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Effect of temperature at flowering on varietal productivity in some avocado-growing areas in Australia

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SYNOPSIS
The flowering patterns of the cvs Fuerte, Sharwil and Hass are defined in relation to maximum and minimum mean temperatures in four commercial production areas in Australia. Controlled environmental chamber studies and yield data are used to assess the potential productivity of these cultivars at each site.

INTRODUCTION

Fruit yield of avocado is low when compared with other fleshy fruits and while this may be explained by way of 'energy cost', actual yields (5,6-21,5 t ha^{-1}) are extremely variable and fall far short of the estimated theoretical maximum of 32,5 t ha^{-1} for avocado (Wolstenholme, 1986), Many factors affect productivity of fruit crops, but with avocado the sensitivity of the complex flowering mechanism to adverse temperatures has been deemed partly responsible for low and irregular yields (Bringhurst, 1952; Bergh, 1967).

Flowering dichogamy in avocado was first described by Nirody (1922) and Stout (1923). Since then many researchers have studied the flowering patterns of the avocado and attempted to relate the abnormalities of dichogamy to environmental conditions (Robinson& Savage, 1926; Hodgson, 1947; Lesley & Bringhurst, 1951; Peterson, 1956). Sedgley (1977), Sedgley & Annells (1981) and Sedgley & Grant (1983) have described the effect of temperature accurately on the flower dichogamy of 'A' and 'B' type cultivars, along with pollination and fertilisation aspects of fruit-set. More recently Whiley (manuscript in preparation, 1987) studied the effect of profiled diurnal temperature patterns and variations in day-to-day temperatures on dichogamy in Hass and Fuerte. The information from the controlled environmental chamber studies of Sedgley and Whiley is used in this paper as a basis for the interpretation of varietal production in Australia.

Avocado production in Australia ranges from latitudes of 16°S (North Queensland) to 34°S (Sunraysia district of Victoria and South Australia) and from elevations of 20 to 650 m above sea level. This gives a diverse environmental range of growing conditions. The industry is based on Mexican and Mexican/Guatemalan hybrid cultivars. The three most important commercial cultivars are Fuerte (early season), Sharwil (mid-season) and Hass (late season). Varietal performance is extremely variable between the various

areas of production. This paper describes the flowering pattern of the cultivars Fuerte, Sharwil and Hass in four production centres, and anthesis is defined in relation to mean maximum and mean minimum temperatures. Average yield of these varieties is correspondingly documented from orchards in each of these areas where flowering data were collected.

MATERIALS AND METHODS

Production Areas

The production areas selected for this study are environmentally diverse, but have in common the commercial production of the three avocado cultivars Fuerte, Sharwil and Hass. The centres chosen were Walkamin, north Queensland at approximately 17°S latitude and 590 m elevation above sea-level, described as highland tropical; Palmwoods in south-east Queensland at approximately 27°S latitude and 20 m altitude, described as warm subtropical; Maleny in south-east Queensland at approximately 27°S latitude and 530 m altitude described as cool subtropical; and Wanneroo, Western Australia at approximately 32°S latitude and 15 m elevation, described as Mediterranean.

Data recorded

In each area estimates of the percentage of flowers which had opened on trees of each cultivar, were recorded at seven to 10 day intervals for the duration of the flowering cycle. Records used are taken from 2 to 20 trees and data were accumulated over two to five years. Mean dates relating to first flowers opened, 50 per cent of flowers opened and last flowers opened, were derived from these records. Maximum and minimum temperatures during flowering were extracted from official meteorological records pertaining directly to or within 10 km of each site. Means were obtained from 10 years of records.

Fruit yields were taken over two years from commercial blocks of mature bearing trees of each cultivar. At least two farms were surveyed in each area and the production adjusted to tonnes per hectare. In all cases yields are higher than district averages.

Defining Optimum Temperatures for Flowering and Fruit Set

Sedgley (1977) and Sedgley & Grant (1983) have defined the optimum diurnal temperatures for flowering, pollination and fruit-set in 'B' type avocado cultivars (eg Fuerte & Sharwil) at 25°C days and 20°C nights (25/20). Under these conditions, overlapping of the male and female cycles occurs and pollen is present for transfer to receptive stigmas. More recently Whiley (manuscript in preparation, 1987) has shown that self-pollination can occur in Fuerte when temperatures are profiled from 25°C day to as low as 10°C night temperature.

Sedgley & Annells (1981) and Sedgley & Grant (1983) demonstrated that dichogamy cycles of 'A' type cultivars (eg Hass) are less sensitive to temperature. They had the opportunity to set fruit over a range of diurnal temperatures from 17/12 to 33/28°C. However, they noted that pollen availability to the female phase was restricted. Whiley (manuscript in preparation, 1987) was able to show that pollen exposure to receptive

females of the same cultivar increased under profiled diurnal temperatures which varied from day to day (eg 20/10 followed by 30/15°C the following day; a more natural situation).

Based on the preceding information, a day temperature range of 23°C to 27°C, with a 10°C or higher night temperature as inducive to self-pollination during flowering was chosen for the interpretation of results presented in this paper. It is acknowledged that 'A' type cultivars will still set commercial crops when flowering outside this narrow temperature range. The identified optimum temperature period for flowering does not mean that every day is ideal for fruit-set. However, there is a higher probability during this period of days occurring when all criteria are met and fruit-set will occur.

RESULTS AND DISCUSSIONS

At **Walkamin,** the most northern area of this study, the major portion of flowering of all three cultivars occurred in the optimum temperature range (Figure 1). Fuerte was the earliest to flower and had the longest flowering period. Sharwil flowering peaked slightly ahead of Hass. Yield figures (Table 1) reflect successful pollination and fruit-set by all three cultivars. The lower Hass yield is probably a reflection of smaller fruit size (data not presented) of this cultivar in this district.

The Palmwoods and Maleny areas are in close proximity (approximately 30 km), but a 510 m difference in altitude substantially changes the climate. At both centres cultivar order of flowering was the same as at Walkamin (Figures 2 and 3), with Fuerte once more flowering for the longest period. At Palmwoods (Figure 2) the time of the year that flowering occurred in all three cultivars was similar to Walkamin. However, most of the flowering of Fuerte and Sharwil occurred outside the optimum temperature range, while the majority of Hass flowering fell inside the defined temperatures.

Fuerte is a commercially-acceptable cultivar at **Palmwoods,** although yields are lower than at Walkamin (Table 1). Sharwil however, is on the borderline of economic viability. The difference in productivity between these two 'B' type cultivars at this site may be explained by the longer flowering period of Fuerte, hence the greater opportunity for set outside the designated optimum temperature range, or the possible greater sensitivity of Sharwil to cold temperatures during flowering. Hass yields reflect optimum conditions for fruit-set (Table 1).

At **Maleny,** most of the Fuerte flowering period fell outside the optimum temperature range, while the majority of Sharwil and Hass flowering occurred under ideal conditions. At this locality average Fuerte yields were low, reflecting sub-optimal temperatures during the flowering period (Table 1). Day temperatures prior to reaching the mean of 23°C were 4°C lower than at Palmwoods, giving little opportunity for good fruit-set. Sharwil and Hass fruit yields are a reflection of ideal environmental conditions at flowering.

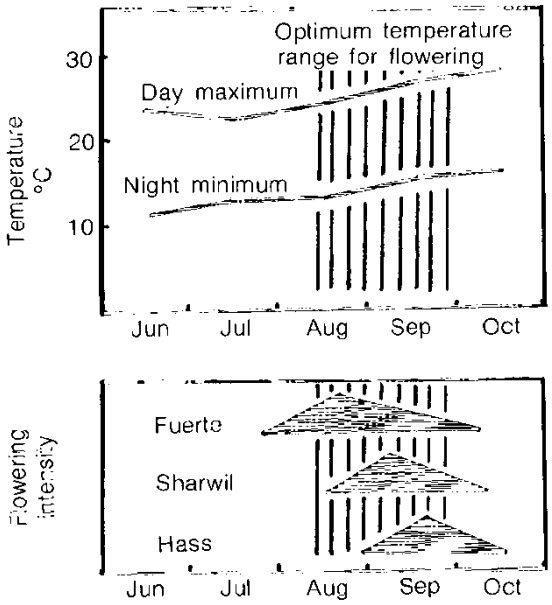

Fig 1 Mean temperatures and flowering patterns of Fuerte, Sharwil and Hass at Walkamin. Temperature data are means from 10 years' records.

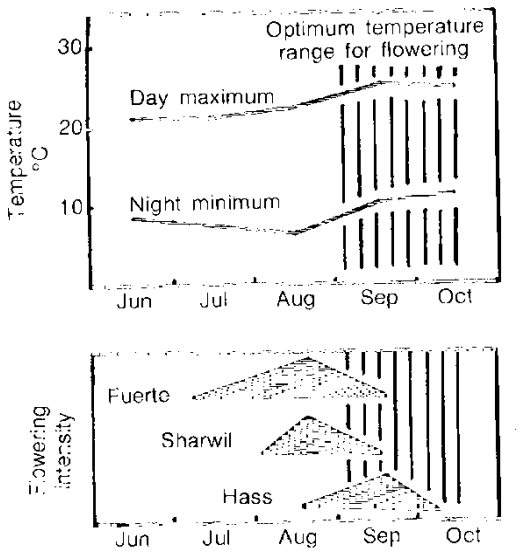

Fig 2 Mean temperatures and flowering patterns of Fuerte, Sharwil and Hass at Palmwoods. Temperature data are means from 10 years' records.

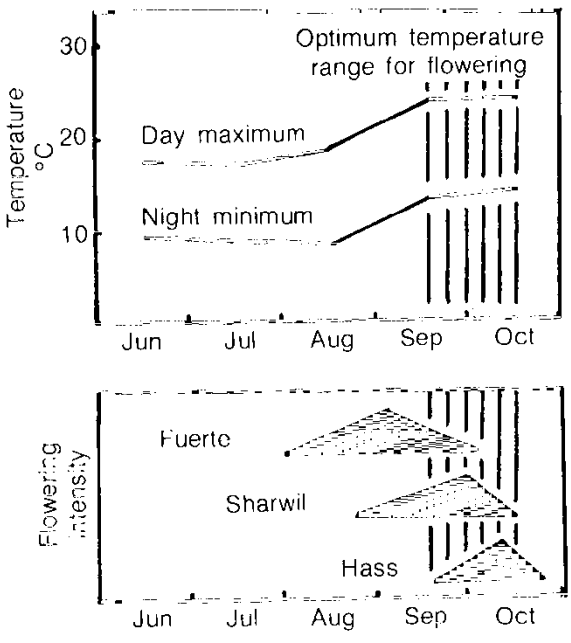

Fig 3 Mean temperatures and flowering patterns of Fuerte, Sharwil and Hass at Maleny. Temperature data are means from 10 years' records.

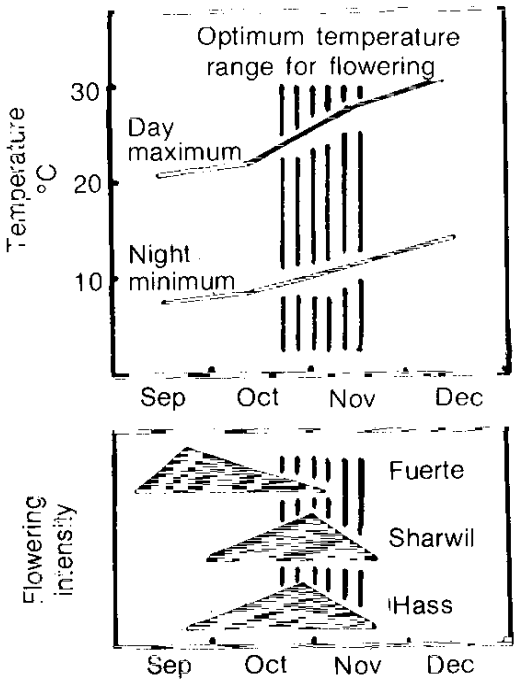

Fig 4 Mean temperatures and flowering patterns of Fuerte, Sharwil and Hass at Wanneroo. Temperature data are means from 10 years' records.

Table 1 Fruit yields of Fuerte, Sharwil and Hass in four production areas in Australia. Yields (t ha^{-1}) area means from two years production off mature trees.

District	Fuerte	Sharwil	Hass
Walkamin	21,2	20,4	18,8
Palmwoods	17,2	8,4	20,1
Maleny	7,8	16,9	22,2
Wanneroo	4,8	8,2	11,1

Flowering of the three varieties was later at Wanneroo than the other centres studied (Figure 4). Once again Fuerte was the earliest to flower and continued over the longest period, though largely outside the optimum temperature band. It is interesting to see that the flowering period of Sharwil was delayed in this environment, coinciding with Hass. Both cultivars flowered mainly in the optimum temperature range.

While fruit yields from this district could be considered disappointing (Table 1), this was not necessarily due to poor pollination. Fruit-set on Fuerte in this district was very poor, with heavy flowering producing few fruit (N Washer, private communication, 1986). This observation is supported by the flowering data in Figure 1. Fruit-set on Hass and Sharwil was heavy to moderate, but large losses occurred during hot, dry summer days under stressful conditions (Whiley, 1986).

CONCLUSION

Variable yield of avocado cultivars is a problem throughout the world. Productivity of cultivars depends largely on their ability in a given environment to reliably set fruit. Many other factors between fruit-set and harvest will affect the ultimate yield, but fruit-set is the fundamental factor affecting the viability of any cultivar in a region.

This study has focused on the variable performance of 'B' type cultivars over a range of environments and, in particular, the need to assess flowering patterns in relation to mean temperatures to evaluate potential productivity. This approach can quickly demonstrate the future prospects of new cultivars introduced to production areas.

The report has shown that, provided there is a compatible flowering/temperature relationship, single variety blocks can be planted without the consideration of cross-pollination. This situation is greatly preferred for the general cultural and management considerations of avocado production.

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