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Flowering, pollination and fruit-set of avocado

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SYNOPSIS
Research has shown that all stages of the reproductive cycle of avocado are temperature sensitive. The tree appears to perform best under a temperature regime of approximately 25°C day and 20°C night. This knowledge of the limits of sensitivity of the various stages of floral initiation, floral development, pollen tube-growth and fruit-set present the opportunity to select the correct cultivar for the environment. In addition, the information can be used by plant breeders as selection criteria.

Yield of avocados is dependent upon successful floral initiation, floral development, pollination and fruit-set. Problems with any of these processes will have a detrimental effect on fruit production which cannot be alleviated by alternative cultural practices. It is important to understand the physiology of the reproductive processes so that the management of the crop includes provision for optimising yield.

Successful floral initiation and development are essential processes in the reproductive cycle. In the Mediterranean climate of southern Australia floral initiation in the cultivar Fuerte occurred in autumn during April and May and flowering occurred in spring during September to November (Scholefield, Sedgley & Alexander, 1985).

Vegetative buds had a shallow terminal meristem with vegetative axillary meristems. During the transition to flowering in April and May elongation of the secondary axillary meristems occurred and tertiary floral axes were produced. Differentiation of the first individual flower buds at the tips of the secondary and tertiary axes was observed in May. The terminal meristem of the bud remained vegetative and only the axillary meristems underwent the transition to flowering. During anthesis in spring the floral axillary meristems were the first to burst, followed by the terminal vegetative meristem of the bud which contributed to the continued extension growth of the tree.

There were two main vegetative growth flushes per year, one in summer just prior to floral initiation and one in spring coinciding with the end of flowering. Carbohydrate levels in the trunk and branches were lowest just prior to floral initiation. Carbohydrates accumulated during the period of floral development in winter, reached maximum levels just prior to flowering and decreased again during the fruit development period. The biennial bearing habit appeared to be related to the carbohydrate status of the tree as heavy yields followed high levels of starch accumulation and low yields followed low levels.

Floral initiation and development is not a problem in southern Australia but poor flowering is regularly observed in the tropical climate of northern Australia (Sedgley, Scholefield & Alexander, 1985). Terminal buds sampled during spring were floral and contained flowers which had differentiated perianth primordia. Thus floral initiation was occurring but the floral buds did not burst. Vegetative extention growth of the tree occurred not from the terminal vegetative meristem of the floral bud but from lateral buds lower down the shoot. This abnormal growth pattern gave the trees a rather straggly appearance. The problem was particularly marked amongst Mexican and Guatemalan type cultivars; less so in West Indian types.

To test the hypothesis that the inhibited reproductive development was caused by high temperature, avocado plants were grown under controlled environmental conditions. Under a tropical temperature regime of 33°C day and 23°C night the trees of the cultivars Fuerte and Hass had fewer flowers and a shorter flowering period than under temperature conditions of 25°C day and 15°C night. The features of unburst floral buds and lateral vegetative extension growth observed in the orchards in northern Australia were reproduced under the controlled environmental conditions. The unburst floral buds were inhibited at the stage of stamen differentiation and it was concluded that in the avocado this stage was particularly sensitive to high temperature.

Avocado flowers show protogynous dichogamy with the female stage followed by a closed stage followed by the male stage. There are two flowering types; type A, with the female stage in the morning, and type B with the female stage in the afternoon. Interplanting of type A and type B cultivars in the orchard ensures that cross-pollination will occur. The floral cycle of the avocado is very sensitive to temperature fluctuations. In the Fuerte cultivar daytime temperatures above 30°C or below 20°C were found to disrupt flowering (Sedgley, 1977a). High temperatures appeared to stimulate vegetative growth at the expense of reproductive development and flowers and developing fruit were shed from the plant. Low temperatures were particularly damaging as less than 10 per cent of the flowers opened in the female stage. Other type B cultivars including Ryan, Edranol, Sharwil and Hazzard also showed female sterility at a daytime temperature of 17°C, although the cultivar Bacon was an exception and had a high proportion of female stage flowers under these conditions (Sedgley & Grant, 1983).

Type A cultivars, including Hass, Reed, Wurtz, Rincon & Jalna responded better than the type B cultivars to low temperatures during flowering (Sedgley & Annells, 1981; Sedgley & Grant, 1983). All had female stage flowers although the floral cycle was extended to over double the normal length in some cases and the main periods of anthesis occurred during the night. This would reduce pollination and fruit-set as pollinating insects would not be active during the night.

Successful fertilisation and fruit-set results from pollination of the female stage flower; the male stage flower is not female fertile (Sedgley, 1977b). The optimum temperature for pollen tube growth of all cultivars tested was 25°C (Sedgley, 1977a; Sedgley& Annells, 1981; Sedgley & Grant, 1983). Pollen tube growth to the base of the style was

rapid and occurred within three hours, but penetration of the ovule by a pollen tube did not occur until 18 to 24 hours after pollination (Sedgley, 1979b). All cultivars tested were cross-compatible and no pollen-pistil incompatibility was detected between any cultivars (Sedgley, 1979a). There were differences in female fertility, however, as the cultivar Fuerte had a higher proportion of defective embryo sacs than Hass and this resulted in a lower proportion of fertilised fruits following pollination (Sedgley, 1979b).

A major problem in avocado production is the high rate of post-pollination fruit shed. The majority of fruits are shed during the month following anthesis although some fruit abscission can occur throughout the developmental period of fruit growth. The anatomy of abscissed fruits was compared with that of actively growing fruits to investigate any possible reasons for the high rate of fruit shed (Sedgley, 1980). During the first weeks after anthesis the majority of the flowers were unfertilised. Less than 20 per cent of the flowers were abnormal and poor pollen transfer was identified as the major reason for this early drop. However, by one month following anthesis all shed fruit were fertilised and had normal embryo and endosperm development. Some of the shed fruits showed some degeneration but this probably occurred during the period between the cessation of growth of the fruit and abscission from the plant. This period was approximately one week. The majority of the shed fruit had reached a stage of embryo and endosperm development corresponding to 14 days after pollination. No anatomical reason for the high rate of fruit shed was observed and it is suggested that competition effects may be responsible for abscission. There is competition not only between developing fruits, but also between the fruits and vegetative flush growth. Following the bursting of the floral axillaries of the buds, the vegetative terminal bursts to continue the extension growth of the shoot. This bud develops expanding leaves which are in direct competition with the young fruits and also enjoy a position apical to the fruits. It is possible that this competition situation may be at least partly responsible for the high rate of early fruit shed.

This work on the reproductive biology of the avocado has benefited the avocado industry in Australia and overseas. In particular the work on temperature sensitivity of flowering in avocado has identified the importance of selecting the correct cultivar for the environment. The work on temperature at flowering time has been further developed for the Australian situation and is valuable information for the Australian industry (Whiley & Saranah, 1986). In addition to the application in improving orchard yields, the work also has relevance to the plant breeding situation. Cultivars and breeding lines can be selected on the basis of their temperature sensitivity during reproductive development and so selection of cultivars for certain areas can be refined. In addition a knowledge and understanding of the breeding system of a crop enables greater manipulation of the species for the improvement of plant breeding.

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