

PROMOTION OF FLORAL INITIATION IN 'FUERTE' AVOCADO BY LOW TEMPERATURE AND SHORT DAYLENGTH

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ABSTRACT

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Potted avocado (*Persea americana* Mill., cv. 'Fuerte') plants were maintained in growth cabinets for up to 32 weeks and new growth observed for flower formation. Flowers were formed if temperatures were 20°C or below, but with 25° or 30°, even if only for 1 hour per day, flower formation was inhibited. Time to flowering was accelerated, but number of flowers reduced, if daylength was shortened from 15 h to 9 h. With low temperature and short days, full bloom was about 4 months after starting experiments. Spring flowering of cv. 'Fuerte' in the field could follow flower induction about 4 months previously with the onset of winter temperatures and daylengths.

INTRODUCTION

The avocado (*Persea americana* Mill.) is a native of elevated locations (up to 1800 m) in southern Mexico and Guatemala, and of parts of the West Indies, areas which lie mostly between latitudes 15°N and 20°N. Approximate hours of daylight (Civil Aviation data) in this region are 11 h 45 min for December and 14 h for June. Mean daily temperatures for elevated regions range from 13°C in December to 22°C in June, and precipitation occurs mainly during the months from May to October. Avocados are grown commercially at latitudes up to 35° (California and southern Australia) as well as in areas of intermediate latitude (Florida, Israel, South Africa). They will therefore fruit with longer summer days and shorter winter days, and also with hotter summer temperatures, than in their native habitat.

Avocados flower in spring, and the cultivar 'Fuerte' flowers in southern Australia in October (Alexander, 1975), in California in March and April (Bergh, 1967), in Florida in March (Robinson and Savage, 1926) and in

Israel during March and April (Blumenfeld and Gazit, 1974). Reece (1942) found that in Florida the earliest primordia of individual flowers were first identifiable in January, only a few weeks before full bloom. Apparently, floral initiation takes place in mid-winter when days are cold and short, but no study has been made of floral initiation under controlled conditions. In this paper we report some observations on flowering of potted avocado trees maintained in growth cabinets.

MATERIALS AND METHODS

Seeds from one source tree were collected, and seedlings from them grown in a glasshouse. The seedlings were grown in a medium of sand: peat : perlite (2 : 1 : 1) with U.C. Mix fertilizer, and the final containers were 20 cm plastic buckets. During the period of treatment in growth cabinets the pots received regular applications of a commercial soluble fertilizer (Aquasol). At 6 months, shoots of 'Fuerte' were grafted onto the seedling rootstocks, and the scion was pruned to give 2 leaders. At 10 months (4 months post-grafting) the shoots were approximately 60 cm high and the diameter of the trunk at 4 cm above ground level was 1.7 cm. The plants were pruned back and on the same day they were placed in growth cabinets under prescribed conditions. New growth arising from buds was confined to 2 main shoots.

The cabinets had both fluorescent and incandescent tungsten lamps giving a working light intensity of 32 klx ($440 \mu\text{E m}^{-2} \text{s}^{-1}$) at the top of the plants. A lower intensity of 16 klx was obtained by removing the fluorescent tubes. Temperature control was accurate to $\pm 0.5^\circ\text{C}$. Humidity was not controlled. Twelve plants were accommodated in each growth cabinet, so that there were 12 replicates per treatment. Some details of the treatments (T) are listed in Table 1. In all these cases light intensity was 32 klx. T1 provided a relatively severe night chilling compared with T2 which provided a milder night temperature. The response to short days was observed in T3 and T4. Both treatments had identical light regimes, but differed in how day/night temperature was provided. In T3 the thermoperiod coincided with the photoperiod, whereas in T4 the "day" temperature was prolonged as for long days. Effects of temperature were compared in T6, T7 and T8. There was a day/night temperature differential of 5°C in each case. To investigate further the inhibitory effect of high temperature, T5, T6 and T9 were compared. In T5 30°C was given for only 9 h daily with an otherwise low "night" temperature. In T9 30°C was given for a pulse of only 1 h at mid-day. It could be assumed that new shoots would not grow on the pruned plants if they received only 10°C for the remaining 23 h each day, so that the alternative temperature for T9 had to be raised to 20°C . In addition to these 9 treatments, a tenth, T10, was identical to T1 except that the light intensity was halved, to 16 klx.

Plants were held in the cabinets until flowering was completed, or up to 32 weeks if flowering did not occur. The time period between transfer to ca-

binet and full bloom (66% of flowers open) was recorded, as well as the number of flowers per plant. Some plants were re-used for a second treatment. At the conclusion of the first use they were transferred to a glasshouse until ready to re-use, when they were pruned back to approximately the same size as at the first pruning, and on the same day replaced in growth cabinets. The diameter of the trunks at 4 cm above ground level averaged 2.6 cm at this stage. Again, 2 new shoots were allowed to develop from buds under the new conditions.

RESULTS

Results for treatments T1 to T9 inclusive are shown in Table 1. Neither time to full-bloom nor number of flowers per plant was affected by the difference in night temperature between T1 and T2. The results were, in fact, nearly identical although the closeness was clearly fortuitous. For T10, light intensity was reduced to 16 klx, with conditions otherwise as for T1. Time to full bloom was 25 weeks and number of flowers per plant was 118 ± 56 . Although halving the light intensity resulted in a lower mean value for flower number, this drop was not significant.

Results from T3 and T4 indicate that plants came into full-bloom much earlier under short days than in any treatment with long days (compare especially with T8 which had identical temperature), but that the number of flowers per plant under short days was low. The similarity between the results of T3 and T4 indicates that the photoperiod itself was the important factor, not a changed thermoperiod.

With day temperatures of 25°C or above (T7 and T6) no flower formation took place, but at 20°C (T8) flowering was profuse although delayed. The block to flower formation with 30°C was operative whether this temperature was given for 15 h per day (T6) or only 9 h per day (T5), and despite the night temperature being held low in the latter treatment. When 30°C was given for only 1 h per day (T9), floral formation was nearly inhibited: only 2 out of 12 plants had become marginally floral by 32 weeks.

DISCUSSION

Plants which flowered were extremely uniform in respect of flowering-date, and standard errors were zero for these values. They were, however, extremely variable in respect of the number of flowers per plant, so that it is not possible, for instance, to determine whether T8 differed from T2. However, the difference between treatments where plants initiated flowers, and treatments where all plants remained vegetative, was very real.

Both low temperature and short daylength promoted flower initiation. In respect of temperature, the results suggest that it was absence of high temperature (e.g. $>20^\circ\text{C}$) rather than actual low temperature which was qualitatively important. Our results do not enable us to deduce what quanti-

TABLE 1

Experimental conditions for Treatments 1—9 with different daylengths (hours) and day and night temperatures, and floral response in terms of number of weeks from start of treatment to full bloom, and the number of flowers per plant. The duration (hours) of the "day" temperature is given; duration of "night" temperature was the balance of the 24 hours. Light intensity was 32 klx. Plants for Treatments 6—9 inclusive were being used a second time. There were 12 plants per treatment.

Experimental conditions					Floral response	
Treatment	Daylength (h)	Day temp.		Night temp. (°C)	Weeks to bloom	Flowers (\pm SE)
		(°C) (h)				
1	15	20	15	5	25	278 \pm 115
2	15	20	15	10	25	278 \pm 116
3	9	20	9	15	17	49 \pm 16
4	9	20	15	15	17	53 \pm 18
5	15	30	9	10	—	0
6	15	30	15	25	—	0
7	15	25	15	20	—	0
8	15	20	15	15	30	424 \pm 159
9	15	30	1	20	26	4 \pm 3

tative influences temperature, below a base level, may have. Among other perennial evergreen plants which have floral induction promoted by low temperature are olive (Hackett and Hartmann, 1963) and citrus (Lenz, 1968, 1969). Short daylengths were not qualitatively essential for flower initiation, but they hastened the expression of flowering, apparently at the expense of flower numbers.

In our experiments, plants which flowered did so between 4 and 6 months after being placed in the growth cabinets. Buds had to burst on these pruned plants and some vegetative growth had to take place before flower initiation could occur. This time period can be compared with about 5 months from the time the mean daily maximum temperature at the site of our field plantings of 'Fuerte' (Alexander, 1975) falls below 20°C (early May) and full bloom (mid-October). It is suggested that in field plantings floral initiation starts in early winter in response to low temperatures (absence of high temperatures) combined with short day lengths.

In the glasshouse and field we have observed that pot-bound plants and cinctured shoots flower more profusely and sooner than vigorously-growing plants or shoots. It is well known that with perennial plants some check to vegetative growth is conducive to flower formation. Under field conditions for avocados in southern Australia this vegetative growth check may be induced by low temperature and short days.

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