# Profitable management packages for canola

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**Abstract**
In rotations, canola can provide a disease break for cereals and a broader spectrum of herbicide options to reduce the risk of herbicide resistance in weeds. However, canola can have higher costs of production than cereal crops. We therefore sought to identify combinations of management practices that would maximise gross margins and reduce the risk of financial loss from growing canola. We simulated continuous canola management packages (combinations of in-season N fertiliser rate, cultivar choice, time of sowing) for 50-years. To compare practices identified for contrasting environments we report results from two locations with relatively high and low average annual rainfall at Breeza, NSW and Minnipa, SA, respectively. Management practices made little contribution to gross margins unless climate variability was accounted for so results are presented within a framework of a hypothetical, always-correct seasonal rainfall forecasts and sowing opportunities. Regionally specific packages of the most profitable practices for sowing single canola crops were identified that can be adopted as sowing opportunities arise. These packages broadly included: decreasing N fertiliser rate in lower rainfall deciles and/or as the growing season progressed; a change in choice of cultivar rate of development from slow to fast when sowing was delayed; and selection of a conventional or hybrid cultivar at Breeza. These findings were relevant despite the lact of perfect seasonal forecasts available for growers.

**Key Words**
gross margin, regression tree, APSIM

**Introduction**
The area sown to canola, and the productivity of canola crops, has increased substantially in Australia since commercial production began in 1969, such that it now occupies 2.3 million ha (in 2017) with an annual production of 4 Mt $yr^{-1}$ (Kirkegaard et al., 2016). A key driver for the adoption of canola in rotations is its value as a break crop between cereals, contributing at the farm scale to breaking pest and disease cycles and to managing herbicide resistance through the use of herbicide-tolerant varieties (Kirkegaard et al., 2016). The latter benefit is of increasing importance in light of the escalating resistance of major weed species to herbicides.

However, canola is often perceived as a risky crop because it requires greater input (variable) costs than cereals (DPI 2012; PIRSA 2018). While grain prices for canola are currently greater than for cereals, canola yields are generally less than cereals and subject to the same climate variability. There is thus a greater risk of financial loss from canola than from cereals if unfavourable conditions limit yields and prevent recovery of input costs. A tension therefore exists between delivering break crop benefits from canola and of delivering profitability from canola in its own right. In this study, we simulated a factorial array of management practices in response to the 50-year weather record in order to capture the effect of both climatic variability and management upon yield. As a result of this study, we have identified a number of management practices at two locations with contrasting rainfall that substantially increase profits when matched to environmental conditions.

**Methods**
*Scenarios*
Canola was simulated at two contrasting locations: at Breeza in the high rainfall zone of NSW (average annual rainfall 663 mm), and at Minnipa in the low rainfall zone of SA (average annual rainfall 329 mm). Soil properties were obtained from past characterization of the sites. Weather data was obtained from the SILO record (Jeffrey et al., 2001). A range of management factors (fixed sowing dates, cultivar type, rates of cultivar development, planting density, N fertiliser rate; Table 1) were simulated in a full factorial at the locations. All crops received a fixed amount of N at sowing as mono-ammonium phosphate (5 kg N/ha at Minnipa; 20 kg N/ha at Breeza), plus an amount of N at 50 days after sowing equal to the target N rate (Table 1) reduced by the amount of soil mineral N in the surface 0.3 m of soil at the time of application. The

sixteen sowing dates were subsequently grouped into eight sowing windows for the half-month periods from 16-31 March to 1-15 July.

*Simulation approach*

Canola crops grown in response to the different combinations of management practices (Table 1) were simulated with the Agricultural Production Systems sIMulator (APSIM) v7.9 (Holzworth et al., 2014; Robertson and Lilley, 2016). Production was simulated with generic cultivars developed to represent the triazine-tolerant open-pollinated (TT-OP), conventional open-pollinated (conventional-OP) and non-triazine tolerant hybrid (nonTT hybrid) cultivar types. At Minnipa only the TT-OP cultivar was simulated, consistent with local practice where this cultivar is the one predominantly sown. In this location, it plays an important role in integrated weed management given high levels of local herbicide resistance, while having less expensive seed costs than many other cultivar types. Crops were assumed to have failed if they did not germinate within two weeks of sowing. Frost and heat stress factors decreased simulated grain yield when the maximum temperature was greater than 30°C during anthesis, and when the minimum temperature fell below 2°C during pod filling (after Lilley et al., 2018). Soil nitrogen and surface crop residues were reset to initial values (including 50 kg ammonium-N/ha) on 1 February each year, to prevent confounding yields with nutritional effects from stubble carryover and long-term changes in soil organic matter. Crops were simulated using the historical weather record of the 50 year-period 1967-2016. Individual years for this period were grouped into low', 'medium' and 'high' amounts of April to October ('growing season') rainfall, defined by the respective rainfall decile groupings 1-3, 4-7 and 8-10. The combinations of management practices with the 50-year period resulted in approximately 200,000 sowings simulated per location.

**Table 1. Management factors applied in combinations to manage crops at the case study locations**

| Management factor | No. | Breeza | No. | Minnipa |
|---|---|---|---|---|
| Sowing date | 16 | 15 March to 12 July in 7-day increments | 16 | 15 March to 12 July in 7-day increments |
| Cultivar type[1] | 3 | TT-OP, conventional-OP, nonTT-hybrid | 1 | TT-OP |
| Rate of cultivar development | 3 | Fast, medium, slow | 3 | Fast, medium, slow |
| Plant density ($m^{-2}$) | 3 | 15, 45, 75 | 3 | 15, 30, 45 |
| Target N fertiliser at 50 DAS[2] (kg N/ha) | 8 | 50, 100, 150, 200, 250, 300, 400, 500 (minimum application of 50) | 8 | 5, 10, 20, 30, 40, 50, 70, 100 (minimum application of 5) |

[1]TT-OP, triazine tolerant open-pollinated; conventional-OP, conventional open-pollinated; DAS, days after sowing.

*Gross margin calculations*

Gross margin data at each location was obtained from industry advisors and published data (hybrid costed as Clearfield ®). The grain price was based on a 10-year average value of \$503 $t^{-1}$ and minimum harvestable yields were set at 200 and 440 kg $ha^{-1}$ at Minnipa and Breeza, respectively. Costings were applied to simulated yields and associated management practices where costs for N fertilizer and seed varied in proportion to the amount applied or sowing density used. Levies and transport costs varied in proportion to crop yield. All other costs (insecticide, fungicide, phosphorus fertilizer, insurance, lime and gypsum) were assumed to be incurred at the same rate for crops within the same cultivar type.

*Analysis*

Gross margin results were interpreted with analysis of variance and with a regression tree classification approach in RStudio (R Core Team, 2016). With the regression tree approach, results are divided successively into two groups at each branch using a process that minimizes the sum of the squared deviations from the mean in the two separate groups. While this process was used to identify practices producing the greatest average gross margin, the practices may on occasion also produce losses. The process was repeated for each combination of sowing window and rainfall decile grouping at each location. The combination of management practices producing the most profitable outcome within each sowing window and rainfall decile grouping are presented in this study.

## Results

*Effect of individual factors on gross margins*

Average gross margins at each location were greater in response to favourable environmental conditions (higher April-October rainfall and early sowing times) than in response to optimal management practices



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(target N rate, cultivar, rate of cultivar development and planting density) (e.g. for contrasting locations Breeza and Minnipa in Table 2). For Breeza, the mean gross margin was $428/ha for all years, sowing times and management practices. However, in response to high decile rainfall or a sowing opportunity in the 1-15 April sowing window, average gross margin increased by $192/ha and $243/ha, respectively. By comparison, the most influential management practice (using a conventional OP cultivar) could increase average location mean at Breeza by around half this amount ($104/ha). At Minnipa, the most favourable rainfall and sowing opportunity more than doubled average gross margins (up to $365/ha), but the best management practices increased average gross margin by only $5 to $14/ha.

**Table 2. Mean gross margin (GM) at Breeza and Minnipa locations in response to all simulated factors, and highest gross margins in response to individual factors, identified by analysis of variance. The levels within each factor are described in Table 1. All factors were significant (p = 0.001).**

| | Breeza | | Minnipa | |
|---|---|---|---|---|
| Management factor | GM ($/ha) | Best practice | GM ($/ha) | Best practice |
| All practices (location mean) | 428 | All practices | 170 | All practices |
| Apr-Oct rainfall decile grouping | 620 | 8-10 | 266 | 8-10 |
| Sowing window | 671 | 1-15 April | 365 | 1-15 April |
| Target N (kg N/ha) | 507 | 200=250 | 184 | 50=70=100 |
| Cultivar | 532 | conv-OP | n/a | Only TT-OP simulated |
| Rate of cultivar development | 436 | Medium = Slow | 182 | Medium = Fast |
| Plant density (/m$^2$) | 440 | 45 plants/m$^2$ | 175 | 30 = 45 |

*Most profitable management practices for differing environmental conditions*

To identify management practices that contributed to the most profitable canola production for given environmental conditions, results were classified into combinations of rainfall and sowing window. The regression tree approach was then utilised to identify most profitable combinations of management practices for static combinations of rainfall and sowing window. For both locations, the highest gross margins occurred in response to the highest rainfall and earliest sowing opportunities and declined as rainfall declined and as sowing opportunities were delayed (data shown for selected sowing opportunities, Table 3). A similar response occurred in crop yields, reflecting the direct relationship between yield and income as well as the greater yield potential of crops provided with a longer growing season and lower water stress.

The most profitable management practices changed with rainfall and sowing opportunity, but in general the optimum rate of inputs and the number of effective management practices tended to decline as the sowing opportunity was delayed (Table 3). The target N rate contributing to the highest gross margins included a range of values because there was a trade-off within gross margins between increases in revenue from higher yield when the N fertiliser rate was increased and increases in fertiliser costs as more was applied; the minimum of the range is recorded here. For both locations, the most profitable target N fertiliser rate declined given lower rainfall and as sowing opportunities were delayed. At Breeza, it was consistently more profitable to use a hybrid or conventional OP cultivar type than the TT-OP cultivar type because of the yield penalty incurred when a TT-OP type was grown, and to use a slow rate of cultivar development if the earliest sowing opportunity was available. At Minnipa, cultivars with a slow to medium rate of development contributed to the grouping with highest gross margins only if the earliest sowing opportunity was available (mid- to end of March), while cultivars with medium to fast rates of development contributed to the highest gross margins for sowing opportunities after mid-April. Choice of plant density did not form part of the most profitable combination of management practices in any rainfall-sowing combination at either location. For the lowest rainfall at Breeza, when combined with the last sowing opportunity, even the most profitable combination of practices had a negative average gross margin (i.e. a loss). At Minnipa, for the lowest rainfall the average gross margin was negative for sowing opportunities after mid-May and was always negative for sowings in the latest sowing opportunity (July), regardless of rainfall.

## Conclusion

The decrease in yield of canola crops exposed to moisture stress (represented by rainfall), and the increase in yield when crops are able to accumulate assimilates over longer periods (facilitated by earlier sowing opportunities), have well-known effects on crop yield (Robertson and Lilley, 2016; Robertson and Holland, 2004). The rate of N to apply at 50 DAS could be better matched to environmental conditions if low, medium and high amounts of growing season rainfall could be reliably forecast. Nevertheless, some refinement to this rate may be made since the choice to apply it occurs after sowing and more is known of growing season rainfall by the time application is due. However, the most profitable choice of some of the practices that were determined at sowing - cultivar type and rate of development - were identified regardless of rainfall. By tailoring crop management to the extent that environmental conditions are known , this study identifies combinations of management practices that can, on average, substantially increase the average gross margins for the conditions experienced.

**Table 3. The combination of management practices contributing to the most profitable production of canola within selected rainfall decile-sowing window combinations at Breeza and Minnipa. Gross margin (GM) values identified for each rainfall decile-sowing window combination represent average values from combined management practices; the group of gross margin values included in this average may span both positive (profits) and negative (loss) values.**

| Location | Sowing window | Apr-Oct decile | Minimum target N (kg/ha) [a] | Rate of cultivar development | Cultivar [b] | Mean GM ($/ha/crop) | Mean yield (t/ha) |
|---|---|---|---|---|---|---|---|
| Breeza | 16-31 | 1-3 | 120 | Slow | H,C | 560 | 2.36 |
| | March | 4-7 | 220 | Slow | H,C | 983 | 3.35 |
| | | 8-10 | 320 | Slow | H,C | 1,211 | 3.98 |
| | 1-15 | 1-3 | 120 | | H,C | 457 | 2.07 |
| | May | 4-7 | 220 | | H,C | 756 | 2.94 |
| | | 8-10 | 220 | | H,C | 898 | 3.29 |
| | 1-15 July | 1-3 | 120 | | | -175 | 1.07 |
| | | 4-7 | 120 | | C | 195 | 1.64 |
| | | 8-10 | 120 | | H,C | 389 | 2.39 |
| Minnipa | 16-31 | 1-3 | 60 | | n/a | 302 | 1.17 |
| | March | 4-7 | 125 | Slow, Medium | n/a | 516 | 1.71 |
| | | 8-10 | 155 | Slow, Medium | n/a | 621 | 1.97 |
| | 1-15 | 1-3 | 60 | Medium ,Fast | n/a | 121 | 0.78 |
| | May | 4-7 | 60 | Medium, Fast | n/a | 330 | 1.26 |
| | | 8-10 | 60 | | n/a | 379 | 1.37 |
| | 1-15 | 1-3 | 60 | | n/a | -133 | 0.25 |
| | June | 4-7 | 60 | | n/a | 28 | 0.63 |
| | | 8-10 | 60 | | n/a | 151 | 0.91 |

[a] Minimum target N rate is 120 kg N/ha at Breeza and 60 kg N/ha at Minnipa. This comprises 50 kg N/ha as soil mineral N at sowing at both locations, N fertiliser applied at sowing to all crops of 20 kg N/ha at Breeza and 5 kg N/ha at Minnipa, and the minimum N fertiliser rate at 50 DAS of 50 kg N/ha at Breeza and 5 kg N/ha at Minnipa; [b] nonTT-hybrid (H), conventional-OP (C) and TT-OP (T) cultivar types at Breeza. The TT-OP cultivar type only was simulated at Minnipa.

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