DEVELOPMENTAL RESPONSES IN SPRING CANOLA CULTIVARS

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INTRODUCTION

In Australia, canola (B. napus) is grown over a wide range of environments, with sowing time varying from April (autumn) to November (spring), depending on location and seasonal conditions. The majority of the crop is autumn or winter sown.

Differences between recently released cultivars in their relative time to flowering have been observed from sowings at different times and in different regions of Australia. Further, Australian cultivars which flower earlier than the Canadian cultivar Westar from autumn sowings in southern Australia are known to flower later than Westar from normal spring sowings in Canada.

In order to understand these differences and to determine the most appropriate developmental types of spring canola cultivars for different sowing times and regions, knowledge of the developmental patterns in the cultivars is required. Early studies showed differences between B. napus cultivars in their response to vernalization, photoperiod and temperature (Thurling and Vijendra Das, 1977; Major, 1980; Myers et al., 1982; King and Kondra, 1986; Mendham et al., 1990). However, the responses of more recent cultivars have not been evaluated.

This paper reports a series of controlled environment studies aimed at investigating the effects of daylength, vernalization, temperature and light intensity on time to flowering in some recent spring canola (B. napus) cultivars from Europe, Canada and Australia.

EFFECT OF DAYLENGTH

The effect of daylength on flowering time in spring B. napus cultivars was examined in two phytotron trials. The first, sown in April (autumn), evaluated eight cultivars, Shiralee, Taparoo (Australia), Westar (Canada), Drakkar (France), Elin, Global (Sweden), Optima (Denmark) and Lirawell (Germany), with six plants of each cultivar per treatment. Daylength treatments were 10, 12, 14, 16 and 19 hours, consisting of 10 hours of natural daylight, supplemented as required by incandescent light, at temperatures of 20/15°C (day/night). The second trial, sown in October (spring), re-evaluated six of the above cultivars at daylengths of 10, 12, 14, 19 and 22 hours, with lighting conditions, temperatures and replicate numbers as previously described.

All of the cultivars tested showed a quantitative long daylength response; as daylength increased time to flowering decreased. Selected results are presented in Figs 1 and 2. With the European cultivars particularly, the response did not begin until the daylength was extended beyond 12 hours. In contrast, Taparoo showed a marked decrease in time to flowering with daylength increasing from 10 to 12 hours. Major (1980) and King and Kondra (1986) used the slope of the response line to estimate photoperiod sensitivity. By this criteria, in the current study the European cultivars were the most responsive to increasing daylength, followed by the Australian cultivars, with the Canadian cultivar Westar, least responsive.

Major (1980) and King and Kondra (1986) also reported that the response of all cultivars tested reached a minimum optimal photoperiod, usually between 16 and 19 hours, after which, the number of days to flowering was constant, thus providing a measure of the length of the basic vegetative stage. In these studies, however, no plateauing in the response of any cultivar was evident, even after 22 hours.

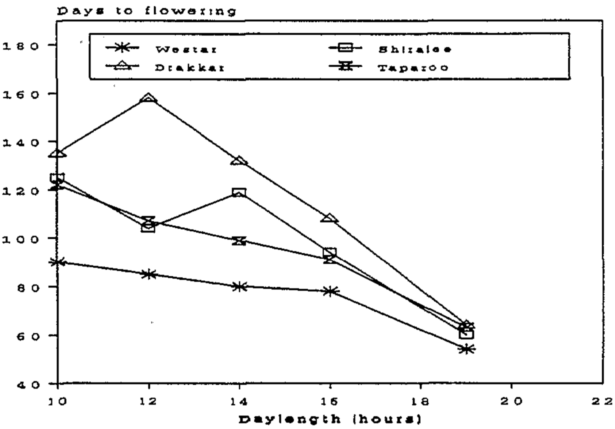

Fig. 1. Effect of daylength on time to flowering in spring canola cultivars in the phytotron (autumn sown)

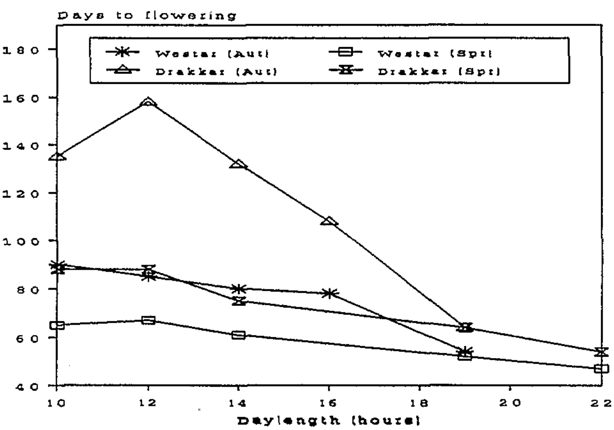

Fig. 2. Effect of daylength on time to flowering from autumn and spring phytotron sowings of canola culitvars

While the ranking of the responses of the cultivars remained the same in the autumn and spring sown experiments, the overall size of the response was quite different (Fig. 2). All cultivars flowered more quickly in the spring sown experiment. Both the daylength and temperature treatments were constant in the two experiments, suggesting that the large differences in flowering time between the experiments may have been due to the different intensity of natural light at the two times of the year.

EFFECT OF LIGHT INTENSITY

To examine possible effects of light intensity, a growth cabinet experiment was conducted to measure the response of flowering to a range of three light intensities. Eight plants of each of three cultivars (Shiralee, Westar and Drakkar) were grown in each of three cabinets having the same temperature (20/15°C) and daylength (14 hours), but with different light intensities. The lowest light intensity (138 $\mu E/m^2/sec$) gave a total accumulation of $7E/m^2/day$, equivalent to a cloudy winter day in Canberra. The intermediate intensity treatment (251μE/m^2/sec) was equivalent to a bright winter day (13E/m^2/day), while the high intensity treatment (444 μE/m^2/sec; 22E/m^2/day) was approaching the 40E/m^2/day usual for a summer's day in Canberra.

For all three cultivars, the time to flowering was significantly delayed by low light intensity (Fig. 3). The effect of intensity was not linear, with the rate of delay between the medium and low intensity treatments being 4-5 times that between the high and medium treatments.

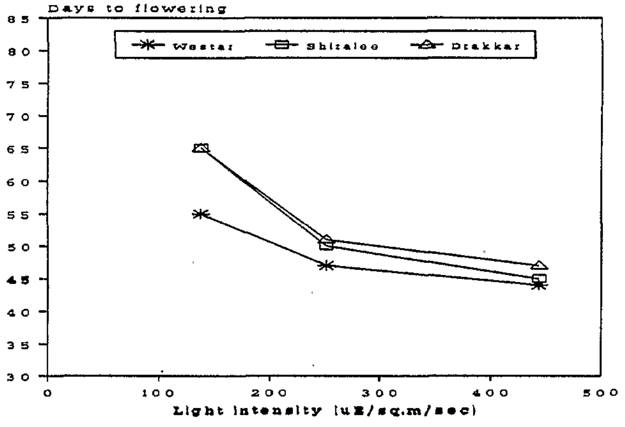

Fig. 3. Effect of light intensity on time to flowering in spring canola cultivars

The response to intensity varied between cultivars. For Westar, the least responsive cultivar, flowering was delayed from 44 days at high intensity to 55 days at low intensity, whereas the delay for Drakkar and Shiralee was approximately twice this magnitude.

Although all cabinets were set at 20/15°C, the possibility exists that the high light intensity might raise the temperature at the leaf surface slightly, thereby hastening development. However, such slight temperature increases would not account for the significant differences in flowering time observed between the high and low intensity treatments.

An effect of light intensity on development, independent of photoperiod responses, does not appear to have been previously reported in canola.

EFFECT OF TEMPERATURE AND DAYLENGTH INTERACTIONS

The effect of the interaction between temperature and daylength on time to flowering was evaluated using three cultivars - Shiralee, Westar and Drakkar. Eight treatments, combining two daylengths (10 and 22 hours) and four temperatures (27/22°C, 22/17°C, 17/12°C, 24/7°C), with eight plants of each cultivar per treatment, were used. The daylength treatments consisted of 10 hours of natural light, supplemented by incandescent light in the long daylength treatment. Day temperatures were maintained for the 10 hours of natural light, with night temperatures for 14 hours, giving mean daily temperatures of 24°C, 19°C, 14°C and 14°C, respectively, for the four temperature treatments.

Major interactions between temperature and daylength were evident (Table 1). At long daylength, time to flowering of Westar and Shiralee decreased with each temperature increase from 17/12° to 22/17° and 27/22°. With Drakkar, increasing the temperature from 17/12° to 22/17° reduced time to flowering, but a further increase to 27/22°C delayed flowering. When a mean daily temperature of 14°C was provided with a higher day temperature and a colder, vernalizing night temperature (24/ 7°C) compared with 17/12°C at long daylength, flowering was delayed in Drakkar and Shiralee, but not in Westar.

Table 1. Effect of the interaction between temperature and photoperiod on time to flowering in spring canola cultivars

	27/22°	22/17°	17/12°	24/7°
22 hours				
Drakkar	72	67	78	88
Shiralee	48	59	73	90
Westar	51	57	71	71
10 hours				
Drakkar	139	111	92	106
Shiralee	86	110	83	87
Westar	85	80	79	86

Cultivar responses to increasing temperature under short daylength were markedly different to those under long daylength. With short daylength, there was no effect of increasing temperature on time to flowering in Westar, with flowering time similar for all temperature treatments. The reaction of Shiralee was similar, except for a delay in flowering at the intermediate (22/17°C) temperature. In Drakkar, time to flowering was further delayed with each increase in temperature. Providing a 14°C mean temperature as 24/7°C rather than 17/12°C had no effect on Shiralee and Westar, but delayed flowering in Drakkar.

Mendham et al. (1990) found that under short, natural daylength, high temperatures inhibited flowering in three Australian spring lines as measured by the node of flowering, but that most plants still flowered earlier than in cooler temperatures, because of faster leaf development at higher temperatures. While leaf numbers were not counted in this experiment, it is likely that the same pattern was occurring in the short daylength conditions, with Westar, for example, opening more leaves at a faster rate with each temperature increase, and flowering at a similar time. High temperature markedly delayed flowering in Drakkar under both short and long daylength.

Increased daylength hastened flowering in all cultivars at all temperatures, with the effect being reduced as temperatures decreased. A similar result had been reported by Mendham et al. (1990) in the earlier experiments, Westar was the least responsive to long daylength and Drakkar the most responsive.

EFFECT OF VERNALIZATION

The cultivars Shiralee, Westar and Drakkar were used to examine the effect of vernalization on time to flowering. Plants of each cultivar were established in cabinets set at 22/17°C under long daylength (19 hours) conditions. At two weeks of age, three groups of eight plants of each cultivar were transferred to a vernalization chamber (constant 4°C with 10 hour daylength) for periods of either 2, 4 or 6 weeks. At the end of the vernalization period, all plants were scored for stage of leaf development and returned to the original (22/17°C) cabinet conditions. Plantings and vernalization periods were timed so as to have all plants complete vernalization on the same day. In addition, control plants which received no vernalization, were planted so as to be at an equivalent leaf stage to the vernalized plants at the end of their treatment. Flowering time was measured as the number of days from the end of the vernalization treatment until the opening of the first flower.

Analysis of variance demonstrated significant effects of vernalization, with four weeks vernalization significantly hastening flowering in all cultivars (Fig. 4). Increasing the vernalization treatment from 4 to 6 weeks only slightly enhanced flowering. Drakkar was the cultivar most responsive to vernalization, with Westar the least responsive. Thurling and Vijendra Das (1977) reported that Canadian cultivars were the least responsive to vernalization of the spring lines they tested.

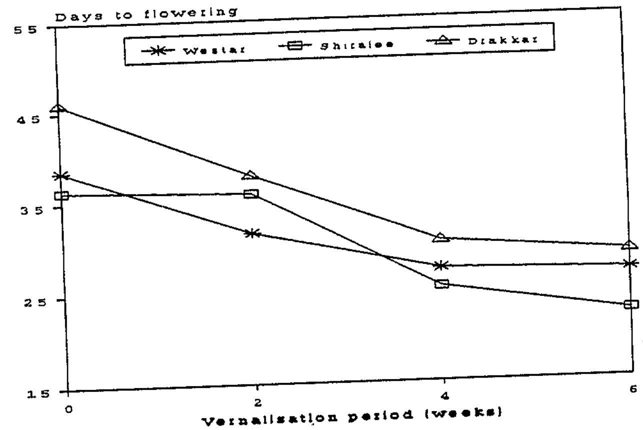

Fig. 4. Effect of vernalisation on time to flowering in spring canola cultivars

Effects of vernalization are traditionally evaluated under long daylength to prevent any delays in flowering due to unsatisfied daylength requirements. However, the results of Thurling and Vijendra Das (1977) and Myers et al. (1982) have indicated that vernalization and long daylength substitute for one another in many spring canola cultivars, such that long daylength will reduce the effect of vernalization. The response to vernalization can also be markedly affected by temperatures following vernalization (Thurling and Vijendra Das, 1977; Mendham et al., 1990), with differences in cultivar response evident.

To understand the response of cultivars to autumn sowing in southern Australia, it would be preferable to evaluate vernalization response under shorter daylength with mild growing temperatures after vernalization. Further information on the effectiveness of different temperatures as vernalizing temperatures is also required.

CONCLUSIONS

Although all the spring *B. napus* cultivars evaluated were responsive to vernalization, photoperiod, temperature and light intensity, there were significant differences between cultivars in their degree of responsiveness. The Canadian cultivar, Westar was less responsive to vernalization and long daylength than the Australian cultivar, Shiralee, with the French cultivar, Drakkar, most responsive.

These developmental characteristics of Westar cause it to flower earlier than Shiralee from a Canadian spring sowing, but later than Shiralee from an Australian autumn sowing. A knowledge of both the developmental responses of a cultivar and the environmental characteristics of a growing region is thus necessary to understanding the likely adaptation of a cultivar to any given environment.

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