SEASONAL CHANGES OF CAMBIAL ACTIVITY IN THE YOUNG BRANCH OF *PSIDIUM GUAJAVA* LINN.[1]

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Abstract: The annual rhythm of cambial activity in guava tree, *Psidium guajava* Linn., was investigated. The period of cambial activity is very long. It begins in early February and ends in November. The most conspicuous stage of cambial activity is seen to be in early June. When the temperature gradually rises the cambial activity increases. But it slows down as the average temperature exceeds 28°C. The foliar buds burst after the beginning of the cambial activity. The relation between the flowering period and the cambial activity shows less correlation.

INTRODUCTION

Since the early part of this century many investigators have worked on the detailed structure of the cambial zone (Bailey, 1920 a, b, 1923; Catesson, 1964; Srivastava, 1966). And their papers dealt with the annual rhythm of cambial activity, the effects of growth hormones and environmental factors (Digby & Wareing, 1966 a, b; Fahn, 1958 a, b, 1959; Snow, 1933, 1935). As to the environmental factors controlling the cambial activity, the effect of temperature can be considered as most important to some species such as *Robinia pseudoacacia* (Waisel & Fahn, 1965) and *Dalbergia sissoo* (Paliwal & Prasad, 1970). But in desert regions, the amount of available water in the soil becomes an important factor in the control of cambial activity. In certain plants, e. g. *Tamarix articulata*, *Acacia raddiana* and *A. tortilis* which grow in the desert regions of Israel, the cambium is active throughout the year because their roots reach the levels that contain a certain amount of moisture even at the end of the dry summer (Fahn, 1958 a, b). The same situation has also been found in *Acacia caven* which grows in Chile (Aljaro, Avila, Hoffmann & Kummerow, 1972). Sometimes the cambial activity coincides with the rainfall such as in *Proustia cuneifolia* (Aljaro, Avila, Hoffmann & Kummerow, 1972). In addition to these factors, the endogenous growth rhythm may persist inspite of the influence of external factors. *Eucalyptus camaldulensis* which is indigenous in Australia, keeps its annual rhythm of cambial activity even when grown in Israel (Fahn, 1959).

Though the cambial activity of some woody dicotyledons growing in the temperate zone is clearly known (Derr & Evert, 1967; Evert, 1961, 1963; Evert & Kozlowski, 1967) scanty data is available concerning the seasonal changes of the vascular cambium of tropical woody plants. In the present report, the workers have studied the seasonal changes of cambial activity in the guava tree, *Psidium guajava* Linn., a tropical evergreen which is common in Taiwan. The effect of temperature on cambial activity and the relation between the cambial activity and the phenology are discussed.

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MATERIALS AND METHODS

About ten-year-old guava trees (*Psidium guajava* Linn.) near the NTU campus in Taipei were used for the present work. Twigs were collected at one-month intervals from November, 1970 to April, 1972. Collections were made in the beginning of each month. Samples were removed from the mid-portion of the side branches which possessed two to three growth rings. Five to seven twigs were sampled at each collection, these were placed in polyethylene bags, and brought to the laboratory. The fresh twigs were sectioned at the the thickness of 25 μ with a sliding microtome as soon as reaching the laboratory. After being fixed in 50% ethanol, sections were stained with safranin and fast green (Johansen, 1940) for microscopic examination.

Seasonal changes regarding external morphology of the trees such as: foliar buds bursting, flowering and fruiting were also recorded at the time of each collection.

RESULTS

As seen in transverse sections, the cells in the cambial zone are more or less rectangular in outline. They are arranged in radial rows. The nucleus is more conspicuous when the cambium is in its active stage. The cytoplasm is stained densely in its dormant period, but lighter when the cambium is dividing actively (Figs. 1d-f, 2a-d). No crystals are seen in the cambial cells, whereas crystals are very common in cells other than the vascular cambium such as: cortex, pith, phloem and xylem (Figs. 1, 2).

Observations were carried out from November, 1970 to April, 1972. The relation of cambial activity to temperature and phenology is summarized in Fig. 3.

1) *The annual rhythm of the cambial activity*

The cambial activity ceased in December, and became active again in February. During this dormant period, the cambium consisted of only a one or two celled layer (Fig. 3) which was closely in contact with the fully lignified cells in the inner side and identifiable phloem cells outwards. The cambial cells were broadly rectangle, i.e. the radial wall and the tangential wall are about the same in length. Their cytoplasm stains denser than those seen in any other stages. The nucleus was not clearly identified (Figs. 1a, 2f). At the beginning of February the cambium seemed to become reactivated since the cambial cells showed flattening in transverse section (Fig. 1b). The number of cell layers in the cambial zone also increased (Fig. 3). Partly lignified cells were found in xylem (Fig. 1b). From late April to early May the cambium became more active. The nuclei of the cambial cells were frequently observed (Fig. 1e). The periclinal cell wall of each cambial cell appeared delicate and pliable. This may be due to the rapid division of the cambial cells. Many vessel elements that were not fully developed were found near the cambial zone. The grand period of cambial activity was seen in early June. A large amount of xylem tissue accumulated and the layers of cells in the cambial zone reached their maximum number (Figs. 1f, 3). In certain areas five-layers of cambial cells were counted. This was the most active stage of cambial activity in the whole year. From July to November the cambial activity was still maintained but the production of new tissues decreased.

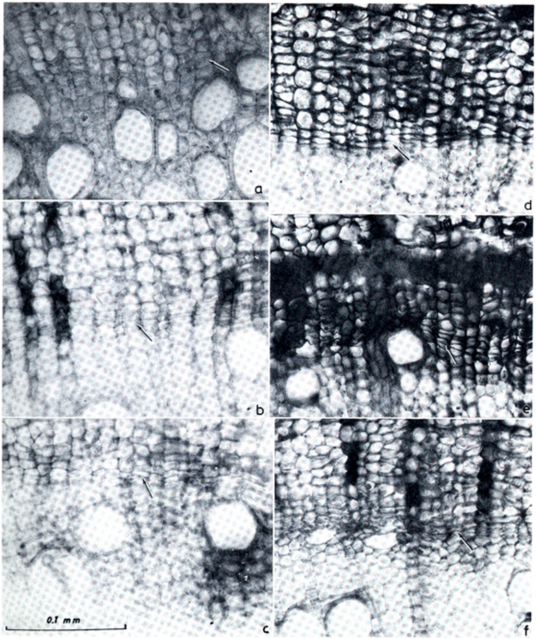

Fig. 1. Photographs showing enlarged views of transverse sections through the cambial zone (arrows) and its close derivatives from January to June, all x375. a) January b) February c) March d) April e) May f) June.

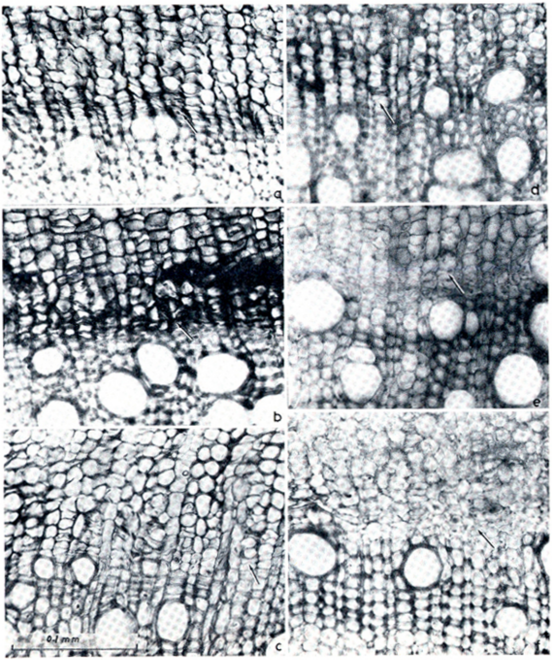

Fig. 2. Photographs showing enlarged views of transverse sections through the cambial zone (arrows) and its close derivatives from July to December, all x375. a) July b) August c) September d) October e) Novembe1 f) December.

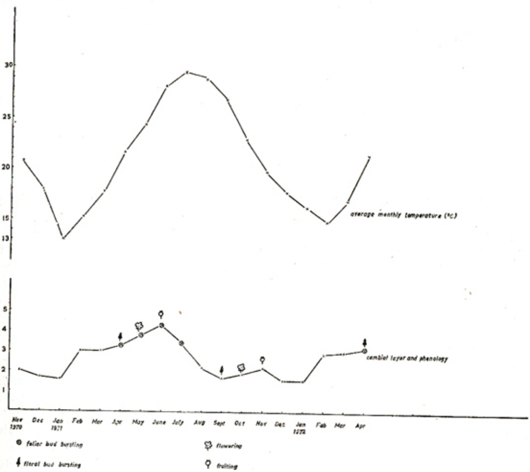

Fig. 3. The relation between cambial activity to temperature and phenology

2) *The relation between the temperature and the cambial activity*

According to the temperature records obtained from the Central Weather Bureau* the lowest average monthly temperature in the year was 13°C (January, 1971) and the highest one was 29.5°C (July, 1971) (Fig. 3). As the temperature gradually rose the cambial activity increased (Fig. 3). The cambial zone possessed many more layers of cells than they did at the dormant stage. Although the temperature continued to rise in July the cambial activity began to slow down. As it is shown in Fig. 3, the cambial activity slowed down when the temperature exceeded 28°C. In early November only a small amount of cambial derivatives were observed.

3) *The relation between the seasonal changes of cambial activity and the other growth phenomena*

As a tropical evergreen, the guava tree bears leaves the year around. When the cambium begins to reactivate in early February the foliar buds are still dormant. It is not until the beginning of April the vegetative buds really begin burst-

* The authors would like to thank the Central Weather Bureau for providing the temperature records.

ing at the tips of the branches. From then on the new leaves continue to grow till late July. This stage most nearly coincides with the most active period of the cambium (Fig. 3). The leaves persist throughout the year unless they are blown off in a typhoon and that often happens during September or October.

When the foliar buds burst open the floral buds begin to differentiate at almost the same time. The first main flowering period is in May. It corresponds with the active stage of the cambium (Fig. 3). The second flowering period is in October. That is at about the end of the cambial activity. But in October, the floral buds may be destroyed by typhoons. After flowering fruiting follows (Fig. 3).

DISCUSSION

It is known that the tropical woody plants have a long period of cambial activity. Some of them even maintain this activity the year around (Fahn, 1967). The present investigation has revealed that in *Psidium guajava* the period of cambial activity is quite long. It begins in early February and ends in November. In December and January the cambium is dormant. The first sign of cambial reactivation is the flattening of the cambial cells caused by the formation of new periclinal walls. During the resumption of the cambial activity periclinal divisions occur throughout the cambial zone and the density of the cytoplasm decreases. The same situation has also been reported in the cambial initial cells of *Robinia pseudoacacia* (Derr & Evert, 1967).

The effect of temperture can be considered as the most important factor for activating the cambial activity. As the temperature gradually rises the cambial activity increases. The grand period of the cambial activity was seen to be in early June. Though the temperature continues to rise in July the cambial activity slows down. Therefore, the rise in temperature which promotes cambial activity also seems inhibitory to cambial activity. For when the temperature goes above a certain limit cambial activity slows down. Paliwal and Prasad (1970) suggested that high temperature is conducive to the initiation of cambial activity. For when the temperature reaches 28°C in day time and 20°C at night the cambium of *Robinia pseudoacacia* was in its most active stage (Waisel and Fahn, 1965). In the present observation, the temperature during early June is about 28°C. The available range of temperature in which the cambium of *Psidium guajava* was most active is about the same as that for *Robinia pseudoacacia.*

The relation between the foliar buds bursting and the initiation of cambial activity depends on which plants possess the diffuse-porous wood or the ring-porous wood (Digby & Wareing, 1966b). In most conifers and ring-porous dicotyledons the cambium reactivates before the leaf buds burst or just at the opening of the buds (Ladefoged, 1952). Digby and Wareing (1966b) investigated several diffuse-porous wood and emphasized that the growth hormones produced from the new bursting buds stimulate cambial activity. But in guava trees, which have a typical diffuse-porous wood, the leaf buds burst in early April and the cambial activity begins in early February. This does not agree with the conclusions of Digby and Wareing (1966b). It is necessary to do more work on the seasonal changes of apical meristems before reaching a general conclusion.

It is likely that the flowering period and the cambial activity do not show any close relationship. In tropical regions, the seasonal changes of cambium are not conspicuous, and the effect of the season on the growth of plants is less distinct.

Therefore, tropical plants always have long, active growing periods throughout their whole lives.

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