Two strategies are compared for transferring blackleg resistance from winter canola into spring canola.

Blackleg (*Leptosphaeria maculans*), also called stem canker, is a serious disease of canola (*Brassica napus* L.). In Australia, where canola is the most important oilseed crop, *L. maculans* is associated primarily with basal stem canker.

Blackleg resistance in canola involves both race-specific resistance conferred by individual dominant genes and polygenically controlled general resistance. Race-specific blackleg resistance in Australian canola has 'broken down' within 3 to 5 years of variety release (Sprague et al. 2006). Polygenic resistance is more stable than race-specific resistance, but its effectiveness has declined over time (Cowling 2007).

In the past, breeders of spring canola in Australia have used spring canola from France and winter canola from Japan as sources of blackleg resistance (Roy 1978, Salisbury et al. 1995). New sources of blackleg resistance were identified in European winter canola (e.g., Carolus). To use these sources to improve the resistance of spring canola, it was necessary to select progeny with resistance but without the need for vernalisation.

Vernalisation is the requirement for an extended period of low temperature to initiate flowering. Without sufficient vernalisation, winter-habit plants will flower significantly later than spring-habit plants. Under Australian conditions, winter canola often yields poorly due to stress from high temperatures and lack of moisture during seed development. The requirement for vernalisation (i.e., winter growth habit) is under genetic control and is generally considered recessive to spring growth habit (Van Deynze and Pauls, 1994), but under Australian conditions, it is dominant (Light, 2009).

Transferring blackleg resistance from winter lines to spring canola

Two strategies were compared for transfer of race-specific blackleg resistance genes from the French winter canola line Carolus into the Canadian spring canola type Westar. Each of these strategies involved sequential selection for blackleg resistance and for spring habit. In one strategy, the selection for blackleg resistance was done first. In the other strategy, the selection for spring habit was done first.

**Strategy 1** started with screening of the F2 generation of reciprocal (Westar/Carolus and Carolus/Westar) crosses for blackleg resistance (Figure 2). F2 plants were sown in late autumn/early winter in a blackleg disease nursery on canola stubble from previous season to maximise the level of infection (Burton et al. 1999). Just prior to flowering, surviving plants were enclosed in bags to ensure self-pollination. At physiological maturity (windrowing stage) surviving plants were harvested and assessed. Those scored as having 20% or less internal stem infection were considered resistant to blackleg. Simultaneous selection for spring habit was not possible under these conditions because the winter-habit plants received enough vernalisation to flower and could not be reliably distinguished from spring-habit plants. To permit selection for spring habit, F3 progeny of each individual resistant plant were grown in a field experiment over summer. In summer, the conditions are too warm and dry for the pathogen to sporulate, so it was easy to distinguish between spring- and winter-habit plants because flowering time for each plant was scored as the date on which its first flower opened. This permitted the selection of spring-habit selections identified.
(early-flowering) plants from among the progeny of plants that had already been selected for resistance to blackleg.

**Strategy 2** (see Figure 3) started with selection for spring habit in a glasshouse. Vernalisation was prevented by maintaining the glasshouse temperature above 20°C, ensuring that winter-habit plants would flower significantly later than spring-habit plants. F1 progeny of selected spring-habit plants were then sown along with parental varieties in a blackleg nursery in the field. The most resistant families were selected.

**Conclusion**

Both Strategy 1 and Strategy 2 were effective, but which one was more appropriate? Given that it was not possible to effectively select for both traits at the same time, which trait should be selected in the F2 generation and which should be selected in the F3 progeny of selected F2 plants? Both approaches used the same method for assessment of blackleg resistance, and this assessment was more difficult than either of the methods (glasshouse or summer nursery) used to assess growth habit. In Strategy 1, part of the effort involved in the resistance screening was wasted, because many of the resistant selections were later discarded based on growth habit. In contrast, in Strategy 2, the disease resistance screening was done only on plants that had been pre-selected for spring growth habit. Further, with disease resistance screening conducted in the F3 generation, it was possible to assess variation both among and within F2:3 families.

**Strategy 1**

1. F2 Selection of spring-habit plants
   - Glasshouse
2. F2 Selection of blackleg resistant progeny
   - Blackleg nursery
3. F3 Blackleg resistant spring-habit selections identified

**Figure 3.** Strategy 2 for developing blackleg-resistant spring canola involved first selecting for spring types, then selecting for blackleg resistance.

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**References**


