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Canola agronomy research in Western Australia

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GRDC
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Cover photo

Martin Harries' DPIRD trial, near Beverley, very early sowing of canola in WA (July 2018).

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Canola agronomy research in Western Australia

Editors Jackie Bucat and Andrew Blake

Foreward

The Tactical Break crop agronomy project and the Achieving stable and high canola yield across the rainfall zones of WA project were initiatives originating from a Western Panel Spring Tour of the low rainfall zone. The panel was focussed on investing in research and development to support the expansion of canola into low-medium rainfall zones where it could be incorporated into short-phase cropping systems. The importance of managing nitrogen application in soil with declining organic matter as farms moved from a long pasture phase system was paramount. Furthermore, understanding the management changes required to transition from OP to hybrid canola and back again was critical.

The key features of the investment included:

- developing low input systems to support canola in the low rainfall zone
- combining knowledge to support the strategic use of canola in the farming system with the tactical requirements for nitrogen, sowing time and seeding rates
- stabilising canola yield across all three rainfall zones

The relative importance of canola in the system is demonstrated in the doubling of area sown to canola in the Kwinana, Albany and Esperance port zones in the past 5 years (as per GIWA crop reports). Recognition for the role of the project teams from the Department of Primary Industries and Regional Development and CSIRO in delivering the expansion of canola in Western Australia needs to be celebrated.

The GRDC will continue to strive for reducing the yield gap in canola in Western Australia.

Dr Julia Easton

Manager, Agronomy and Farming Systems West

Grains Research and Development Corporation

Contents

Project Acknowledgements

The information presented is from canola research delivered through DPIRD and CSIRO projects.

Tactical break crop agronomy project, of the Department of Primary Industries and Regional Development (DPIRD), formerly Department of Agriculture and Food, Western Australia (DAFWA). The target outcome of the project is for growers to have the tools to choose and profitably manage the most appropriate break crop for their circumstances. (DAW00227)

CSIRO project **Achieving stable and high canola yield across the rainfall zones of WA.** This project performs physiological research to underpin canola agronomy across the low, medium and high-rainfall areas of WA to target industry needs in collaboration with the DPIRD break crop agronomy team. We are interested in understanding how agronomic management impacts yield, profitability and specific adaptation to low and high-rainfall environments across the different canola technologies available to growers. (CSP00169)

The Grains Research and Development Corporation (GRDC) has invested in these projects along with DPIRD and CSIRO, to improve the profitability of grain growers.

CSIRO project team

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DPIRD staff have worked closely with farmers and farmer groups for trials, field days and industry information.

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Acknowledgement and thanks to the technical team, who have worked hard to make sure the real work gets done. We appreciate your efforts.

Field research units

Thank you to the DPIRD Field Research Units for sowing, harvesting and managing the trials: Represented by the managers; Steve Cosh (Geraldton), Vince Lambert (Merredin), Julie Roche (Northam), Gavan d'Adhemar (Katanning) and Chris Matthews (Esperance).

Farmers and farmer groups

DPIRD staff have worked closely with farmers and farmer groups for trials, field days and industry information. Trials have been based with the following farmer groups: Holt Rock, Liebe, Mingenew-Irwin Group (MIG), Northern Agri Group (NAG), North Mallee Farm Improvement Group, SEPWA, WANTFA and Wittenoom Hills and also hosted by Bob Nixon at Kalannie. DPIRD project staff have presented at updates or field walks for all these groups as well as Corrigin FIG, Facey group, FEAR, Fitzgerald Biosphere Group, MAD FIG, RAIN, Southern Dirt, Stirlings to Coast, West-Midlands Group and Yuna FIG.

Early sowing profitable in 2015 and 2016

Martin Harries, Mark Seymour and Imma Farre, DPIRD

Key messages

- Sowing early is the key to maximising canola yield
- An extra 40kg/ha per day was gained when sowing in mid-April compared to late April at Binnu in 2015
- Changes in climatic, pest and disease risks must be considered when sowing early.

Background

Sowing canola in mid-April has become standard practice in the far north of the WA cropping zone. However, there is little research data on the effect of these sowing dates on yield. The Tactical Break Crop Agronomy team took advantage of early sowing opportunities in 2015 and 2016 to sow trials early and fill this knowledge gap.

Method

Two trials were undertaken which tested a range of canola varieties sown at two different sowing dates (TOS 1 and TOS 2). In 2015 a trial was sown at Binnu on 15 April and 29 April. In 2016 very early sowing occurred at Wongan Hills on 31 March and 15 April (Figure 1).

At Binnu there were 10 varieties (5 TT and 5 RR); CB Telfer (very early), ATR Stingray (early), ATR Bonito (early/mid), Hyola® 450TT (mid), Hyola® 559 (mid/late), Pioneer 43Y23 (early), Hyola® 404 (early/mid), GT41(early/mid) GT50 (mid), Hyola® 525 (mid).

At Wongan there were six varieties; all were Round-up Ready hybrid plant types; Pioneer 43Y23 (early), Hyola® 404RR (early/mid), GT50 (mid), Hyola® 525RT (mid/late), Hyola® 600RR (late), Hyola® 725RT (very late).

Results

Yield Binnu

The overall yield of the Binnu trial was 1322kg/ha. Averaged across all varieties TOS 1 yielded 1647kg/ha compared to TOS 2 yielding 997kg/ha. Hence 650kg/ha less yield from delaying sowing by 15 days, a loss of 43kg/ha/day.

Figure 1 DPIRD researcher Martin Harries at the Wongan Hills trial looking at sowing times for canola; March sown plots (left) and mid-April sown plots (right), photo taken 5 July

There was a variety response (P<0.001), with the more recently released hybrids among the highest yielding varieties).

There were no significant differences between varieties in their response to sowing time. Roundup Ready varieties yielded 1362kg/ha on average and triazine tolerant varieties yielded 1282kg/ha (Figure 2).

Yield Wongan Hills

The overall yield of the trial was 2755kg/ha. Canola sown on 31 March yielded 2853kg/ha compared to 2658kg/ha for canola sown on 15 April, averaged across all varieties. Hence delaying sowing by 15 days led to 195kg/ha less yield, which is equivalent to an average loss of 13kg/ha/day.

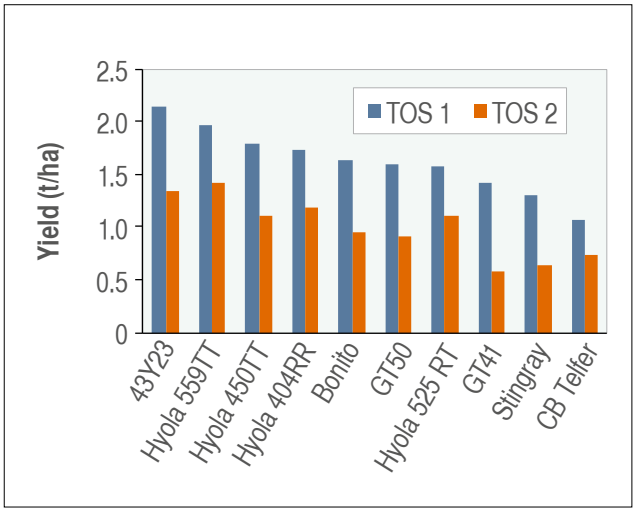

Figure 2 Yield, Binnu 2015 trial. TOS 1 = 15 April, TOS 2 = 29 April

For the early maturing varieties, Pioneer 43Y23 and Hyola® 404RR, there was no advantage to seeding in March compared to April. For the mid-season maturity varieties, GT50 and Hyola® 525RT, yields increased by 360kg/ha (24kg/ha/day) or 11% and 12% respectively with March sowing. For the long-season maturity varieties, Hyola® 600RR and Hyola® 725RT, yields increased by around 260kg/ha from March sowing (17kg/ha/day) or 9% and 10% respectively (Figure 3).

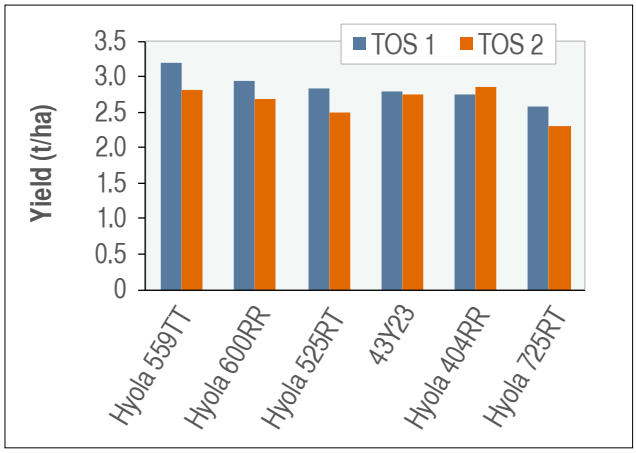

Figure 3 Yield, Wongan Hills 2016 trial, TOS 1 = 31 March, TOS 2 = 15 April

Seed quality

For both trials there were significant differences in seed oil content between varieties but not between the sowing times.

Plant growth

In both trials, plants that emerged earlier produced more biomass, although this response was less pronounced in the short-season, smaller plant-type varieties (Figure 4).

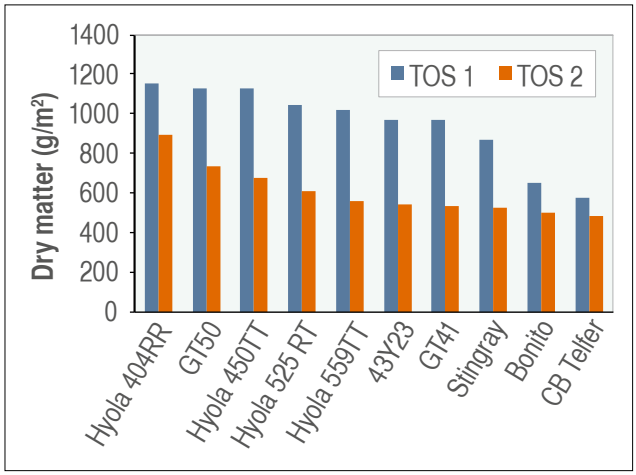

Figure 4 Plant biomass Binnu 2015 trial on 18 August. TOS 1 = 15 April, TOS 2 = 29 April

APSIM simulation modelling comparison

The yields obtained in the Wongan Hills trial were compared to predicted yields using the APSIM model.

On average, the optimum time of sowing for Wongan Hills is simulated to be 7 April - 6 May, with lower yields for March sowing (Figure 5).

The trial yields were close to that simulated by the model for the 2016 season. In 2016, simulated yield increased when sown in March compared to April, due to summer rain and early season rainfall. However, the model output for 2000-2015 suggests this is not common.

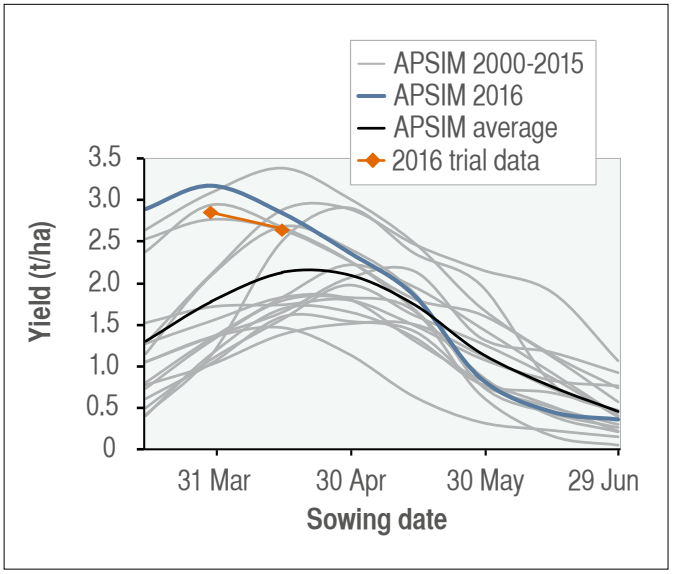

Figure 5 Comparing yield at different seeding dates for trial results and APSIM simulations at Wongan Hills

Conclusions

The research to date strongly indicates, if a mid-April sowing opportunity occurs growers should take it. This will maximise yield and reduce the risk of experiencing a long delay to the next sowing opportunity. Although there will be increased disease and pest risk, due to the longer period of exposure, and increased risk of a dry spell after sowing.

APSIM simulations are a valuable tool in understanding and simulating (predicting) particular seasonal results.

More work is required to investigate very early sowing of canola over a wider range of years and locations.

Optimum sowing window to maximise canola yield in Western Australia using simulation modelling

Imma Farre and Jackie Bucat, DPIRD

Key messages

- The optimum sowing window that maximises canola yield for low and medium rainfall locations is in April, and for high rainfall locations is in April or May.
- If the sowing opportunity is late, assess the risk of achieving a certain yield.

Introduction

In the last decade, there has been a trend towards earlier and earlier sowing of canola. However, there is little experimental data on very early sowings before mid-April. The yield response to sowing date is a function of crop growth period, water and frost stress. Sowing too early or too late, when temperatures are high, causes fast crop growth, reducing biomass at flowering and cutting potential yield. Early sowings are more likely to suffer frost damage and late sowing often leads to water stress during grain filling. As a consequence, in water limited environments, there is a trade-off between sowing date to escape frost or to escape terminal drought.

This computer modelling study was designed to establish the optimum sowing window to maximise grain yield for different locations in Western Australia. The Agricultural Production Systems sIMulator (APSIM) (Keating *et al.*, 2003) was used in this simulation study. The APSIM-Canola (v.7.9) model, validated for Western Australian conditions (Farre *et al.*, 2002), was used to explore the effect of time of sowing on canola yields for different environments.

Long-term simulations, using rainfall and temperature data, for 1976-2016 were run for 24 locations in the grain growing areas of Western Australia, with eight times of sowing from mid-March to end-June at 15 day intervals, three soil types (sandy, duplex and clay) and three canola cultivars. The locations were chosen to represent low (LRZ), medium (MRZ) and high (HRZ) rainfall zones in the wheatbelt of WA. The canola cultivars were generic short (for example, Stingray), medium e.g., ATR Bonito) and long (e.g., Hyola® 650 TT) season cultivars, equivalent to series 3-4, 5 and 6-7 of the current cultivars, respectively. 10mm irrigation was applied at sowing to ensure that the crop was successfully established. Crop emergence occurred 9-13 days after sowing. Crop management was simulated to reproduce best management practices in each rainfall zone. A yield reduction to account for frost and heat damage based on air temperature around flowering and early grain filling was applied to the simulated yields (Lilley *et al.*, 2015).

Optimum sowing window

The optimum sowing window for each location was defined as the sowing period when average yield was within 95% of the maximum yield (Table 1). The optimum sowing window

Table 1 Canola optimum sowing window for 24 WA locations for a mid-variety (ATR Bonito). Locations grouped according to AgZones and Rainfall zones (L=Low, M=Medium, H= High).

AgZone	Location	Optimal sowing window
L1/M1	Mullewa	7 Apr – 1 May
L2/M2	Dalwallinu	8 – 30 Apr
L3	Kellerberrin	7 – 27 Apr
L3	Merredin	3 – 26 Apr
L3	Southern Cross	26 Mar – 23 Apr
L4	Hyden	5 – 28 Apr
L5	Salmon Gums	26 Mar – 26 Apr
M1	Mingenew	9 Apr – 9 May
M1/2	Carnamah	8 Apr – 2 May
M2	Wongan Hills	7 Apr – 6 May
M3	Cunderdin	5 – 30 Apr
M3/H3	Northam	8 Apr – 4 May
M3/4	Corrigin	7- 26 April
M4	Lake Grace	3- 26 Apr
M4/H4	Wagin	2 Apr – 5 May
M5W	Ongerup	3 – 30 Apr
M5E	Ravensthorpe	3 Apr – 8 May
H1	Geraldton	13 Apr – 15 May
H2	Badgingarra	12 Apr – 18 May
H4	Wandering	13 Apr – 15 May
H5W	Kojonup	31 Mar – 18 May
H5W	Frankland	29 Mar – 7 Jun
H5W	Mount Barker	29 Mar – 9 Jun
H5E	Gibson	1 Apr – 13 May

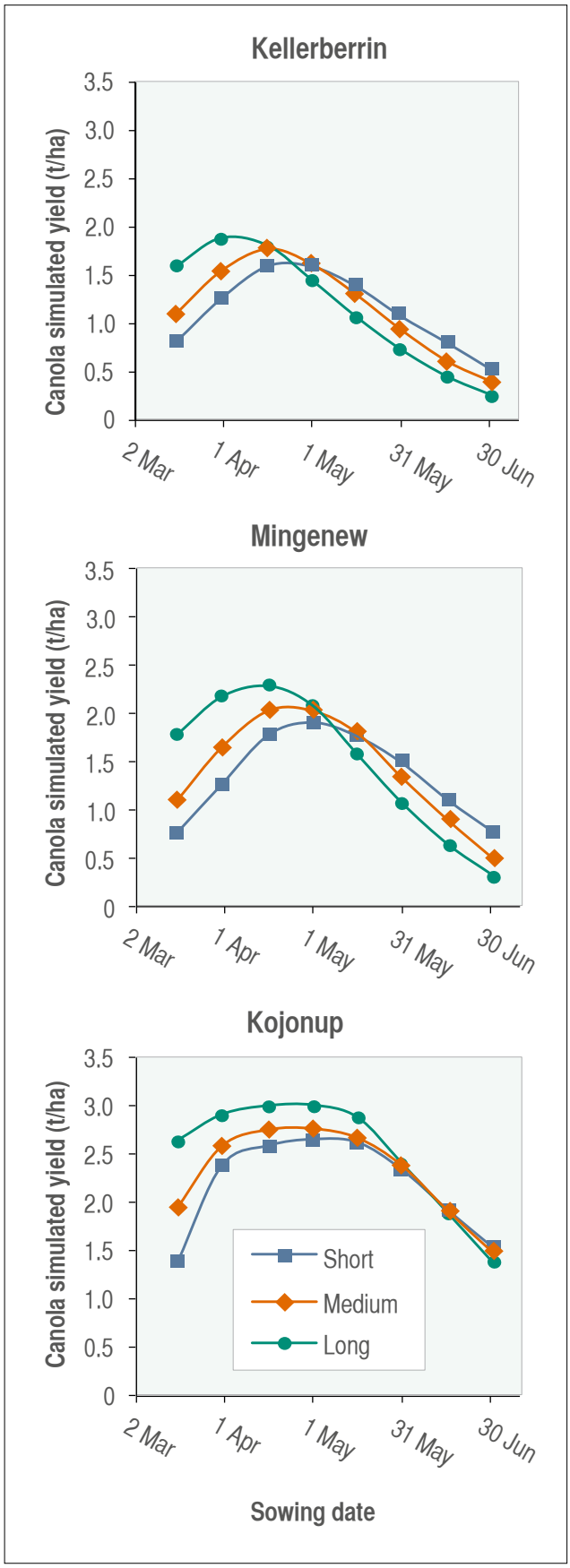

Figure 1 Yield response to sowing date for Kellerberrin (LRZ), Mingenew (MRZ) and Kojonup (HRZ), for a short, medium and long season cultivar, on a duplex soil. Average simulated yields for the period 1976-2016 (41 years).

varied with location, soil type and cultivar. As a rule of thumb, the optimum sowing window for a medium maturity cultivar in low and medium rainfall locations is April and for high rainfall locations is from early or mid-April to mid-May or late-May.

The optimum sowing window was earlier and shorter in duration in low rainfall locations and longer in high rainfall locations (Table 1). For example, the optimal sowing window for ATR Bonito on a duplex soil was 7-27 April in Kellerberrin (20 days duration) and 31 March-18 May in Kojonup (48 days duration) (Table 1).

Sowing windows in Table 1 are for a duplex soil or soil with a medium water holding capacity. In general, light soils have earlier and shorter optimum sowing windows than heavy soils. The duration of the sowing windows was 3-15 days shorter on light (sand) soil than on duplex soil, and it was up to 13 days longer on heavy (clay) soil compared to the duplex soil.

Peak yield

Simulated average yields increased from very early sowing up to a peak or maximum yield at the optimum sowing window and decreased with later sowing (Figure 1). Yields were higher for high rainfall locations. Peak simulated yields

for ATR Bonito (medium maturity cultivar) on a duplex soil at Kellerberrin (LRZ), Mingenew (MRZ) and Kojonup (HRZ) were 1.8, 2.0 and 2.8t/ha, respectively (Figure 1).

Different maturity varieties have slightly different optimum sowing times. The biggest difference in cultivar performance is for early sowing times, where yield of long maturity cultivars was significantly higher than short and mid maturity cultivars (Figure 1). With late sowings, yield differences between cultivars decreased and short maturity cultivars out-yielded the other cultivars in general.

Risk

If the sowing opportunity is late, it is important to assess the chances of achieving a target yield or break-even yield (Figure 2). This information can help make an informed decision regarding when it is too late to sow canola. For example, there is only a 15% chance of achieving at least 1.5t/ha with end-May sowing at Kellerberrin, but 45% at Mingenew and 95% at Kojonup (Figure 2), based on the last 41 years of climate data.

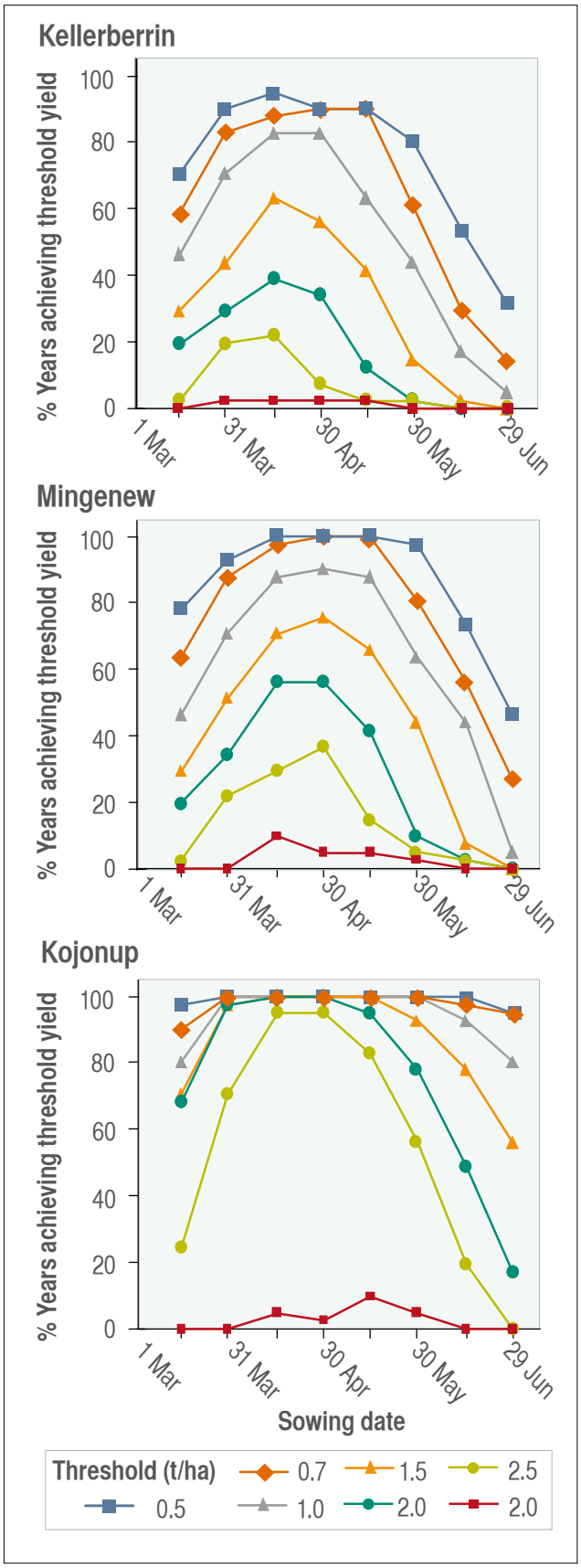

Figure 2 Percentage of years (%) with yield above certain thresholds for different sowing dates, at Kellerberrin (LRZ), Mingenew (MRZ) and Kojonup (HRZ), on a duplex soil, sowing ATR Bonito (mid cultivar). Yield thresholds were 0.5, 0.7, 1, 1.5, 2.0, 2.5 and 3.0t/ha. Based on 41 years of climate data.

When is too late to sow?

The last possible sowing date which returns the break-even yield, depends on the location and the level of risk accepted. For example, the last sowing dates that have 90% chance of achieving a yield of 0.7t/ha in low and medium rainfall locations, and a yield of 1t/ha in high rainfall locations, are presented in Table 2. In some low rainfall locations, the chances of achieving 0.7t/ha are lower than 90% for any sowing date, so there is no date that fulfils the condition. In the medium and high rainfall locations, the dates in Table 2 can be used as an indication of the latest possible sowing dates for high chances of achieving break-even yields.

Table 2 Last canola sowing date to achieve nominated yields of ATR Bonito. Based on 90% chances of achieving 0.7t/ha in the low and medium rainfall locations and 90% chances of achieving 1t/ha in the high rainfall locations. Locations grouped according to AgZones and rainfall zones (L=Low, M=Medium, H= High).

AgZone	Location	Last sowing date
L1/M1	Mullewa	No date
L2/M2	Dalwallinu	18-May
L3	Kellerberrin	15-May
L3	Merredin	26-Apr
L3	Southern Cross	No date
L4	Hyden	15-May
L5	Salmon Gums	No date
M1	Mingenew	23-May
M1/2	Carnamah	15-May
M2	Wongan Hills	3-Jun
M3	Cunderdin	19-May
M3/H3	Northam	3-Jun
M3/4	Corrigin	23-May
M4	Lake Grace	15-Apr
M4/H4	Wagin	16-Jun
M5W	Ongerup	6-Jun
M5E	Ravensthorpe	2-Jun
H1	Geraldton	6-Jun
H2	Badgingarra	12-Jun
H4	Wandering	10-Jun
H5W	Kojonup	18-Jun
H5W	Frankland	after 30-June
H5W	Mount Barker	after 30-June
H5E	Gibson	12-Jun

Conclusions

As a rule of thumb, sowing in April will achieve the maximum canola yield in most locations in the WA cropping region, especially in low and medium rainfall locations. For long season environments and/or mild conditions (high rainfall locations) this period extends to mid-May or end-May.

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Yield of different herbicide-tolerant canola varieties: are there any differences among TT, RR, Clearfield and conventional canola technologies?

Heping Zhang and Jens Berger, CSIRO; and Mark Seymour, Jackie Bucat and Raj Malik, DPIRD

Key messages

- The yield difference between Triazine Tolerant (TT), Clearfield® and conventional canola is small and insignificant in the low rainfall zones of Western Australia and in low yielding environments.
- Roundup Ready® (RR) canola produced 0.2-0.3t/ha higher yield than TT in the medium and high rainfall zones, but the yield difference was small for trials in the low rainfall zone.
- Different herbicide tolerant technologies offer growers alternative weed control options. Growers need to take into account weed control issues and adopt herbicide tolerant technologies in line with grower specific needs.

Background

Herbicide tolerant technologies have been widely used in canola production in order to control weeds. Four types of herbicide tolerant technologies (Triazine Tolerance (TT), Roundup Ready® (RR), Clearfield (CL) and conventional (CV)) are currently used in Australian canola production. Each technology has its potential benefit in controlling weeds and impact on yield. TT varieties offer an inexpensive method of weed control, with intermediate effectiveness, but at the cost of reduced yield potential associated with lower rates of photosynthesis. Conversely, RR canola provides stronger weed control, has no yield penalty, but attracts higher input costs and a potentially lower price for the harvested GM grain. Growers are interested in the yield advantage of different herbicide tolerant technologies compared with the widely used TT technology and their potential role in farming systems. We conducted a trial series across high, medium and low rainfall zones of WA to investigate the yield performance of these four types of technologies.

The experiments

A multiple-environment trial (MET), consisting of 19-20 canola varieties each year, were conducted in the low (Merredin), medium (Cunderdin), and high (Kojonup) rainfall zones in WA from 2013 to 2017 (Figure 1). Current varieties were used, balanced by heterosis (Open pollinated, (OP) and hybrid), herbicide group (TT, RR, CL and CV) and phenology (early, mid and late flowering) as much as possible.

Figure 1 High yielding site (left) at Kojonup and low yielding site (right) at Merredin

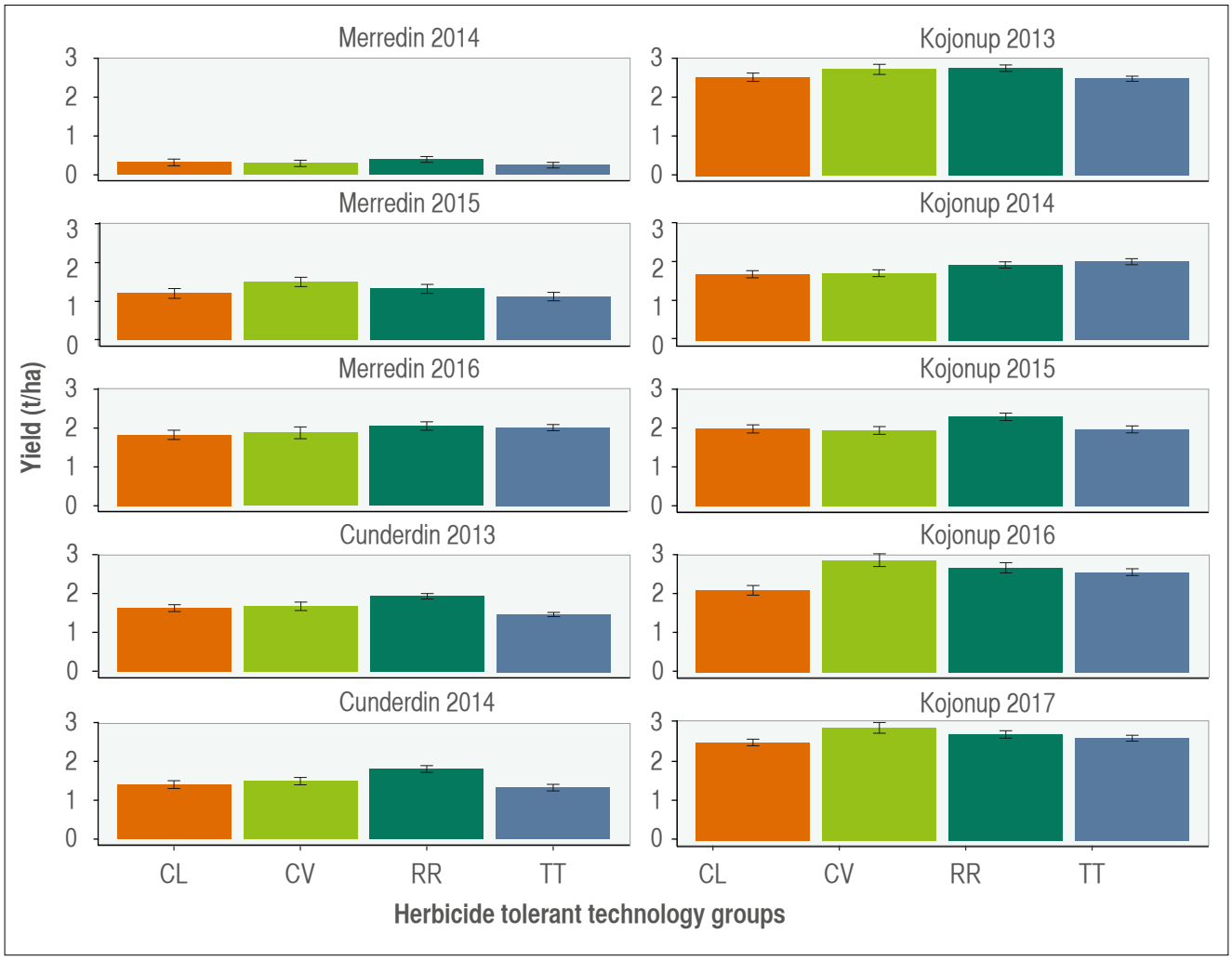

Figure 2 Average yield of different herbicide tolerant technologies (CL: Clearfield; CV: conventional; RR: Roundup Ready; TT: triazine tolerance) in the low rainfall zone (Merredin 2014-2016), the medium rainfall zone (Cunderdin 2013-2014), and the high rainfall zone (Kojonup 2013-2017). The bars indicate the standard error of the yield

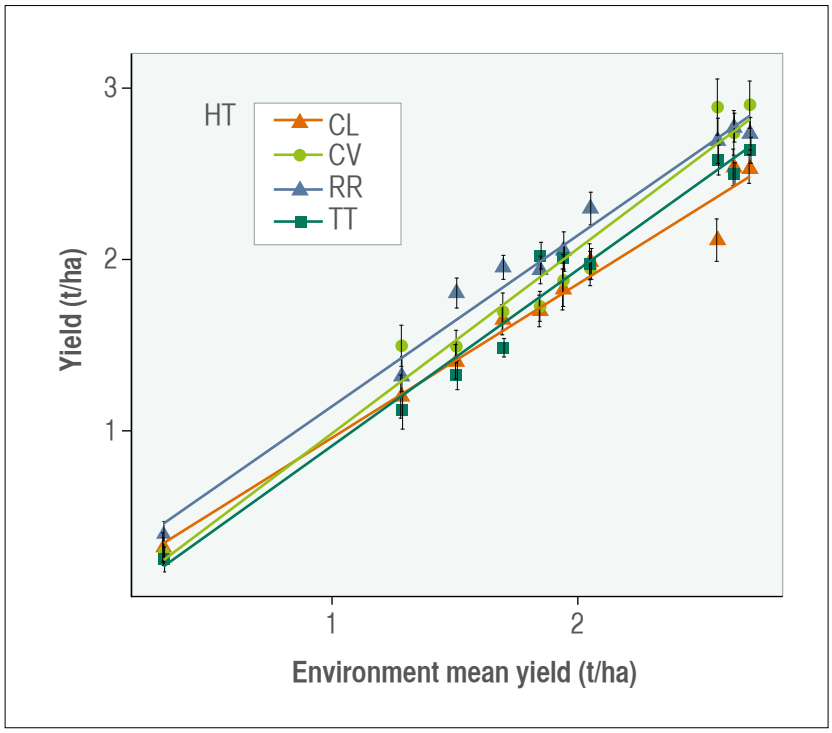

Figure 3 Relative yield of four herbicide tolerant technologies (CL: Clearfield; CV: conventional; RR: Roundup Ready; TT: triazine tolerance) across low (Merredin), medium (Cunderdin) and high (Kojonup) rainfall zones in WA. Individual treatment data is plotted against environment mean yield. Treatments varied and included high and low nitrogen, early and late sowing, rain fed and irrigation. The bars indicate the standard error of the mean yield

Yield performance

Among the herbicide tolerant technologies, RR canola produced higher yield than Clearfield, and TT canola in four of the 10 trials: Cunderdin 2013, 2014, Kojonup 2013, 2015 (Figure 2). Conventional canola had significantly higher yields than OP TT at 4 trials: Merredin 2015 and Kojonup 2013, 2016 and 2017. The Finlay-Wilkinson analysis across all combined experiments showed that RR canola produced 0.2-0.3t/ha more yield than the OP TT canola across a wide range of environments from 1.3t/ha to 3.5t/ha (Figure 3). The yield difference between the TT, Clearfield and conventional canola was small when yields were less than 2t/ha. However, conventional canola produced similar yield to RR canola when yield was above 2.5t/ha.

Conclusion

In summary, RR canola had a yield advantage of 0.2-0.3t/ha compared with TT and Clearfield canola. In high yield conditions, conventional canola produced similar yield to RR canola. The yield difference between TT and Clearfield canola was small across a wide range of yields and from the low to high rainfall zones of WA. Different herbicide tolerant technologies offer growers alternative weed control options. Growers need to take into account emerging weed control issues and adopt these technologies in line with their specific needs.

Hybrid versus open-pollinated TT canola: which one wins where?

Heping Zhang, CSIRO, Jackie Bucat, Mark Seymour, DPIRD and Jens Berger, CSIRO

Key messages

- Growers could consider changing from open pollinated TT varieties to TT hybrid varieties where yields are expected between 1.1 and 1.9t/ha, depending on their approach to risk.
- Growers should continue to choose RR hybrids primarily for the weed control opportunities.

Background

Most canola grown in Western Australia is from open pollinated (OP) triazine tolerant (TT) varieties (78% in 2017). Growers also have access to hybrid TT, Roundup Ready (RR) and Clearfield (CL) hybrid varieties. Hybrids grow more vigorously (Figure 1), some have high disease tolerance and can produce higher yields than open pollinated TT varieties. However, hybrid canola has a considerably higher seed cost, compared with OP canola meaning that the risk is borne at the start of the season when the potential yield is unknown. As canola expands into the low rainfall zone and the OP cultivar choice becomes more restricted with fewer variety releases, it becomes important to understand gross margin trade-offs among the range of canola options.

Method

The latest WA National Variety Trial (NVT) data (2013-2017) was used to compare the yield of different hybrid canola types with open pollinated TT varieties. There were 85 TT trials, providing the best data comparison. RR and CL hybrids were compared with open pollinated TT varieties at 55 co-located RR trials and 35 co-located CL trials, providing an estimate of difference between the types. The yields were calculated using the average yield of all varieties of each type, for each location.

The gross margin for TT, RR and CL hybrids were compared with open pollinated TT canola based on yield differences only, not including weed control benefits. The gross margin analysis was conducted based on a farm gate grain price of $550/t and $510/t for GM varieties, $5 end point royalty for OP TT varieties, seed costs of $2/kg for TT OP, $26/kg for TT and CL hybrids and $35/kg for RR hybrids, seeding rates of 4kg/ha for TT OP varieties 2.5kg/ha for hybrids, and variable cost for nitrogen fertiliser. The same ($60/ha) herbicide cost was used for all herbicide types.

We define the breakeven threshold (1:1 return) as the yield at which the extra input costs from hybrid seed are covered by the extra yield from hybrids. At this threshold, hybrids deliver the same profit as open pollinated TTs. However, at this threshold the growers face extra financial

Figure 1 Open-pollinated canola (left) and hybrid canola (right) and showing vigour difference at vegetative growth stage

risk from the upfront seed cost and extra production risk from using lower seed rates. Growers may want to have a higher return on their investment in seed costs to mitigate these risks. We considered the yield at which each extra $1 invested in seed returned $2 profit, the 1:2 return threshold.

Yield results

Overall, hybrids out yielded open pollinated TT varieties and the differences were greater at the highest yielding sites (Table 1). Where OP TT had yields of 2t/ha, yields for TT, RR and CL hybrids were 2.2, 2.3 and 2.3t/ha, respectively.

Table 1 Comparison of TT OP yield (t/ha) with TT, RR and CL hybrids, in WA NVT 2013-2017

TT OP	TT Hybrid	RR Hybrid	CL hybrid
0.5	0.5	0.6	0.6
1	1.1	1.2	1.2
2	2.2	2.3	2.3
3	3.4	3.5	3.4

Gross margin analysis

The cost of growing hybrid canola is $65-87/ha more expensive than OP, due to greater seed costs. Gross margins were strongly linked to yield potential and hybrid canola was only more profitable when the gains from higher yield outweighed the greater cost of production (Figure 2).

The gross margins accounted for yield differences but did not account for rotation or system benefits from better control of problem weeds.

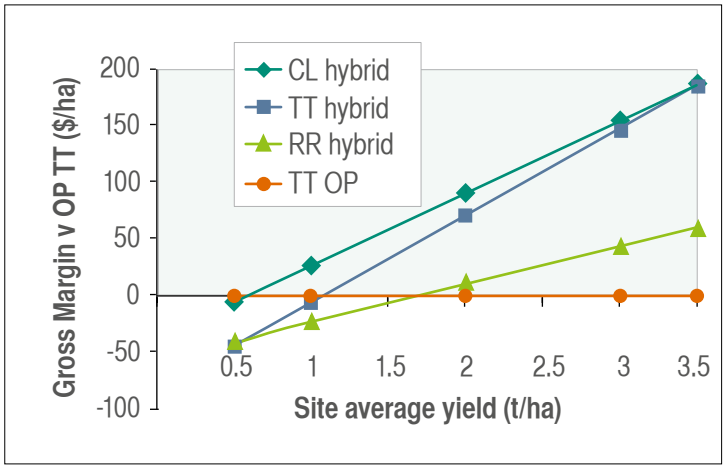

Figure 2 Difference in gross margin for TT, RR and CL hybrids, compared with OP TT canola. The intercept on x-axis indicates the profit break-even yield threshold, compared to OP TT canola

Hybrid TT canola

For hybrid TT canola the breakeven profit threshold compared with open pollinated TT is 1.1t/ha, and the 1:2 return rate threshold is 1.9t/ha (Table 2). Growers could consider using TT hybrids, rather than OP TT varieties, somewhere between these thresholds. The middle rate of return (1:1.5) has a yield threshold of 1.5t/ha.

NVT is an excellent system to compare varieties under standardised management. However on farm, growers usually reduce hybrid seeding rates and grade OP seed for a bigger seed size. Both of these management tactics are likely to reduce the yield gap between hybrids and OP.

Table 2 Breakeven yields (t/ha) for changing from OP TT canola, or 1:1, 1:1.5 and 1:2 return rates

	TT Hybrid	RR Hybrid		CL hybrid
Grain price	$550	$510	$530	$550
1:1 return	1.1	1.8	1.1	0.6
1:1.5 return	1.5	3.1	1.9	1.1
1:2 return	1.9	4.4	2.7	1.6

Roundup ready canola

Hybrid Roundup ready varieties have the highest advantage over OP TT yield (Table 1). However the gross margin is disadvantaged and complicated by the variable GM discount, which is typically $20-40 less than the non GM price. This causes large variability in the gross margin; and the breakeven threshold varies between 1.1-1.8t/ha, and 2.7-4.4t/ha at a 1:2 return rate (Table 2). The higher costs and lower income of RR canola, compared with TT canola, caused the very high thresholds at the 1:2 return rate.

If we change the herbicide costs to RR- $45/ha and TT-$75/ha, by sowing the RR dry and adding propyzamide to the TT, then the profit breakeven threshold drops to 0.5-0.9t/ha, and the 1:2 return rate threshold drops to 2.2-3.5t/ha, for GM discounts of $20-40/t, respectively.

Although RR varieties out yield OP TT varieties on average, RR gross margins are variable and it would be difficult to reliably meet the high 1:2 return rate thresholds for RR canola. The real benefit of RR canola is weed control options for growers, to realise the break crop rotational benefit to wheat, assessed as 0.4t/ha in WA. Growers should continue to use RR varieties for weed control options.

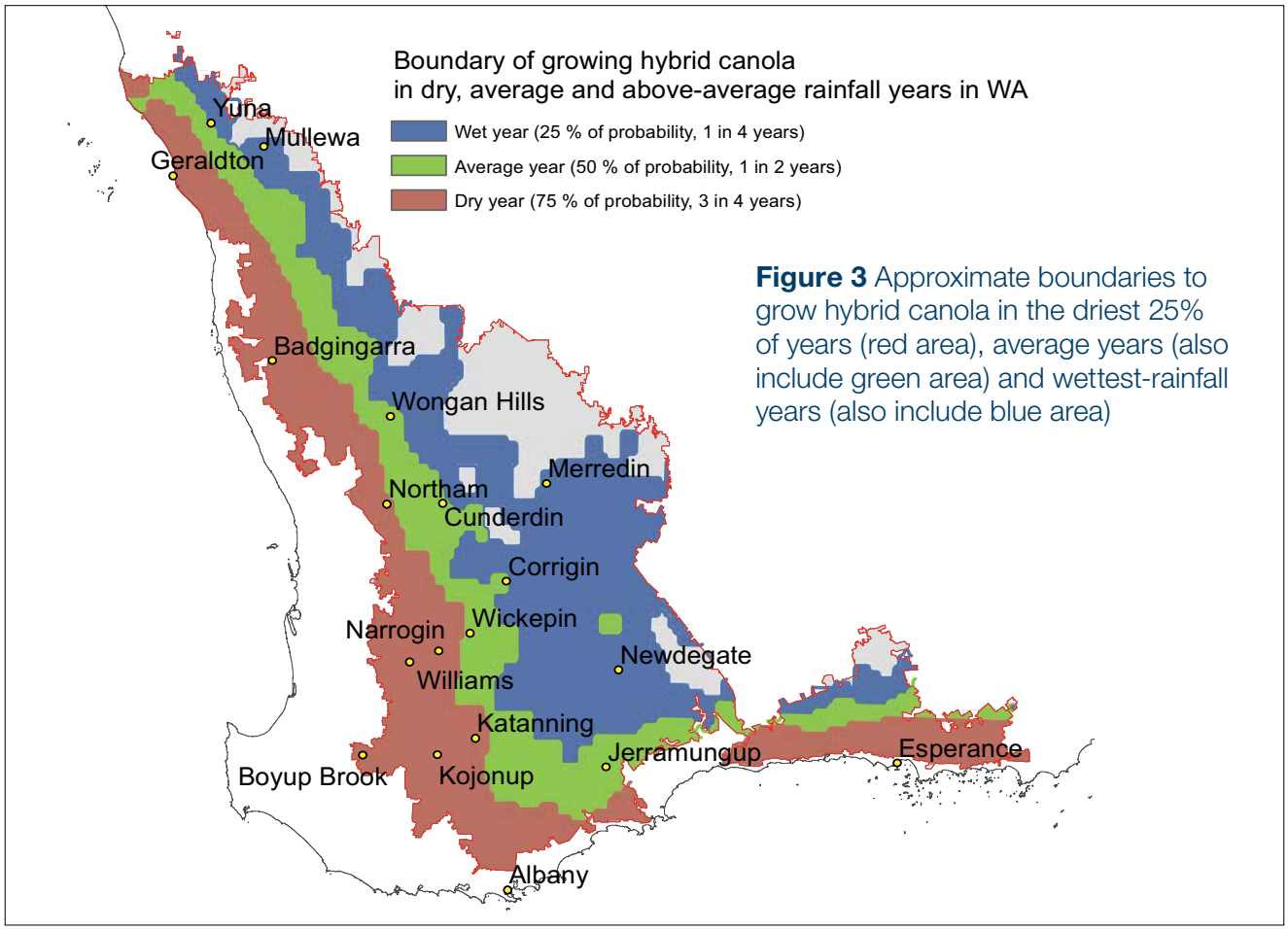

Figure 3 Approximate boundaries to grow hybrid canola in the driest 25% of years (red area), average years (also include green area) and wettest-rainfall years (also include blue area)

Clearfield canola

On average, Clearfield hybrid varieties have a yield advantage over open pollinated TT. The profit breakeven threshold to change from OP TT to Clearfield hybrid, based on increased canola yield, is 0.6t/ha and 1.6t/ha for 1:2 return rate. Results are considerably lower than for NVT 2012-2016 (1.2/2.2t/ha), so should be treated with caution.

The possibility of Clearfield herbicide residues affecting following crops is a serious risk factor for CL canola, especially in low rainfall areas.

The results show that there is opportunity to change from OP TT varieties to Clearfield hybrids, based on the yield advantage. However risks are higher than for other hybrid types.

Growing season rainfall and choice between open pollinated TT and hybrids

Having determined the break-even yield for changing from OP TT to hybrid varieties, we related the break-even yield to the growing season rainfall. Based on the relationships between yield and growing season rainfall, it was estimated that the growing season rainfall of around 240-265mm is enough to achieve 1.1-1.2 t/ha for south-western Australia. We conservatively take 265mm as the critical value above which hybrids become more profitable than OP canola. Based on the long term growing season rainfall from April to October, we developed a map showing the potential areas of growing hybrid canola profitably in the dry, average and wet rainfall year in WA (Figure 3).

In the 25% driest years, hybrid canola is best limited to the high rainfall zone (red area of Figure 3). In average rainfall years (25 to 75th percentiles), the use of hybrids could extend to include the green shaded area, and in the very wettest years (top 25%) can be further extended to include some traditional low rainfall areas shaded in blue on Figure 3.

When considering the 1:2 return rate, growers in the high rainfall (>330mm growing season rainfall) area are more likely to meet the 1:2 return threshold of 1.9t/ha and therefore can switch from OPs to hybrids to take advantage of high rainfall and longer growing season in order to lift their current canola yield.

Later flowering canola for the high rainfall zone?

Jens Berger and Heping Zhang (CSIRO), Mark Seymour (DPIRD)

Key messages

- Matching cultivar flowering and maturity dates (referred to as phenology) to target environment is critical for both yield stability and potential in canola. Low rainfall regions need early flowering for drought escape, high rainfall needs later flowering for yield potential.
- Current spring canola cultivars are too early to extend the flowering range much in the WA high rainfall zone (HRZ), while winter canola flowers too late, even if sown early.
- Spring-winter hybrids like the recently trialled Pacific Seeds K series can fill the phenology gap between winter and spring canola and appear to have excellent potential for the HRZ.

Background

Matching cultivar phenology to target environment is critical for both yield stability *and* potential in canola. Low rainfall environments require early flowering cultivars to escape the end of season drought, while later flowering cultivars will yield more in higher rainfall regions because they will exploit the longer growing season more effectively (Zhang, Berger, et al., 2013). Victorian work demonstrates that winter canola has the potential to substantially increase grain yield production in the high rainfall zone (HRZ) of south-eastern Australia compared to current shorter season spring cultivars (Christy, O'Leary, et al., 2013). However, winter canola has a strong vernalisation responsive, requiring an extended cold period in order to induce flowering. South-eastern Australia is much colder than the WA HRZ. Accordingly, the winter canola cultivars recommended for the south-eastern HRZ may not work in WA.

Here we set out to test a wide range of current canola cultivars across different environments in WA to establish the potential for widening the phenological range available to growers.

Testing canola phenology across the state

To test the stability of flowering date across different phenology groups, a wide selection of canola cultivars was grown by CSIRO and DPIRD in field trials throughout the Wheatbelt (Table 1), and flowering time recorded. This wide array of experimental locations returned a wide range of vegetative phase temperature, day length and vernalisation (vernal days), that generated a similarly wide range of flowering times.

These environmental signals regulated flowering differently among the canola phenology groups. As a result we see

Table 1 Canola varieties were evaluated for flowering time across the WA Wheatbelt and under controlled temperature/daylength environments

Varieties
Early spring; ATR Stingray, CB Tango, CB Telfer, GT-41, GT Viper, Hyola® 404RR, H 450TT, H 500RR, IH 30RR, Diamond, Pioneer 43C80CL, Pioneer 43Y23RR, Pioneer 44Y90, Sturt TT
Mid spring; ATR Bonito, ATR Gem, AV Zipon, AV Zircon, CB Atomic, CB Status RR, DG460, GT 50, GT Cobra, Hyola® 474CL, Hyola® 50, Hyola® 505RR, Hyola® 525RT, Hyola® 555TT, Hyola® 559TT, Hyola® 575CL, IH50 RR, ATR Mako, Pioneer 43Y85, Pioneer 44Y26RR, Pioneer 44Y87CL, Pioneer 45Y22RR, Pioneer 45Y86CL, Pioneer 45Y88CL, Pioneer 45Y91
Late spring; Archer, ATR Wahoo, AV Garnet, Crusher TT, GT- 53, Hyola® 577CL, Hyola® 600RR, Hyola® 635CC, Hyola® 650TT, Hyola® 725RT, Hyola® 750TT, IH52 RR, Pioneer 45Y25RR, Pioneer 46Y78, Pinnacle, R5520P, Victory7001
Winter-spring cross; CBI 306, K50054, K50055, K50056, K50057, K50058
Winter canola; AGF437, AGF484, AGF524, Arazzo, CB Taurus, Hyola® 970CL, Hyola® 971CL, SF Sensation, SF Brazzil, SF Edimax
Field sites
Cunderdin 2013-14; Floreat 2015; Geraldton 2014-15 (*TOS1 and 2); Gibson 2014 (TOS1, 2, 3, 4 and 5), Kojonup 2013-17 (TOS1 and 2); Merredin 2014-15 (TOS1 and 2); Mukinbudin 2014 (TOS1, 2 and 3)
Controlled environments
2016: 15 and 20°C, 10 hrs day length, +/-vernalisation; 2017: 16°C, 13 and 16 hrs daylength, no vernalisation

*TOS = time of sowing treatment

big differences between groups that are proportional to phenology: late types (for example, canola with low flowering rates) are less responsive than early types (Figure 1). These differences largely reflect different temperature responses among the canola groups. Field trial flowering date is negatively correlated to temperature (r=0.66): early flowering sites tend to be warm. Early spring types are more temperature responsive than mid and late spring types, which are in turn more responsive than spring-winter crosses, which are themselves more responsive than pure winter canola. As a result flowering time differences between categories tend to be largest in early flowering environments, and smallest in high rainfall environments

Temperature responses are modified by vernalisation, a period of low temperature early in the lifecycle that accelerates the rate of progress to flowering. Our controlled environment studies show that while all Australian cultivars appear to respond positively to vernalisation, late types appear to have a greater requirement for the accumulation of vernal days (optimal vernalisation temperature = 8°C).

Focusing on the HRZ

These differences in temperature and vernalisation response make the relatively cool, long season HRZ an interesting place to test canola phenology, because the greater vernalisation requirement of the later winter-spring and pure winter lines is likely to cause interaction with sowing time (TOS). Two years of time of sowing trials in the Kojonup-Boyup Brook regions indicates that this is indeed the case. In both years the later flowering winter-spring crosses and pure winter lines became relatively earlier in TOS2, indicated by negative deviations from the 1:1 line (Figure 2). This may be a response to the increase in early vernal days in TOS2 as delayed sowing exposes the seedlings to lower temperatures with the onset of winter. In contrast, the early to mid-spring types became earlier in the warm 2016 TOS1 (15 April), but did not change in the relatively cooler 2017 TOS1 (9 May). These cultivars have a lower vernalisation requirement which was satisfied by early sowing in both years. Consequently their strong temperature response promoted very early flowering in the relatively warm 2016 season in TOS1, but not the comparatively cooler TOS2 and 2017.

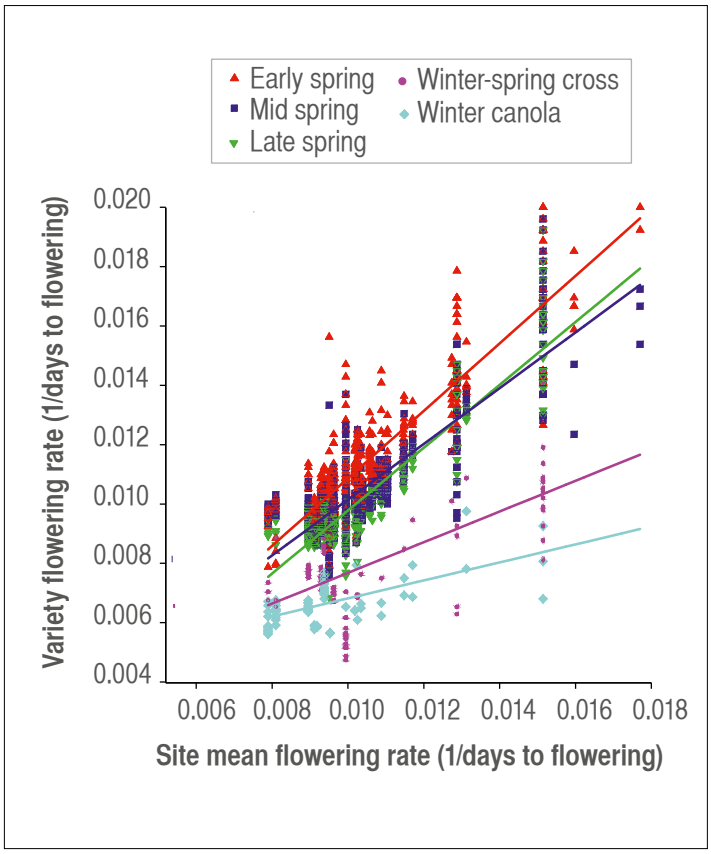

Figure 1 Canola flowering response across the WA Wheatbelt is proportional to phenology: (a) late types are less responsive than early, leading to bigger differences between the groups at early flowering sites. Note that the rate of progress to flowering (1/days to flowering) is presented rather than flowering days per se to simplify the analysis and facilitate modelling of temperature and photoperiod effects in fluctuating environments (Summerfield, Roberts, et al., 1991). 2%=50 days to flower, 1%=100 days, 0.66%=150 days)

This interacting flowering behaviour has a number of consequences for growers. Early sowing of highly temperature responsive early-mid spring canola is risky because they will flower too early if there is a warm start to the growing season. In 2016, the early-spring sown (15 April) canola started flowering at the end of June, exposing the pod set to frost. Conversely, the opposite TOS interaction occured in the winter-spring crosses, whereby late sown material became relatively earlier, making these lines more suited to the HRZ because of their more stable phenology. In both years the early-sown winter-spring crosses reached 50% flowering in early to mid-September, while later sown plots flowered only 1-2 weeks later. These results lead us to conclude that the winter-spring crosses effectively fill the flowering

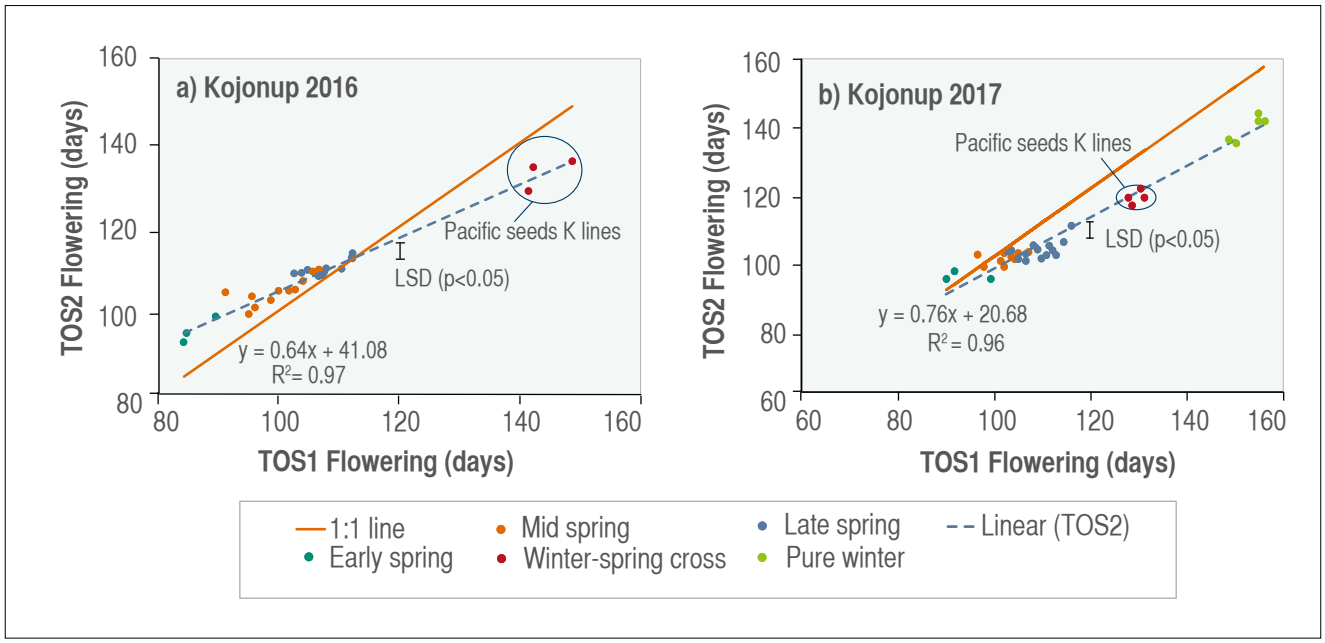

Figure 2 Flowering over two times of sowing (TOS) in Kojonup-Boyup Brook in: a) 2016 (TOS1=15 April, TOS2=12 May), b) 2017 (TOS1=9 May, TOS2=6 June). Note that deviations from the 1:1 (—)line show interaction. Varieties above the 1:1 line are earlier in TOS1 than in TOS2 while varieties below the 1:1 line are earlier in TOS2 than in TOS1

gap between spring and winter canola (Figure 3). While the true winter types are even more responsive to TOS than the winter-spring crosses (Figure 2b), their phenology is still too late for the WA HRZ, flowering in early-mid October in TOS1, and approximately two weeks later in TOS2.

This contrasting flowering behaviour has important implications on yield (Figure 4). The 2016 trial returned a classic flowering by TOS interaction for yield, where there was a positive linear relationship between phenology and yield in TOS1, but no relationship in TOS2. This is a function of frost escape, where flowering too early reduced podset because of frost damage in TOS1, while podset in the later flowering TOS2 (early group: mid-August, winter-spring crosses: mid-late September) escaped frost. By contrast the 2017 trial returned typical optimum flowering window results, where flowering too early, and particularly too late (as in winter canola) was associated with a yield penalty. We are currently using a modelling

Early spring ATR Stingray | Winter-spring cross: K line | Pure winter: SF Edimax

Figure 3 Winter-spring crosses fill the flowering gap between spring and winter canola: winter canola: photos from TOS 1 taken on 4 October 2017

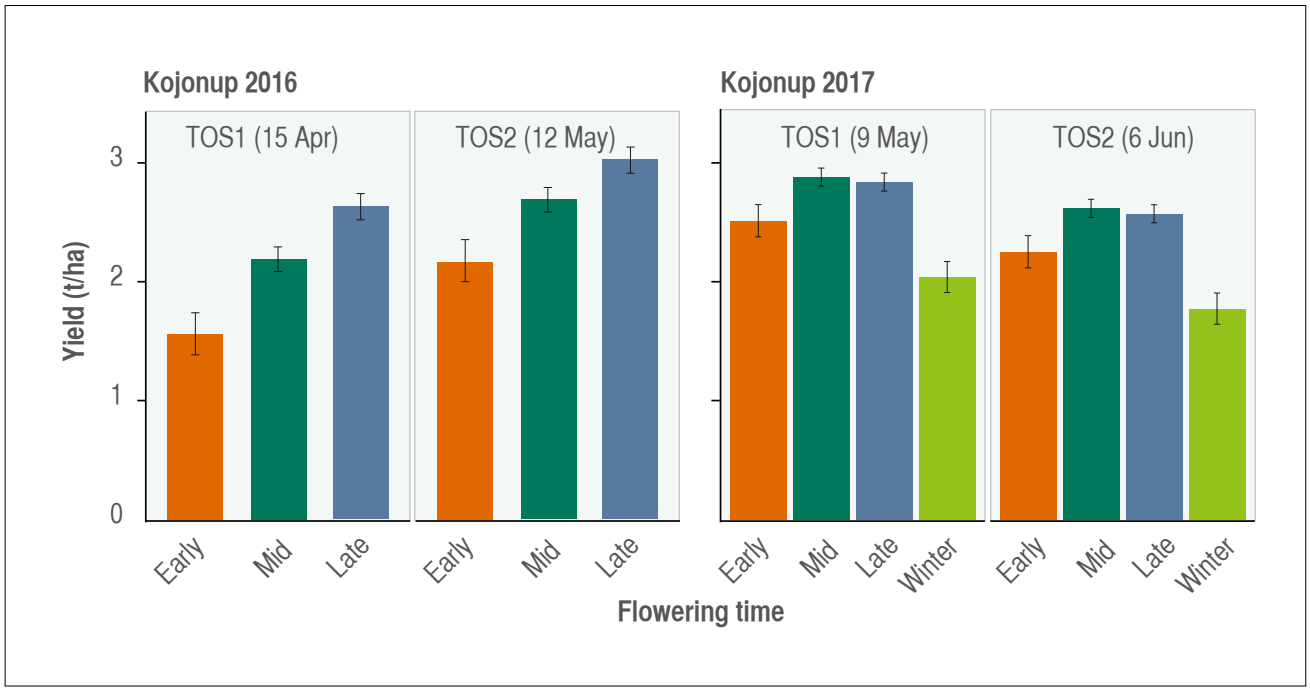

Figure 4 Yield over two times of sowing (TOS) in Kojonup-Boyup Brook in: a) 2016, b) 2017. (Note that the winter-spring crosses are represented in the late group)

approach to put these results into context to learn which yield response is the most common in the WA HRZ.

These results demonstrate that winter-spring hybrids can effectively bridge the phenology gap between spring and winter canola, making them an ideal option for the HRZ (Figure 3). Given that unreleased Pacific Seed breeding material is already very competitive with modern spring cultivars aimed at the HRZ, it augurs well for their further development. A well-adapted, early sown winter-spring hybrid that combines high harvest index with high biomass accumulation during a long growing season will out-yield more conservative, later-sown spring types, meeting the yield potential of the HRZ.

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Optimum canola density

Bob French, Mark Seymour and Jackie Bucat, DPIRD

Key messages

- Optimum density to maximise canola gross margin depends on grain price, seed cost, seed size, germination percentage and field establishment.
- Open pollinated canola grown from farmer-retained seed has a higher optimum density than hybrid canola grown from new seed because its seed is cheaper.
- Deviating from the optimum by less than 10 plants/m² has a minor effect on gross margin but larger deviations can reduce it substantially.

Introduction

More crop plants in a unit area generally means greater economic yield. Eventually a maximum will be reached above which yield declines with further increases in density, but there is often a broad plateau where yield changes very little over a wide range of densities (Figure 1). It only makes economic sense to increase density when the extra yield is worth more than the cost of the extra seed required, so the economic optimum density occurs when the increase in revenue from raising density is equal to the cost of raising it. Crop optimum densities do not depend only on the shape of the yield-density response curves (such as shown in Figure 1) but also on other factors affecting revenue and costs associated with raising density. The most important of these factors are the price received for grain and seed cost. Seed size, germination percentage and field establishment are also important because they determine the seed rate required to achieve the desired crop density (see below).

Field establishment is the proportion of live seeds that become established plants, this can vary considerably in canola.

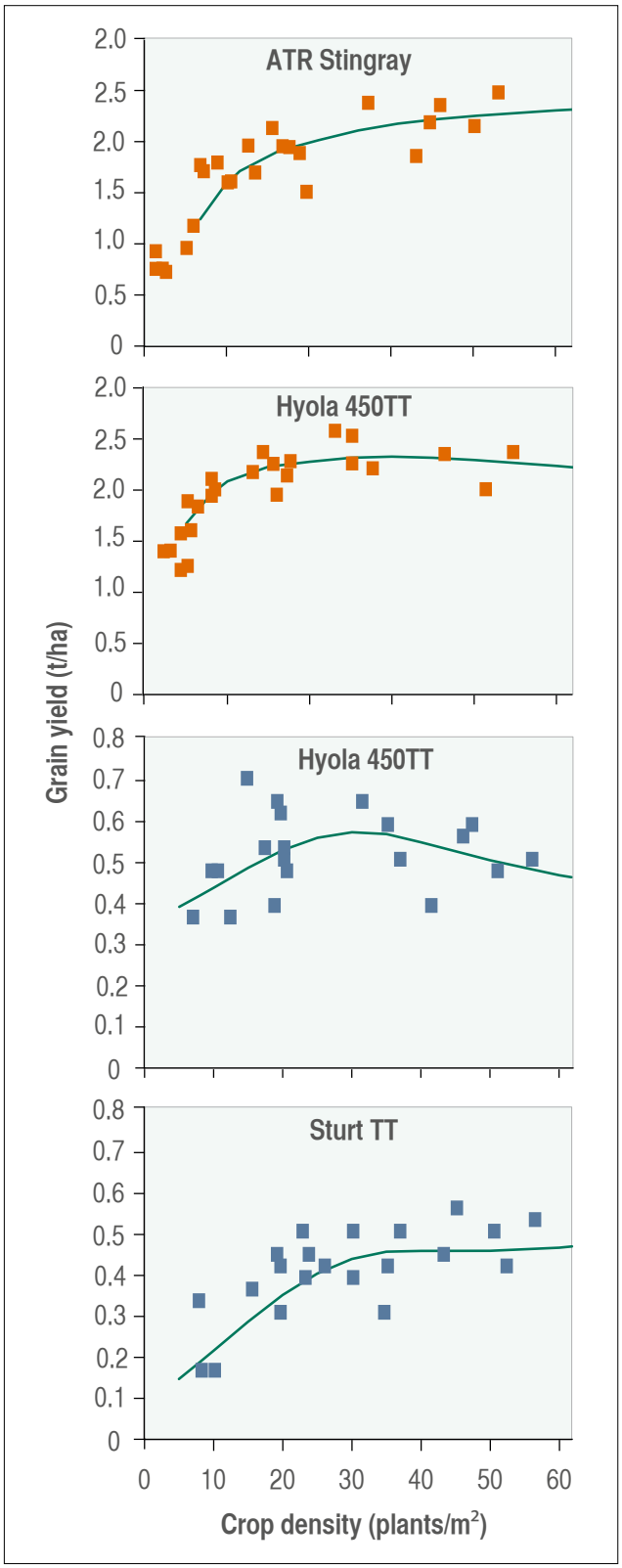

Figure 1 Grain yield response of open-pollinated (ATR Stingray and ATR Sturt) and hybrid (Hyola® 450TT) canola to increasing plant density at Katanning in 2013 (high rainfall, red symbols) and at Buntine in 2014 (low rainfall, blue symbols)

$$\text{seed rate (kg/ha)} = \frac{\text{target density (plants/m}^2\text{) x 100 000 000}}{\text{field establishment (\%) x seeds per kg x germination (\%)}}$$

Our research

Between 2010-2014 we conducted 24 canola density × variety trials across the main canola production environments of Western Australia (Figure 2).

Each trial contained an open-pollinated (OP) and hybrid cultivar from the triazine-tolerant (TT) and Roundup Ready® (RR) herbicide resistance groups and some also contained imidazolinone-tolerant (IT) or Clearfield® cultivars. Yield response curves were fitted to data from these trials giving a total of 112 individual response curves. However, since RR OP cultivars are no longer available we will not consider them further in this article. We identified the optimum density for each response curve by choosing the critical point where the return from extra yield was exactly balanced by the cost of extra seed. This is a function of grain price, seed cost, seed size, germination percentage and field establishment; each depending on cultivar. The values we assumed for each are given in Table 1. For further details of how the critical slope was calculated see French *et al.* (2016) *Crop and Pasture Science* **67,** 397-408.

There is a big difference between cultivar types in the critical slope, particularly between OP and other cultivars. This is mostly driven by seed cost; we assumed OP seed would be retained on farm at low cost, but fresh hybrid seed must be purchased each year which necessarily costs more. We also assumed a lower field establishment for OP cultivars based on consistent differences observed in our research. The values in Table 1 are means across all the trials in this dataset.

Results

Examples of response curves from high and low rainfall environments are shown in Figure 1. In these examples the optimum densities were 45 and 33 plants/m² respectively for ATR Stingray and Hyola® 450TT at Katanning and 36 and 26.5 plants/m² respectively for

Figure 2 Locations of 24 canola density trials conducted from 2010-2014. Dark blue symbols 2010, green 2011, light blue 2013 and pink 2014

SturtTT and Hyola® 450TT at Buntine. The true optimum density for ATR Stingray at Katanning is likely to be higher than 45 but this was the highest density achieved in the trial. Table 2 summarises optimum density from these trials for OP and hybrid canola cultivars across rainfall zones, showing that optimum densities tend to be higher in better rainfall environments and are higher for OP cultivars than hybrids. While Figure 1 shows hybrids have a steeper response than OP cultivars at low density, the difference in optimum density is almost entirely due to the lower price of OP seed. The density response of RR hybrids was similar to TT hybrids so only a single category is presented for hybrids in each rainfall zone in Table 1.

Table 2 Recommended optimum densities for hybrid (RR & TT) and open-pollinated and open-pollinated canola in different rainfall regions of Western Australia

	Optimum density (plants/m²)		
Rainfall	Low	Medium	High
Hybrid	25-35	25-40	40-60
OP	30-40	40-50	50-70

Table 1 Assumed values for grain price, seed cost, seed size, germination percentage and field establishment (FE) for choosing optimum densities for different plant types in Western Australia

Cultivar type	Grain price ($/t)	Seed cost ($/kg)	Seed size (seeds/kg)	Germination (%)	FE (%)
IT or TT OP	550	3	250 000	90	58
IT or TT hybrid	550	24	250 000	90	70
RR hybrid	505	32	250 000	90	70

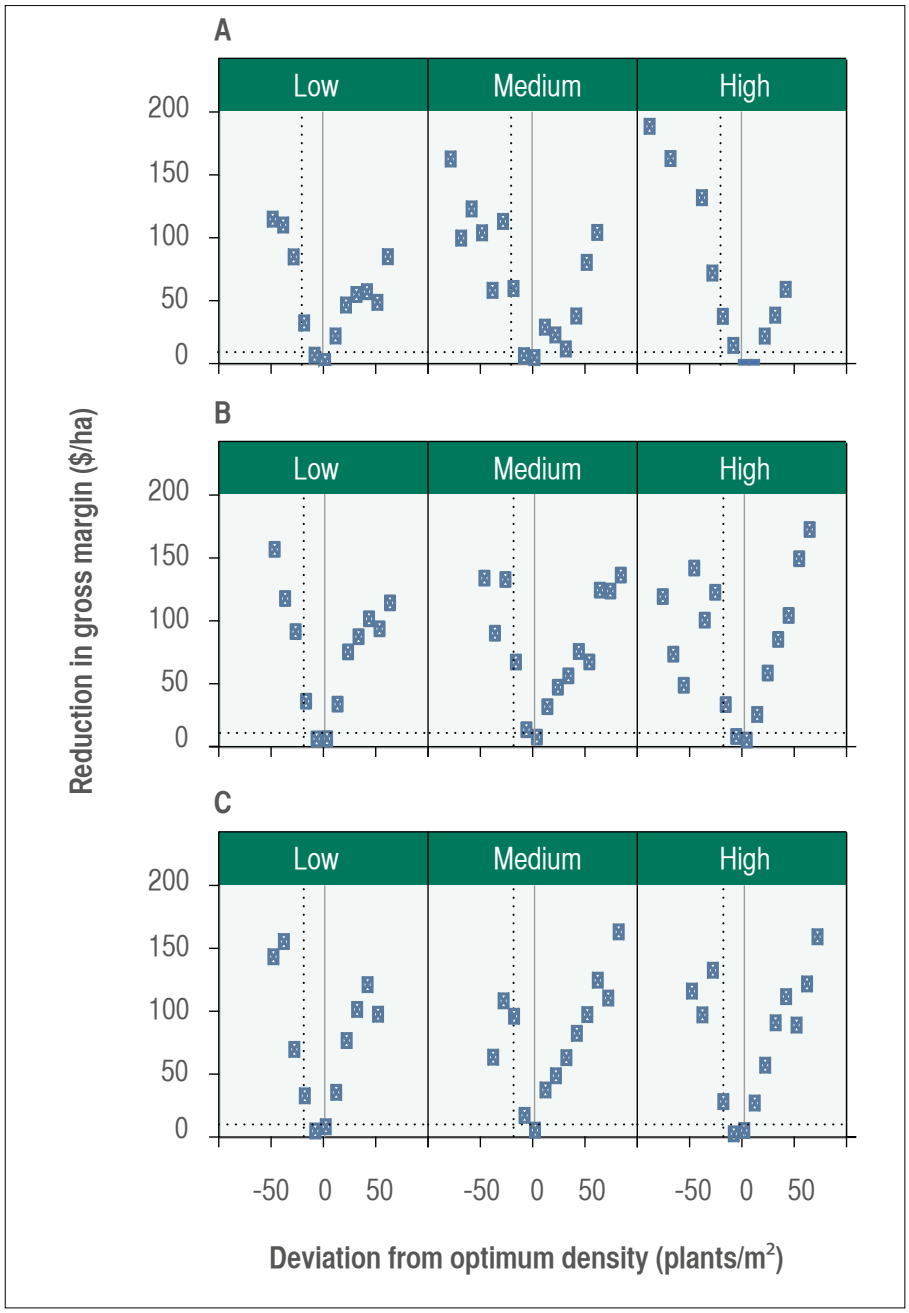

Figure 3 Mean reduction in crop gross margin when density deviates from the optimum by different amounts in different rainfall regions. Horizontal lines show a gross margin reduction of $10/ha and vertical lines show a deviation of -20 plants/m². A – OP TT cultivars, B – hybrid TT cultivars, C – Roundup Ready® cultivars

While it is possible to predict the optimum density for a cultivar in a particular environment within a broad range it is not possible to predict it precisely. It is also not possible to accurately predict what density will be achieved from a given seed rate because field establishment cannot be known until the crop has emerged. We therefore investigated how sensitive crop gross margin is to either failing to reach or exceeding the optimum. Using our standard assumptions for germination, seed size, field establishment etc. we calculated the changes in revenue and seed costs and therefore the change in gross margin for each response curve in our data set when density varied from the optimum. Figure 3 summarises these calculations.

Figure 3 presents mean changes in gross margin rather than results from individual trials so hides some detail, but we can draw some general conclusions. Deviating from the optimum by up to 10 plants/m² generally reduced gross margin by less than $10/ha but larger deviations resulted in much larger reductions. Gross margin was generally more sensitive to negative than to positive deviations from the optimum density so it is better to exceed the optimum slightly than to fall short. Deviation from the optimum had more effect on gross margin at low optimum densities (that is, hybrids in LRZ and MRZ) compared with higher optimum densities, although this is not very clear in Figure 3.

Figure 4 Canola density trial at Buntine 2014

Conclusions

Optimum density for canola depends on both biological and economic factors. In Western Australia it can vary from as little as 10 to more than 100 plants/m², but generally falls in the range 25-70 plants/m².

- Optimum density is higher for open-pollinated cultivars grown from farmer-retained seed than hybrid cultivars where new seed is purchased each season. This difference is driven almost entirely by differences in seed cost, meaning the optimum density for OP canola is less if it is grown from purchased seed than retained seed.
- Optimum density is higher in high rainfall environments with good yield potential compared to low and medium rainfall environments.
- Small deviations in density from the optimum (less than 10 plants/m²) only slightly affect crop gross margin but larger deviations can have large effects. Generally, exceeding the optimum will have less effect on gross margin than falling short by the same amount.
- The appropriate seed rate to achieve a target plant density depends on germination percentage and seed size which can vary between and within cultivars so it is important to acquire and use this information. Field establishment is also important but can only be estimated.

Keep canola density over 20 plants/m² to combat weeds

By Jackie Bucat, Bob French, Mark Seymour and Raj Malik, DPIRD

Key messages

- Canola crops with a density less than 20 plants/m² are vulnerable to increased ryegrass seed set.
- There were significant increases in ryegrass heads in OP TT, hybrid TT and RR varieties.
- The number of ryegrass heads increased in trials with high and low weed pressure.

Introduction

Maintaining weed control is one of the biggest challenges in farming and is particularly important for canola crops. A major benefit of canola in the rotation is the opportunity to control grasses and provide a disease break for the subsequent cereal crops.

Crop density and herbicide system are two factors that affect the level of weed control. Growers faced with increasing resistance to grass selective herbicides and triazine herbicides have turned to Roundup Ready varieties for more effective ryegrass control. Conversely, growers purchasing hybrid seed are motivated to use lower seeding rates. This is of concern since crop competition is an important contributor to weed control.

Method

Crop density and weed data were obtained through the canola density trial series (see previous paper). Weeds were observed in five of the 24 density trials and weed data was collected. The trials provided a comparison of weed suppression in canola crops with density ranging from very low (<5 plants/m²) to high (40-80 plants/m²).

The weed control program was a single or double knockdown, trifluralin at seeding, a grass selective post emergent and two atrazine sprays for the TT plots with one or two glyphosate applications for the RR plots (Table 1)

Results

Ryegrass head numbers were higher at low crop densities, especially below 20 plants/m² (Figure 1). The crop threshold of 20 plants/m² for suppressing ryegrass weeds appeared to be similar across all five weedy trials, from the high weed density site at Katanning to the lower weed pressure sites at Holt Rock and Wongan Hills.

TT

The open pollinated TT canola had the biggest increase in ryegrass heads, with crop density below 20 plants/m². Ryegrass head numbers were consistently lower for the hybrid TT cultivars than for the OP cultivars, although this difference was not statistically significant at all densities. The lower weed number in the hybrid TT varieties may have been due to more vigorous growth and faster closing of the crop canopy that is typical of hybrids, although this effect was not measured.

Table 1 Herbicide applications at weedy canola density trials. Number of sprays specified for TT and RR plots

Herbicide treatment	Katanning 2013	Holt Rock 2013	Wongan Hills 2013	Wongan Hills 2014
Knockdown 1.5L glyphosate	✓			✓
Knockdown 1.5L sprayseed	✓	✓	✓	✓
1.5L trifluralin	✓	✓	✓	✓
Grass selective -500mL clethodim	✓	✓	✓	✓
TT plots- atrazine 1.1kg/ha	2	2	2	1 (2.2kg)
RR plots- glyphosate 900g/ha	1	1	2	1

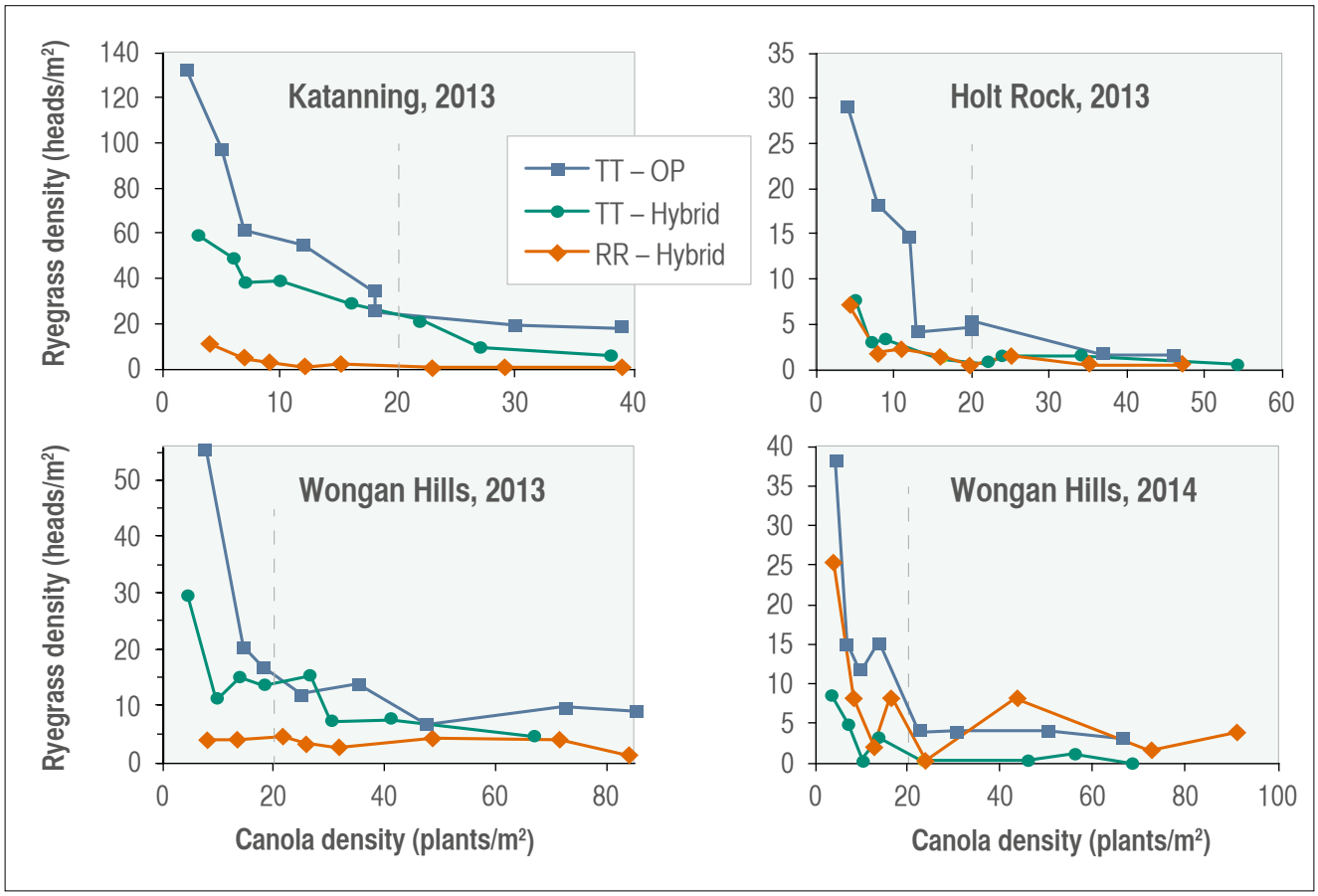

Figure 1 Increased ryegrass heads at crop densities below 20 plants/m² (dashed vertical line), in weedy crop density trials (note different scales for ryegrass densities)

Roundup Ready

As expected, glyphosate provided superior ryegrass control to atrazine, and ryegrass populations were consistently lower for RR plots, compared with TT plots. However, within the RR plots, there was a significant increase in ryegrass heads for low density crop treatments in the 2013 Katanning trial, 2013 Holt Rock trial and 2014 Wongan Hills trial. There was only a single post-emergent application of glyphosate in these trials. The second glyphosate application may also be missed on-farm, especially with early sowing when the crop matures quickly and may be past the six leaf spray window by the time ryegrass germinates.

Management conclusions

Ensure crop density is at least 20 plants/m² to suppress ryegrass seed set:

- including when using expensive hybrid seed, especially TT hybrid varieties
- including when yield expectations could be met with lower crop densities, for example when considering the need to re-sow.

Figure 2 Glyphosate provided superior ryegrass control; clean Roundup Ready plot (left) but grass weeds evident in TT plot (right)

Retaining canola seed

Mark Seymour and Dr Bob French, DPIRD

Key messages

- Farmers can retain stored open-pollinated (OP) seed and use OP seed grown on their own farm from year to year – but it is always wise to check germination every year.
- Previous work indicates that yields of retained hybrid canola can be reduced by 25% in higher rainfall areas.
  - In low and medium rainfall areas keeping seed from hybrid TT varieties may increase variability in flowering and result in increased anther sterility.
  - In lower rainfall areas yields are reduced by an average of 4% - equivalent to 50kg/ha – therefore the cost of buying fresh hybrid TT seed each year often out-weighs the reduced performance of retained hybrid seed.
- Currently OP canola varieties are a better choice in lower rainfall areas.

Background

The majority of canola varieties grown in WA are open-pollinated (OP) and triazine tolerant (TT). WA growers are currently reliant on one breeding company (Nuseed) releasing OP varieties. There are concerns amongst growers and the industry that the rate of release of OP varieties will slow down and farmers may be forced to keep the same variety for many years. Similarly growers may move towards using hybrid TT seed which have a higher upfront cost than OP varieties. Inevitably some farmers may consider keeping seed from hybrid TT crops to use as seed in the following year.

To test if keeping OP and hybrid seed for many years, or using seed kept from multiple years of harvesting canola results in reduced performance in the low and medium rainfall zones we conducted three field experiments comparing generations of OP TT canola and eight field experiments comparing generations of hybrid canola In some of the OP TT generation experiments we had extra treatments of +/- graded seed (>1.85mm sieve), but we report here on comparisons between ungraded commercial seed (Generation 1) and graded Generation 2, 3 and/or 4 seed as that closely mirrors the way in which growers could manage their seed lots. In the retained hybrid seed experiments we had a number of treatments – including combinations of +/- grading, low and high densities (25 or 40

Figure 1 Generation 3 hybrid plant from Wittenoom Hills in 2016 – this plant had male sterile flowers and flowered earlier than most of the plants in the plot, so initially it could not be fertilised by its neighbours - hence the missing pods at the base of the plant. Once the neighbouring plants started flowering, this plant could receive pollen and set pods higher up the plant.

Figure 2 First Generation Hyola® 450TT at 25 plants/m² (left) compared to graded Generation 3 Hyola® 450TT sown at 40 plants/m² (right) at Grass Patch on 3 August 2016. Note the Generation 3 plot started flowering earlier

plants/m²), mixes of Hybrid Generation 1 (25%) and Hybrid Generation 2 (75%), but here we report only on Ungraded Hybrid Generation 1 sown at low densities (25 plants/m²) compared to graded retained hybrid generation seed or OP TT seed sown at 40 plants/m².

Keeping seed for many years in storage can sometimes be ok

In a number of experiments we have used the same seed source which has been kept in normal office spaces or in sea containers within sheds without mishap. We tested the seed each year and found the germination rate remained fairly constant. Occasionally seed which was fine one year had low germination rates (<70%) the following year. This occurred more often with seed that had been treated with fungicides and/or insecticides. However, the optimum seed storage for canola seed whether treated or untreated is in cool rooms at 10-15 degrees at less than 45% humidity. Germination is only one component of seed quality, with seed vigour being more responsive to long term storage conditions.

Keeping the same OP variety grown out on your farm for many years is OK

We have grown out ATR Bonito at Grass Patch for a number of years and compared it to the original seed at a few sites. There was no difference in plant density in the experiments once we adjusted seeding rates for seed size and laboratory germination rates. We observed no consistent visual difference (or NDVI) between the generations of ATR Bonito in our plots, and no difference in flowering time,

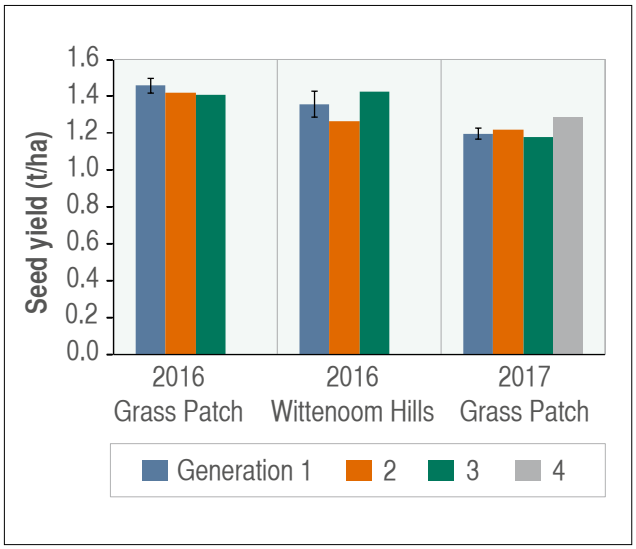

Figure 3 Retained ATR Bonito seed (Generation 2-4) yields the same as commercially purchased new seed (Generation 1) at three WA sites in 2016 and 2017. Vertical bars indicate LSD

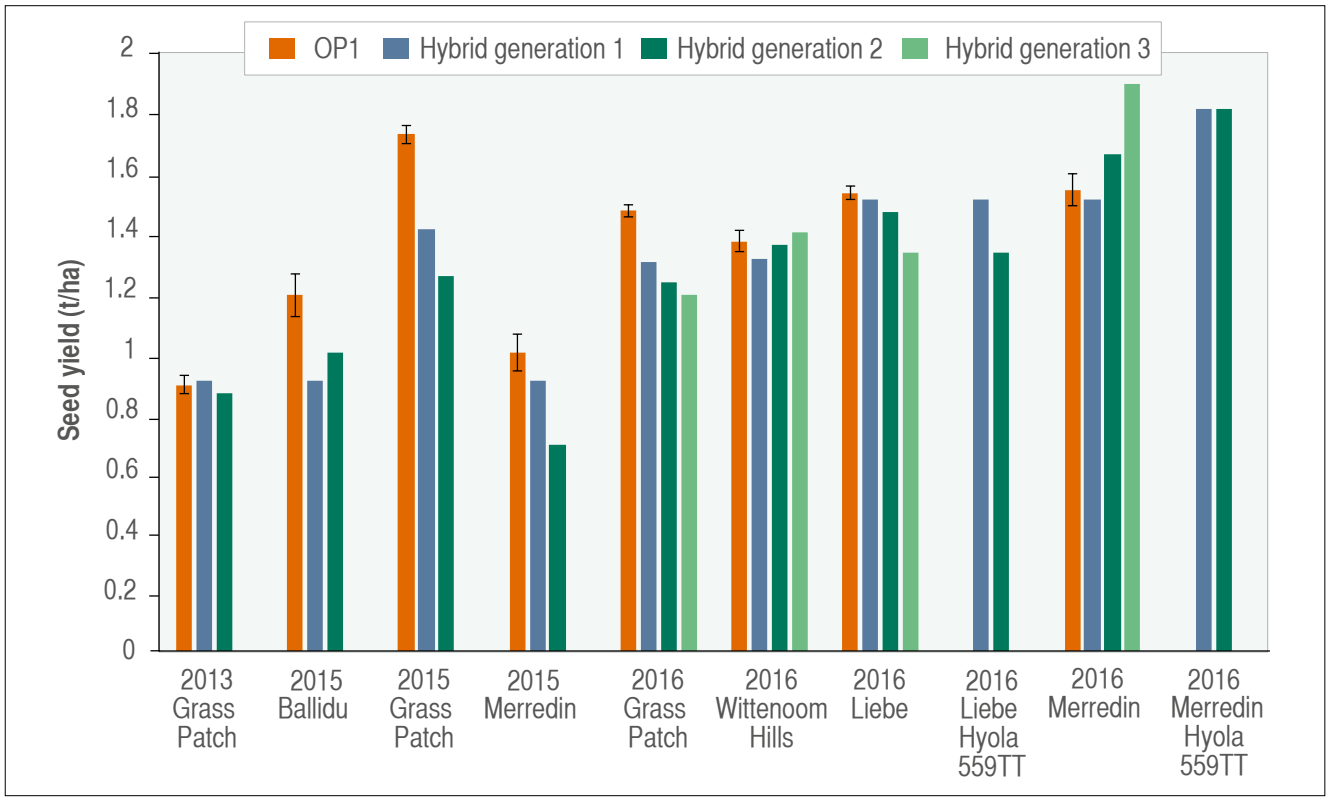

Figure 4 Seed yield (t/ha) of open pollinated (OP), newly purchased hybrid seed (Generation 1, CB Junee HT in 2013, Hyola® 450TT or Hyola® 559TT in 2015 and 2016) and retained hybrid seed (Generations 2 or 3) at eight locations in Western Australia. Vertical bars indicate LSD

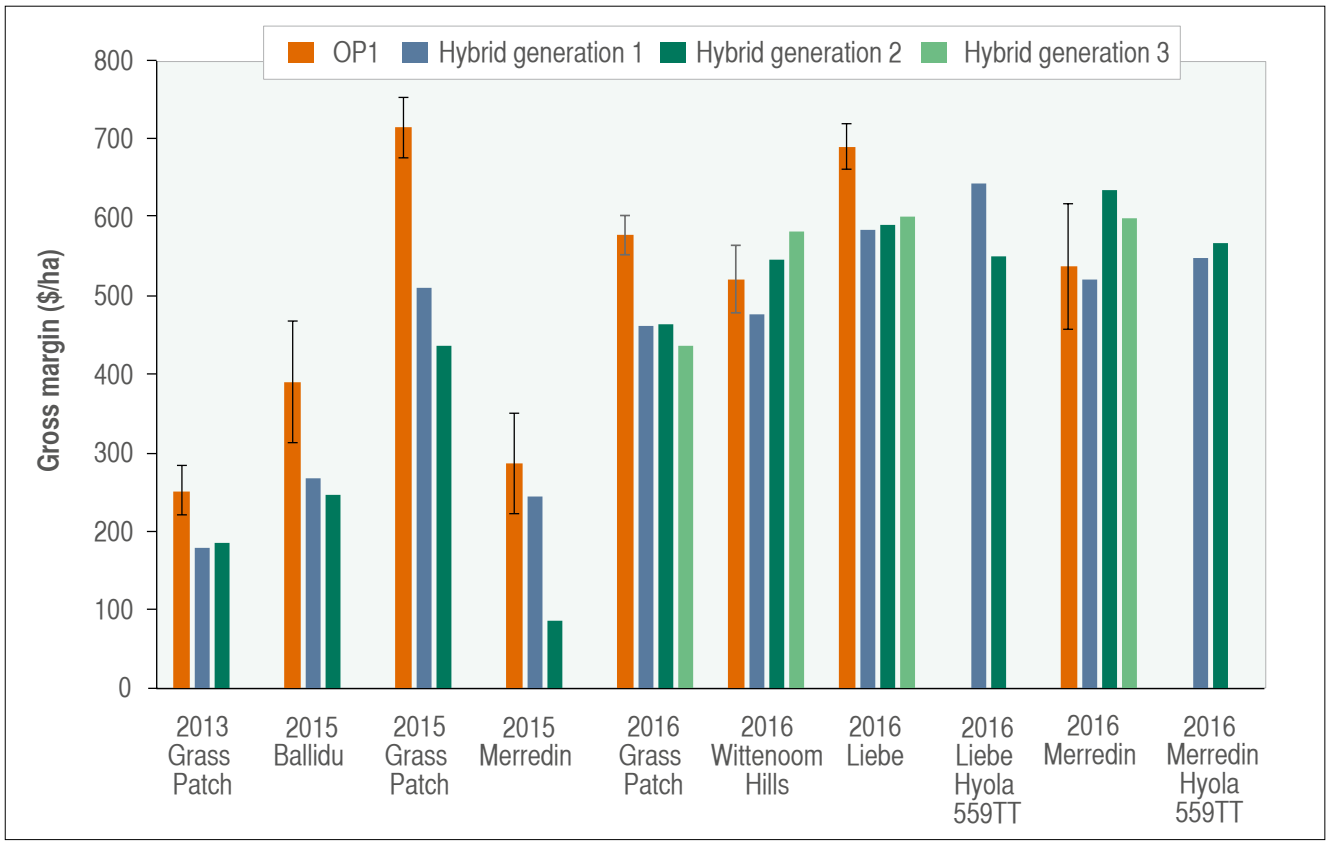

Figure 5 Gross margin ($/ha) of open pollinated (OP), newly purchased hybrid seed (Generation 1, CB Junee HT in 2013, Hyola® 450TT or Hyola® 559TT in 2015 and 2016) and retained hybrid seed (Generations 2 or 3) at eight locations in Western Australia. Vertical bars indicate LSD

% of flowers with sterile anthers. (all nil) or maturity. Consequently we found the different generations of ATR Bonito produced similar seed yield and oil percentage to each other and to newly purchased commercial seed.

Keeping seed from a hybrid TT crop will reduce crop performance, but the financial effect will depend on your canola yield –we suggest you keep growing OP canola

Previous work has shown that keeping seed from hybrid canola can lead to variability in flowering, increase in the number of flowers with anther sterility, reduced disease resistance, reduced vigour and reduced yield of 25-30% (Potter et. al. 2009, Kudnig et. al 2010).

The majority of the previous experiences were in high yielding situations (>1.8t/ha) or comparisons kept the seed rates of F1 hybrids and retained hybrid seed (called here Generation 2) the same. Whereas in WA canola is widely grown in areas with lower yield potential and farmers are likely to grade Generation 2 hybrid seed and sow it at a similar rate to OP varieties. In this series at eight sites over three years, yields ranged from 0.9-1.8t/ha (mean = 1.3t/ha) and when we compared graded Generation 2 or 3 hybrid seed at a target density of 40 plants/m² to commercial hybrid seed sown at 20-25 plants/m² we found that 80% of the time seed yields were either statistically the same or higher. Seed yields of Generation 2 hybrids were on average 50kg/ha (4%) lower yielding than commercial hybrid seed treatments. These are lower losses than that found by previous researchers in higher rainfall environments. 86% of the time gross margins from plots sown to graded Generation 2 or 3 hybrid seed sown at a target of 40 plants/m² were equal to or higher than commercial first Generation hybrid seed sown at 20-25 plants/m².

Generation 2 and 3 hybrid plants produced male sterile flowers (up to 9%) resulting in some pod gaps on the main flowering raceme – however podding commenced further up the raceme and the plants sometimes compensated with larger seeds. We also noticed Generation 2 and 3 hybrids sometimes produced earlier flowering individual plants. There was very low disease pressure in our low rainfall experiments – therefore we cannot comment on the disease resistance of Generation 2 or 3 hybrids.

In all of our experiments we compared commercial and retained generation hybrids to OP varieties. In the majority of experiments choosing to grow an OP variety and sowing at a target of 40 plants/m² produced higher yields and returns than any of the hybrid treatments. Our conclusion is that farmers should keep growing OP varieties in lower rainfall areas.

Wide row spacing and precision seeding for the northern agricultural region

Martin Harries, Mark Seymour, Bob French and Sally Sprigg, DPIRD.

Key messages

- Trials have shown that canola can be grown in rows 50cm apart without compromising yield in the north.
- Precision seeding may save seed input costs and improve yield.

Background

Growers in the northern agricultural region are interested in growing canola in wide rows. To determine whether this is a good option, several trials were implemented from 2014–2016 looking at a range of agronomic aspects.

Growers involved in these trials consider benefits other than yield to be important in deciding to use wide rows; reduced fuel costs at seeding (approximately 30%), better stubble handling and improved crop safety of incorporation by sowing (IBS) herbicides.

Weed control and paddock erosion risks need to be taken into account for growers using wide rows and low plant densities.

Row spacing

To test the effects of row spacing, five trials were conducted around the Binnu area in 2014 comparing canola grown in narrow and wide rows at various seeding rates. These included small plot and farmer sown replicated trials.

Wide rows (approximately 50cm) yielded 97% of narrow rows (approximately 25cm) over a yield range from 1.0 to 1.6 t/ha. Row spacing and seed rate combinations were tested and the wide row, low seeding rate combination was the highest yielding treatment in three of the five trials. This has opened the way to refine agronomic packages for wide rows and investigate the usage of precision seeders to reduce up front input costs.

Figure 1 Ben Cripps from Binnu in a farmer-sown row spacing trial. The high seed rate (3kg/ha) 30cm spacing treatment yielded 88% of the low seed rate (1.5kg/ha) 60cm spacing treatment in this trial

Precision seeding

To test precision seeding, an Agricola K-series vacuum plate seeder was used at Ogilvie and Binnu in 2015. Seeding rates ranged from 2.5kg/ha down to 0.3kg/ha.

Figure 2 Agricola precision drill used to seed canola with even spacing between plants

Yields at the lower seed rates were comparable to yields at higher seed rates of 1.0 and 2.5 kg/ha when using this machinery, even though

the 0.3 and 0.5 kg/ha seeding rates had plant populations of less than 10 plants/m². There was a trend of lower yield at lower seeding rates but this was not statistically significant (Table 1).

Table 1. Measurements of plant density, growth and yield from precision sown trial at Ogilvie 2015.

Seed rate (kg/ha)	GM ($)	Plants /m²	Yield (kg/ha)	Pods/ plant	Seed Oil%
0.31	$820	5	2198	1622	47.6
0.54	$875	8	2315	790	47.6
1.01	$860	15	2312	357	47.8
2.50	$883	40	2463	136	47.5
Lsd			280	258	
F Prob			NS	$P < 0.001$	NS

Also of note is that the trials were on 50cm row spacing and yields of over 2.4t/ha were achieved. This yield is well above the long term average for canola in the district and indicates that in this environment canola can yield well in favourable seasons when sown at wide row spacing.

There was a high level of plant plasticity observed with many more pods on plants in lower density plots; with over ten times as many pods on plants in the 0.31kg treatment compared to the 2.5t/ha treatment (Table 1). The gross margin was similar for the 2.5kg/ha, 1.0kg/ha and 0.5kg/ha treatments, showing that seed costs could be reduced without impacting profit.

Figure 3 DPIRD Research Officer Marty Harries in a plot with canola plants spaced evenly apart

Figure 4 Even spacing of plants at 10 plants/m²

Figure 5 Uneven spacing of plants at 10 plants/m²

Uniform seed placement

To understand potential benefits of precision seeding, DPIRD investigated the effect of uniform plant spacing on yield in a trial at Wongan Hills in 2016. Plants were arranged in four plant densities, 80, 40, 20 and 10 plants/m² and at each density plants were spaced at even distances apart, to mimic a precision seeder, or unevenly, as occurs with a conventional air seeder (Figures 4 and 5). The even spaced plots were achieved by using a high sowing rate with the air seeder, then hand thinned to the required even spacing.

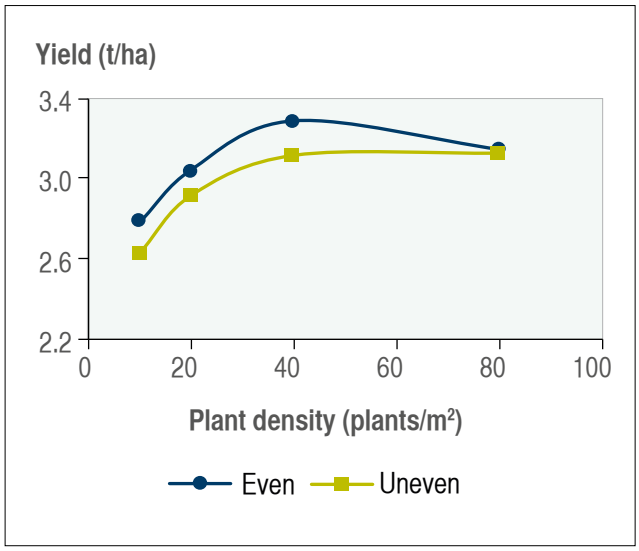

Figure 6 Highest yields at 40 plants/m², evenly spaced at Wongan Hills in 2016

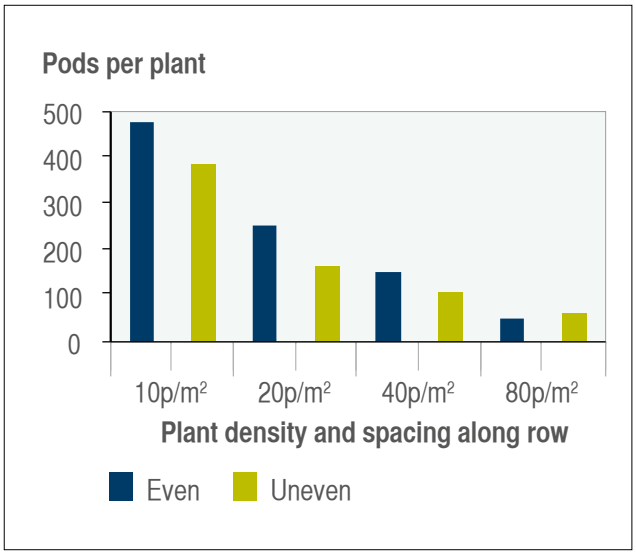

Figure 7 Pods per plant as affected by plant density and geometry at Wongan Hills in 2016

There was a trend of more yield from evenly spaced plants in the lower density plots. At densities of 40 plants/m² and below, yield was around 5% higher for the evenly spaced plants, (Figure 6), however this was not statistically significant. Spacing plants more evenly affected some aspects of plants growth. There were more pods per plant in the evenly spaced plots (Figure 7). For example there were 480 pods per plant in the evenly spaced plants and 390 for the unevenly spaced plants, at the 10 plants/m² density.

Conclusions

The series of trials have demonstrated that canola can be grown successfully in wide rows, of around 50cm.

Precision seeding systems that deliver the seed much more accurately are now being tested commercially and we have shown that even plant spacing may increase profit by reducing seed costs and increasing yield.

Weed control needs to be considered for low density crops.

Acknowledgments

Thanks to the Northern Agri Group for their work on these trials.

Sow shallow with big seed for best bet canola establishment

Martin Harries, Bob French, Sally Sprigg and Jackie Bucat, DPIRD

Key messages

- Seeding at 1.0-1.5cm in hot drying conditions was better than seeding at 3 or 7cm to chase sub-soil moisture.
- Large seed had better emergence, in harsh seeding conditions.

Background

It is important to obtain the best establishment possible to ensure seed costs are minimised and target plant densities are achieved. As early sowing to improve yield potential is becoming widespread, it is more common for canola crops to be sown into conditions, often with warm temperatures and drying soil.

A series of trials were run which evaluated the best seed depth and seed size to establish canola in these challenging conditions.

Method

There were four trials in 2016 at Eradu, Mingenew, Dalwallinu and Merredin. All trials were sown in mid-April at sites where there was substantial stored soil moisture. Seeding occurred 3-4 days after an inch of rain or more had fallen at the sites.

Three treatments were used; seed depth, seed size and OP (ATR Bonito) vs hybrid (Hyola® 559 TT) varieties. At Mingenew and Eradu, seed depths were 1, 3 and 7cm. Each seed lot was graded into three sizes. The overall seed size of the Hyola® 559TT was much larger than the ATR Bonito, which is typical of a hybrid compared to an OP variety, so the **largest** seed of the OP was similar to the **smallest**

Figure 1 Eradu 2016 seed depth by seed size trial with less plants emerging from deeper sown plots

seed of the hybrid Hyola® 559TT (Table 1). At Dalwallinu and Merredin, seed depths were 1.5, 3 and 6cm. There were five seed sizes of OP ATR Bonito seed (2.8-4.0mg) and 5.0mg hybrid Hyola® 559TT seed.

Table 1 Size of seed used in Eradu and Mingenew trials

Variety	Seed Size	Sieve sizes (mm)	Seed size (mg)	Seeds/ kg
OP ATR Bonito	V. Small	<1.7	2.7	370 370
	Small	1.7-2.0	3.6	277 778
	Medium	>2.0	4.3	232 019
Hybrid Hyola® 559TT	Medium	<2.0	4.3	234 742
	V Large	2.0-2.36	6.4	156 250
	VV Large	>2.36	8.2	122 399

Seeding depth

The seed depth had a large effect on both field establishment (FE) and yield.

Establishment

Field establishment was reduced with deeper sowing, at all sites. Lower field establishment resulted in lower density plots (Table 2).

Table 2 Field establishment (%) and plant density (plants/m^2) reduced by seeding depth at four locations in 2016

Depth	1-1.5cm		3cm		6-7cm	
	FE	p/m^2	FE	p/m^2	FE	p/m^2
Eradu	24	15	11	7	5	3
Mingenew	21	13	8	5	2	1
Merredin	62	33	42	22	15	8
Dalwallinu	58	31	28	15	6	3

Yield

Seeding depth had the greatest influence on yield, as expected given the large impact of this treatment on plant density. Overall seeding at 3cm reduced yields by 18% compared to the 1-1.5cm seeding option. Deeper seeding at 6-7cm reduced yield by 60-65% compared to 1cm (Figure 2).

Seed size

Establishment

There was a good relationship between seed size and field establishment, although it had a smaller effect overall than seed depth. In the early warm seeding conditions experienced in these trials, field establishment was higher with bigger seed, at each seed depth and at each of the four sites There was a positive seed size effect up to 6.4mg seed size (150 000 seeds/kg). Overall establishment at Mingenew and Eradu was poor with several days above 30 degrees C in the week following seeding (Figure 3).

There seemed to be no advantage of the very large hybrid seed (8.2mg) used at Eradu and Mingenew or the large (5mg) seed sown shallow at Dalwallinu and Merredin. Otherwise, both OP and hybrid canola had a similar relationship between seed size and establishment, so the higher FE of the hybrid seed was explained by the larger seed size, rather than in intrinsic hybrid effect in these trials.

Yield

There was a smaller effect of seed size on yield, compared with field establishment, but it was evident at Mingenew (Figure 4), Dalwallinu and Merredin.

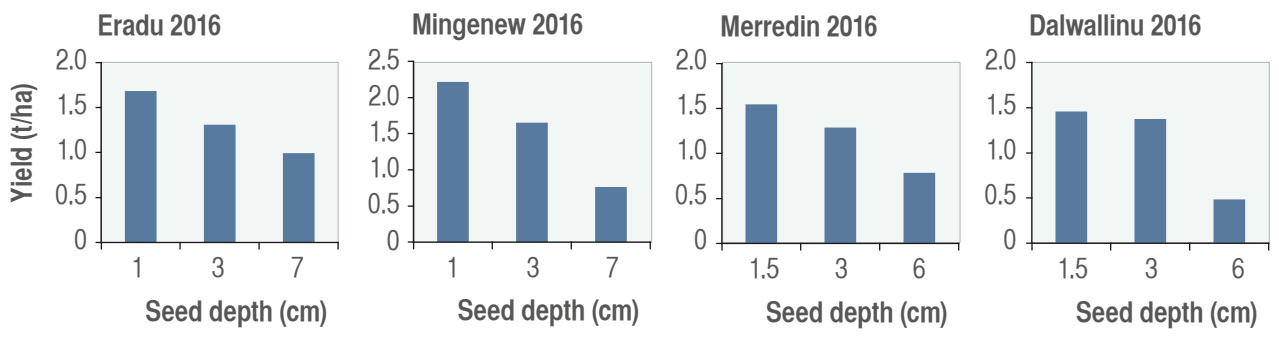

Figure 2 Decreasing yield with seed depth at all sites

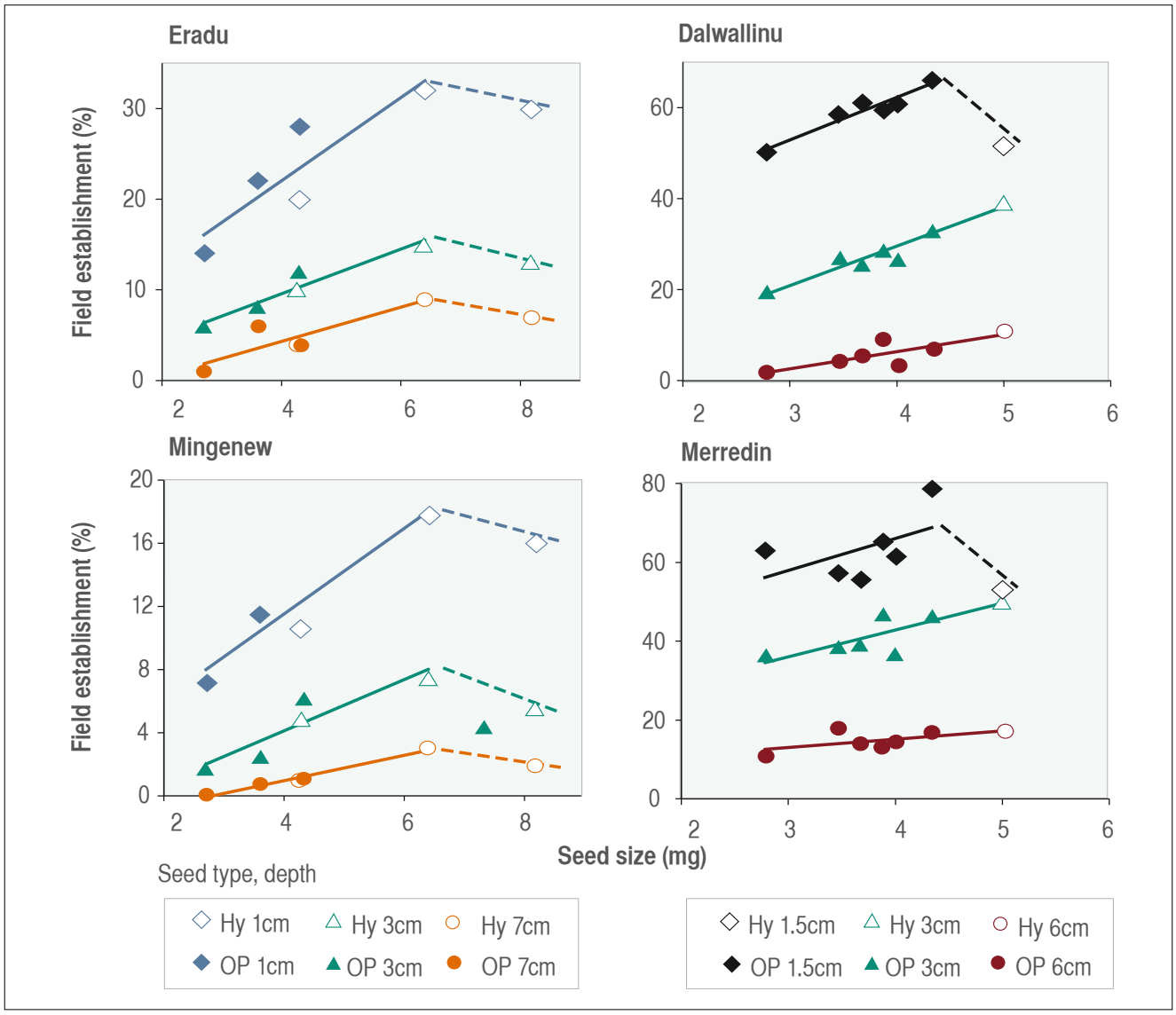

Figure 3 Higher field establishment with bigger seed size for all seed depths and locations. Fitted solid lines shows positive relationship and dotted line indicates where there was no further improvement in FE from larger seed size

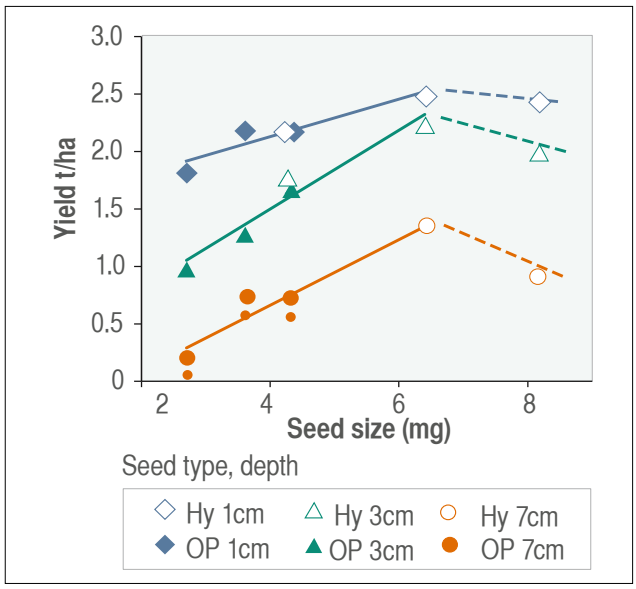

Figure 4 Yields increased with larger seed size at Mingenew in 2016

Management conclusions

Both seed depth and seed size were important for maximising canola yield, although seed depth had a larger effect.

- Stick to shallow seeding 1-1.5cm, even under hot and drying seedbed conditions.
- There was a seed size benefit up to 6.4mg size (150 000 seeds/kg), with no extra benefit from bigger seed.
- Grade OP seed for maximum seed size.
- The better emergence of hybrid seed was explained by seed size, in these experiments.
- The plasticity of the canola plant in the northern region environments was demonstrated with yields above 1.0t/ha achieved from less than 10 plants/m^2, sown in mid-April.

When to reseed canola

Mark Seymour, DPIRD

Key messages

- Reseeding early sown RR hybrid canola paddocks is only worthwhile if plant density is below seven plants/m² or if weed control is likely to be compromised.
- Reseeding TT canola paddocks is likely to be more beneficial than reseeding RR hybrid canola paddocks. Only consider reseeding TT OP canola if plant density is below 15 plants/m².
- Weed control may be compromised below 20 plants/m², especially for TT canola.

Background

Canola is often the first crop sown each autumn, however, as the seed is small it is best suited to shallow seeding, making it susceptible to drying soil conditions. If growers don't get a good break or decent follow-up rains they may have to consider reseeding 2-3 weeks later.

The big question for growers is whether they should leave their low density crop – less than 10 plants per square metre – alone or reseed it.

We can use information from the canola density trials and from a reseeding trial to help answer this question.

Trial results

Plant density

Since 2010 DPIRD have conducted 24 plant density experiments throughout WA.

On average hybrid canola with seven plants/m² achieved 80% of the yield of an optimum density crop, and 90% with 15 plants/m² (Figure 1).

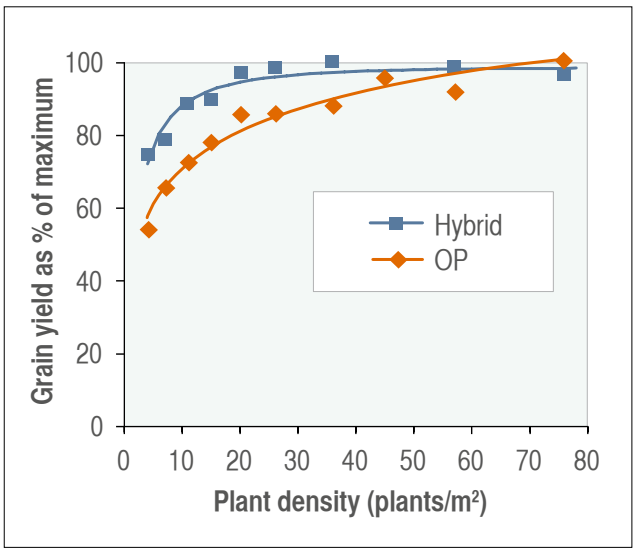

Figure 1 Response to plant density of canola

Hyola® 404RR sown on 17 April, at five plants/m² (right) yielded 80% of the maximum at Salmon Gums in 2013

Open-pollinated (OP) canola produced their maximum yield at higher densities than hybrid canola varieties, and therefore require higher densities to achieve 80-90% of maximum yields. For OP canola 80% of potential yield was achieved at 15 plants/m² and 70% at 10 plants/m².

Reseeding

In 2014 year we conducted a series of reseeding trials, where we compared the value of different re-seeding options;

- sowing before or at the break of the season, at plant densities of 5, 10, 15 and 30 plants/m² compared with
- sowing three weeks later, at densities ranging from 5-60 plants/m² (to mimic reseeding) and
- reseeding over the top of some of the early sown low density plots in an effort to add to early sown plants.

The most successful trial of this series was at the Northern Agri Group's (NAG) main trial site at Ogilvie. The first sowing time of Pioneer 43Y23RR was on 29 April and we established about 90% of the target plants. The second sowing time was 16 May when conditions were actually drier and less favourable than the April sowing, and consequently we only established around 40% of our target plants. The resown plots were in offset rows and only just tickled in, to reduce damage to the earlier sown plants. This was not as successful as sowing normally at that time, due to the dry conditions and only 13% of the target plants emerged, and no extra yield was produced.

As expected, the April sown plots out yielded plots sown in May, at every comparable plant density (Figure 2). April plots that had only 5-10 plants/m² produced equal or higher yields than later sown plots at higher densities.

Over a number of years in DPIRD trials we have seen RR canola produce 60-80% of maximum yield at around 5 plants/m² and 80-90% at 10 plants/m². For example Hyola® 404RR sown on 17 April, at five plants/m² at Salmon Gums in 2013, yielded 80% of the maximum (see photograph).

Sticking with low plant numbers sown early appears to be an acceptable approach, in terms of yield. However weed control may be compromised at these low densities. For example in our DPIRD plant density trial at the Liebe site in 2013 we observed more ryegrass spikes in TT canola when the crop density was below 20 plants/m² whilst in the RR hybrid plots we found no effect of plant density on ryegrass numbers (Figure 4). This indicates that if you have a competitive variety such as RR hybrids and effective herbicides such as glyphosate then low crop densities are less of an issue than less competitive crops such as TT canola combined with a less effective herbicide system.

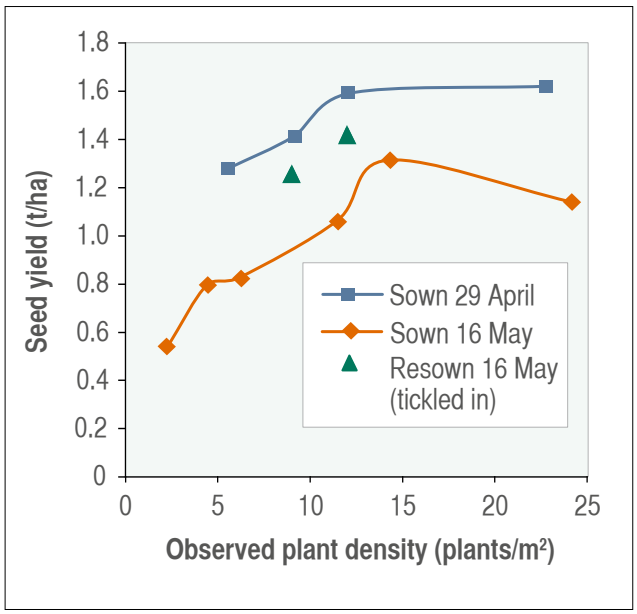

Figure 2 Time of sowing by density and reseeding canola at Ogilvie in 2014

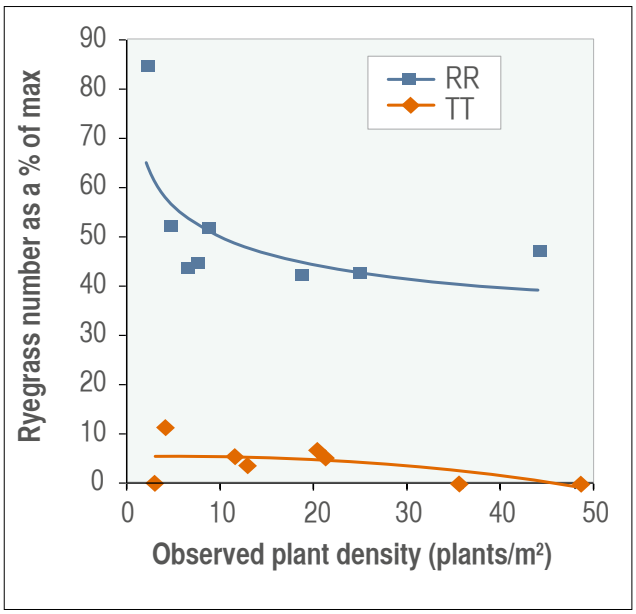

Figure 3 Ryegrass spikes (expressed as a % of maximum) of TT and RR canola at North Miling (Liebe main trial site) in 2013

Timing of nitrogen for lower rainfall canola in Western Australia

Mark Seymour and Sally Sprigg, DPIRD

Background

Farmers growing canola in lower rainfall areas usually aim to have a low risk cropping program. One way to reduce risk is to reduce inputs. Some inputs such as weed and insect control are often mandatory, while fertiliser inputs are often considered optional or are matched to target yields which may vary from year to year. At a cost of $1-$1.50/kg, nitrogen (N) is a major input cost and delaying the decision on how much N to apply until later in the year may allow growers to have a better assessment of yield potential of their crop, and if the seasonal outlook is poor, perhaps reduce the rate of N applied.

To assist WA farmers in low and medium rainfall areas making decisions on N inputs, we conducted 15 experiments from 2012-2014 to assess the response of canola to N and to determine if the timing of N could be delayed in WA until later in the growing season. In most experiments five rates of N were tested ranging from either 0-75, 0-100, or 0-150 kg N/ha. Nitrogen was applied at four different times (seeding, four weeks after sowing (WAS), green bud – early stem elongation at eight WAS or early flowering at 12 WAS) or split between these timings.

Figure 1 Sequence of photos taken at Salmon Gums in 2013 showing the same Hyola® 404RR plots. (a) 19 June, eight weeks after sowing Plot 3008 on the right is yet to get any N, (b) 15 July, 12 weeks after sowing Plot 3008 has just received 25kg N/ha, (c) 10 days later (d) at harvest – similar yields and oil

Key messages – timing of nitrogen

- Surveying farmers throughout WA over recent years indicated that the majority of farmers apply a proportion of their N at seeding and then apply extra ('top-up') N at 6-8 weeks after sowing (WAS).
- We found applying N at seeding, during the early vegetative stage (4WAS) and about the time of stem elongation (8WAS) produced similar seed yields.
- We also found that in the majority of instances applying top-up N around the time of the commencement of flowering (12WAS) produced similar seed yield responses to earlier timings.
  - On occasion delaying N until 12 weeks reduced seed yield or reduced oil levels, however we found these reductions were not large enough to reduce gross margins.
  - Reduced oil and seed yield levels with application of N at 12 weeks were more likely if low or no nitrogen was applied at seeding and then high rates of N (>50kg N/ha) were applied in a single application.
- Therefore we suggest growers continue to aim to apply top-up N at eight weeks, but if conditions are uncertain applying top-up N at 12 weeks may be a viable strategy. The extra time would allow farmers to be better informed about the likely performance of their crop, and in poor conditions allow them to reduce or eliminate further inputs.

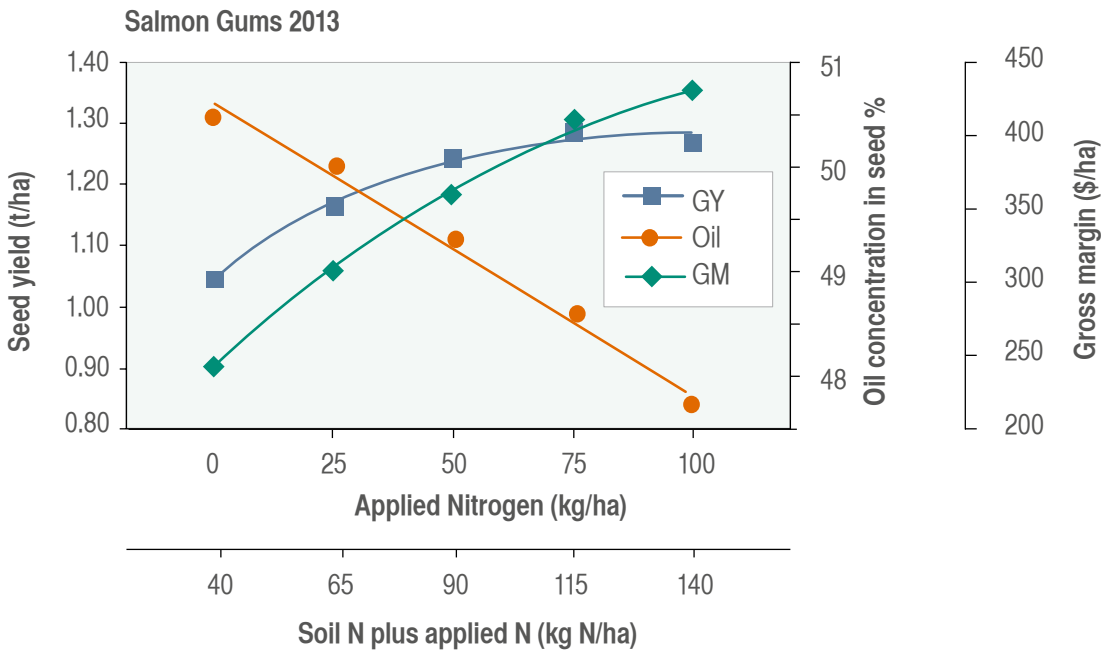

Figure 2 Relationship between fertiliser N and total available nitrogen from soil, plant residue and fertilisers and the seed yield (t/ha), oil concentration in seed (%) and gross margin of canola at Salmon Gums in 2013

Key messages – response to nitrogen

- Canola growth (dry matter) and seed yield responded positively to N fertiliser in most experiments, with 90% of maximum seed yield achieved at an average of 46kg N/ha. However 90% of maximum gross margin was achieved at a lower average nitrogen rate of 17kg N/ha, due primarily to the relatively small yield increase compared to the reduction in the concentration of oil in the seed with applied N and the cost of N and its application.
- N fertiliser decreased the concentration of oil in the seed of canola at a rate of 0.01-0.04% oil per kg N/ha.
  - We found the rate of decrease in oil concentration was greater in low rainfall regions and in experiments where the seed yield response to N was small (<200 kg/ha)
- In 80% of cases the first 10kg N/ha applied provided a return on investment in N greater than $1.50 for every $1 invested. The next 20kg N/ha applied provided a return on investment of $1.25 for every $1 invested in N 80% of the time and further increases would most likely breakeven.

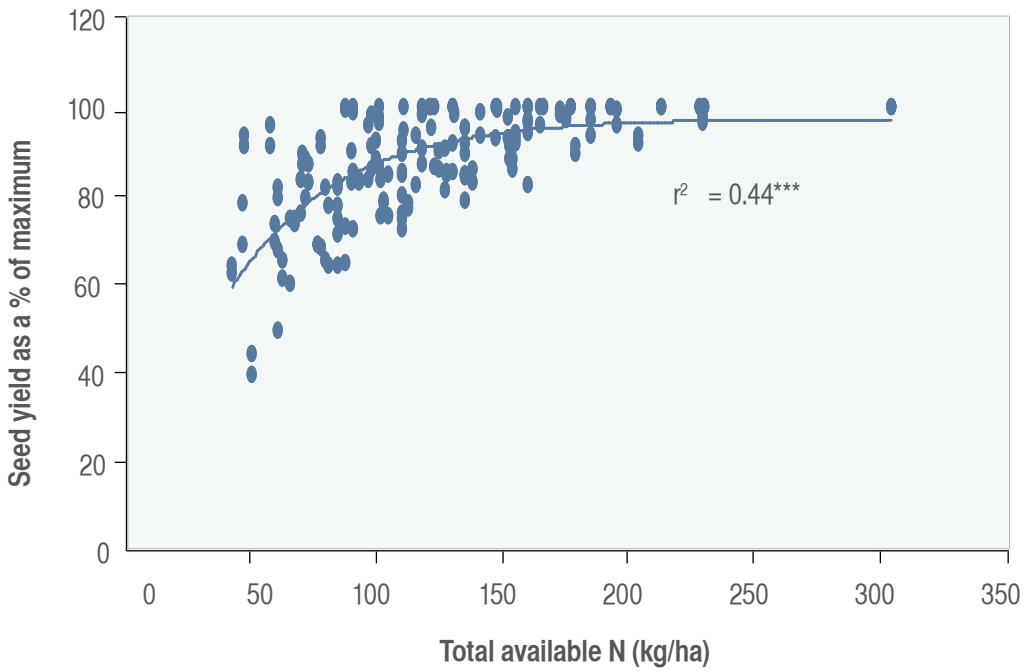

Figure 3 Relationship between total available nitrogen from soil, plant residue and fertilisers and the seed yield of canola (% of maximum of individual variety at each site) in lower rainfall sites in WA 2012-2014

Nitrogen rates are more important than timings in high rainfall canola in Western Australia

Dr Raj Malik and Mark Seymour, DPIRD

Key messages

- Canola yields, oil percentages and gross margins respond more to rates of applied nitrogen than timing.
  - Increasing nitrogen rates generally increased canola grain yield and reduced oil.
- In high rainfall areas we suggest growers continue to apply most of the nitrogen in the first eight weeks (that is, before the green bud is visible/stem elongation begins) to set up high biomass and yield potential.
  - Further top-up nitrogen decisions can be delayed until flowering (12 weeks after sowing) or even as late as 14 weeks in coastal areas (for example, Gibson) or 16 WAS in cooler inland areas (Kojonup) as the seasonal outlook unfolds.
- We found Triazine tolerant (TT), hybrid Roundup Ready® (RR) and hybrid Clearfield (CL) responded similarly to the rate and timing of applied nitrogen.

Background

The majority of canola growers apply top-up nitrogen within eight weeks of sowing – prior to the start of stem elongation. We wanted to see if nitrogen applied later in the year at the start of flowering (or later) provided a similar response to nitrogen applied earlier. We conducted six trials from 2013-2016 in high rainfall zones (Kojonup and Gibson) using a range of nitrogen rates and timing strategies to investigate if elite open pollinated (OP) cultivars of Triazine tolerant (TT), hybrid Roundup Ready® (RR) and hybrid Clearfield (CL) canola continue to respond to nitrogen past 12 weeks (start of flowering) or even 14-16 weeks (mid flowering and early pod set).

Results and Discussion

Canola yield and oil percentage responded to applied nitrogen at all six sites (Figure 2). Yield was optimised at rates of applied nitrogen ranging from 100kg N/ha at Kojonup in 2014 and 2016 to 150kg N/ha at Kojonup in 2013.

On average canola yielded 7kg/ha per unit of nitrogen applied for the first 25kg of nitrogen applied (0-25kg N/ha), 6kg/ha for the next 25kg of N applied (25-50kg N/ha), 4kg/ha for the next 25kg N/ha (50-75kg N/ha) and 3kg/ha for every unit of N above 75kg N/ha.

Figure 1 Mark Seymour and Raj Malik in canola timing of nitrogen experiment at Kojonup

Oil percentage decreased as the rate of applied nitrogen increased at an average rate of -0.004% for every unit of nitrogen applied.

The diminishing gain in yield with increased applied nitrogen relative to the cost of increasing nitrogen, combined with the negative effect of applied nitrogen on the concentration of oil in the seed resulted in optimum gross margins being achieved at markedly lower rates of applied nitrogen than seed yields. On average optimum gross margins were achieved at 50% of the rate of nitrogen which produced optimum seed yield – ranging from 25kg N/ha at Gibson in 2014 (compared to 150kg N/ha for maximum yield) to 100kg N/ha at Kojonup in 2014 which maximised both yield and gross margins.

It should be noted that maximum gross margins were achieved over a wide range of applied nitrogen – including the highest rates tested (with the exception of the 250kg N/ha treatment at Gibson in 2013) – such that on most occasions it is the opportunity cost of the dollars spent on nitrogen rather than another input around the farm that needs to be considered. That is, high rainfall growers are unlikely to lose money by applying too much nitrogen on their canola - they just might make more money by spending that dollar somewhere else.

Generally time of nitrogen application had no significant effect on grain yield, gross margins and oil concentration. See Figure 3 for an example of the effect of split/late timing of application of the same total rate of nitrogen (100kg N/ha) at Kojonup in 2016. In the two trials conducted in 2013 at Gibson and Kojonup when the same total amount of nitrogen applied at seeding is compared to other timings in 96% of cases, timing of nitrogen had no effect on grain yield; in 92% of cases timing of nitrogen had no effect on gross margins and in 100% of cases timing of nitrogen had no effect on oil percentage. In the trials conducted in 2014, 2015 and 2016 which included later timing of applications, out of 36 split nitrogen treatments timing of nitrogen application had no effect on any of the comparisons for grain yield and gross margins. Oil was not affected by time of application for lower rates of applied nitrogen (up to 80kg N/ha) at any of the sites. However, split application of 240kg N/ha in 2013 at Gibson and 100kg and 125kg N/ha in 2014 at Kojonup significantly reduced oil percentage.

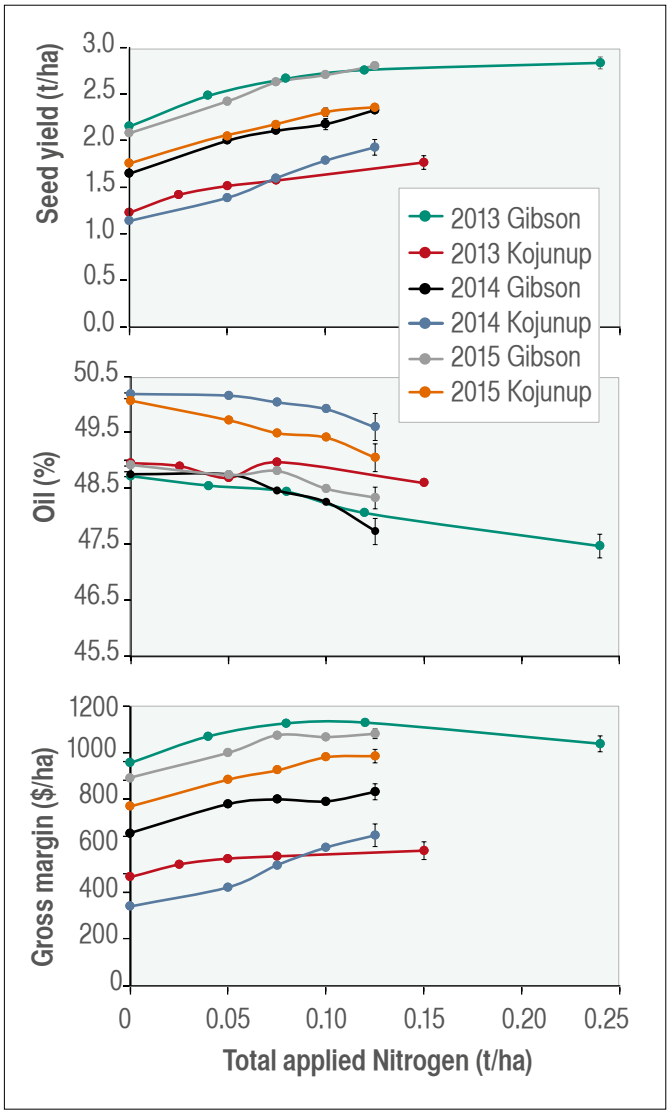

Figure 2 Response of canola grain yield (t/ha), oil (%) and gross margin ($/ha) to increasing rates of nitrogen in high rainfall nitrogen experiments at Gibson and Kojonup-W from 2013 to 2016

In the majority of instances varieties or herbicide tolerance system had no effect on the response to nitrogen or nitrogen timing. In four out of the six experiments, varieties produced similar yields, whilst at Gibson in 2014 RR hybrid variety Hyola® 404RR produced higher yields of 2.3t/ha than the OP TT variety ATR Wahoo at 2.0t/ha and at Kojonup 2016 both the OP TT and RR hybrid varieties produced higher yields (2.3t/ha) than the Clearfield hybrid variety (2.0t/ha). Kojonup 2016 was also the only experiment where we measured a difference in the gross margin of varieties - with the CL hybrid variety having lower gross margins than the OP TT and RR hybrid varieties.

The seed yield, oil percentage and gross margins of all types of canola reacted in

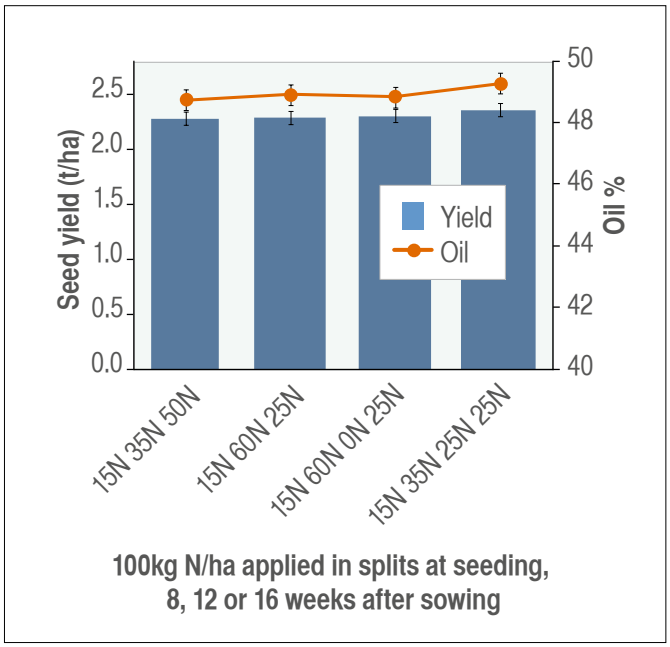

Figure 3 Response of canola grain yield (t/ha) and oil (%) to 100kg N/ha applied in split applications at Kojonup in 2016

the same way to applied nitrogen, that is regardless of rate of applied nitrogen or when it was applied OP TT, RR hybrid and CL hybrid showed the same response. Thus if growers are using nitrogen rate calculators such as Select Your Nitrogen (SYN) which were developed using data from OP TT experiments in WA, they can continue to use them. However, if growers have found CL or RR hybrids produced higher yields on their property than OP TT canola and have decided to switch to hybrids they should continue to use OP TT target yields in the calculators – otherwise the rate of applied nitrogen suggested by the model may be too high.

Conclusions

Generally delaying some of the nitrogen application beyond eight weeks after seeding did not affect yield or gross margins, meaning that growers can still top-up nitrogen beyond eight weeks. These results provide growers with potential flexibility in making decisions on nitrogen inputs later in the season. Growers may be able to reduce nitrogen inputs earlier in the season until they have a better idea of seasonal outlook and yield potential of their crop and continue to top up nitrogen during flowering.

Overall our work demonstrates nitrogen fertiliser increases the yield of canola in high rainfall areas and that timing of application is less important than the rate of applied nitrogen. In many circumstances the higher the rate the higher the yield – but the economic responses to applied nitrogen are likely to be lower than those which maximise yield. Our work provides confidence to growers that they can take a conservative approach when determining what rate of nitrogen to apply in high rainfall areas in the first eight weeks knowing that top-up nitrogen can be applied at later dates once there is better knowledge of seasonal conditions and potential yields. In most experiments we showed applying 75kg N/ha in the first eight weeks produces good results and decisions to add another 25kg N/ha can be delayed until the start of flowering (12 weeks after sowing) or indeed as late as 14-16 weeks after sowing when the crop has small pods and is mid to late flowering.

What rate of nitrogen?

Identifying the optimal nitrogen rate for any given paddock and season is challenging.

There are a range of industry-developed nitrogen budget calculators and tools such as 'Select Your Nitrogen' (SYN) (available from DPIRD) and the 'N Broadacre' app (from Planfarm) that can help with nitrogen fertiliser decision-making.

These models will need information in order to determine your crop nitrogen requirement. These include soil background nitrogen from soil tests, organic carbon status of your soil, rotation history, soil texture, rainfall and gravel content and they will usually estimate the soil mineralisation potential during the season.

Most models ask growers to input a target yield – we find that's often the hardest part!

Growers should continue to estimate yields based on OP TT varieties – rather than the potentially higher yields of hybrid varieties – otherwise the models may suggest higher N rates.

Critical nutrient levels for canola in WA

Andrew Blake, DPIRD, Ross Brennan, formerly DPIRD

A new tool produced by the Tactical Break Crop Agronomy project will help users interpret soil and tissue test results. Users will be able to check whether their canola crop is at risk of losing yield due to low nutrient levels, by comparing their test results with the critical levels presented in the tool.

The tool uses a 'traffic light' colour coded system to indicate the urgency of addressing the issue. Deficiencies coded red indicate losses of more than 25% are likely. Table 1 presents the critical levels for a manganese tissue tests result, indicating that 25% yield loss is likely when plant tissue levels are lower than 15mg/kg. Data from numerous DPIRD trials conducted over many years has contributed to the development of these critical levels for both macro and micronutrients.

Management of fertiliser inputs (particularly the macronutrients) can have a major impact on the profitability of canola crops. Understanding the supply of nutrients a canola crop is able to obtain from a particular soil is fundamental to tailoring a fertiliser program, and soil and tissue testing is the best way to gauge this.

Table 1 Predicted canola yield loss (%) due to manganese deficiency based on manganese status of young plants as determined by tissue analysis

Yield Loss	>25%	15-25%	5-15%	<5%
Manganese in whole tops of young plant (mg/kg)	<15	15-25	25-35	>35

The tool also presents critical levels for a range of soil constraints including soil pH, aluminium toxicity, salinity, compaction and sodicity. These can help users determine the urgency of addressing a particular soil constraint, or the suitability of a particular paddock for growing canola.

It also contains information about the concentration of nutrients typically found in canola seed and stubble (Table 2). Harvesting canola seed removes these nutrients from the paddock, so the basis of a good nutrition program will be to replace these nutrients.

The Critical nutrient levels for canola in WA tool is available on the DPIRD website:
www.agric.wa.gov.au/soil-nutrients/critical-nutrient-levels-canola-western-australia

Table 2 Range and average nutrient content found in one tonne of canola seed or stubble

	Macronutrient content (kg/tonne)						Micronutrient content (g/tonne)		
	N	P	K	S	Mg	Ca	Cu	Zn	Mn
Seed	26-40	2-6	6-9	3.2-6	2-4	2-4	1.5-5	22-45	16-40
Average	33	4	7	4	2.5	2.5	2.1	30	27
Stubble	6-10	1-3	18-30	3.4-6.5	0.6-2	4-7	2.6	10-15	10-30

Low fertiliser inputs to canola in lower rainfall areas

Mark Seymour and Raj Malik, DPIRD

Key messages

- Canola responded to phosphorus by 70-200kg/ha – in line with expectations based on previous research
- Soil testing to depth can indicate adequate levels of sulfur and potassium for canola in low rainfall areas
- We did not observe any responses to foliar applications of a zinc and manganese mix.

Background

Canola yields are inherently low and variable in low rainfall areas. Therefore it is inevitable growers will choose low input and low risk agronomy. However inputs such as herbicides and insect control, are either mandatory or outside of their control. One of the few inputs growers might be able to manipulate is fertiliser.

Over two years we evaluated the response of canola in lower rainfall areas to phosphorus, sulphur, potassium and micronutrients. Our sites in 2016 were located at Grass Patch, Pingrup and Varley and in 2017 at Grass Patch and Lake Grace.

Main treatments in 2017 included:

- No fertiliser
- No fertiliser + 10kg N/ha at sowing
- 100kg Superphosphate/ha (9.1% P, 11% S)
- Superphosphate + 10kg N/ha at sowing as urea (46%N)
- No fertiliser at sowing plus 120kg* gypsum/ha (15%S) applied six weeks after sowing
- No fertiliser at sowing plus 100kg Muriate of potash/ha (MOP, 50% K) applied six weeks after sowing
- Superphosphate + 10kg N/ha at sowing + 120kg gypsum/ha

Figure 1 Grass Patch low fertiliser experiment 25 August 2017. (Right) No fertiliser at sowing plus 120kg Gypsum/ha top-dressed six weeks after sowing plus 35N top-up, (Left) No fertiliser at sowing plus 120kg Gypsum/ha top-dressed six weeks after sowing

Grass Patch low fertiliser experiment 25 August 2017. (Right) 100kg/ha Superphosphate + 10kg N/ha at sowing + 35N top-up, (Left) 100kg ha Superphosphate + 10kg N/ha at sowing

- Superphosphate + 10kg N/ha at sowing + 120kg gypsum/ha + 100kg MOP/ha
- Superphosphate + 10kg N/ha at sowing + 120kg Gypsum/ha + 100kg MOP/ha + Micro sprays (0.4kg Zn/ha and 1kg Mn/ha sprayed onto foliage six weeks after sowing)

*400kg Gypsum/ha in 2016

At 6-8 weeks we also included a +/- top-up nitrogen treatment of 25-45kg N/ha (rate was site dependent) as urea granules or a solution of urea and ammonium nitrate (UAN) which is 42% N by volume..

Response to Phosphorus (P)

Previous work has shown canola is known to require 30-50% less phosphorus (P) than cereals (Bolland 1997) and Brennan and Bolland (2007) found yield response of less than 200kg/ha when P soil tests (Colwell P) were greater than 20mg/kg. Our experiments in lower rainfall areas in 2016 and 2017 closely followed the response to P shown by previous researchers with responses ranging from 70kg/ha at Lake Grace in 2017 with a soil test of 34mg/kg, to 200kg/ha at Varley in 2016 with a soil test of 25mg/kg (Figure 2).

Response to Potassium (K)

Brennan and Bolland (2006) and our experiments in lower rainfall areas in 2016 and 2017 found yield responses of less than 150kg/ha when potassium (K) soil tests of the top 10cm or in the 10-30cm layer of soil were >60mg/kg (Figure 3).

Response to Sulfur (S)

Brennan and Bolland 2006b found no relationship between sulfur levels in the top 10cm of soil and canola yield. Similarly canola yield was not related to soil tests at 10-20cm or 20-30cm. However if the sulfur soil test results from each layer is added together a good relationship with canola yield was found (Figure 4).

Sulfur levels in the top 30cm of soil were greater than 30mg/kg at the three sites in 2016 and at Grass Patch in 2017. Therefore we expected and observed no yield response to applied S in canola. Note if we used only the top 10cm of soil to evaluate S levels we would have classed the Grass Patch 2016 and 2017 sites as deficient. At Lake Grace in 2017 sulfur levels in the top 30cm of soil was only 12mg/kg, therefore we expected a large yield response to applied S of 250kg/ha, but recorded a grain yield increase of only 50kg/ha.

Our main method of applying S was to top-dress 400kg gypsum/ha in 2016 and 120kg gypsum/ha in 2017 at 4-6 weeks after sowing, supplying 18-58kg S/ha. However it should be noted the superphosphate treatments would also supply 11kg S/ha so we would have supplied up to 69kg S/ha in some treatments. At Pingrup and Grass Patch in 2016 we observed some ill thrift in canola plants following the application of the gypsum, which we believe may have been a salt effect so we reduced the rate of gypsum in 2017.

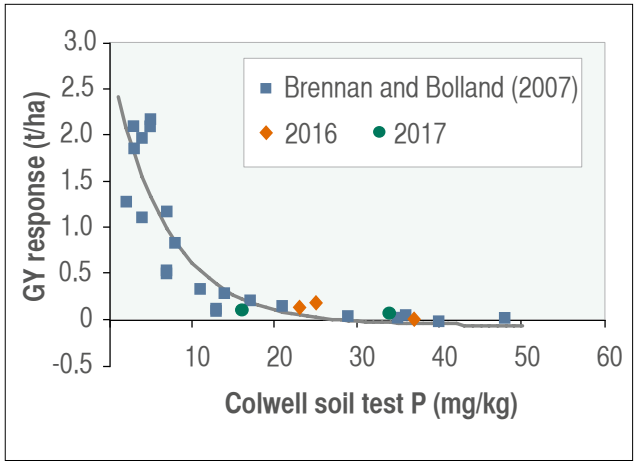

Figure 2 Grain yield response of canola in WA to 40kg P/ha (Brennan and Bolland 2007) and to 9kg P/ha at three sites in 2016 and two sites in 2017

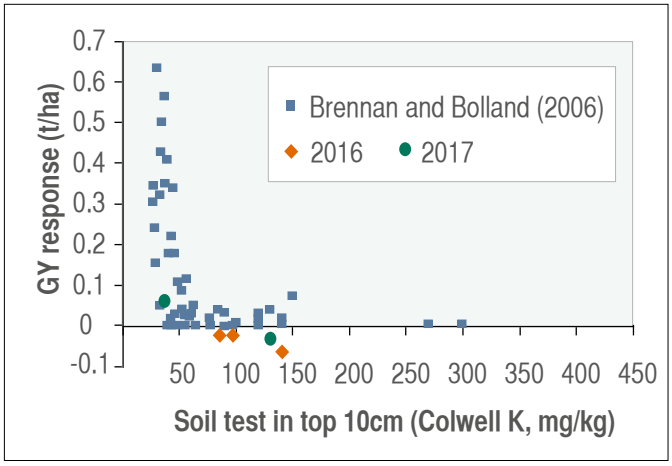

Figure 3 Grain yield response of canola to 60kg K/ha (Brennan and Bolland 2006) and to 50kg K/ha at three sites in WA in 2016 and two sites in 2017

Response to micro-nutrients Zn and Mn

In the Mallee areas in the south-east of WA it is normal practice to apply zinc (Zn) and manganese (Mn) as foliar sprays to cereals, but it is unclear if canola will also respond to Zn and Mn sprays.

Critical soil levels of zinc and manganese are not available for canola and should be used with caution for cereals in WA. We found Zn levels at Grass Patch in both years (1.5mg/kg in 2016 and 0.6mg/kg in 2017) and Pingrup in 2016 (1.5mg/kg) to be higher than the critical DTPA levels for wheat of 0.3mg/kg, whilst Varley in 2016 (0.3mg/kg) and Lake Grace in 2017 (0.3mg/kg) were considered marginal. Critical DTPA Mn levels appear to be ill defined for crops in WA. In the USA critical soil Mn levels for corn are 1mg/kg and all of our sites except Lake Grace in 2017 (0.9mg/kg) had levels greater than 1mg/kg.

We applied Zn and Mn as a foliar spray 5-6 weeks after sowing using 1kg $ZnSO^4$/ha and 4kg $MnSO^4$/ha to supply 0.4kg Zn/ha and 1.44kg Mn/ha.

We observed no significant yield response to micro-nutrient sprays at any site.

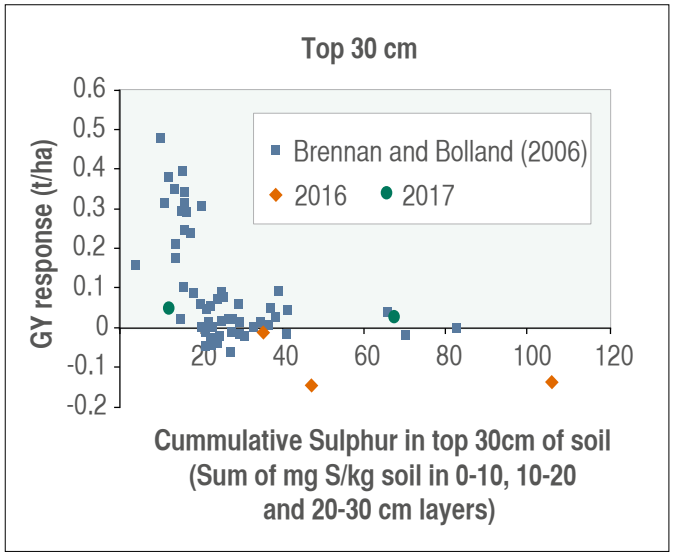

Figure 4 Grain yield response of canola of canola to 15kg S/ha (Brennan and Bolland 2006b) and to 58-69kg S/ha at three sites in WA in 2016 and 29kg S/ha at two sites in 2017

Response to Nitrogen (N)

We top-dressed 10kg N/ha as urea (46% N) at sowing immediately in front of the seeder and then came back within eight weeks to top-dress 15kg N/ha as urea at Pingrup and Varley in 2016 and Lake Grace in 2017. At Grass Patch in 2016 we applied top-up N as a foliar spray of UAN (42% N) at eight weeks (15N) and a further 15kg N/ha at 10 weeks due to continued wet conditions. Similarly in 2017 at Grass Patch we applied top-up N as a foliar spray of UAN (42% N) at eight weeks (15N) and a further 20 kg N/ha at 12 weeks due to continued wet conditions.

Even with a relatively good background N, canola responded to applied N in 2016. Response to N ranged from 4kg of grain per unit of N applied at Grass Patch to 9kg at Pingrup. In 2017 both sites had low soil N levels, whilst canola did respond to applied N, the magnitude of the responses to N were lower than expected – due perhaps to low yields at both sites.

Yield loss to aphids

Martin Harries and Svetlana Micic, DPIRD

Key messages

- Feeding damage from cabbage aphids caused 10% yield loss for every 1cm of spikelet colonised (trial 1)
- Green peach aphids (GPA) caused little yield loss from late season feeding damage (trial 2)
- Turnip yellows virus (TuYV) is transmitted by GPA and can cause up to 40% yield loss.

Introduction

There have been concerns that the yield loss of canola to aphids is underestimated. There are two main mechanisms whereby aphids cause yield loss:

1. Feeding damage, by species such as cabbage or turnip aphid, which colonise flowering and podding spikelets.
2. Infection with virus; of particular concern is green peach aphid (GPA) transmitting turnip yellows virus (TuYV), formerly know as beet western yellows virus. In 2014 this virus caused widespread damage to South Australian canola crops.

Two trials were run at the DPIRD Geraldton research facility to assess the feeding damage by cabbage aphid (trial 1) and green peach aphid (trial 2).

Significant feeding damage by cabbage aphid (trial 1)

Feeding damage of cabbage aphid on canola was assessed in a 2015 trial at Geraldton.

Treatments included four insecticide spray regimes;

1. Unsprayed (no insecticide)
2. One spray: applied at six leaf stage
3. Two sprays: at six leaf stage and big bud stage
4. Three sprays: control treatment, low aphid numbers.

Aphids were found at the site from 28 May and built up to very high numbers by the end of July. The length of the flowering canola spikelet colonised was measured on three dates and showed that the aphid infestation varied with less aphids for each additional insecticide spray (Table 1).

Table 1 Length of stem infested with aphids (cm)

	Date of inspection (days after sowing)		
Insecticide treatment	16 July (79)	23 July (86)	30 July (93)
Unsprayed	3.2	4.7	5.5
1 spray: 6 leaf	2.6	3.8	4.6
2 spray: 6 leaf + big bud stage	1.7	2.4	3.1
3 spray: Control (low aphids) timing	2.1	1.9	1.8
Lsd	1.1	0.8	1.2
	NS	$P<0.001$	$P<0.001$

Biomass cuts confirmed visual observations of significant reduction in plant growth with increasing aphid numbers (Figure 1).

Figure 1 DPIRD research officer Martin Harries between an untreated plot infested with cabbage aphids (left) and a plot sprayed with insecticide (right), on 4 August 2015

Yield and seed oil (%) were also significantly reduced with increasing aphid pressure (Table 2). In this trial, approximately 10% of yield was lost for every 1cm of spikelet covered in cabbage aphids, at the end of July (Figure 2).

Table 2 Seed yield (kg/ha) and oil concentration in seed (%) increased with insecticide treatments

	Yield (kg/ha)	Oil (%)
Unsprayed	347	38.8
1 spray (6 leaf)	464	39.3
2 spray (6 leaf/big bud)	643	41.8
3 spray (Control -nil aphids)	888	43.7
Lsd	294	2.2
F Prob	*P*<0.05	*P*<0.05

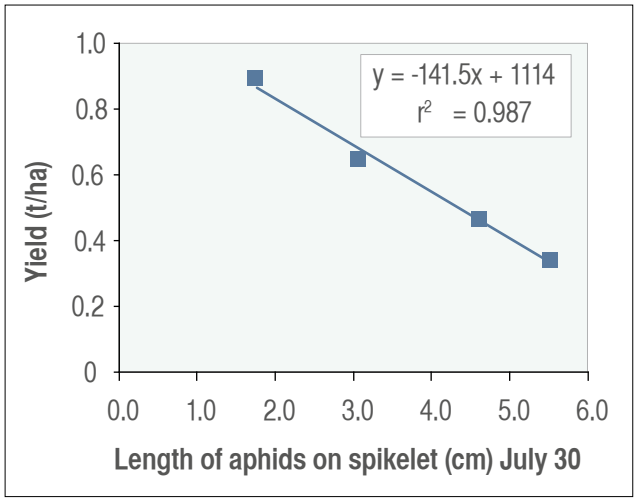

Figure 2 Relationship between average length of cabbage aphid colony on spikelet and yield loss

No significant feeding damage from green peach aphid (trial 2)

The second trial to investigate feeding damage of GPA was sown on 12 April 2016 at Geraldton. Aphids free of virus were introduced at staggered times during the season (Table 3). The trial was located inside insect proof tents (Figure 3).

Table 3 Timing of GPA introductions.

Treatments
1) Control (no aphids)
2) Early (27 May) aphid introduction
3) Mid (21 June) aphid introduction
4) Late (19 July) aphid introduction

Aphid populations responded as expected and numbers were highest in the tents with the earliest introduction of aphids (Figure 4).

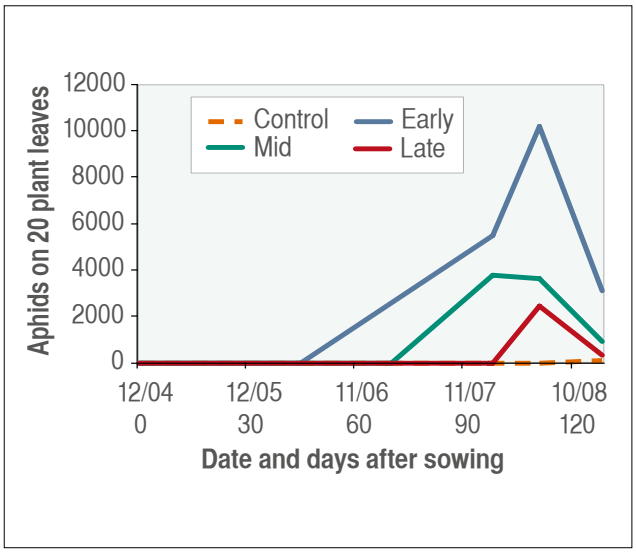

Figure 4 Aphid population dynamics from different dates of introduction; Early = 27 May, Mid = 21 June, Late = 19 July, control = Nil.

Figure 3 Insect proof tents for trials determining feeding damage of GPA without virus effects

Yield was not significantly affected by the timing of aphid introduction (Figure 5); however, yield and grain weight were lowest in the treatment with the earliest introduction of aphids (and the largest aphid population).

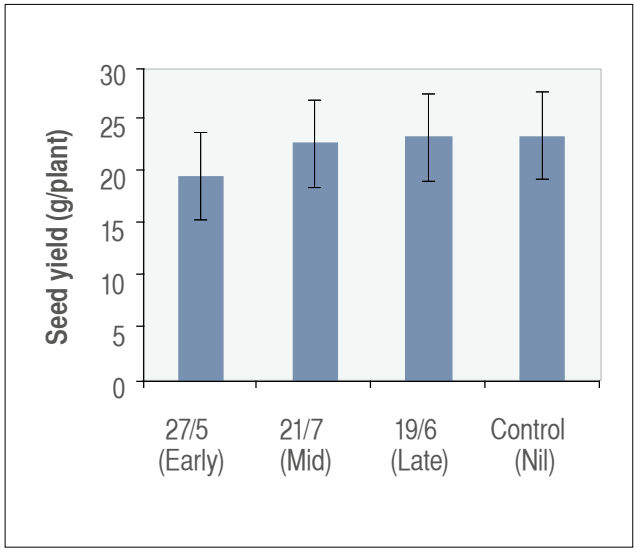

Figure 5 Average single plant seed yield from each aphid introduction time

Management conclusions

It is important to determine the species of aphid colonising the plant and likelihood of virus infection to manage aphids effectively.

Insecticide application is warranted if cabbage or turnip aphids colonise plants early. The current threshold for insecticide application is more than 20% of plants infested with colonies of cabbage or turnip aphids. The additional information of 10% yield loss from each cm of spikelet colonised can be used as a rough estimate of yield that will be protected by insecticide application.

Green peach aphids transmit turnip yellows virus and yield losses to TuYV are greater if they infect plants at young growth stages. Insecticide seed dressings will decrease likelihood of colonisation of GPA in higher risk situations, where there was a green bridge over summer. GPA should only be controlled up to the early reproductive plant stage if crops are not outgrowing feeding damage. GPA readily develop resistance to insecticides and should only be sprayed if crop loss is occurring.

Herbicide tolerance of canola

Dr Harmohinder Dhammu and Mark Seymour, DPIRD

Key messages

- ATR Bonito may be sensitive to propyzamide, ATR Snapper to s-metolachlor and ATR Mako to clopyralid + haloxyfop at label rates and timings on sandy soils.
- ATR Bonito had narrow crop safety margin for s-metolachlor, ATR Mako for metazachlor (Butisan®), Sturt (TT) for propyzamide, Hyola® 404RR and Pioneer® 45Y88CL for butroxydim at the label rates and timings.
- Triazine Tolerant and Roundup Ready® (TT+RR) varieties Hyola® 525RT® and Bayer 3000TR tolerated a sequential application of glyphosate (621g a.i./ha) followed by two-way tank mix of glyphosate with atrazine, butroxydim, clethodim, clopyralid, haloxyfop and terbuthylazine at the label rates quite well.
- When growing canola after wheat or other cereals where soil active and residual herbicides like isoxaben and terbuthylazine were used during cereal phase, pay careful attention to the label recommended replanting intervals for canola. Gallery® (isoxaben) used as pre-emergent (at 70-140g/ha), or early post-emergent (at 70-100g/ha) in wheat and barley has a plant back period of 22 months with more than 300mm rainfall (over two seasons) for canola. However, Nuseed GT-50 showed sensitivity to terbuthylazine residues on a sandy loam soil even after satisfying the plant back period of 6 months with 175mm rainfall.

Background

Weeds are one of the major production problems in canola. Herbicides are still the main method of weed management in canola in Western Australia. Herbicides can cause grain yield losses in canola. A small reduction in yield due to herbicide damage may be acceptable if weeds are competing strongly with the crop. However, yield reductions greater than 10% due to herbicides may be as significant as weeds in limiting yield.

New canola varieties have been bred or modified to be tolerant to specific herbicides in Australia, for example, triazines (TT), imadazolinones (IT/CL), glyphosate (RR) and triazine + glyphosate (TT+RR). However, there is a range of herbicides (apart from these specific herbicides) which are registered on all canola types. Moreover, canola varieties have been reported to differ in their tolerance to these general herbicides worldwide. The differences in tolerance may be due to any combinations of morphological and physiological characters among canola varieties. Environmental conditions under which a crop grows (before, at or after herbicide application) also strongly influence the level of crop safety of most herbicides.

As canola is grown as a break crop in rotation with cereals, the soil residual herbicides applied to wheat or other cereals may affect plant establishment, growth and development, and grain yield of of subsequent canola in rotation. Different herbicides have different residual lives in soil. Herbicides are broken down mainly via chemical or microbial degradation and additionally both processes are enhanced by heat and moisture.

A total of eight field trials under weed free conditions were conducted from 2014-2017 at Mullewa (1), Mingenew (3) and Katanning (4) using criss-cross design to determine:

- Tolerance of new canola varieties to herbicides common to all canola production systems, that is, conventional (CC), Triazine Tolerant (TT), Roundup Ready® (RR), Triazine Tolerant and Roundup Ready® (TT+RR) and Clearfield® (CL).

- Tolerance of TT+RR canola varieties to glyphosate mixes with other herbicides to reduce selection pressure on glyphosate.
- Residual effect of herbicides applied to wheat on a range of canola varieties grown in rotation.

Herbicide tolerance of canola varieties

A total of three canola herbicide tolerance trials were conducted, two at Mingenew on sandy soils (pH $CaCl_2$ 4.9-5-5) during 2014 and 2015 and one at Katanning on loamy sand soil (pH $CaCl_2$ 5.1) during 2017. A range of pre and post-emergent herbicides (registered on all canola types) were tested at label rates and timing against ATR Bonito, ATR Mako, ATR Snapper, ATR Stingray, Hyola® 404RR, Hyola® 450TT, Hyola® 525RT®, Nuseed GT-53(RR), Pioneer® 43Y23RR, Pioneer 45Y88CL, Sturt (TT) and Yetna. All herbicide x variety combinations were not tested across all the three years. The key findings were:

- Trifluralin (for example, TriflurX®), clethodim (for example, Select®) and clopyralid (for example, Lontrel®) + clethodim at label rates and timing were tolerated well by all the varieties.
- S-metolachlor (for example, Dual Gold®) applied before seeding at 240g a.i./ha (label rate) reduced grain yield of ATR Snapper significantly whereas its crop safety margin was narrow for ATR Bonito. S-metolachlor (Group K) at 240g/ha rate provides control of Toad Rush (*Juncus bufonius* L.) in canola.
- Propyzamide (for example, Edge®/ Rustler®) applied before seeding at 500g a.i./ha (label rate) caused significant grain yield loss in ATR Bonito and its crop safety margin was narrow for Sturt (TT). Propyzamide (Group D) at 500g/ha provides control of annual ryegrass and other grass weeds in canola.
- Metazachlor (for example, Butisan®) incorporated by sowing (IBS) at 900g a.i./ ha was tolerated well by all varieties. Its crop safety margin was narrow for ATR Mako. Metazachlor (Group K) is a new registration for control of ryegrass, wild oats and wire weed in canola.
- Clopyralid (for example, Lontrel®) at 90g a.i./ha + haloxyfop (for example, Verdict™) at 52g a.i./ha applied at the 2 leaf crop stage caused significant yield loss in ATR Mako. All the other varieties tolerated this mixture.
- Butroxydim (for example, Factor®) at 20g a.i./ha applied at the 4 leaf crop stage was tolerated by all varieties. Its crop safety margin was narrow for Hyola® 404RR and Pioneer 45Y88CL. According to the label, butroxydim is registered only for conventional, TT and CL canola varieties.

Dr Harmohinder Dhammu (far left) presenting canola trial to farmers and consultants at Mullewa Dryland Farmers Initiative Inc. field day during 2015

Tolerance of canola varieties to glyphosate mixtures

To investigate the effect of glyphosate mixtures with other herbicides on canola variety Hyola® 525RT®, a total of three trials were conducted, one at Mingenew on sandy soil (pH $CaCl_2$ 5.5) during 2015 and two trials at Katanning on loamy sand - sandy loam soil (pH $CaCl_2$ 4.9 - 5.1) during 2016 and 2017. The trial during 2017 also included canola variety Bayer 3000TR.

- Glyphosate 621g a.i./ha applied mixed with atrazine or clethodim or clopyralid at the label rates at the 3-4 leaf crop stage or sequential application of glyphosate at 621g a.i./ha at the 1-2 leaf crop stage followed by glyphosate at label rate alone or in two-way tank mixes with atrazine, butroxydim, clethodim, clopyralid, haloxyfop or terbuthylazine (for example, Terbyne® Xtreme®) at the label rates applied at the 4-5 leaf crop stage were tolerated by Hyola® 525RT® and Bayer 3000TR.
- Pre-emergent propyzamide or simazine at label rates followed by glyphosate at 621g a.i./ha mixed either with atrazine or atrazine + terbuthylazine at the label rates applied at the 1-2 leaf crop stage and then followed by another application of glyphosate at 621g a.i./ha at the 4-5 leaf crop stage was safe to both Hyola® 525RT® and Bayer 3000TR.
- Glyphosate at 621g a.i./ha in mixture with non-registered or off label canola herbicides reduced grain yield of Hyola® 525RT® significantly during 2015. Agricultural chemicals can only be applied according to their label registrations.

Residual effect of wheat herbicides on canola

The residual effect of a range of herbicides/herbicide mixtures applied to six wheat varieties at Mullewa during 2014 and at Katanning during 2015 was assessed on six canola varieties grown in sequence/rotation during 2015 and 2016, respectively.

- Isoxaben (for example, Gallery®) at higher than label rate (experimental rate) applied to wheat at 3-4 leaf stage on a red loam soil (pH $CaCl_2$ 5.8) at Mullewa during 2014 season, inhibited almost completely the emergence of all the six canola varieties tested during 2015 season (ATR Bonito, Hyola® 404RR, Hyola® 450TT, Hyola® 525RT, Hyola® 577CL and Yetna). The total rainfall within a period of 10 months from isoxaben application in wheat during 2014 to seeding of canola during 2015 was 202mm. Pre-emergent and early post-emergent isoxaben at 53-105g a.i./ha (Gallery® 70-140g/ha) is registered on wheat, barley and triticale for control of wild radish. Isoxaben is also one of the components in X-Pand® herbicide (100g a.i./ha) that is registered as an early post-emergent on wheat, barley and triticale. According to the label, if you use pre or post-emergent isoxaben at 53-105g a.i./ha in cereals, then the plant back period for canola is 22 months along with more than 300mm rainfall in total (first and second seasons).
- Terbuthylazine (for example, Terbyne® Xtreme®) at 1.05kg a.i./ha and at higher than the label rate applied pre-emergent to wheat on a sandy loam soil (pH $CaCl_2$ 5.1) at Katanning during 2015 reduced grain yield of Nuseed GT-50 canola significantly (12-15%) during 2016 season. It did not have similar negative effect on grain yield of other canola varieties ATR Bonito, Hyola® 404RR, Hyola® 525RT®, Hyola® 559TT and Pioneer® 43Y23RR included in the trial. The total rainfall at Katanning from application of terbuthylazine on wheat during 2015 to seeding of canola after 11.5 months was 435mm. According to the label, plant back period for canola after terbuthylazine application is six months with 175mm rainfall.

Crop safety margins: Higher than label rates of some herbicides were included in the trials to determine the crop safety margin of the herbicides at the maximum label rates.

Good crop safety margin means that a herbicide at its maximum label rate and at the higher rate(s) was tolerated well by a crop variety.

Narrow crop safety margin means a variety tolerated a herbicide well at the maximum label rate, but at higher than the label rate(s) there was statistically significant yield loss. A narrow crop safety margin implies that when spraying under less than optimal conditions, herbicide damage and yield loss may occur even at the label rate.

Grazing canola

Mark Seymour, DPIRD

Key messages

- Don't graze canola too hard in medium and low rainfall areas – don't graze lower than 5cm.
- Clip grazing where the animals only remove the top 5cm of the crop is the safest option – use low stocking rates on large areas of crop.
- The later you graze canola the greater the amount of dry matter you need to leave behind – when grazing at or near stem elongation aim to leave at least 1t/ha of dry matter.
- Grazing past the end of July will usually reduce seed yields in WA.

Background

The majority of experience with grazing canola has been in high rainfall areas in the eastern states. The principals remain the same in lower rainfall areas – that is; start grazing once the crop is anchored and remove stock prior to flower buds of canola reaching the top of the canopy. However, some aspects were thought to need modification.

Western Australia has a much shorter growing season than the areas where most of the grazing experience has been gathered. As grazing was extended into shorter growing season areas, there were concerns that even if critical crop development guidelines were followed there may not be sufficient biomass or time for crops to recover from grazing – particularly if the crop is crash grazed.

Trials

As part of a collaborative project with John Kirkegaard at CSIRO, DPIRD conducted time and height of grazing experiments in WA in 2012 at 13 locations – Amelup (2), Cunderdin, Gibson, Gnowangerup, Grass Patch, Katanning, Kendenup, Pingrup, Tambellup, Wandering, Wittenoom Hills and Wongan Hills. The experiments were conducted in farmer paddocks sown from 23 April to 5 June (11 sown before 11 May) using widely grown varieties such as Crusher TT, ATR Cobbler and Hyola® 404RR. Flower buds were visible and therefore vulnerable at around 87 days after sowing. Grazing was simulated by hand cutting canola at various heights and times.

The trial showed

- A clear trend of reduced canola grain yield as grazing occurred later in the growing season and dry matter removed increased (Figure 1). The exceptions to this were treatments which removed only the top

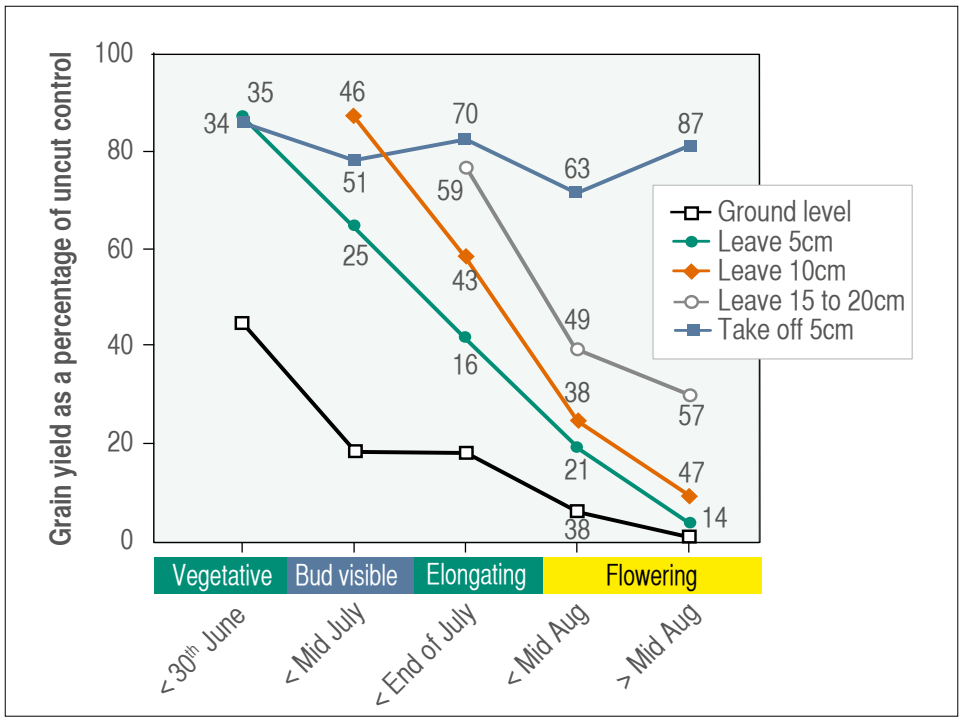

Figure 1 Relationship between the time of cutting (Date groups, with associated approximate growth stage), height of cutting (as per legend) and the grain yield of canola expressed as a percentage of uncut treatment yields from 13 sites in WA in 2012. Residual biomass (% of uncut controls) at the time of cutting is shown beside the symbols.

Figure 2 Cattle grazing canola at Gibson in 2011

5cm of the crop, which had a similar flat response over the whole season.

- Yield reductions were closely related to dry matter recovery and dry matter at maturity. Treatments which had no effect on grain yield produced on average 5.8t/ha of dry matter at maturity whilst treatments which reduced yield produced 3.0t/ha of dry matter.
- In order to avoid a yield decrease, we found that residual dry matter increased with the growth stage of canola, such that at the start of bud initiation stage (6-10 leaf) approximately 600 kg/ha of residual dry matter (@50% of uncut controls) was required whilst at the start of stem elongation this increased to 60% of uncut controls which was equivalent to an average residual dry matter of 1t/ha in 2012.
- The treatments which simulated clip grazing (removing top 5cm) without affecting grain yield removed on average 0.3t/ha of dry matter, with a range of 0.1-0.5 t/ha. In six out of 11 sites where clip grazing did not reduce grain yields, we removed less than 0.3t/ha of dry matter.

Reference

Seymour, Mark, Jonathan H. England, Raj Malik, David Rogers, Andrew Sutherland, and Allen Randell. “Effect of timing and height of defoliation on the grain yield of barley, wheat, oats and canola in Western Australia.” *Crop and Pasture Science* 66, no. 4 (2015): 287-300.

Direct heading canola – less shedding in PodGuard varieties

Mark Seymour, DPIRD

Key messages

- Shedding losses were generally acceptable (less than 10%) but were a big problem (up to 60% yield loss) during extreme conditions.
- The PodGuard lines IH51RR and InVigor R 5520P had significantly less shedding than other varieties.
- PodGuard varieties are suited for delayed swathing or delayed harvest situations.

Background

More farmers are switching from swathing to direct harvesting canola. We investigated how well adapted different varieties are for direct heading, and delayed direct heading, including the new PodGuard varieties. The direct heading experiments were conducted at Esperance Downs Research Station in 2014 and 2015. The PodGuard varieties tested were IH51RR in 2014, and InVigorR 5520P in 2015. Other varieties tested in both 2014 and 2015 experiments were ATR Stingray, Hyola® 404RR and IH30 (RR).

Shedding losses were assessed multiple ways;

- Shedding before harvest -by measuring dropped seed and pods in gutter trays left in the plots (Figure 1).
- Shedding at harvest - by measuring dropped seed and pods in gutter trays placed in the plots before harvest (Figure 2).
- Total yield decline assessed from differences in harvested yield.

Figure 1 Collecting pre-harvest losses with gutter tray

Figure 2 Collecting harvest losses with gutter tray

Figure 3 Gutter tray after harvest

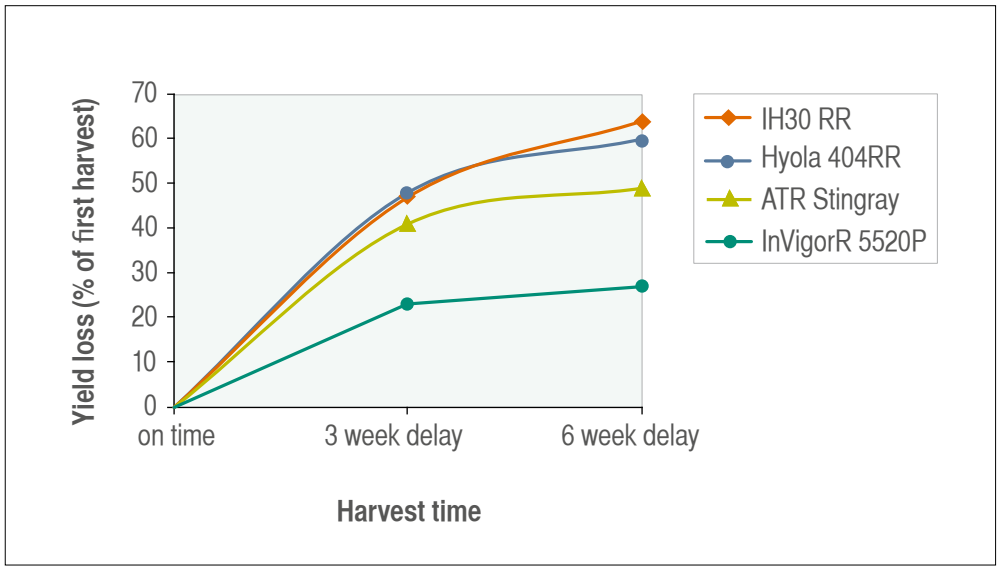

Figure 4 Yield decline with delayed harvest in 2015

There were three harvest times for each trial. The first harvest was on-time and the last harvest was four weeks later, in 2014, and six weeks later, in 2015.

1. Seed losses collected before harvest

Shed seed collected in the gutter trays before harvest was variable. Losses were 1-2% when harvested on time and only increased to 3% with delayed harvest in 2014, in spite of a thunderstorm with 44mm of rain and strong winds three days before the second harvest.

However in 2015, average pre-harvest losses were 33% with delayed harvest, after extreme winds. These wind gusts of 87km/hr and 40°C temperatures caused widespread catastrophic fires in the Esperance region on 17 November 2015.

The 33% seed measured in the gutter trays was less than the decline in harvested yields, in 2015. This is likely to be due to seed blowing past the collection gutters during the strong winds. The average decline in machine harvested yield over the same period was 50%.

2. Seed losses collected during harvest

There was a moderate (less than 10%) amount of seed and pod collected in the gutters during harvest, over all harvests of both trials.

There was a marked difference in the shedding of different canola cultivars. The two PodGuard varieties IH51RR and InVigor R 5520P had significantly less shedding than other varieties, both at harvest and before harvest. Shedding losses of Podguard varieties were mainly due to whole pods dropping off the plant. Other varieties generally dropped seed from pods opening and releasing seed.

3. Differences in yield at later harvests

There was a relatively small decline in harvested yields with delayed sowing in 2014. Non-PodGuard varieties lost 6-8% yield (up to 228kg/ha) after the four week delay, while there was no yield loss in the IH51RR at the last harvest.

In 2015, there were high losses by the six week delayed harvest, after the catastrophic winds. Non-PodGuard varieties lost 49-64% (up to 1.4t/ha), while the yield decline for InVigorR 5520P peaked at 27% (735kg/ha) (Figure 4).

Gross margins

In 2014, IH51 had a slightly lower gross margin than other RR varieties for on-time harvest, due to slightly lower yields. However, at later harvests, yields became similar due to the lower shedding loss of IH51 and the gross margin between varieties was similar. In 2015, InVigorR 5520P had the highest yields at the on-time harvest, and this yield advantage grew as harvest was delayed. InVigorR 5520P also had the highest gross margin and the gross margin advantage increased over subsequent harvests (although overall gross margin decreased with delayed harvest).

The Podguard varieties offered a measure of harvest risk management.

Further reading

Scientific Journals

These articles can be accessed via the following webpage: agric.wa.gov.au/n/7303
Found under the Further reading heading (Page 2).

Seymour M, Kirkegaard JA, Peoples MB, White PF, French RJ (2012) Break-crop benefits to wheat in Western Australia – insights from over three decades of research. *Crop and Pasture Science* **63,** 1-16

French RJ, Seymour M, Malik RS (2016) Plant density response and optimum crop densities for canola (*Brassica napus* L.) in Western Australia. *Crop and Pasture Science* **67,** 387-408

Seymour M, Sprigg S, French RJ, Bucat J, Malik R, Harries M (2016) Nitrogen responses of canola in low to medium rainfall environments of Western Australia. *Crop and Pasture Science* **67,** 450-466

Zhang H, Berger J, Seymour M, Brill R, Herrmann C, Quinlan R, Knell G (2016) Relative yield and profit of Australian hybrid compared with open-pollinated canola is largely determined by growing-season rainfall. *Crop and Pasture Science* **67,** 323-331

Malik RS, Seymour M, French RJ, Kirkegaard JA, Lawes RA, Liebig MA (2015) Dynamic crop sequencing in Western Australian cropping systems *Crop and Pasture Science* **66,** 594-609

French RJ, Seymour M, Malik RS (2015) Crop-sequence effects on productivity in a wheat-based cropping system at Wongan Hills, Western Australia. *Crop and Pasture Science* **66,** 580-593

Harries M, Anderson GC, Huberli D (2015) Crop sequences in Western Australia: what are they and are they sustainable? Findings of a four-year survey *Crop and Pasture Science* **66,** 634-647

Sprague SJ, Kirkegaard JA, Graham JM, Bell LW, Seymour M, Ryan M (2015) Forage and grain yield of diverse canola (Brassica napus) maturity types in the high-rainfall zone of Australia *Crop and Pasture Science* **66,** 260-274

Seymour M, England JH, Malik RS, Rogers D, Sutherland A, Randell A (2015) Effect of timing and height of defoliation on the grain yield of barley, wheat, oats and canola in Western Australia *Crop and Pasture Science* **66,** 287-300

Seymour M, Brennan RF (2017) Cultivars of Canola Respond Similarly to Applied Nitrogen in N-Deficient Soils of South Western Australia. *Journal of Plant Nutrition* **40,** 2631-2649

Research Updates

These articles can be accessed via the following webpage: agric.wa.gov.au/n/7303

Found under the Further reading heading (Page 2).

Dhammu H, Seymour M (2018). Herbicide tolerance of canola varieties – a summary.

Farre I, Seymour M, Harries M, French B, Bucat J (2018). Optimising grain yield of canola in Western Australia accounting for the risk of frost and heat stress.

Harries M, French B, Seymour M, Boyce S (2018). Canola yield and heat stress in the Northern Agricultural Region.

Harries M, Shea G (2018). Comparing canola and lupin varieties by time of sowing in the Northern Agricultural Region.

Davey M, Bucat J (2017). Canola National Variety Trial Results 2016.

Harries M, Seymour M, Bucat J, French B, Sprigg S (2017). Agronomy for early sown canola.

French B (2017). Do Australian canola cultivars differ in their tolerance of soil Al?

Harries M, Seymour M (2017). Canola establishment: seed depth, seed size and hybrid vs OP.

Harries M, Seymour M (2017). Is it worth switching to a longer season canola variety when you sow in March? - very early sown canola variety trial, Wongan Hills

Harries M, Seymour M, Boyce S (2017). Seeding uniformity and canola yield.

Malik R, Seymour M (2017) Nitrogen rates and timing in high rainfall canola in Western Australia.

Harries M, Micic S, Seymour M (2016). Reassessing canola yield loss to aphids.

Zhang H, Berger J, Seymour M, Brill R, Quinlan R, Knell G (2016). Canola hybrids vs OPs: which one wins and where?

French B, Bucat J, Seymour M, Malik R, Harries M (2016). Open pollinated canola still a better option than hybrid or retained hybrid seed in low rainfall areas.

Harries M, Seymour M (2016). Canola variety by time of sowing in the Northern Region.

Harries M, Seymour M (2016). Precision placement of canola seed, can we get the same or better yield from less seed?

Harries M, Seymour M, Pinkney C, Suckling K, Cripps B, Forde R (2015). Wide row canola why bother; a summary of a series of small plot and farmer trials and farmer experiences.

Seymour M, Sprigg S, French B, Malik R, Bucat J, Harries M (2015). Timing of nitrogen for canola in lower rainfall areas in WA. f

Seymour M, French B, Malik R, Bucat J (2014). Plant density of canola in the low and medium rainfall regions of Western Australia.

DPIRD webpages

Canola agronomy research in Western Australia Bulletin webpage: agric.wa.gov.au/n/7303

All DPIRD webpages listed below are accessible via the 'See Also' section of this page.

Canola seed rate calculator. The easy way to calculate canola seed rate for a given target density from germination percentage, field establishment, and seed size.

Canola seed rate information. Further information on choosing seed rates so you can make best use of the seeding rate calculator.

Canola landing page.

Tactical break crop agronomy project: canola and pulse agronomy trials and information

Estimating the size of retained canola seed. How to estimate the size of canola seed using a ruler.

Critical nutrient levels for canola. How much of each plant nutrient does canola need, and how to recognise deficiencies.

MyCrop canola diagnostic tool. Helps diagnose pests, diseases, and nutrient deficiencies.

Canola sowing time information. Modelled optimum sowing dates for canola across a wide range of wheatbelt locations. How modelled sowing time response compares with field trial results

Essentials for growing a successful canola crop. The title says it all!

Canola variety guide. The most up-to-date information on canola varieties currently available in Western Australia.