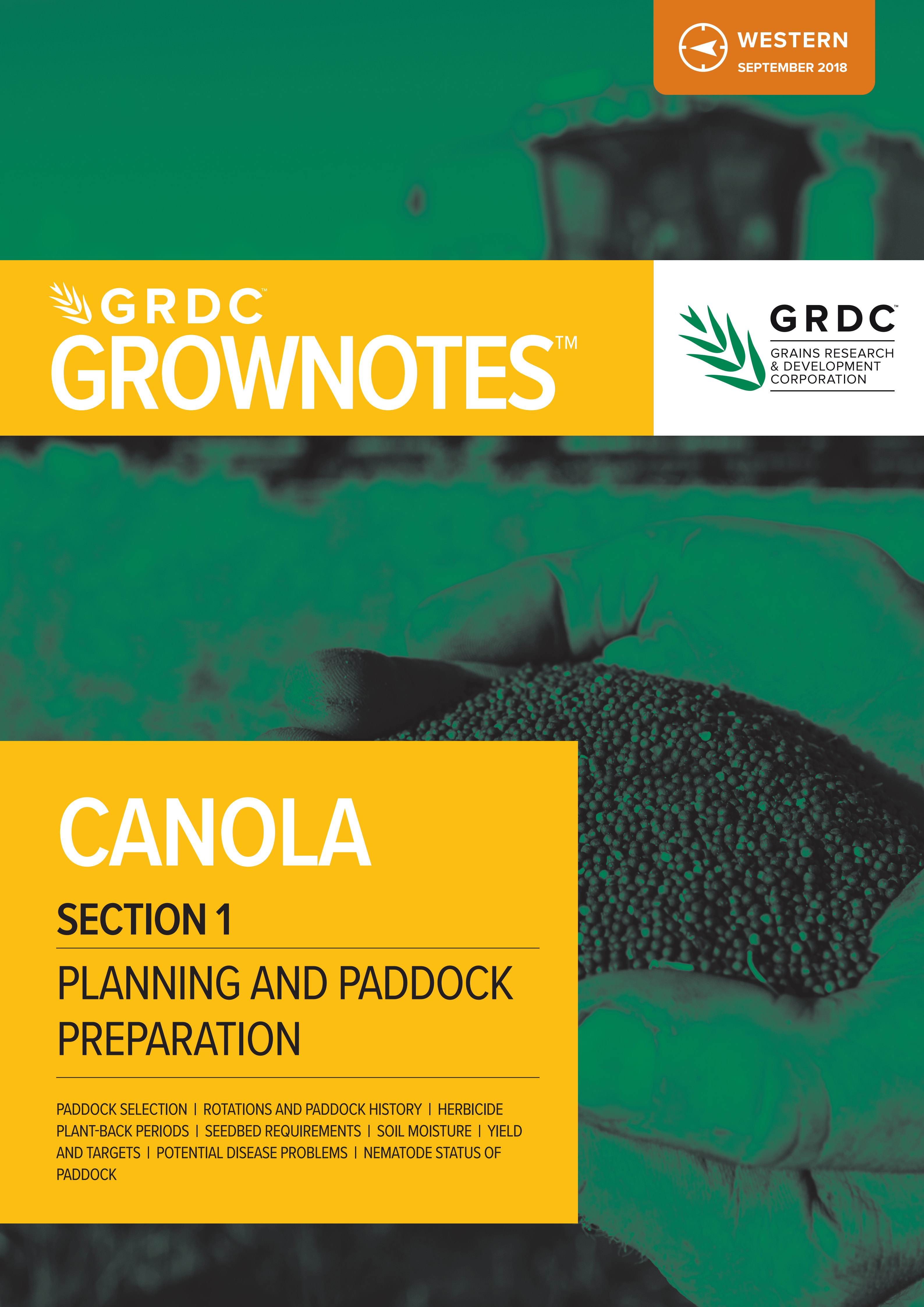

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CANOLA

SECTION 1

PLANNING AND PADDOCK PREPARATION

PADDOCK SELECTION | ROTATIONS AND PADDOCK HISTORY | HERBICIDE PLANT-BACK PERIODS | SEEDBED REQUIREMENTS | SOIL MOISTURE | YIELD AND TARGETS | POTENTIAL DISEASE PROBLEMS | NEMATODE STATUS OF PADDOCK

SECTION 1

Planning/Paddock preparation

1.1 Paddock selection

In addition to early preparation and good crop management, success with canola cropping depends on careful paddock selection. The major considerations when selecting a paddock to grow canola in rotation with other crops are:

- soil type
- potential disease problems
- previous herbicide use
- broadleaf weeds

Choosing more reliable and weed-free paddocks is the best option (Figure 1). It is desirable to soil-test prior to sowing the crop and to continue to manage broadleaf and grass weeds prior to sowing.

When considering the rotation, using crops such as wheat or barley prior to sowing canola will allow for increased broadleaf control through more herbicide options and increased crop competition. Well thought out weed control can have significant benefits, especially where problem weeds are difficult to control in canola. [1]

Many growers are now growing canola to control weeds not able to be controlled in wheat. This is through use of Roundup Ready or Triazine Tolerant (TT) varieties.

DAFWA: Canola Diagnostic Tool

[1] P Parker (2009) Crop rotation and paddock selection. Ch. 4. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

Figure 1: Choosing more reliable and weed-free paddocks is the best option for canola. (Photo: Evan Collis Photography)

1.1.1 Soil types

Canola is adapted to a wide range of soil types. Whilst sandy soils can grow canola successfully, particularly in areas with winter dominant rainfall, canola is best adapted to red-brown earths and clay soils. These soils generally have higher organic matter and inherent fertility. Canola has a high requirement for Nitrogen that will need to be met by fertilizer application in soils of lower fertility. Canola will perform best on neutral to alkaline soils, with good tilth. Paddocks with a uniform soil type will permit more even sowing depth and seedling emergence and more even crop ripening.

Research paper: Climate and Soils

Avoid growing canola where the following problems occur:

Hardpans

Although canola is a tap-rooted plant, it is not strong enough to penetrate some tight hardpans and can still suffer from ‘J’ rooting problems. Paddocks should be checked 12 months in advance by using a soil probe or by digging a small pit to visually assess a suspected problem and determine the depth of working or ripping that may be required to break up any hardpan.

Crusting soils

The surface of a soil can crust after rainfall and reduce plant establishment if it is poorly structured with low organic matter levels, or a sodic clay that disperses after wetting. The use of gypsum and/or stubble retention on hard-setting sodic clay soils may improve seedling emergence and early growth.

Acid soils

Canola is more susceptible to low pH and aluminium (Al) toxicity than most other crops. If you expect the pH in calcium chloride ($CaCl_2$) to be <5.0, have the prospective canola paddock soil-tested in the previous season. If acidic subsoil is suspected, take split samples of soil depths 0–10 and 10–20 cm. Where a pH($CaCl_2$) <4.7 is combined with exchangeable Al level of ≥3%, do not grow canola before obtaining specific advice. Other indicators of acidity problems are poor growth in barley, or if oats and triticale grow better than wheat. Consider using lime when the topsoil pH($CaCl_2$) drops to <5.0.

Sodic subsoils

Soils with a sodic clay subsoil of low permeability become waterlogged when rainfall exceeds their infiltration capacity. A sodic subsoil problem can be identified by a simple soil testing procedure (dispersion test) backed up by laboratory chemical analysis. Avoid these soils unless they have a good depth of well-drained topsoil, which allows for adequate root growth even after heavy rainfall. Use of raised beds has been a successful strategy for reducing the impact of waterlogging in high-rainfall areas of south-western Western Australia. [2]

More information

Canola best practice management guide for south-eastern Australia

1.2 Rotations and paddock history

Canola can reduce but not eliminate the incidence of some cereal root and crown diseases, such as crown rot and take-all. Research has shown canola to be the most effective winter crop for reducing levels of crown rot in subsequent wheat crops. [3]

Canola is not a host for arbuscular mycorrhizal fungi (AMF) and will result in lower levels following the crop. This may disadvantage subsequent crops that are highly dependent on AMF, particularly if environmental conditions and progressive fallows have also reduced AMF levels. Crops with a reliance on AMF include faba beans and chickpeas.

Research has shown that wheat yield increases of ~0.6–1.0 t/ha can be expected when following canola compared with following wheat.

[2] P Parker (2009) Crop rotation and paddock selection. Ch. 4. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

[3] L Serafin, J Holland, R Bambach, D McCaffery (2005) Canola: northern NSW planting guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0016/148300/canola-northern-NSW-planting-guide.pdf

Figure 2: Canola has benefits for subsequent cereal crops as it can reduce the incidence of some cereal root and crown diseases.

No-tillage, which retains more stubble, is increasing the carryover of many of the main cereal diseases, such as crown rot. Canola fits well into this system by allowing an additional season for cereal stubble breakdown to occur, therefore reducing the carryover of disease.

Ideally canola should not be included in the rotation more frequently than one in every four years. This reduces the potential for canola disease build-up and also allows for rotation of herbicide and weed control tactics. The use of triazine-tolerant (TT), imadozoline-tolerant (IT or Clearfield), Roundup and Triazine Tolerant (RT) canola systems and Roundup Ready (RR) canola systems can also be used strategically as for hard to control weeds.

When planning cropping systems on the farm consider placement of future crops in relation to potential insect pest host crops. Rutherglen bugs may be present in large numbers on canola stubble around harvest time. [4]

1.2.1 Profitable paddock rotations in WA's wheatbelt

Crop rotations in Western Australia's wheatbelt are heavily dominated by 4 crop types and pasture, with around 94% of farm paddocks using some combination wheat, canola, lupins, barley or pasture.

Canola is a part of 53% of rotations in the southern wheatbelt and 30% of northern wheatbelt rotations after 3 years of DAFWA trial measurements (2010-12).

[4] L Serafin, J Holland, R Bambach, D McCaffery (2005) Canola: northern NSW planting guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0016/148300/canola-northern-NSW-planting-guide.pdf

Common rotations

The most popular individual rotation across the 3-year dataset is currently wheat/wheat/wheat, accounting for 18%. Wheat/wheat/canola (15%) and wheat/canola/wheat (16%) rotations combined account for 31% of paddock rotations.

When wheat/lupin/wheat (15%) along with wheat/wheat/lupin (3%) are added to this mix almost 70% of all paddock rotations are accounted for within these 3 crop types.

The rotations can be further broken down if we split the data in the north and south of the wheatbelt. There are significant differences between the prevalence of different rotations across the state, with the most obvious example being the previously mentioned wheat/wheat/wheat rotation which accounts for 25% of all paddocks monitored in the north, whilst only 5% of those in the south.

Rotation profitability

The appearance of canola in the most profitable rotations should leave little doubt as to the reasons behind the rapid uptake of canola across the state. Equally, all but 2 of the 8 most profitable 3-year sequences have at least 2 years of wheat which supports the idea that the ability to get tight wheat rotations into the system being a key driver of profitability for much of the wheat belt. However, as most paddocks in this system area on rotations of 4 or more years it is too early to draw too many conclusions in terms of overall profitability.

Looking at the most popular rotations we can identify whether or not there are any significant differences between a wheat/wheat/wheat rotation when compared to a wheat/canola/wheat rotation. Looking at the third year wheat component of these rotations it doesn't appear as though there is any significant difference in either average fertiliser costs or the range of fertiliser costs, coming in at an average $85/ha (i.e. $28 - $115/ha) and $87/ha (i.e. $28–$121/ha) respectively.

As we would expect after 3 years of wheat, there does appear to be a difference in chemical costs. The WCW rotations have an extremely narrow range, with 18 of 21 samples being between $6 and $33/ha. The WWW rotations on the other hand were largely between $24 and $56/ha, with the average cost being approximately 25% higher than WCW rotations. It is likely that at least part of this differential can be explained by the difference in Take-all and Rhizoctonia concentrations between sequences (Table 1), specifically the impact of canola on reducing disease concentration.

Table 1: Disease concentration by rotation in focus paddocks

PDK Sequence	n	Rhizo 2010	Rhizo 2013	% of initial	TA 2010	TA 2013	TA% of initial
Wheat/Wheat/Wheat	21	3.4	18.4	547	0.5	1.2	257
Wheat/Canola/Wheat	19	40.2	11.2	28	1.8	1.5	80
Wheat/Wheat/Canola	16	4.4	1.7	38	1.4	1.8	135

Weed numbers also play a key role in explaining this difference in chemical costs. As with disease there is a significant difference between the two rotations, with average

More information

[Profitable paddock rotations: Is the choice of break crop costing you money?]

[Profitable crop and pasture sequencing 2013 trial report]

[Over the bar with better canola agronomy]

[Canola best practice management guide for south-eastern Australia]

[Crown rot in winter cereals]

weed numbers declining by 40% over the 3 years in Wheat/Canola/Wheat rotations, and increasing by 374% for Wheat/Wheat/Wheat rotations (Table 2).

Table 2: Weed numbers by rotation in focus paddocks

PDK Sequence	n	Weeds Per m Sq 2010	Weeds Per m Sq 2012	% of initial
Wheat/Canola/Wheat	21	20.9	12.5	60%
Wheat/Wheat/Wheat	19	12.6	47	374%

Current paddock rotations are dominated by five main choices, and whilst the secondary reasons for crop rotation choice may differ from year to year (ranging from controlling weed pressure, being used as a disease break, or as a nitrogen injection), the primary reason is always long term rotational profitability.

Canola's role in the system has increased dramatically over time, with Focus Paddock project data suggesting it has a place in 53% of rotations in the south of the wheatbelt and 30% in the north. The reasons for its inclusion appear obvious with the weed and disease data presented in combination with its profitability.

In many locations, particularly in the lower rainfall zones, tightness of wheat in the rotation appears to be the primary goal, and wheat/wheat/wheat rotations are common. Whilst currently this system does appear to be among the most profitable, the fourth year performance may drastically alter the overall profitability of varying rotations, especially where fallow is a part of the system. [5]

1.3 Herbicide plant-back periods

Canola is particularly susceptible to a range of residual herbicides. Under dry seasonal conditions or in alkaline soils, residues from a herbicide applied to a previous pulse or cereal crop can persist into the next cropping season. For example, the sulfonylurea group (e.g. chlorsulfuron, sulfosulfuron) used in cereal crops have a canola plant-back period of 24–30 months. Similarly, some herbicides registered in pulse crops can have plant-back periods ranging from 9 months (simazine) to 24 months (flumetsulam) to 34 months (imazethapyr). The use of these herbicides can therefore restrict crop options and prevent the sowing of canola for up to 3 years. The use of various herbicide-tolerant (TT or Clearfield®) canola varieties coupled with their companion herbicides (triazines or imidazolinone herbicides) can restrict crop-selection options in the following year. Plant-back periods are provided on herbicide labels for sensitive crops under these conditions. [6]

Plant-back periods do not begin until there has been a significant rainfall event.

Plant-back periods are the obligatory times between the herbicide spraying date and safe planting date of a subsequent crop.

5 http://www.giwa.org.au/pdfs/2014/Not_Presented_Papers/Hagan%20James%20-%20Profitable%20paddock%20rotations%20Is%20the%20choice%20of%20break%20crop%20costing%20you%20money%20PAPER%20-%20EOI36%20DR.pdf

6 P Parker (2009) Crop rotation and paddock selection. Ch. 4. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

[Soil behaviour of pre-emergent herbicides in Australian farming systems: a reference manual for agronomic advisers]

Some herbicides have a long residual. The residual is not the same as the half-life. Although the amount of chemical in the soil may break down rapidly to half the original amount, what remains can persist for long periods, as is the case for sulfonylureas (chlorsulfuron) (see Table 3). Herbicides with long residuals can affect subsequent crops, especially if they are effective at low levels of active ingredient, such as the sulfonylureas. On labels, this will be shown by plant-back periods, which are usually listed under a separate heading or under 'Protection of crops etc.' in the 'General Instructions' section of the label. [7]

Table 3: Residual persistence of common pre-emergent herbicides, and noted residual persistence in broadacre trials and from paddock experience [8]

Sources: CDS Tomlinson (Ed.) (2009) The pesticide manual (15th edn), British Crop Protection Council; Extoxnet, http://extoxnet.orst.edu/; California Department of Pesticide Regulation Environmental Fate Reviews, www.cdpr.ca.gov/

Herbicide	Half-life (days)	Residual persistence and prolonged weed control
Logran® (triasulfuron)	19	High. Persists longer in high pH soils. Weed control commonly drops off within 6 weeks
Glean® (chlorsulfuron)	28–42	High. Persists longer in high pH soils. Weed control longer than triasulfuron
Diuron	90 (range 1 month–1 year, depending on rate)	High. Weed control will drop off within 6 weeks, depending on rate. Has had observed, long-lasting activity on grass weeds such as black/stink grass (*Eragrostis* spp.) and to a lesser extent broadleaf weeds such as fleabane
Atrazine	60–100, up to 1 year if dry	High. Has had observed, long-lasting (>3 months) activity on broadleaf weeds such as fleabane
Simazine	60 (range 28–149)	Medium–high. 1 year residual in high pH soils. Has had observed, long-lasting (>3 months) activity on broadleaf weeds such as fleabane
Terbyne® (terbuthylazine)	6.5–139	High. Has had observed, long-lasting (>6 months) activity on broadleaf weeds such as fleabane and sow thistle
Triflur® X (trifluralin)	57–126	High. 6–8 months residual. Higher rates longer. Has had observed, long-lasting activity on grass weeds such as black/stink grass (*Eragrostis* spp.)
Stomp® (pendimethalin)	40	Medium. 3–4 months residual
Avadex® Xtra (triallate)	56–77	Medium. 3–4 months residual
Balance® (isoxaflutole)	1.3 (metabolite 11.5)	High. Reactivates after each rainfall event. Has had observed, long-lasting (> 6 months) activity on broadleaf weeds such as fleabane and sow thistle
Boxer Gold® (prosulfocarb)	12–49	Medium. Typically quicker to break down than trifluralin, but tends to reactivate after each rainfall event
Sakura® (pyroxasulfone)	10–35	High. Typically quicker breakdown than trifluralin and prosulfocarb; however, weed control persists longer than with prosulfocarb

More information

Australian Pesticides and Veterinary Medicines Authority

Using pre-emergent herbicides in conservation farming systems

Weed control in winter crops

Sulfonylurea spray contamination damage to canola crops

[7] B Haskins (2012) Using pre-emergent herbicides in conservation farming systems. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/431247/Using-pre-emergent-herbicides-in-conservation-farming-systems.pdf

[8] B Haskins (2012) Using pre-emergent herbicides in conservation farming systems. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/431247/Using-pre-emergent-herbicides-in-conservation-farming-systems.pdf

More information

Canola best practice management guide for south-eastern Australia

DAFWA: Dry seeding- more wins than losses

1.4 Seedbed requirements

Seed–soil contact, especially under dry conditions, is crucial for helping moisture to diffuse into the canola seed. Emergence of canola seedlings can be reduced by the formation of soil crusts in hardsetting, sodic or dispersing soils. Sodic or dispersing soils that surface-seal will reduce the emergence of canola seedlings.

A firm, moist seedbed provides uniform seed germination and rapid seedling growth. Adequate soil moisture at the seedling and elongation stages promotes the development of a strong, healthy plant less prone to lodging and with maximum leaf growth by the end of July. [9]

1.5 Soil moisture

Soil moisture is vital for both germination and emergence. Canola must absorb a high percentage of its weight in water before germination begins. It will germinate when the seed moisture content has risen to approximately 24%.

Water absorption is a passive process. The ability of seeds to absorb water depends on the difference in water potential between the seed and the surrounding soil. Seeds can absorb water even at very low soil-water potentials, but low water potentials may induce secondary dormancy.

Seed size influences the rate of water absorption. Small seeds have a high surface-to-volume ratio, which means that less time is required to absorb adequate moisture for germination.

In soils with a low moisture content, the germination rate will be lower and emergence slower (Table 4).

Table 4: Effect of soil moisture content on final emergence percentage and days to 50% emergence

Source: Modified from Canola Council of Canada (2003)

Total soil water content (% weight)	Final emergence percentage	Days to 50% emergence
18%	82%	9
15%	59%	12
13%	45%	13
11%	4%	–

The trial was established in a growth chamber at constant day–night temperatures of 8.5°C–10°C. In summary:

- The higher the total soil water content, the higher the final germination percentage.

[9] J Edwards, K Hertel (2011) Canola growth and development. PROCROP Series. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/516181/Procrop-canola-growth-and-development.pdf

- The higher the soil water content, the quicker the time to 50% seedling emergence. [10]

Water is essential for plant growth. Adequate soil moisture:

- promotes root growth
- promotes a large, abundant leaf area
- helps plants to retain their leaves longer
- lengthens the flowering period
- increases the numbers of branches per plant, flowers forming pods and seeds per pod
- increases seed weight and seed yield

Moisture stress is more important during podfill than at the vegetative stage. However, too much or too little water at any growth stage reduces yield potential. Factors that may limit yield include:

- the amount of moisture stored in the soil over summer
- the rate and duration and timing of rainfall during the growing season
- the ability of the soil to absorb water, store it, and make it available for plants

More information

Is there a place for canola on irrigation?

Yield of wheat and canola in the high rainfall zone of south-western Australia in years with and without a transient perched water table

Modifying some of these factors can improve moisture availability and efficiency of water use.

When soil water and nutrients are abundant, the balance of root to stem and leaf growth typically shifts in favour of stem growth at the expense of roots. When water is limited, the opposite usually occurs. Roots account for ~25% of plant dry matter at stem elongation in moisture-stressed canola, compared with ~20% in unstressed plants.

1.5.1 Moisture stress during rosette formation and elongation

Canola has limited ability to withstand severe drought. To avoid dehydration, the plant closes its stomata and rapidly sheds leaves.

Moisture stress during the early vegetative stages reduces the ability of stomata to conduct carbon dioxide and therefore slows photosynthesis. This in turn reduces leaf area expansion and dry matter production. It also limits root growth, which reduces nutrient uptake. More severe water deficits inhibit photosynthesis because of cell and chloroplast shrinkage.

This is important in seasons with dry winters. It is also important in low-rainfall areas where the period of crop growth is restricted at the start of the season by lack of rainfall and at the end of the season by water deficits and high temperatures.

[10] J Edwards, K Hertel (2011) Canola growth and development. PROCROP Series. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/516181/Procrop-canola-growth-and-development.pdf

Plants under early-season moisture stress will usually recover normal growth with subsequent rainfall or irrigation. Stressed plants are able to recover leaf area, form flowers, set pods and fill seeds when water becomes available, but with hastened development rates, crops have early maturity and lower yields. The worst time for drought stress in canola is during stem elongation or flowering.

Long periods of drought will reduce yields more than frequent, short periods of drought. The impact will be greatest on coarse-textured soils and shallow soils with low water-storage capacity.

Adequate soil moisture tends to lengthen the number of days to maturity by up to 10 days. Additional soil moisture will result in no further increase in yield and may cause yield reductions through poor soil aeration and/or increased lodging and diseases. [11]

infocus

1.5.2 How much moisture is enough to successfully establish April-sown canola?

Key messages

- The criteria for successful wet sowing are that rainfall should connect with deeper soil water or one should allow for evaporation till the next effective rain, especially under dry and warm conditions.
- For dry sowing, the maximum allowable rainfall was estimated at about 5 mm for sandy, 8 mm for loamy and 10 mm for clay textured soils, failing which a day or two after the rain (depending on evaporation rate) should be allowed before dry seeding.
- For the first 15 days after stress, daily seedling mortality under water deficit conditions was about 2% more than the usual mortality (about 0.8%) under unstressed conditions.
- Since additional branching can offset mortality losses, a low plant population of the early sown canola can still be sufficient for maximum yield, especially in low yielding seasons.

Aims

Dry sown and early wet sown canola crops are increasing in Western Australia. Both present an opportunity to maximise yield but are accompanied by major risks of seed and seedling mortality due to early drought conditions.

Economic losses could be substantial if a dry sown crop was sown 'too wet' (i.e. with enough soil water present to germinate but not to establish the plants); and conversely, a wet sown crop was sown too dry. Hence, this paper intends to highlight

[11] J Edwards, K Hertel (2011) Canola growth and development. PROCROP Series. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/516181/Procrop-canola-growth-and-development.pdf

moisture considerations relevant to this issue and provide some indicators that farmers might use in making educated decisions.

Method

We used two years' data, a literature review and common knowledge on soil-plant water relations to estimate the maximum allowable and minimum required rainfall in order to successfully avail a dry or a wet sowing opportunity, respectively.

The field experiments were conducted at Kellerberrin (2011, 2012) and Merredin (2011). The Kellerberrin experiments were unreplicated and the Merredin experiment contained four replicates.

In 2011, canola was dry sown followed by irrigation to create a moisture gradient. For the 2012 experiments, sowing was done after irrigation. Irrigation levels in 2011 ranged from 15 mm to 52 mm with increments of 2.5 mm while 5 mm increments were used in 2012.

Plants were counted twice a week till the season/rains started. Seedling mortality per day was calculated as percentage of the maximum emerged counts.

For modelling purposes, dry and wet sown criteria of plant available water (PAW) were used as proposed by Abrecht and Robertson (unpublished) and soil specific PAWC limits as proposed by Burk and Dalgliesh (2008) and Oliver (2010).

Results

Results are presented for plant mortality and then for rainfall requirements to suit dry or wet sowing.

Emergence

The percentage of plant emergence increased progressively with increasing irrigation (up to 30 mm). Secondly, we observed two situations, one in Merredin 2011 when no further emergence took place after the break of the season and the other at Kellerberrin in 2012 where a second cohort of emergence was noticed on a water-repellent sandy textured soil (Figure 3). This suggested that smaller amounts of irrigation at Merredin evaporated too soon resulting in pre-emergent mortality. In contrast, owing to the non-wetting nature of the sandy textured soil at Kellerberrin (2012), such small irrigation amounts were insufficient to wet up the seedbed thoroughly resulting in some seed surviving. These saved seeds germinated at the next rains (break of the season). Such a bimodal germination pattern on non-wetting sands can perhaps provide buffering to a dry sown crop against false or partial breaks while sowing on other soils with limited rainfall (and limited moisture in the seedbed) will put germinating seedlings to high lethal risk.

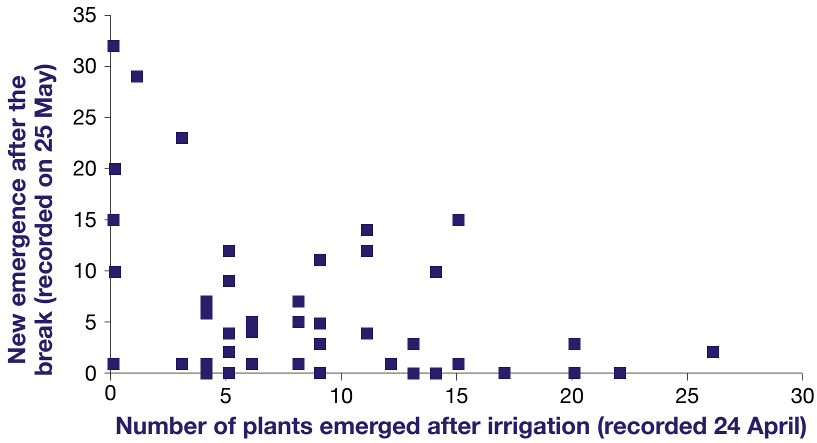

Figure 3: New plants emerged after break of the season at spots where initial emergence (after irrigation) was low at Kellerberrin 2012.

Note that new emergences (y-axis) are more where only few could emerge (x-axis) in the first instance and vice versa.

Survival of the emerged seedlings

Of the four experiments, seedling mortality due to water deficit was not noticeable at Merredin 2011 and either of the Kellerberrin 2012 sites irrespective of the emergence percentage and irrigation level. For example, the points on 1:1 line in Figure 4 imply no mortality from max count date (x-axis) to the last count date (y-axis) for any of the treatments.

To understand this, soil moisture levels were compared with seedling mortality. In all the three sites where mortality rate per day was similar among irrigation treatments, we found plenty of moisture at 20 cm for all treatments and it had connected with the stored moisture underneath (Figure 5). In contrast, Kellerberrin 2011 had clearly two irrigation categories, less than and more than 35 mm irrigation, which coincided with seedling mortality and moisture at 20 cm depth (Figure 6); notably, in comparison to 35 mm, the 25 mm irrigation treatment had less moisture in the 10-20 cm zone and suffered much higher seedling mortality.

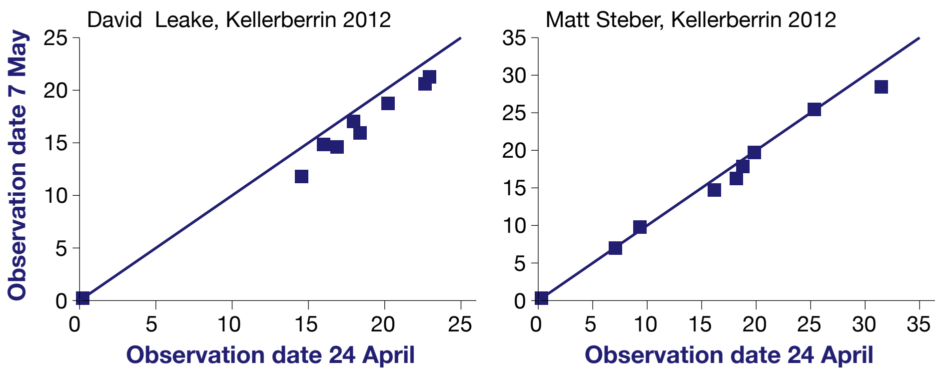

Figure 4: Change in plant density at two sites in 2012.

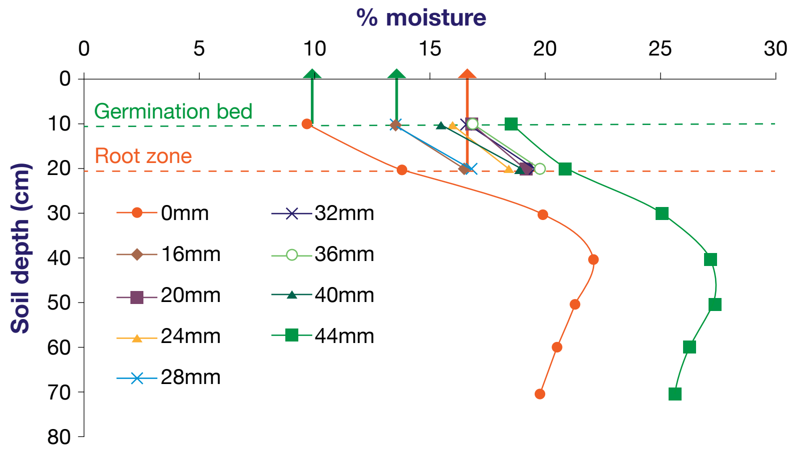

Figure 5: Soil moisture on heavy land at Kellerberrin (2012). To avoid cluttering in the figure, moisture data below 20 cm has not been shown for treatments between nil and 44 mm. Note that even the lowest irrigation level had plenty of moisture at 20 cm (root zone) depth.

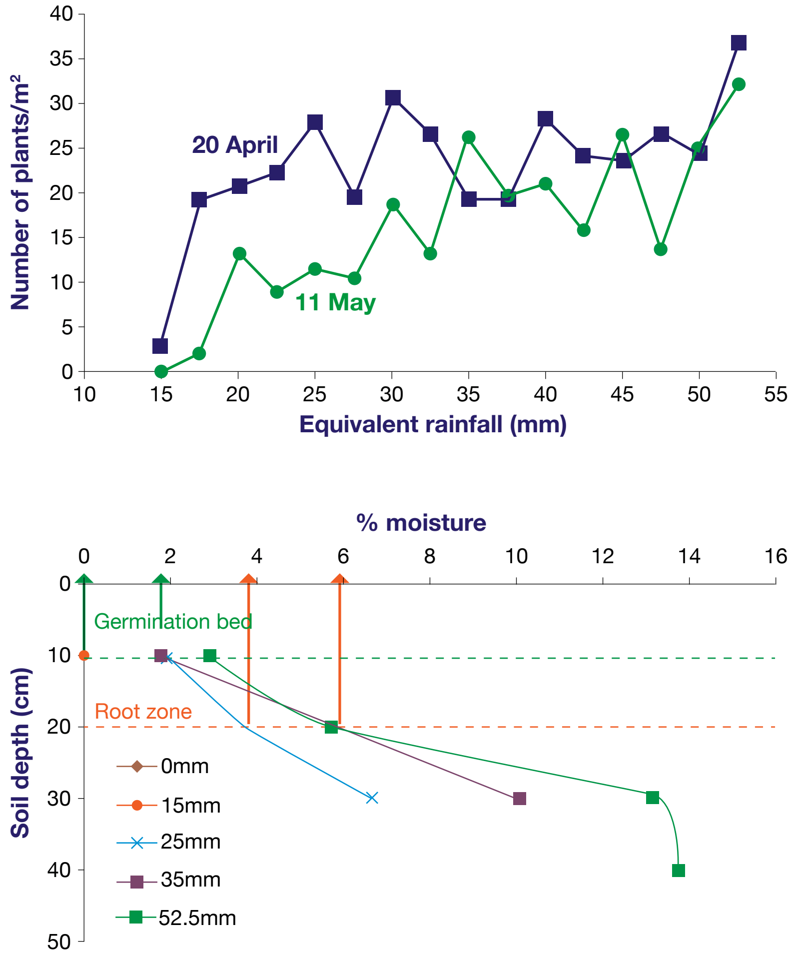

Figure 6: Changes in plant density with time of a 6 April sown canola crop and soil moisture at different irrigation levels. Note that moisture at 20 cm (root zone) depth was lower for 25 mm irrigation compared to 35 mm and above.

How much rainfall?

For a dry sowing, soil moisture must not be more than 30% of PAWC (Table 5). Preliminary calculations reveal that this corresponds to about 4 mm of rainfall on sandy textured soils to a maximum of about 10 mm on clay loam. This implies that dry sowing should be deferred to such a time that moisture in excess of this level gets evaporated.

Duration of this waiting period would vary according to evaporation rate but the estimation of actual evaporation rate from pan evaporation rate (as available from meteorology websites) can be challenging. Determination of actual evaporation rate from soil relative to the pan evaporation rate is complex and is a function of soil moisture percentage, soil type, stubble cover and some other farm practices. From simultaneous consideration of these factors it appears that actual evaporation from soil under most WA conditions should lie from half to three-fourths of the pan evaporation.

Table 5: Estimated maximum allowable rain (mm) on a dry surfaced soil for dry sowing#

$ The significance of 30% PAWC is that this is the approximate water availability above which water is not limiting for plant growth and development

#Falls in excess of this must be allowed to evaporate the difference before dry sowing can be started.

	Soil layer	Depth range (cm)	PAWC$	Sand	Sandy loam	Clay loam
Criterion 1	Seed bed	0-10	< 10%	1.1	1.7	2.3
Criterion 2	Top soil	0-20	< 30%	4.4	6.8	9.9

For wet sowings, more experimental data is needed to model minimum water requirements for early sowing. Nonetheless, following observations from Kellerberrin 2011 (Figure 7) should assist in decision making.

- The mortality rate was higher with less water applied (e.g. compare 25 with 52.5 mm irrigation).
- The mortality rate changed with time. For example, it was higher after 20 April for the moderately stressed treatments (20 and 25 mm) compared to higher irrigation treatments (30 and 52.5mm).
- Average daily evaporation rate for April 2011 at Kellerberrin was 5.4 mm.

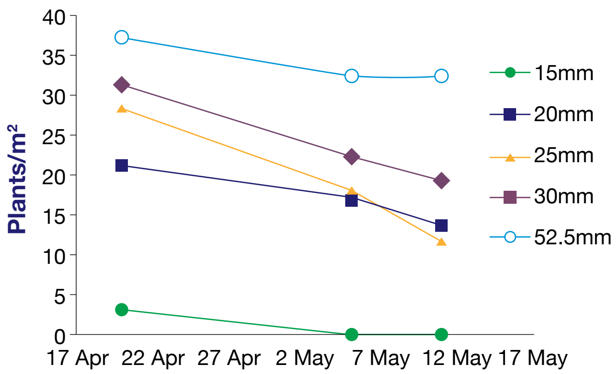

Figure 7: Repeated plant counts for different irrigation levels applied on 6 April to a dry sown crop in Kellerberrin 2011.

Conclusion

For dry sowing, soil type differences exist for maximum acceptable rainfall. Any rain in excess of these limits must be allowed to evaporate before seeding, failing which there will be economic losses due to seed and fuel costs besides the lost opportunity costs in the event of re-seeding.

For wet sowing, plant survival and soil moisture comparison clearly demonstrated that it is not just the availability or the depth to which moisture is available at the time of seeding; it is important that there is sufficient moisture in the seedbed (0-10 cm) for the duration of germination to achieve good plant numbers and adequate deeper moisture to sustain them (10-20 cm and preferably beyond). The best seeding situation is when rainfall reaches stored moisture underneath. [12]

1.6 Yield and targets

Canola has traditionally yielded approximately half of what wheat would yield in the same situation. Said another way it achieves only half the water use efficiency of that of wheat (kg of grain per mm of water available).

More recently with improved varieties and the agronomy and management of the crop many growers are now targeting 50% of typical wheat yields.

As discussed in Section 2, varieties vary in yield performances. However, several generalisations can be made:

- TT varieties will often perform less well than conventional, Clearfield or Roundup Ready varieties as there is a fitness penalty integral to breeding herbicide tolerance. This is often referred to as yield drag and quoted as up to 15% compared to conventional varieties. However some agronomists believe this is over-estimated in some regions and it must be remembered that the TT tolerance allows control of weeds that could otherwise not be controlled. TT varieties often have less seedling vigour which can hinder establishment and this can have ramifications through to harvest.
- Hybrid varieties generally have higher yield potential than open pollinated varieties. This is achieved through the hybridization process, enabling coupling of strong and desirable traits from the parent varieties. Many breeding or seed companies are also investing greater effort into hybrid varieties as gains are easier and quicker to achieve as well as ensuring seed sales each year.
- GMO varieties, specifically Round Up Ready or glyphosate-tolerant varieties, promise improved yield potential and performance but at present these varieties are achieving only average performance, not withstanding weed management benefits.

In setting yield targets or expectations, growers also need to take into account sowing date, seasonal conditions (particularly rainfall and fallow moisture) and disease and pests. In southern regions Blackleg, and more sporadically Sclerotina, can impact

[12] D. Sharma, C. Peek, G. Riethmuller and D. Abrecht, (2013), How much moisture is enough to successfully establish April-sown canola. Department of Agriculture and Food, Western Australia

More information

DAFWA Seasonal Climate Outlook

Grain marketing—wheat, canola and barley outlook

Agribusiness Outlook 2015

Canola agronomy research in central NSW

Irrigated canola - Management for high yields

Growing hybrid canola

heavily on crop performance but the northern region does not seem to experience the same level of disease, particularly Blackleg, so this should not in many cases be too much of a yield barrier.

Pre-seeding planning to manage frost risk in WA

1.6.1 Seasonal outlook

DAFWA's Season Climate Outlook (SCO) is a monthly newsletter that summarises climate outlooks for the next three months produced by DAFWA's Statistical Seasonal Forecast (SSF) system specifically for the Western Australian wheatbelt, and by the Australian Bureau of Meteorology. It provides a review of recent climate indicators, including ENSO (El Niño Southern Oscillation), the Indian Ocean Dipole, the Southern Annular Mode, as well as local sea surface temperature and pressure systems. At appropriate times of year it also includes an overview of the rainfall outlook for the growing season produced by the SSF. [13]

1.6.2 Fallow moisture

Like wheat, canola will benefit from stored subsoil moisture, particularly in marginal cropping areas where winter and spring rainfall is unreliable. Manage fallows efficiently to maximise the amount of moisture at sowing. [14]

1.6.3 Nitrogen- and water-use efficiency

Nitrogen fertiliser can increase the water-use efficiency (WUE) of early-sown canola. The additional N enables the crop to cover the ground quicker and develop a dense leaf canopy, resulting in reduced soil evaporation and better WUE. [15]

A University of Adelaide study in 2013 of canola under different water regimes with N showed that grain yield was mainly driven by biomass production. It also revealed that the timing of N had little impact on yield; however, split application improved oil content.

Canola crops extracted water to 60–80 cm, and addition of N increased the drying of the profile by maturity but had little effect on total water use relative to nil N. Both N-use efficiency and WUE were improved by additional water availability. [16]

13 https://www.agric.wa.gov.au/newsletters/sco

14 L Jenkins (2009) Crop establishment. Ch. 5. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

15 P Hocking, R Norton, A Good (1999) Crop nutrition. Australian Oilseeds Federation, http://www.australianoilseeds.com/__data/assets/pdf_file/0013/2704/Chapter_4_-_Canola_Nutrition.pdf

16 A Riar, G McDonald, G Gill (2013) Nitrogen and water use efficiency of canola and mustard in Mediterranean environment of South Australia. GRDC Update Papers, 13 February 2013, https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Nitrogen-and-water-use-efficiency-of-canola-and-mustard-in-South-Australia

1.6.4 Estimating maximum yield per unit water use by location and nitrogen

Researchers propose a three-step procedure to derive the ‘slope’ parameter representing maximum yield per unit water use accounting for N and location.

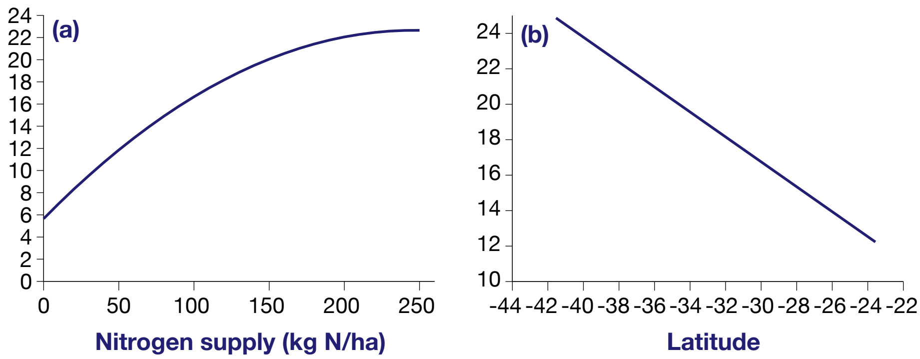

Figure 8: Maximum yield per unit water use (kg/ha.mm) as a function of (a) nitrogen and (b) location.

Step 1

Use the data in Figure 8a to account for the effect of N on maximum yield per unit water use. For severely limited crops (N supply <50 kg N/ha), maximum yield per unit water use would be about 5–6 kg grain/ha.mm. For crops with abundant N supply (>200 kg N/ha), the parameter approaches 24 kg grain/ha.mm. For intermediate N supply, maximum yield per unit water use can be estimated graphically using this curve.

Step 2

Use the line in Figure 8b to correct for location. For a latitude of –41.5° (Launceston, the southernmost location in this study), maximum yield per unit water use would be ~24–25 kg grain/ha.mm. For a latitude of –23.5° (Emerald, the northernmost location), maximum yield per unit water use would be ~12 kg grain/ha.mm. For intermediate locations, maximum yield per unit water supply can be estimated graphically using the line in Figure 8b.

Step 3

Select the lowest value from steps 1 and 2. For example, if we want to estimate the maximum yield per unit water use for Dalby (latitude –27.1°) with intermediate N supply (100 kg N/ha), the location correction would return 14.7 kg/ha.mm and the N correction would return 16.6 kg/ha.mm. We therefore select the lowest value, 14.7 kg/ha.mm, as a benchmark for this combination of location and N supply. [17]

[17] V Sadras, G McDonald (2012) Water use efficiency of grain crops in Australia: principles, benchmarks and management. GRDC Integrated Weed Management Hub, http://www.grdc.com.au/GRDC-Booklet-WUE

Table 6: Water-use efficiency based on total biomass (WUEdm) or grain yield (WUEgy) of different crops

Water-use efficiency is based on the biomass or yield per mm of crop water use. Values are mean and range.

Crop	Region	WUEdm (kg/ha.mm)	WUEgy (kg/ha.mm)	Source
Canola	Victoria	24.0 (17.1-28.4)	6.8 (4.7-8.9)	Norton and Wachsmann 2006
Canola*	NSW		13.4	Robertson and Kierkegaard 2005
Chickpeas	Western Australia	16.0 (11.1-18.3)	6.2 (2.6-7.7)	Siddique et al. 2001
Lentils		12.7 8.5-16.7)	6.7 (2.4-8.5)	
Lupins		17.3 (9.3-22.3)	5.1 (2.3-8.3)	
Faba beans		24.2 (18.7-29.6)	10.4 (7.7-12.5)	
Peas		26.2 (17.6-38.7)	10.5 (6.0-15.9)	
Vetch		18.2 (13.4-22.4)	7.5 (5.6-9.6)	
Chickpeas	Tel Hadya, Syria	13.7 (9.4-18.1)	3.2 (2.1-5.2)	Zhang et al. 2000
Lentils		8.7 (5.0-14.2)	3.8 (1.9-5.5)	
Wheat	South Australia	36.1 (21.2-53.1)	15.9 (9.2-23.2)	Sadras et al. (unpublished)
	South-east Australia		9.9 (max =22.5)	Sadras and Angus 2006

*Based on simulated estimate of crop water use

More information

Water use efficiency of grain crops in Australia

Nitrogen and water use efficiency of canola and mustard in South Australia

Nitrogen use efficiency in canola

Water-use efficiency of canola in Victoria

There are intrinsic differences in the WUE of crops (Table 6), with wheat more water-use efficient than grain legumes or canola, in terms of both total biomass production and grain yield. Differences in the composition of the grain—it is more energy efficient to produce starch than oil or protein—partially explain the higher grain yield per unit water use of wheat compared with oilseed crops and pulses.

Further, canola and the grain legumes are grown at lower plant densities and/or have less vigorous seedlings than wheat, contributing to greater early losses of moisture through soil evaporation, and hence to lower WUE. The amount of winter growth made by the crop is therefore an important factor in determining crop WUE. [18]

1.7 Potential disease problems

Blackleg is the major disease of canola in Australia and can significantly reduce yields, especially in higher rainfall districts. Research has shown that 95–99% of blackleg spores originate from the previous year's canola stubble.

Spores can travel >1 km on the wind but most travel shorter distances, so selecting a paddock as far away as possible from the previous season's canola stubble will help to reduce disease pressure. Where possible, a buffer distance of 500 m is recommended.

On larger farms, it may be possible to implement a system of block farming whereby blocks of several paddocks of a particular crop type are rotated around the farm to maintain an adequate buffer distance. Reducing canola stubble by raking and burning

18 V Sadras, G McDonald (2012) Water use efficiency of grain crops in Australia: principles, benchmarks and management. GRDC Integrated Weed Management Hub, http://www.grdc.com.au/GRDC-Booklet-WUE

provides only limited benefits in reducing the disease level because not all of the infected stubble and old roots are destroyed.

Use of blackleg-resistant varieties in combination with an appropriate fungicide treatment, if necessary, is the best way to minimise yield losses. Careful paddock selection can also assist in reducing the impact of another potentially serious canola disease, Sclerotinia stem rot (caused by *S. sclerotiorum*).

Sclerotinia stem rot - Managing the disease in 2013

More information

AGWEST Plant Laboratories for seed and plant testing

For more information, see GrowNotes Section 9, Diseases.

Sclerotinia stem rot is an intermittent problem in many canola-growing districts, particularly northern regions of WA. It has a wide host range of broadleaf plants and weeds, including lupins, chickpeas, field peas, faba beans, sunflowers, cape weed and Paterson's curse. Growing canola after any of these crops or in paddocks that have had large populations of these weeds can increase the risk of Sclerotinia stem rot, especially when canola is grown under irrigation or in higher rainfall areas. [19]

Sclerotinia infection occurs when there is rainfall around petal drop but only when those petals have Sclerotinia spores on them. Predicting infection is difficult but fungicides can be applied to combat the infection. The economic benefits of this approach in the western region are questionable.

1.8 Nematode status of paddock

More information

Variety choice and crop rotation key to managing root lesion nematodes

For more information, see GrowNotes Section 8. Nematodes.

Canola is considered moderately susceptible to *Pratylenchus neglectus, P. quasitereoides* and *P. penetrans*.

Testing soil is the only reliable way to determine whether root-lesion nematodes are present in a paddock. Before planting, soil tests can be carried out by PreDicta B (SARDI Diagnostic Services) through accredited agronomists, to establish whether crops are at risk and whether alternative crop types or varieties should be grown. Growing-season tests can be carried out on affected plants and associated soil; contact local state departments of agriculture and PreDicta B. [20]

To organise testing and sending of soil samples, visit the PreDicta B website.

[19] P Parker (2009) Crop rotation and paddock selection. Ch. 4. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

[20] GRDC (2015) Root-lesion nematodes. GRDC Tips and Tactics, February 2015, http://www.grdc.com.au/TT-RootLesionNematodes