The inheritance of vernalisation requirement in winter x spring canola (Brassica napus L) crosses.

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ABSTRACT

Research on the inheritance of vernalisation requirement from crosses involving winter and spring canola has important breeding implications. In summer 2003/04, F2 populations of reciprocal crosses involving the European winter cultivar Aviso (strong vernalisation requirement) and the spring cultivar Westar (no vernalisation requirement) were assessed for segregation of the spring habit (no vernalisation requirement). When grown under summer conditions that ensured plants were not subject to any vernalisation, Westar flowered after 52 days while Aviso did not flower. The inheritance of vernalisation requirement was not significantly affected by the maternal genotype and appears to be controlled by a single dominant gene. Further work will build on these preliminary results and assist in determining potential linkage between vernalisation requirement and other traits such as blackleg resistance. An opportunity exists to significantly improve selection strategies based on a sound knowledge of inheritance and genetic relationships among traits of interest.

INTRODUCTION

In Australia, a major priority for canola (Brassica napus) breeding programs is the development of alternative and improved sources of resistance to the fungal disease blackleg. Potential new sources of resistance have been identified in European winter B. napus cultivars. Transfer of potentially useful genetic variation from winter canola to spring canola may provide desirable new levels of genetic variation for blackleg resistance, as well as other commercial characters such as yield and tolerance to sub-optimal conditions. However, high levels of effective blackleg resistance from winter B. napus are difficult to achieve in spring cultivars, indicating that high levels of blackleg resistance may be linked with winterness. In this study, we report on the inheritance of vernalisation requirement in F2 lines derived from reciprocal crosses between the European winter cultivar Aviso (strong vernalisation requirement) and the spring cultivar Westar (no vernalisation requirement).

MATERIALS AND METHODS

The study was carried out in an outdoor nursery located at the Grains Innovation Park, Horsham Victoria, Australia (36°43'S 142°13'E) between 22 December 2003 and 10 May 2004. Weekly maximum and minimum temperatures for the duration are shown in Figure 1.

![Figure 1. Maximum and minimum weekly temperatures for the duration of the experiment from 22 December 2003 to 10 May 2004.](image-url)
Populations

The plant populations were derived from reciprocal crosses involving the European winter cultivar Aviso and the Canadian spring cultivar Westar. Plant populations used for this study comprised F2 seed harvested from 5 F1 bagged plants of the Aviso x Westar and Westar x Aviso crosses, plus the parental cultivars Aviso and Westar. All lines were sown into single 2m rows of no less than 30 plants per line, with each row identified by individual tag markers.

Measurements

Flowering date for each single plant was scored as the date on which the first flower opened on an individual plant. This method for determining response to vernalisation was found to be most accurate assessment by Dahanyake and Galway (1999). Plants that did not flower or that flowered after 14th April 2004 were designated as having a vernalisation requirement (winter types). Those that flowered between sowing and 7th April 2004 were designated as spring (no vernalisation requirement). Chi-squared determination for goodness-of-fit to the expected ratios was performed.

RESULTS & DISCUSSION

The plants experienced a range of growing conditions during the duration of the study. Effective vernalizing temperatures were not received until March/April, with April 2004 minimum temperatures as low as 0°C, resulting in some plants flowering after 14 April 2004.

Westar flowered 52 days after sowing. It is an early maturing, superseded Canadian cultivar considered to be insensitive to vernalisation. In contrast, all plants of the winter parent, Aviso, remained in the vegetative physiological stage. Aviso is a European cultivar that has a strong vernalisation requirement. Approximately 75% of the F2 population did not flower. The spring types in the F2 population derived from Aviso/Westar population flowered between 54 and 91 days after sowing (mean = 74 DAS). Spring F2 plants from the Westar/Aviso population flowered between 63 and 83 days after sowing (mean = 73 DAS). There was no significant difference in number of days to first flower (without vernalisation) between the two crosses ($\chi^2 = 0.015$, $p=0.795$).

Segregation in the F2 suggests a single dominant gene for inheritance of vernalisation requirement (Table 1), with vernalisation requirement being dominant over no vernalisation requirement. The one dominant gene model fits the data with a $\chi^2$ probability of 0.50-0.95. The mean percentage of F2 plants that flowered from the Aviso/Westar cross was 24 % (Table 1, Figure 2). The number of F2 plants derived from the Westar/Aviso cross was 19 %, lower than the reciprocal cross, but the differences were not significant ($P>0.05$). This indicated that flowering in such crosses in not maternally inherited. The presence of slight cytoplasmic effect on vernalisation in canola has been established by Murphy and Scarth (1998) but in our study there was no significant maternal effect on flowering.

Table 1. Segregation of flowering plants in the F2 generations of the Aviso/Westar reciprocal cross

<table>
<thead>
<tr>
<th>Parents and crosses</th>
<th>Type</th>
<th>Total</th>
<th>Number of Plants</th>
<th>$\chi^2$ for segregation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Winter Types</td>
<td>Spring types</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Non-Flowering)</td>
<td>(Flowering)</td>
</tr>
<tr>
<td>Westar</td>
<td>Spring</td>
<td>31</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>Aviso</td>
<td>Winter</td>
<td>37</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>Westar/Aviso</td>
<td>F2</td>
<td>102</td>
<td>83</td>
<td>19</td>
</tr>
<tr>
<td>Aviso/Westar</td>
<td>F2</td>
<td>192</td>
<td>145</td>
<td>47</td>
</tr>
</tbody>
</table>
The finding of a single major gene controlling vernalisation requirement support findings by Ferreira et al. (1995) that one major gene controlled vernalisation responses in an F_1-derived doubled haploid population between a winter and spring canola cross. Van Deynze and Pauls (1994) and Thurling and Vjendra Das (1979) reported that vernalisation response in spring rapeseed is controlled by simply inherited major and minor genes. Van Deynze and Pauls (1994) concluded that the effect of major and minor genes cannot be distinguished or separated in a pedigree F_2 population, but only in a F_2-derived doubled haploid population.

While photoperiod response largely determines time to flowering in canola in southern Australia, there is a possible adaptive value of vernalisation response in ensuring optimal yield potential. This vernalisation response could delay flowering until after the probability of frost is low in early-sown (late April-early May sowings) crops in the low rainfall, temperate, Mediterranean environments of the southern canola growing areas of Australia at a time when high temperatures and long photoperiod would promote early initiation. In many other regions of the world however, vernalisation requirement is equally or more important than photoperiod response to ensure synchrony of flowering and timing of flowering to avoid winter freezing and/or summer drought. Canola breeders must decide the relative importance of these traits when developing adapted genotypes.

Further work will build on these preliminary results and assist in determining potential linkage between vernalisation requirement and blackleg resistance and other traits. An opportunity exists to significantly improve selection strategies based on a sound knowledge of inheritance and genetic relationships among traits of interest.

**REFERENCES**


Van Deynze, A., P. Pauls, 1994: The inheritance of seed colour and vernalisation requirement in *Brassica napus* using double haploid populations. Euphytica 74: 77-83