites rather than targeting damaged areas. A larger number of small samples is better than fewer large samples.

When sampling, make notes on number of pests, damage estimates and any beneficial species present (including mummified aphids which indicate parasitoids are active). Recording the findings provides information on trends which will indicate if the beneficial species are controlling pest numbers or if chemical intervention is warranted. These notes also provide a paddock history that can be used in following years rather than relying on memory.

Visual inspections, sweep netting and suction sampling are the most common sampling methods post-sowing. Soil samples and traps should be taken pre-sowing to look for slug, earwig and beetle pests.

Know when and where to sample. Redlegged earth mites are more active in the mornings and can be found on the leaves and on the ground, whereas balaustium mites are more frequently found feeding near the tips of the plants during the warmer parts of the day. Checking the borders of the crop may be all that is required, for example aphids often fly in on prevailing winds. Early checks in these areas may indicate potential threats.

## 3. Economic thresholds

In order for the cropping enterprise to be profitable, the value of outputs must be greater than inputs. Crops can tolerate some damage and still be profitable. Where thresholds do exist, most are based on old data and do not take into account the fluctuating costs of chemicals, fuel and crop values. In addition, no canola economic thresholds include any benefit from natural enemies. Therefore, most economic thresholds should only be used as a guide to determine if chemical control is required.

With frequent monitoring, trends of pest numbers in relation to natural enemies can emerge. Control action should be considered when pest numbers are increasing and there is no coincidental response in natural enemy abundance.

Other factors to consider for thresholds are upcoming weather events (heavy rain can wash off some pests), stage of the crop (mite damage is generally minimal during vegetative and flowering stages), and life stage of the pest (heliathis may not have time to inflict economic damage if the crop is to be windrowed soon).

## 4. Control measures

Knowing if and where there is a risk is the key component of effective insect management. This knowledge can be used to indicate measures that may minimise that risk. For example, crop rotations to avoid canola following pasture to reduce damage from mites; the presence of *Turnip yellows virus* (previously named *Beet western yellows virus*) in the previous year, especially when combined with warm conditions and early aphid flights, indicates a risk where an insecticide seed treatment would be a preventative measure.

Control of insect pests with insecticides should be the last option. When used they should be strategic and target the pest with effective application techniques. Where available use selective insecticides. Rotate different chemical classes to try and prevent resistance developing. Insurance sprays may appear to save money on application costs, but can result in a pest outbreak later in the season due to the loss of natural enemies.

Seed insecticide treatments are still chemicals but limit the effect of that chemical to a small area. They are a useful tool to deter attack from pests, such as wireworms and aphids, until the plants are established. However, their effect is limited when large numbers of pests are present.

## Useful Resources

### I Spy Manual

- Provides in-depth coverage of insect management in broadacre crops in southern Australia
- <https://grdc.com.au/resources-and-publications/all-publications/bookshop/2012/11/i-spy>

### Crop Insects – the Ute Guide: Southern Grain Belt Edition

- Information on pest and beneficial species
- Hard copies only

### PestFacts South-east and South Australia

- Alerts and notifications of pests causing damage during the current cropping season. Both tools rely on input from local agronomists and growers
- <http://cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern>
- [http://www.pir.sa.gov.au/research/services/reports\\_and\\_newsletters/pestfacts\\_newsletter](http://www.pir.sa.gov.au/research/services/reports_and_newsletters/pestfacts_newsletter)

### The Beat Sheet

- Provides technical information, pest risk alerts and practical management information relevant to northern NSW and Queensland grain growing regions.
- <http://www.thebeatsheet.com.au>

### Websites

- [www.dpi.nsw.gov.au](http://www.dpi.nsw.gov.au)
- [www.agriculture.vic.gov.au](http://www.agriculture.vic.gov.au)



# Weed management

Aaron Preston, NSW DPI Wagga Wagga

Canola is a useful break crop allowing the selective control of grass weeds that compete with wheat. Irrigation adds new elements to weed management due to the need to manage aquatic weeds in channels and weeds on channel banks as well as the dynamics of irrigation.

As canola is vulnerable to weed competition in early stages of development, early weed control is imperative. Good weed management requires accurate and early identification and treatment. Knowledge of expected weeds may make the use of pre-emergent herbicides a viable option; however, care should be taken with the use of these herbicides and the irrigation schedule as too much water can move herbicides away from the root zone of weeds.

In irrigated canola, major weeds are annual ryegrass, hogweed (wireweed), capeweed, charlock, wild radish, wild turnip, wild cabbage, shepherds purse, turnip weed, musk weed and the various mustard species.

Helpful resources for the identification of weeds include the DPI WeedWise and GRDC Weed ID: The Ute Guide apps. Download links for mobile devices are listed below.

DPI WeedWise

- iPhone - <http://apple.co/1BS9uD8>
- Android - <http://bit.ly/2hy1TGZ>

GRDC Weed ID: The Ute Guide

- iPhone – <http://apple.co/2AEhFEP>
- Android - <http://bit.ly/2zy4t6U>

## How can they be controlled?

There are multiple options for weed control in irrigated canola. Broadly these can be broken down into herbicide and non-herbicide options.

Herbicide options are the standard pre-sowing knockdown, pre- and post-emergent herbicides and pre-harvest desiccation methods of weed control. In irrigated canola, propyzamide is a commonly used pre-emergent herbicide for the control of grass weeds, hogweed (wireweed) and fumitory. Although propyzamide can be incorporated by irrigation, care should be taken to examine the soil type as too much water in sandy soils can drive propyzamide below the root zone of weeds, reducing its control.

Post-emergent options include selective herbicides (Group A) that can be used for the control of broadleaf and grass weeds although the development of herbicide resistance has made this untenable in some situations.

Canola has the advantage of herbicide tolerant varieties to assist with weed management. Triazine tolerant (TT), Roundup Ready® (RR), and Clearfield® canola have enabled the use of triazine, glyphosate and imidazolinone (IMI) herbicides as post-emergent options. TT canola is often paired with paddocks with high populations of fumitory, shepherd's purse and wild radish or other weeds of the *Brassicaceae* family as triazines offer knockdown and residual control. Another advantage is triazines are a Group C herbicide offering a herbicide group rotation option to assist in the prevention of herbicide resistance. Although yields of TT varieties have increased in later released varieties, be aware that these varieties still suffer a yield penalty when compared with conventional varieties.

RR canola is paired with Plantshield®, the only glyphosate formulation registered for use with RR varieties. This combination can achieve excellent control of weeds although its lack of residual activity means that multiple applications of glyphosate may be required. This can be overcome if paired with an effective residual herbicide as it will reduce the burden on a single mode of action and lessen the need for multiple applications.

OnDuty® and Intervix® herbicides are registered for use with Clearfield® canola varieties. Both of these are Group B herbicides within the IMI subgroup and are used to control wild oats, annual ryegrass, shepherds purse, wild radish or other weeds of the *Brassicaceae* family. These herbicides have high residual activity that ensures effective weed control.

However, strict re-cropping intervals must be observed to prevent subsequent crop damage due to herbicide residues. Only other Clearfield® crop varieties (wheat or barley) should be planted immediately after a Clearfield® canola variety and Clearfield® herbicide have been used. Pulses and other non-Clearfield® cereals can be sown after 10 months. Conventional or other herbicide tolerant canola varieties can be planted 34 months after initial application of these herbicides.

Due to the high risk of herbicide resistance developing with Group B herbicides, particular care should be taken with these herbicides to preserve their use and the use of Clearfield® canola. They should not be used in paddocks with known or suspected resistance to other Group B herbicides (sulfonylurea (SU), other imidazolinone (IMI) and sulfonamides).

Each of these herbicides have important considerations in irrigated canola. The pre-emergent efficacy of triazine herbicides can be compromised in flood irrigated situations requiring careful monitoring of water inputs.

The use of IMI herbicides with Clearfield® canola limits crop sequence options as it requires a significant plant-back period (10–34 months, crop dependant) for non-Clearfield® crops.

Herbicide resistance is a significant concern for each of the aforementioned herbicides, particularly for IMI herbicides due to the potential for rapid selection for herbicide resistance weeds. Care should be taken not to overuse herbicides or herbicide tolerant varieties and ensure they are used in rotation to reduce the risk of herbicide resistance. If herbicide resistance is suspected, use a herbicide resistance testing service to confirm (e.g. Charles Sturt University or Plant Science Consulting), and use other control strategies to prevent its spread. Conscientious stewardship is required to preserve each of these herbicide tolerant technologies.

Due to the expense of herbicide tolerant varieties, it is best to use them when specific circumstances require. Pair weedy paddocks with herbicide tolerant varieties that match the most suitable herbicide to be applied, but this should be avoided when weed pressure is high as it creates a high selection pressure for the development of herbicide resistance. Another consideration is that hybrid non-TT varieties generally have better establishment than open pollinated TT varieties and will be more competitive with weeds. These higher yielding varieties generally have early crop development and higher biomass which act as an extra benefit as they can provide crop competition.

Ideally, herbicides should be used in conjunction with non-herbicide options for more effective weed control and the preservation of herbicides. These include:

- Higher sowing rates are an effective way of increasing crop competition against weeds. A plant population of 25–40 plants/m<sup>2</sup> for hybrid varieties and 40–50 plants/m<sup>2</sup> for open pollinated varieties will improve competition with weeds. Care should be taken as higher plant populations will increase risk of lodging and disease.
- Alternatively, crop competition can be improved by reducing row spacing and increasing sowing rate to create a more competitive environment, which in conjunction with varietal leaf architecture can be used to effectively out-compete weeds.

- Windrowing and pre-harvest desiccation are useful tactics for weed control as they can target late winter weeds. Use narrow windrow burning to destroy weed seeds before they can enter the seed bank.
- On-farm hygiene e.g. ensuring that vehicles and equipment are cleaned to prevent transfer of weed seeds from dirty to clean paddocks.
- Maintain weed-free channel banks and fencelines. Weeds can be introduced into paddocks by incursions from irrigation channels and fencelines. It is therefore important to control these weeds to prevent them getting into the crop areas. These weeds can be controlled by slashing, mowing, cultivation or an application of a knockdown herbicide. The development of glyphosate resistant weeds, particularly annual ryegrass, on fencelines is of significant concern as it can quickly spread into paddocks and render RR varieties ineffective.
- Use high quality seed or seed that has been cleaned and sourced from weed-free paddocks.
- Finally, rotate crops and rotate varieties allowing a diversity of control measures and timings to be implemented.

## Develop a plan

Once weeds have been identified on-farm, it is important to develop a long-term management plan. Know your paddocks, pair weedy paddocks with herbicide tolerant varieties and suitable integrated weed management strategies. Develop a clear objective for the effective treatment and continuing management of weeds.





# Case study

## Increasing irrigated canola production efficiencies in the Murray Valley, southern NSW

<b>Growers</b>	Geoff, Jenny and Lachlan McLeod
<b>Farm</b>	Barragundah, Finley, New South Wales
<b>Rainfall</b>	400 mm (annual average)
<b>Enterprise</b>	Continuous cropping
<b>Farm area</b>	1400 ha
<b>Irrigated area</b>	1000 ha (1300 ha is irrigable)
<b>Water source</b>	Murray River

“Returns per megalitre is what drives decisions”

### The enterprise

Barragundah is a continuous cropping enterprise located 5 km north-east of Finley, NSW (Figure 20). It is operated by Geoff and Jenny McLeod together with their son Lachlan. The average annual rainfall is 400 mm and the average winter growing season rainfall (April–October) is 250 mm. The soil types range from loam to medium clay.

Although 1300 ha of the 1400 ha is irrigable, an average of 1000 ha is under irrigation each year. Approximately 700 ha is under overhead irrigation (centre pivot, pivoting lateral move), 50 ha is beds of zero grade terraced bays with the remaining 250 ha lasered border check bays.





Figure 20 Location of Barragundah, Finley, New South Wales.

A wide variety of winter and summer crops are grown each year including wheat, barley, oats, canola, faba beans, lupins, chickpea, maize and soybean. Cotton is likely to be grown in the future following the introduction of raised beds into the system in 2016.

A common winter crop sequence is wheat – canola – wheat – pulse (type depends on layout). Double cropping sequences include barley – soybean – barley – soybean, and legume silage – maize – wheat – fallow – canola, both under overhead irrigation. The silage crop before the maize crop allows earlier sowing of the maize (early October), provides the opportunity to clean up herbicide resistant weeds (annual ryegrass), increases soil fertility and provides income diversification.

The farming system is completely direct drilling except for preparation of the maize paddocks which include deep ripping to incorporate fertiliser (urea and MAP) and lime. Stubble is mostly cut, baled and removed by contractors for the dairy industry. Burning is only carried out when the stubble is not removed and the stubble load is too high to be sown into. The nitrogen budget for an irrigated canola crop targeting 4 t/ha is 182 kg N/ha (excluding starting N and N mineralised during growing season) (Table 5). The topdressed urea is applied in three passes between 50% ground cover and bolting.

Table 5 Nutrition program for irrigated canola crops with a yield target of 4 t/ha.

Target yield – 4 t/ha		Nitrogen (N)	Phosphorus (P)	Sulfur (S)
Pre-sowing	100 kg/ha Sulphate of Ammonia	21.0 kg/ha		24.0 kg/ha
Sowing	125 kg/ha DAP	22.5 kg/ha	25 kg/ha	1.9 kg/ha
Topdressed	300 kg/ha Urea	138.0 kg/ha		
<b>Total</b>		<b>181.5 kg/ha</b>	<b>25 kg/ha</b>	<b>25.9 kg/ha</b>

## The challenges

The most significant factors that adversely impact canola production in the McLeod's enterprise are:

1. High air temperatures during flowering (critical growth period) – not controllable.
2. Lack of autumn rain – the introduction of overhead irrigation has enabled better control over timing and amount of water applied resulting in timely sowing and better crop establishment.
3. Lack of suitable agronomy packages – although moderately high yields are already being achieved, the McLeod's believe there is plenty of scope for improvement.
4. High value of water – this impacts profitability and drives decisions such as what crops to grow and how intensively they are irrigated.

## Management adaptations

Water is the single input that has the biggest effect on the farming system. Irrigation efficiency i.e. producing maximum output per unit of water is what drives the entire system. It is the key influence on decisions including what crops to grow when, and what yield to target. It is a limited resource that is anticipated to keep rising in value in the future.

For this reason, the McLeod's have moved away from rice, the major crop grown on their farm historically, and have not grown rice since 2005. The winter and alternative summer crops now grown provide significantly greater water use efficiencies (kg/ML) and have a better fit to their farming system and irrigation layouts.

Following the move away from growing rice, the McLeod's committed major investments into overhead irrigation systems in 2007–08. The two primary reasons for this were to increase water use efficiency and improve timeliness of crop establishment (increase yield). The McLeod's wanted to increase their target yields and felt there was a 'yield ceiling' with their border check and rice layouts. Additional benefits of the overhead system include crop diversification, increased labour efficiencies and increased machinery efficiencies (long runs of up to 2 km).

The infrastructure change has resulted in a 40–70% increase in water use efficiency. The McLeods currently produce 1.7 t winter cereal grain/ML under overhead irrigation compared to 1–1.2 t/ML previously under surface irrigation. The cost of the overhead irrigation systems was calculated to be similar to full re-development of lasered border check bays but had the disadvantage of the full cost being required upfront (lasered bays can be done in small areas at a time). Overhead irrigation also has higher ongoing operation and maintenance costs.

The McLeods are considering increasing the area of raised beds in bays to replace some of the lasered border check bays. Surface irrigation in border check bays results in temporary waterlogging (6–48 hours) which occurs 3–4 times in a winter crop and 10–12 times in a summer crop. The McLeods believe this adversely impacts crop growth and development and that if you're targeting high yields you can't afford to put the crops under this stress. The bed layouts will also allow for increased summer crop diversification (cotton). Bed layouts are increasing in the area however transition has been slower than other areas due to the strong rice growing history in the region.

Watermark® sensors are used to monitor soil moisture levels in-crop. Irrigation is applied when the soil tension reaches 60–70 kPa, before the crop is visibly moisture stressed.

In order to increase canola yields, three main changes were made to management. Hybrid canola varieties replaced TT varieties, sowing was brought forward to early April, nitrogen fertiliser applications were increased and a greater proportion of the fertiliser was applied earlier to increase the crop biomass prior to flowering. The McLeods target 3.5 t/ha of irrigated canola grain and commonly achieve 3.0–3.2 t/ha. They believe they should be able to consistently produce 4.0 t/ha (or even higher), a common grain yield of irrigated canola

“We moved to overhead irrigation as we were targeting higher yields, couldn't get crops established on time, and wanted to increase water use efficiency”

experiments in their region. Canola is currently yielding 0.85–0.90 t grain/ML or 8.5–9.0 kg/mm of water.

The McLeods can accurately calculate their water use efficiency (kg/mm) using yield data from the crop area under the overhead irrigators and the adjoining crop area that receives no irrigation (dryland). The yield difference is divided by the irrigation water applied using the following formula:

$$\text{water use efficiency (kg/mm)} = \frac{\text{irrigated crop yield (t/ha)} - \text{dryland crop yield (t/ha)}}{\text{irrigation water applied (ML)}}$$

## Goals

The McLeods are aiming to continue to increase profitability of their enterprise to stay ahead of increasing input costs. They plan to further improve irrigation infrastructure on their property, produce higher yields of a range of winter and summer crops, and continue to strengthen their collaborations with local grower groups and research agencies, an area they believe has enormous opportunity to provide results for growers.

Geoff, Jenny and Lachlan all have formal qualifications in agriculture and Geoff has many years' of industry experience which complements his farming experience. As a result, he is able to rely on his own knowledge, research and networks to inform management decisions. He is also heavily involved with the local grower group, Southern Farmers Inc., and works closely with research organisations such as NSW DPI which involves hosting on-farm experiments.

Collaborating with NSW DPI and GRDC by hosting experiments and contributing to project ideas is important for the McLeods as a way of overcoming barriers to achieving consistent higher yields.

“We are considering increasing the area of raised beds to avoid the temporary waterlogging that occurs following each irrigation. When you're targeting higher yields you can't afford to waterlog the crop every time you water”

Disclaimer: This case study is based on one grower's experience only and the information contained herein should not be taken as recommendations or advice. Independent professional advice should be sought on a case-by-case basis.

# Case study

## Diversification of irrigated farming systems in the Northern Midlands, Tasmania

<b>Growers</b>	Askin and Will Morrison
<b>Farm</b>	Pisa Estate, Cressy, Tasmania
<b>Rainfall</b>	600 mm (annual average)
<b>Enterprise</b>	Cropping, livestock, poppies
<b>Farm area</b>	2600 ha
<b>Irrigated area</b>	1500 ha
<b>Water source</b>	Lake River and Brumbies Creek

“We know we can grow the grains, money spent on developing the markets would be really beneficial”

### The enterprise

Askin and Will Morrison operate a mixed farming enterprise 12 km south-west of Cressy in the Northern Midlands region of Tasmania (Figure 21). They have 2000 ha and lease an additional 600 ha nearby on which they run approximately 5500 crossbred ewes and 100 cattle. Thirty-six centre pivot irrigators are used over 1500 ha of the farm with water sourced from the Lake River and Brumbies Creek. The farm is characterised by duplex soils consisting of a shallow (10 cm) topsoil of loam or gravelly loam over clay, with bleached A2 horizons in some areas. The average soil pH<sub>Ca</sub> is 4.3–5.5.

In Tasmania, merino wool production has somewhat been replaced by cropping, and the previously strong poppy industry is weakening with global oversupply. Research and development into irrigated canola production has facilitated the expansion of the canola industry in Tasmania. Pisa Estate has evolved with the changing market and is now a diverse, flexible enterprise.

Approximately 1500 ha of the Morrison’s farm is sown to wheat, canola, barley, peas, poppies, pasture grass (seed) and clover (seed). Typical crop sequences include:

Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Wheat	Poppy	Wheat	Peas				
Pasture grass seed	Poppy	Wheat	Canola	Barley			
Wheat	Fallow	Barley	Fallow	Canola		Wheat	Peas

The average long-term irrigated canola yield at Pisa Estate is 3 t/ha (1 t/ML of irrigation plus rainfall). The highest yield achieved was 4.2 t/ha (1.33 t/ML of irrigation plus rainfall) in 2015–16 with some parts of the paddock yielding over 5 t/ha. This was a very dry season so no waterlogging occurred and irrigation was applied when required. At Pisa Estate, the dry years are most productive and profitable as there is minimal or no waterlogging, and the ability to irrigate when required allows the crop to avoid moisture stress. The canola crop was grazed. The Morrisons now aim to produce 5 t/ha of irrigated canola consistently.



“Winter canola varieties suited to grazing are now available. This has led to an increase in gross margin of roughly \$500/ha in grazing value without a yield penalty”

Figure 21 Location of Pisa Estate, Cressy, Tasmania.

## The challenges

The Morrisons have struggled to produce high-yielding, highly profitable irrigated canola on a consistent basis. One of the most challenging constraints to irrigated canola production on the Morrison’s property is waterlogging. Currently, the only strategy they can utilise to minimise the impacts of waterlogging on production is paddock selection. Variable rate centre pivot irrigators may reduce the impacts of localised waterlogging in the future but are not currently available.

Canola plant height is also a major issue as the very tall plants makes windrowing and harvesting difficult. The canola crop is direct headed where possible and plant growth regulators and grazing both have been evaluated this year to determine their effect on plant growth.

## Management adaptations

Grazing winter type canola varieties have been adopted and have added a level of complexity to the cropping regime as seeding now takes place in December. The results so far have been positive with the highest yield to date (4.2 t/ha) achieved despite the grazing, and with no additional inputs or costs except an extra two irrigations due to the dry season. It also provided the additional benefit of supplying much-needed green feed for fattening lambs in a feed-gap period. The Morrisons estimate a \$500/ha increase in the gross margin from grazing without a yield penalty.

The release of winter canola varieties suited to grazing made it possible for the Morrisons to implement grazing canola into their enterprise. They attended a Southern Farming Systems Agrifocus event in 2014 and visited other farms in the high rainfall region of Victoria which gave them the idea initially. They decided to adopt a ‘try it and see’ approach which has paid off for them so far.

One challenge that remains is the size of the canola plants. They expected shorter plants as a result of the grazing however their crop still produced a very large canopy. The Morrison's will continue to look for innovative ways to reduce the plant canopy.

## Goals

The Morrisons short-term (1–5 years) goal is to produce 5 t/ha of irrigated canola consistently. Their long-term (5+ years) goal is to see a solid, steady market for canola grain in Tasmania, ideally a local crusher or oil industry. If growers can achieve higher, more stable yields this could contribute to the development of the canola industry in Tasmania.

The Morrisons source their information and advice from local agronomists who gather ideas from mainland Australia and overseas, and Southern Farming Systems who ground-truth the theories. They believe that ongoing experiments and technical knowledge is important for them to achieve their goals, as well as market development.

“Ongoing experiments and technical knowledge creation will be important for us to achieve our goals”

Disclaimer: The case study is based on one grower's experience only and the information contained herein should not be taken as recommendations or advice. Independent professional advice should be sought on a case-by-case basis.



# Appendix 1: project overview

## 'Southern irrigated cereal and canola varieties achieving target yields'

### Objectives

The objective of the 'Southern irrigated cereal and canola varieties achieving target yields' project was to demonstrate an increase in irrigated cereal and canola production, and ultimately water use efficiency, through improvement of grower and adviser knowledge of high yielding cereal and canola varieties and specific agronomy management that will increase production and improve profitability under irrigation. The project area extended from the Lachlan Valley in NSW to Victoria, Tasmania and across to south-eastern South Australia.

The project comprised a series of research experiments to identify the cereal and canola varieties, and agronomic management practices, best suited to irrigated farming systems in each region. Specific research questions were tailored to each research node (geographical area) based on surveys of targeted primary producers (Table 6).

### Project outputs

The outputs of the project include:

1. Database – comprised of three years' data from irrigated cereal and canola experiments conducted throughout south-eastern Australia from 2014–2017.
2. Variety specific agronomy packages (VSAPs) – regionally specific technical information based on the research experiments undertaken in each research node.
3. Best management practice manuals – a wheat manual and a canola manual outlining best management practice guidelines for irrigated wheat and irrigated canola production in south-eastern Australia.



Table 6 The research nodes, organisations undertaking the research and research questions (treatments).

Research node	Organisation	Research questions
<b>Murrumbidgee Valley</b> (Leeton)	NSW DPI	Variety Plant population Nitrogen management Sowing date Irrigation frequency
<b>Murrumbidgee Valley</b> (Coleambally)	NSW DPI	Variety Nitrogen management Plant population
<b>Murray Valley</b> (Jerilderie, Finley, Deniliquin)	NSW DPI	Variety Nitrogen management Plant population Sowing date
<b>Northern Victoria</b> (Kerang)	Irrigated Cropping Council	Variety Nitrogen management Plant growth regulators Fungicides
<b>Lachlan Valley</b> (Condobolin)	Central West Farming Systems	Variety Plant population Nitrogen management
<b>Lachlan Valley</b> (Hillston)	Ag Grow Agronomy and Research	Variety Nitrogen management Sowing date
<b>SE South Australia</b> (Naracoorte, Bool Lagoon)	MacKillop Farm Management Group	Variety Nitrogen management Grazing Sowing date Fungicides
<b>Tasmania</b> (Cressy, Hagley)	Southern Farming Systems	Variety Fungicides Plant growth regulators Grazing Irrigation frequency

## Experiment locations

### Murrumbidgee Valley

The Murrumbidgee Valley in NSW covers 84,000 km<sup>2</sup> and has a river length of 1,600 km (Figure 22). The major dams in the Murrumbidgee Valley are Burrinjuck Dam near Yass and Blowering Dam near Tumut. The annual natural flow averages 4,400,000 ML with a diversion of 2,200,000 ML (Anon. 2017).

The Murrumbidgee Valley is the major rice growing region in Australia producing 50% of Australia's rice. The annual farm-gate value of irrigated production in the valley is \$98 million for rice, \$190 million for horticulture and other crops and \$20 million for livestock products (Anon. 2015). The catchment also produces 25% of NSW's fruit and vegetables, and 42% of NSW's grapes (Anon. 2017).

There are two main irrigation areas within the Murrumbidgee Valley – the Murrumbidgee Irrigation Area (MIA) and the Coleambally Irrigation Area (CIA).

The MIA covers 660,000 ha of which 170,000 ha are irrigated. The primary offtake from the Murrumbidgee River to the MIA is at Berembred Weir which is 386 km, or five days flow time, from Burrinjuck Dam. It is then fed into the irrigation canal system owned and maintained by Murrumbidgee Irrigation Limited (MI). The dam to farm flow time is approximately seven days (Anon. 2017).

The CIA is located in the southern Riverina between Darlington Point and Jerilderie, south of Griffith. It has approximately 491 irrigation farms of about 200 ha each in size. The farms generally have sophisticated layouts and recycling systems to maximise water efficiencies. The major crops produced in this region are rice, wheat, corn, cotton, barley, soybeans and canola as well as a variety of fruit and vegetables. Coleambally Irrigation Co-operative Limited is wholly owned by farmer members and is Australia's fourth largest irrigation company. It delivers water across 400,000 ha of which 79,000 ha is intensively irrigated (Coleambally Irrigation Co-operative Limited 2017).

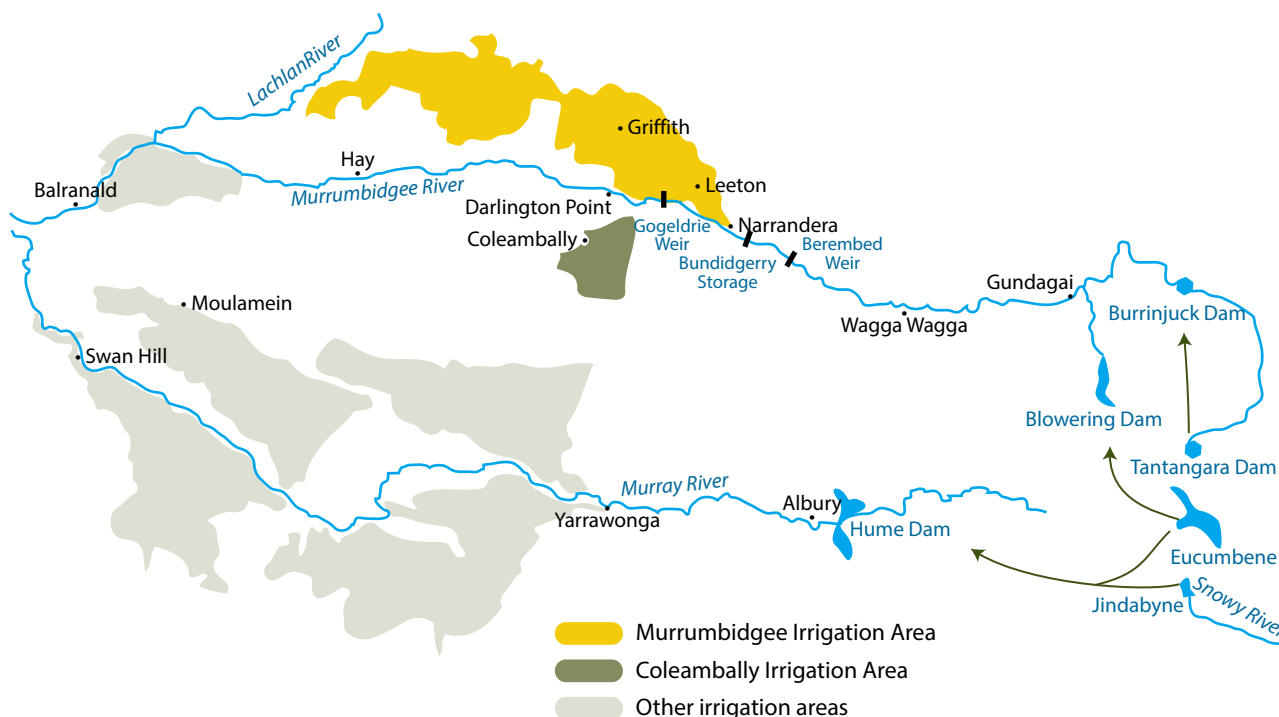


Figure 22 Map of the Murrumbidgee Valley irrigation catchment (Murrumbidgee Irrigation 2017).

## Murray Valley

The Murray Valley irrigation region in southern NSW expands from Mulwala in the East to Moulamein in the West (Figure 23). It covers approximately 748,000 ha of farmland and over 2,300 farms. Water is supplied through almost 3,000 km of energy efficient, gravity-fed channels. The Murray River is the main river system supplying the area via the Mulwala Canal from Lake Mulwala. Branches of the Murray River including the Edward River and Wakool River also supply water to irrigation farms located along their paths.

Majority of the water in the Murray Valley is managed by Murray Irrigation Limited, the largest private irrigation company in Australia. Other smaller irrigation schemes include West Corurgan and Moira. Production in the Murray Valley is diverse. Cereals, legumes, rice, pasture and hay, maize, tomatoes, potatoes, onions, fruit, milk, beef cattle, prime lambs and wool all significantly contribute to irrigated agricultural production in the area (Murray Irrigation 2017).

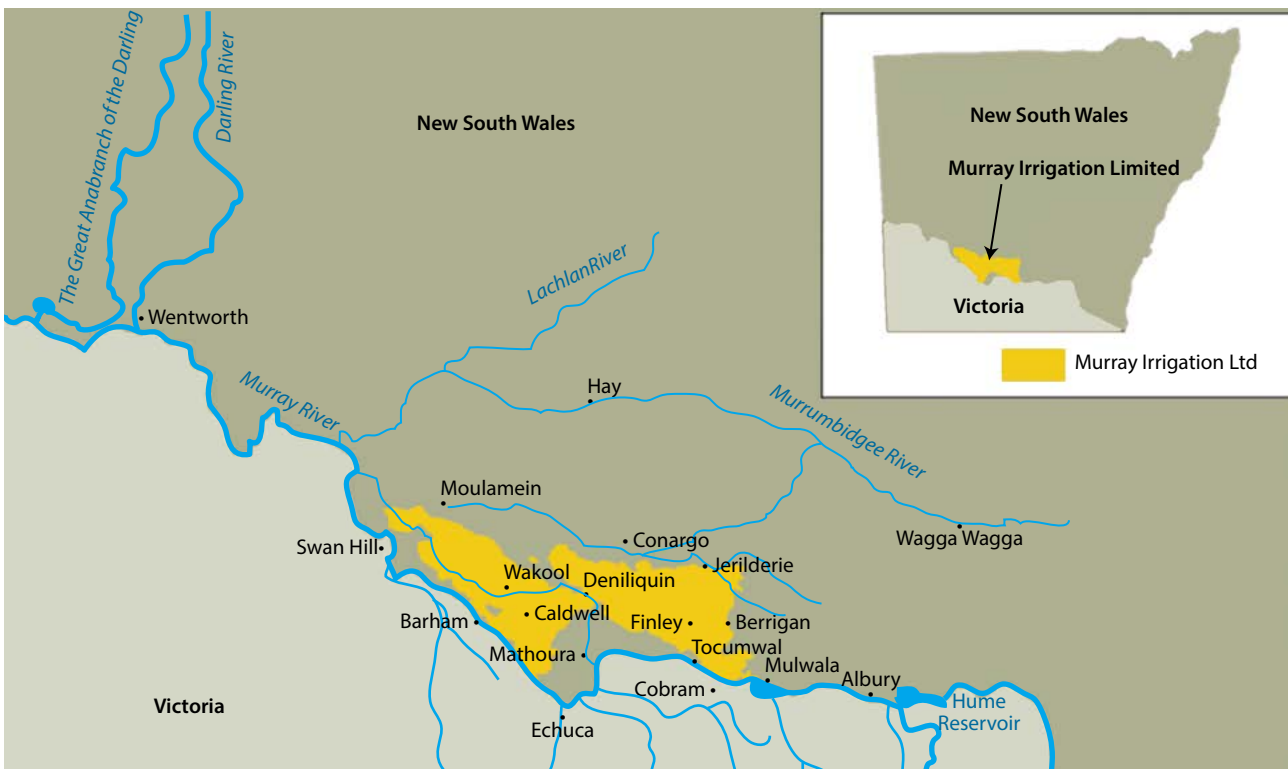


Figure 23 Map of the Murray Valley irrigation catchment (Murray Irrigation 2017).

## Lachlan Valley

The Lachlan Valley encompasses 84,700 km<sup>2</sup> (8,470,000 ha) from Crookwell and Gunning in the East to Oxley and Ivanhoe in the West (Figure 24). The Lachlan River stretches from Yass in the East to near Hay in the West. Wyangala Dam near Cowra is the main water storage on the Lachlan River with a capacity of 1,217,000 ML. Other storages include Lake Cargelligo (36,000 ML), Carcoar Dam (36,000 ML) and Lake Brewster (153,000 ML) (Lachlan Valley Water 2017).

Approximately 1% of the Lachlan Valley land area is under irrigation. The region is renowned for producing high quality lucerne hay and also grows a range of irrigated crops including cereals, cotton, canola, grapes, potatoes, citrus, vegetables and other horticultural crops. Dairying, feedlots and piggeries also depend on river water. The peak body representing irrigators in the Lachlan Valley is Lachlan Valley Water (Lachlan Valley Water 2017).

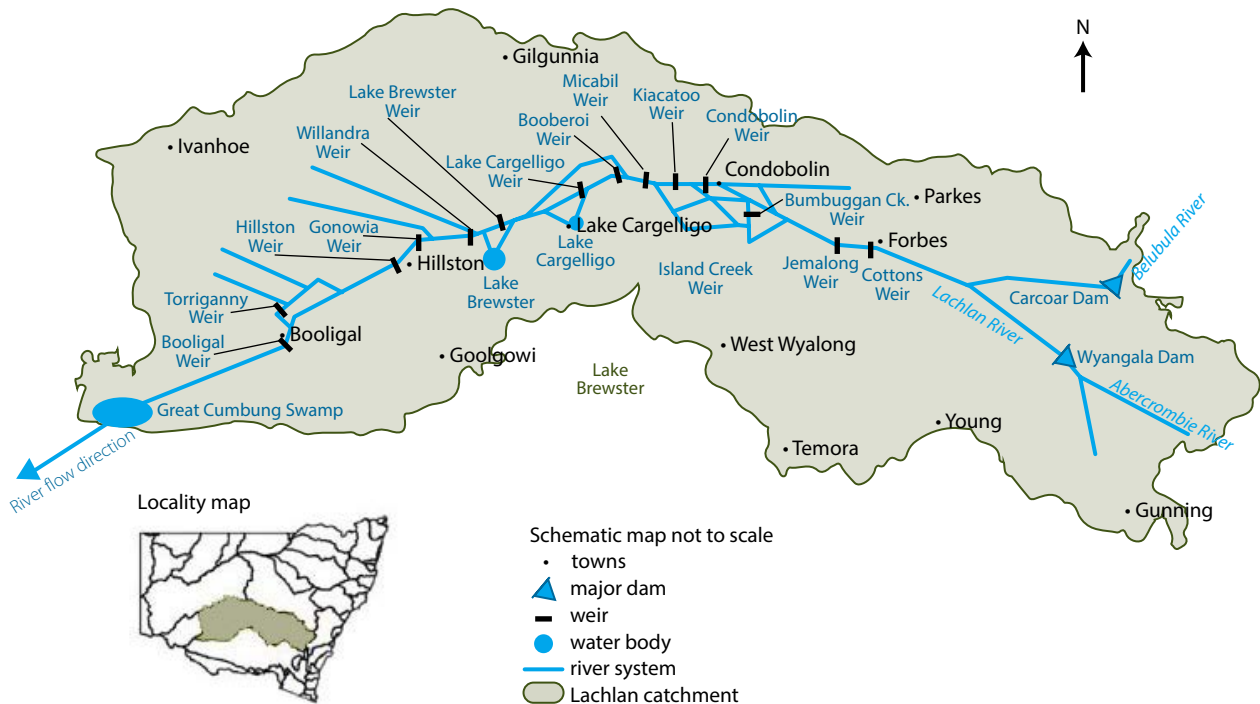


Figure 24 Map of the Lachlan Valley irrigation catchment (Lachlan Valley Water 2017).

## North-west Victoria

Northern Victoria's water supply is stored, managed and delivered by Goulburn-Murray Water (GMW), in the Goulburn-Murray Irrigation District (GMID). They service a region of 68,000 km<sup>2</sup> (6,800,000 ha) from Corryong in the east to Nyah in the west, and the Great Dividing Range in the south to the Murray River in the north (Figure 25). GMW provides water for more than 39,000 customers (surface water and ground water). Approximately 95% of the water supplied by GMW in northern Victoria is used for irrigation (environment 3%; regional towns and communities 2%) (Goulburn-Murray Water 2017).

The western GMID is subdivided into irrigation areas including Torrumbarry (where most experiments for the 'Southern irrigated cereal and canola varieties achieving target yields' project were conducted), Pyramid-Boort, Normanville, West Loddon and East Loddon.

The irrigation areas in the northern irrigation areas have a high proportion of dairy operations but also broadacre cropping, livestock, intensive animal production (pigs, poultry and eggs) and horticulture (stone fruit, grapes and vegetables) (Goulburn-Murray Water 2017).

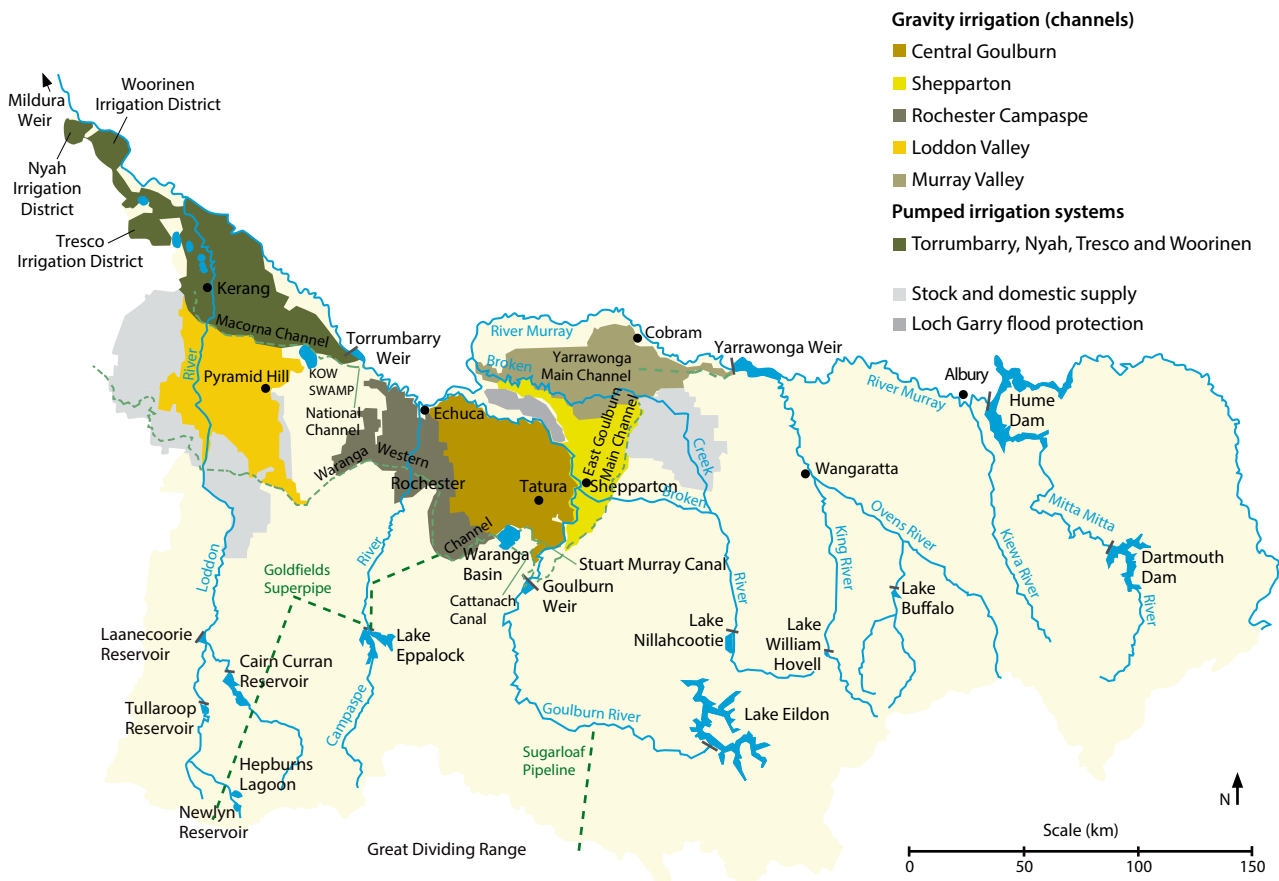


Figure 25 Map of the Goulburn-Murray irrigation district (Goulburn-Murray Water 2017).

### South-east South Australia

The Limestone Coast region in the south-east of South Australia is bordered by the South Australian coastline in the west and south, the Victorian border in the east and the South Australian Mallee (township of Keith) in the north (Figure 26). It is supplied with high quality groundwater, the primary (and in some locations the only) source of water. Irrigation uses 90% of water in the Upper Limestone Coast and 56% in the Lower Limestone Coast region (where experiments for the 'Southern irrigated cereal and canola varieties achieving target yields' project were conducted). The remaining water is used for forestry, domestic, recreational, industrial, stock and environmental purposes (Primary Industries and Regions SA 2017).

The groundwater is contained in two aquifer systems – the upper unconfined aquifer and a deeper confined aquifer. Water used for irrigation is generally sourced from both aquifers. Groundwater extraction is regulated by regional Water Allocation Plans.

Approximately 82,000 ha of irrigated crops in the Limestone Coast region utilised the groundwater resource in 2008–09. The resource has enabled the expansion of crop and fodder production, as well as the viticulture and horticulture industries.

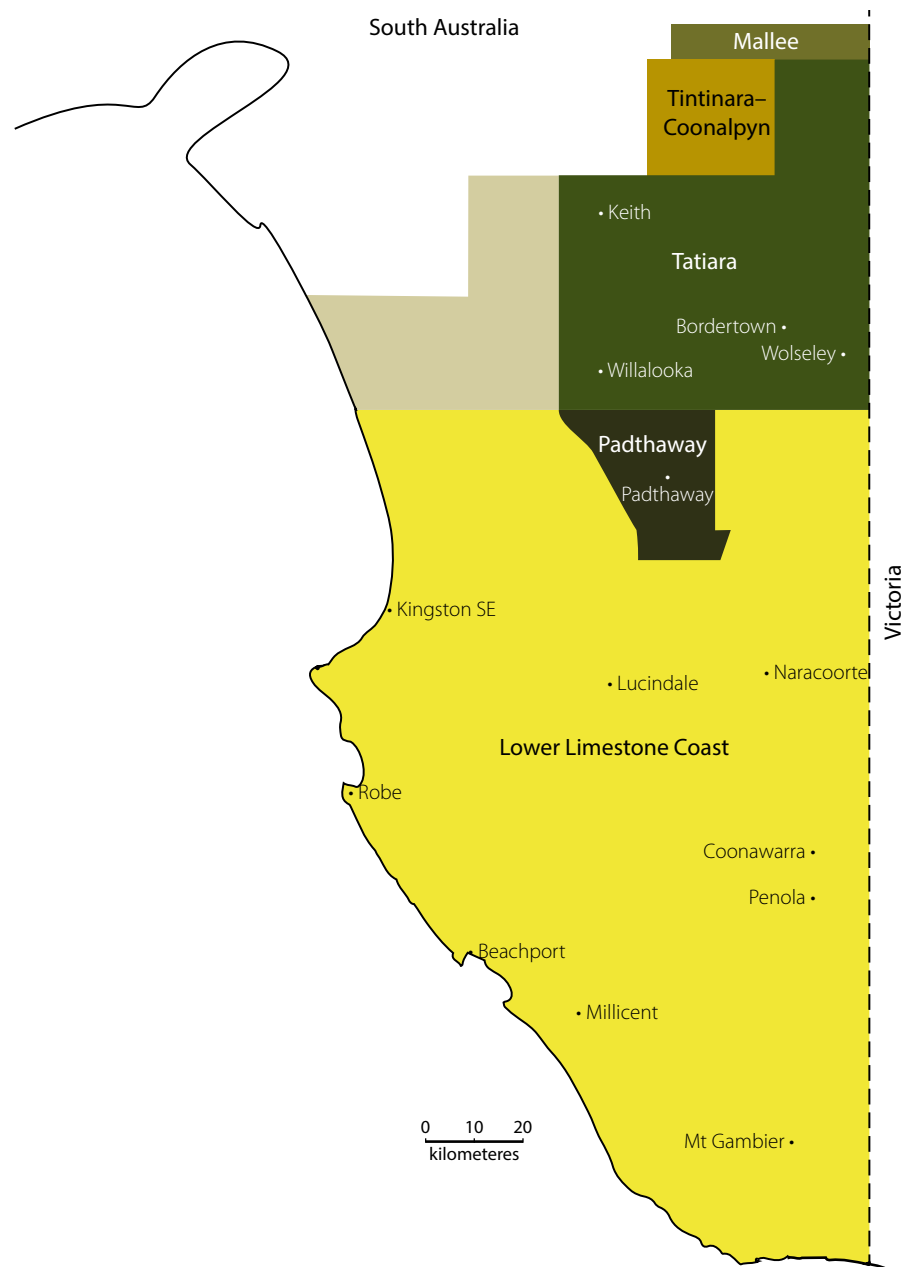


Figure 26 Map of the Limestone Coast irrigation catchment (Primary Industries and Regions SA).

## Tasmania

Tasmania covers a total of 68,000 ha and has several irrigation schemes (Figure 27). The northern region, where the experiments for the project were conducted, includes the Meander River, the Caveside Dairy Plains, Quamby-Osmaston, Rubicon and Hagley pipelines, and the Whitmore, Cressy Longford, North Esk and Lower South Esk irrigation schemes. The main agricultural products from this region are dairy, poppies, potatoes, pyrethrum, vegetables, cereals, canola, pasture seed, berries, hazelnuts and livestock.

Having 13% of the nation's total annual water run-off, there is potential to significantly increase irrigated agricultural production in Tasmania. A number of water development projects have been undertaken in recent years (and continue currently) to improve the reliability of irrigation water as this is the major factor limiting growth of the primary production sector in Tasmania (Water Connects Us 2017).

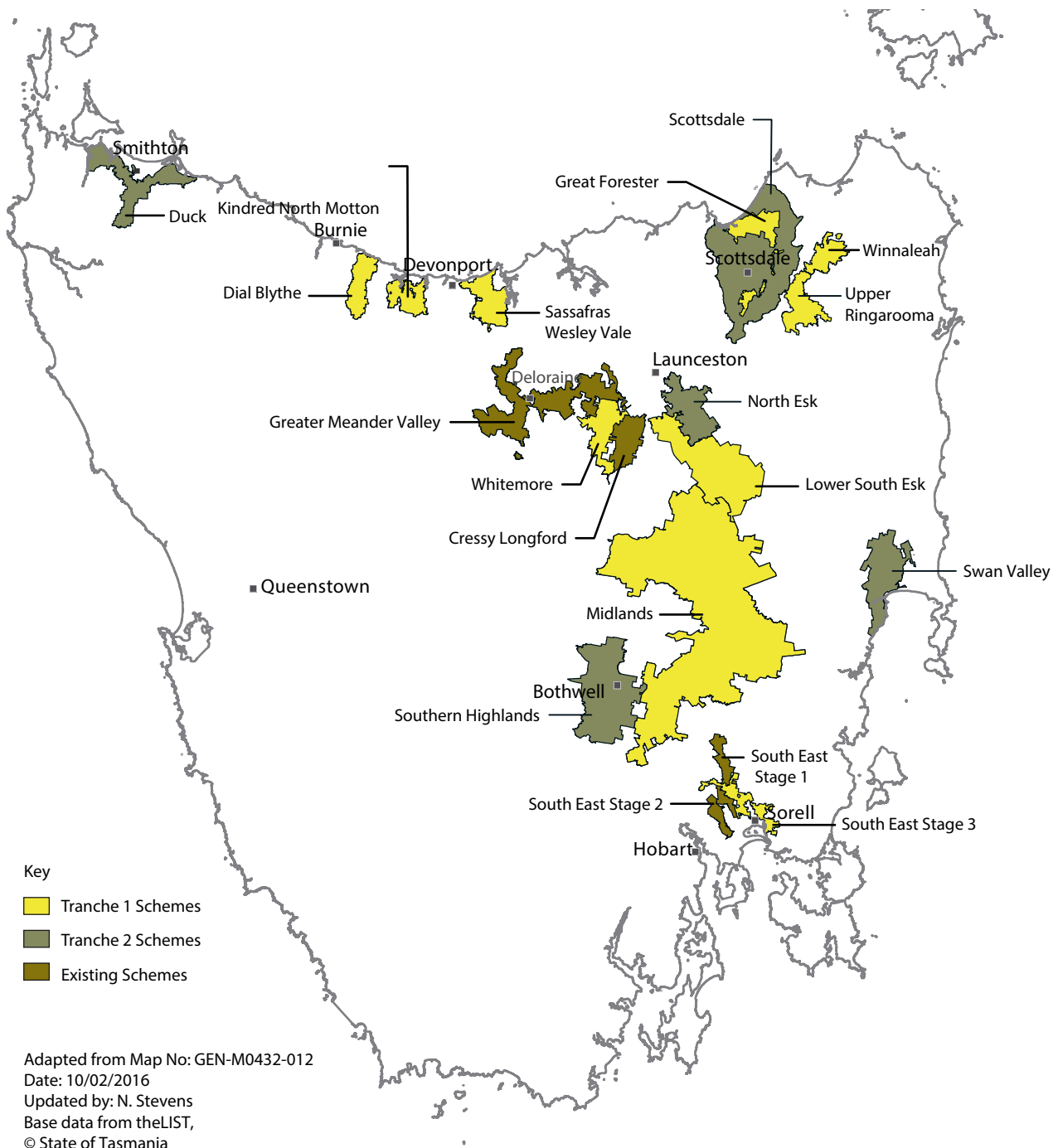



Figure 27 Map of the Tasmanian irrigation catchments (Water Connects Us 2017).



# Appendix 2: constraints

## Current irrigated cropping production constraints – the growers' perspective

In 2014, a survey of irrigation farmers in south-eastern Australia (southern NSW and northern Victoria) identified the most common irrigation layouts, crop types and constraints to irrigated farming systems in this region. The survey had a total of 129 respondents.

### Irrigation layouts

Irrigation farmers in south-eastern Australia use diverse irrigation layouts to deliver water to crops from flood or surface irrigation to overhead sprinkler systems such as centre pivot or lateral move irrigators.

A major focus for survey respondents is to further improve irrigation layouts utilising terraced/bankless channels, spray irrigation and border check layouts. The infrastructure developments will improve timeliness of crop establishment, reduce opportunity time (water on/off time), improve water use efficiency, increase productivity and reduce labour requirements. Furthermore, it adds dimension to the farming system including enabling the introduction of double cropping.

There has been a dramatic increase in the area irrigated by overhead lateral move or centre pivot irrigators and subsurface drip irrigation across all irrigation areas. In the survey this comprised up to 25% of the area reported by participants. Additionally, more on-farm dams are being constructed to increase bay flow rates and importantly to shorten drainage time.

### Irrigated crop types

The survey identified winter grains (wheat, barley, oats, canola, pulses) as the dominant crop(s) in farming systems in southern NSW and northern Victoria for 49% of respondents, followed by rice (23%) and fodder (12%) across all irrigation areas (Figure 28). When the irrigation areas were separated, the Murray Valley followed a similar trend with winter grains at 54% followed by rice (36%) and fodder (8%). Northern Victoria had an even higher proportion of winter grains (69%) followed by fodder (25%). In contrast, the Murrumbidgee Irrigation Area (MIA) and Coleambally Irrigation Area (CIA) combined had approximately equal proportions of cotton (28%) and rice (26%), closely followed by winter grains (23%).



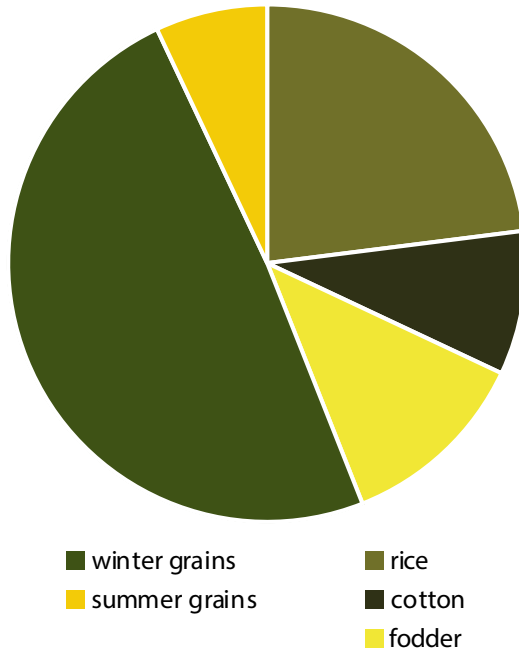


Figure 28 Estimated proportions of irrigated crop types across all irrigation regions in southern NSW and northern Victoria from the survey of growers conducted in 2014.

Irrigated wheat and irrigated canola are predominantly grown on border check layout which accounted for 80% of each crop. This was followed by terraced/bankless layouts for wheat (25%) and overhead spray (centre pivot or lateral move) for canola (25%) (Figure 29).

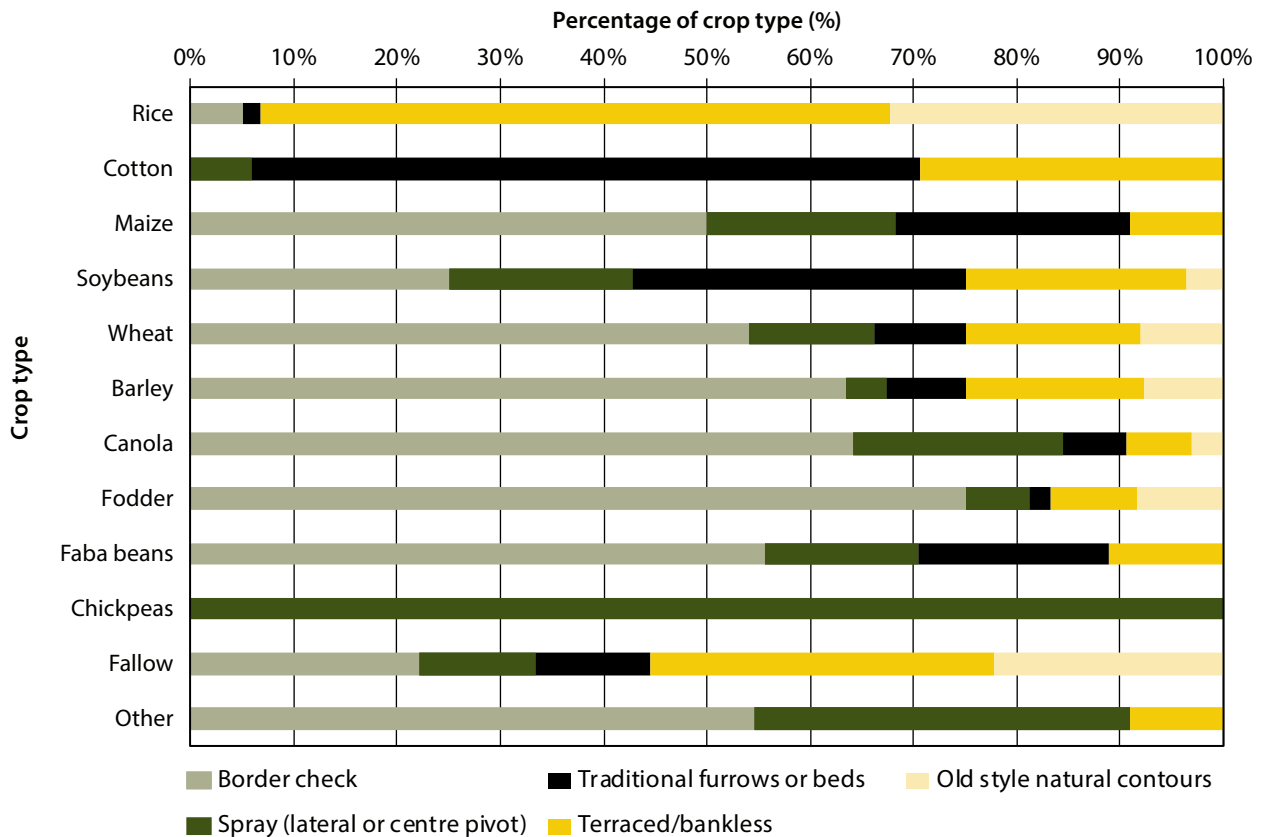


Figure 29 Irrigation layouts for each crop type across all irrigation regions.

## Constraints to irrigated cropping systems

The survey identified water availability and price as the main constraint to irrigated farming systems with 65% of respondents stating it is a major constraint or severe constraint. This was closely followed by input costs (which may include water costs) with 58% of respondents stating it is a major constraint or severe constraint (Figure 30).

Other significant production constraints identified include plant nutrition, weed control, stubble management and soil constraints.

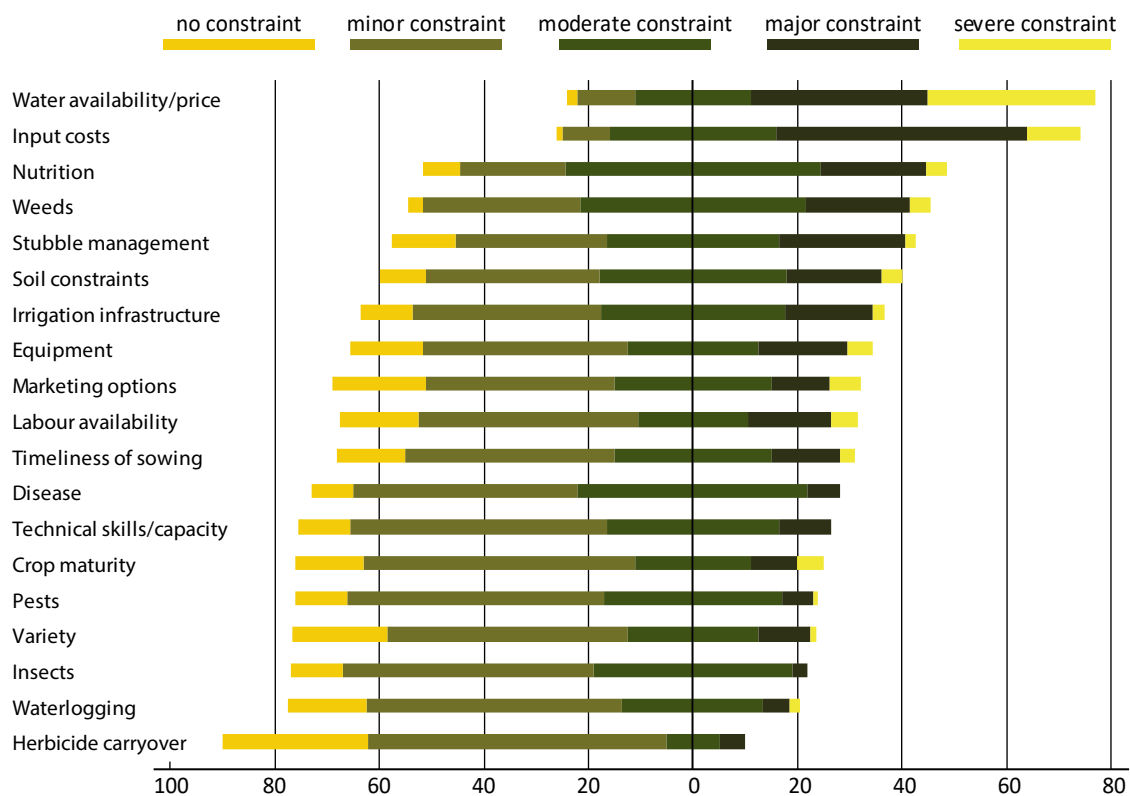


Figure 30 Constraints to irrigated cropping systems in southern NSW and northern Victoria identified by the survey of growers conducted in 2014 presented as a percentage of total survey respondents (figures rounded to whole numbers).



## **Irrigated canola**

IN SOUTHERN CROPPING SYSTEMS



Department of  
Primary Industries