Later flowering canola for the high rainfall zone?

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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

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Early spring; ATR Stingray, CB Tango, CB Telfer, GT-41, GT Viper, Hyola’ 404RR, H 450TT, H 500RR, IH 30RR, Diamond, Pioneer43C80CL, Pioneer43Y23RR, Pioneer 44Y90, Sturt TT</th>
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<tr>
<td>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</td>
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<tr>
<td>Winter-spring cross; CBI 306, K50054, K50055, K50056, K50057, K50058</td>
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<tr>
<td>Winter canola; AGF437, AGF484, AGF524, Arazzo, CB Taurus, Hyola’ 970CL, Hyola’ 971CL, SF Sensation, SF Brazzil, SF Edimax</td>
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Field sites

Cunderdin 2013-14; Floreat 2015; Geraldton 2014-15 (*TOS1 and 2); Gibson 2014 (TOS1, 2, 3 and 4), Kojonup 2013-17 (TOS1 and 2); Merredin2014-15 (TOS1 and 2); Mukinbudin 2014 (TOS1, 2 and 3)

Controlled environments

2016: 15 and 20°C, 10hrsdaylength, +/-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 $= 8^\circ$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 occurred 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
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...
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.

References

