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## **DIFFERENTIATION OF AVOCADO BLOSSOM BUDS IN FLORIDA**

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**(WITH THIRTEEN FIGURES)**

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Many species of cultivated deciduous fruit trees have been studied to determine the time of floral initiation, but less is known regarding the time of fruit-bud differentiation in evergreen tropical and subtropical fruit trees. Such knowledge is important because of the possibility of influencing differentiation by cultural practices.

Most deciduous fruit trees (for example, apple, pear, plum, and cherry) initiate flowers during the summer following their period of vegetative growth in the spring. Most of the floral organs are formed before the leaves fall and emerge the next spring after a period of dormancy. Fruit trees of the tropics and subtropics, which usually exhibit several distinct cycles of vegetative growth within the season, are not in such a category. Frequently it is difficult to distinguish between a flower bud and a purely vegetative one before it opens, either from its size or position. ABBOT<sup>2</sup> has shown that blossom-bud differentiation takes place in citrus during initiation of growth in the spring or upon resumption of growth at any other season as the result of a period of favorable environmental conditions. Flowers may thus appear on axes which did not exist a few months earlier.

Terminal and lateral buds of the avocado were collected at monthly intervals, beginning October 8, 1940, from trees of the Lula and Nabal varieties, growing on the grounds of the United States Horticultural Field Laboratory at Orlando, Florida. Some variation in the stage of development existed over various parts of a tree, so that each collection was taken from branches which represented as nearly as possible the average stage of bud development at the time of collection. From these branches the terminal buds and the four to six lateral buds nearest the terminal portion were taken for sectioning. The buds were killed in 70 per cent alcohol, imbedded in paraffin, and sectioned longitudinally at 10-15  $\mu$ .

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<sup>2</sup>Abbot, C. E., Blossom-bud differentiation in citrus trees. Amer. Jour. Bot. 22:476-485. 1935.

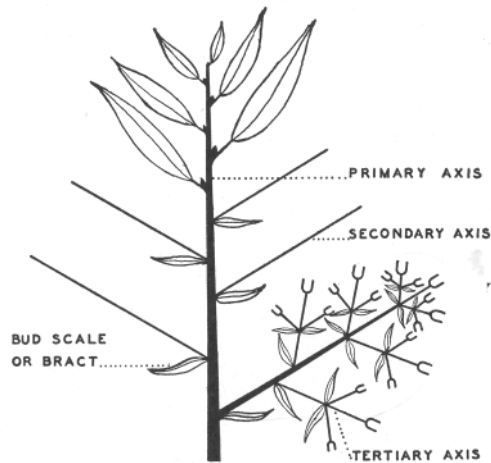
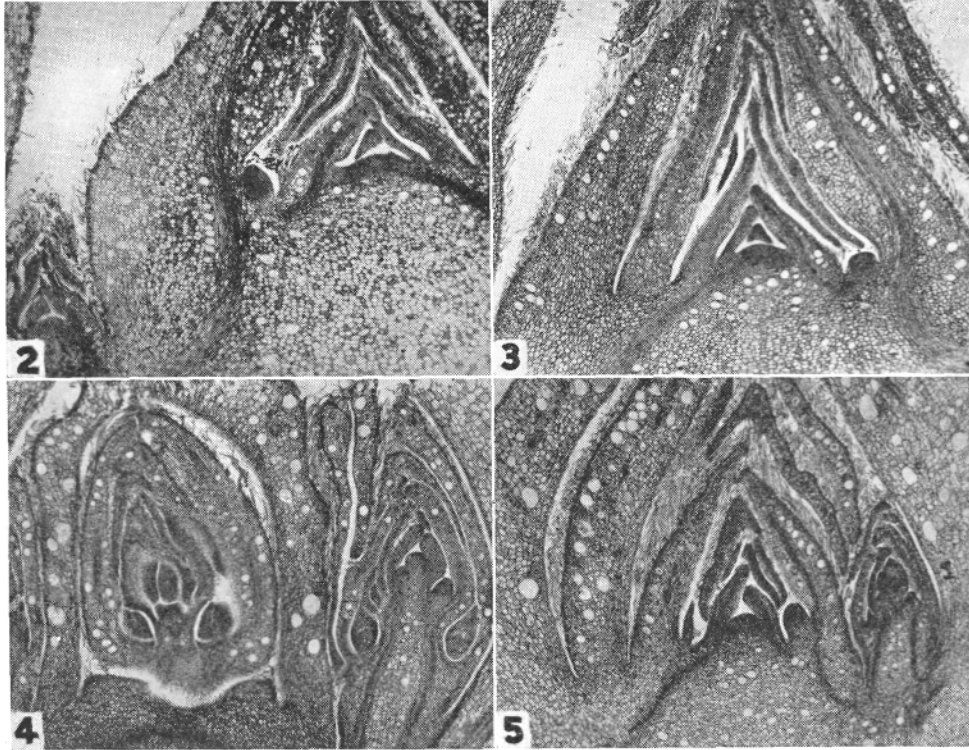


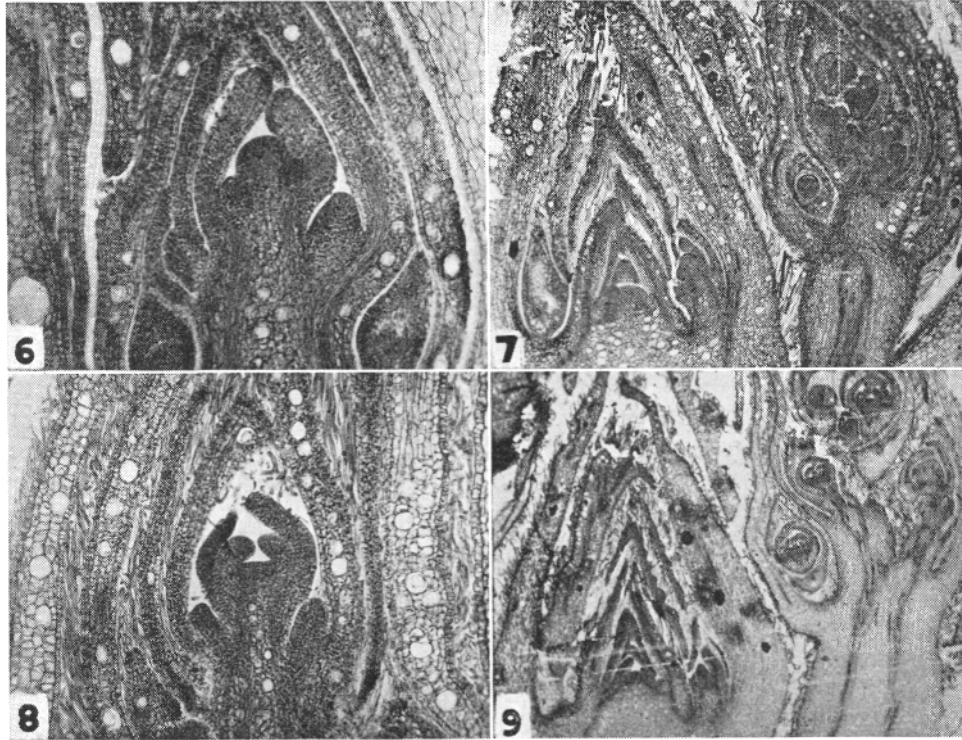
FIG. 1.—Diagram of floral and vegetative growth developed from terminal or lateral winter buds of avocado.

At first, as the terminal and lateral winter buds unfold, growth appears to consist of inflorescences only. Each inflorescence seems several times compound. Later it becomes evident that each main axis is an indeterminate branch. The first leaves formed on this axis are bractlike, and each subtends an axillary bud which develops into an inflorescence (fig. 1). These lateral inflorescences or secondary axes are alternately arranged on the primary indeterminate axis of the winter bud and develop acropetally, giving the whole group the appearance of a compound raceme or panicle. Subsequent development shows that actually the secondary axes constitute the inflorescences. On these axes the terminal or central flowers mature first, and the clusters are therefore cymes. The growing point of the primary axis extends the vegetative growth of the shoot beyond the region of the diverging inflorescences. Foliage leaves are formed, and the buds in their axils are vegetative.



FIGS. 2-5.—Fig. 2, terminal bud of Lula variety on Oct. 8; bracts appear on lowest secondary axis. Fig. 3, terminal bud of Nabal variety on Oct. 8; meristems of secondary axes show no differentiation. Fig. 4, longitudinal section of Nabal terminal bud, Dec. 10; secondary axes with bracts differentiated and meristems for tertiary axes apparent. (Section not truly median and therefore does not show primary apical meristem.) Fig. 5, Lula terminal bud on Dec. 10; lower secondary axis appears and differentiation is progressing. A higher secondary axis does not show differentiation. Apical meristem of primary axis appears in this section.

In mid-September most branches of the trees were actively vegetative. The first collection was made on October 8, 1940, when growth elongation had ceased and terminal buds had formed. The condition of terminal and lateral buds was found so similar in the case of each variety that this discussion will be confined to terminal buds. In October meristematic areas were present in the axils of the bud scales. Occasionally the lowest meristem within the bud had differentiated several bracts (fig. 2); in other buds the meristems for secondary axes consisted of undifferentiated mounds of cells (fig. 3). One month later no change was recognizable in most of the buds of both varieties. One bud showed some elongation of the lowest secondary axis, but only bracts were differentiated on it. Meristematic areas in the axils of the distal bud scales were undifferentiated in all buds at this date.



FIGS. 6-9.—Fig. 6, secondary axis of Nabal terminal bud on Dec. 10, 1940. Meristems of tertiary axes appear in axils of bracts, which are arranged alternately on secondary axis. Fig. 7, terminal bud of Lula variety of Jan. 13, 1941; lower lateral branches show early stages in flower development; higher and younger branches within bud are in various stages of development. Fig. 8, rudimentary flower terminating secondary axis in a Nabal bud, Jan. 13. Fig. 9, longisection of Lula bud collected Feb. 11; axes of orders and flowers in various stages of development.

From November 8 to December 10 the formation of the lower secondary axes progressed, and meristematic areas appeared in the axils of the bracts on the secondary axes (fig. 4). From the alternate arrangement of bracts and meristematic areas (fig. 6) it is obvious that this condition cannot be an early stage in the differentiation of a flower but is simply a secondary axis with bracts and axillary meristems. Whether or not a particular meristematic area would have given rise to a single flower or continued the axial ramification of the inflorescence cannot be determined. Prior to December 10 no flower primordia could be detected.

By January 13 the lateral branches within a terminal bud were in various stages of development, and the proximal lateral branches showed early stages in flower development (fig. 7). These branches, or inflorescences, ultimately become cymose, and the floral differentiation and anthesis of the cymules become basipetal, the middle flower opening first (fig. 1). In material collected at this time rudimentary sepals and petals were evident in the terminal flower on the secondary axis (fig. 8), and meristematic areas which would have given rise to tertiary axes appeared beneath it. A flower terminating a tertiary axis and a portion of an axis of a fourth order also appeared in this section.

Material collected February 11, 1941, showed highly complicated buds with many lateral axes of various orders and flowers in various stages of development (fig. 9). Even at

this time, however, the younger distal secondary axes of the bud appeared only as meristematic mounds of cells. However, there were more well developed axes upon the various radii than were present at progressively earlier dates.

In order to compare the regional variation in the differentiation of the inflorescences of these varieties, as well as that from year to year, buds were collected bi-monthly from the trees at Orlando during the winter season of 1941-42 and monthly from trees of the same varieties on the grounds of Mrs. W. H. Krome at Homestead, Florida.

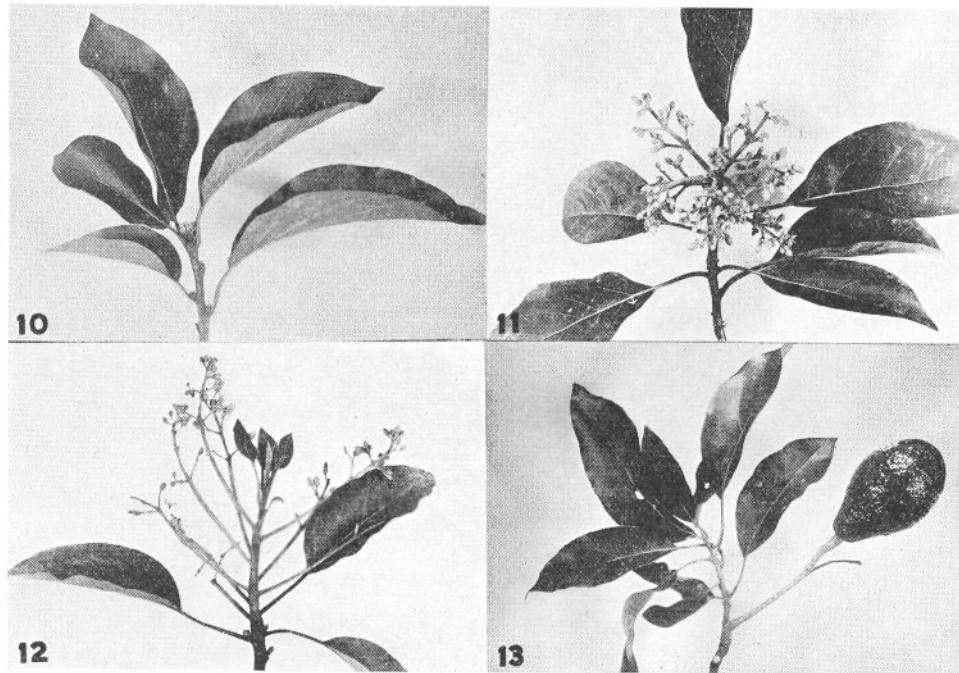
The inflorescences began their differentiation later during the winter of 1941-42 in the Orlando district than they did in 1940-41. Lula terminal buds collected December 31, 1941, were in approximately the condition shown in figure 5, which illustrates the stage reached by Lula buds at Orlando on December 10, 1940. In the Homestead region differentiation was even further delayed, and on January 14, 1942, Lula buds were still in the stage illustrated in this figure. Buds of both varieties collected the following day at Orlando showed early stages in the differentiation of flowers with the appearance of the first sepal primordia. Thus, during the period between December 31, 1941, and January 14, 1942, development took place approximately equal to that covered by the period from December 10, 1940, to January 13, 1941. Subsequent growth of the inflorescences in 1942 closely paralleled the development in the preceding year. At Orlando on February 10, Lula buds contained many flowers in which sporogenous tissue was present in the stamens, and ovule development had begun. Nabal buds were slightly less advanced and did not have sporogenous tissue. Although on January 14, 1942, buds of the Lula variety in the Homestead district were less advanced by 2 weeks than were buds at Orlando, and by a month in comparison with Orlando buds of the preceding year, by February ii they equaled the development at Orlando. The same cannot be said of the development of the inflorescences of the Nabal avocado at Homestead. Buds collected on March 10 had developed little during the entire year. The lowest secondary axes appeared like those of the Lula variety on December 10, 1940 (fig.5).

With the exception just mentioned, during early March the buds expanded rapidly (fig. 10), and the secondary branches from the bud underwent marked development. These secondary axes develop acropetally and give rise to tertiary branches which may either be alternate or apparently opposite in arrangement.

These tertiary branches have flowers in small clusters (cymules) in which the central blossoms opened first (fig. 11).

In the entire growth of the primary axis of the bud an indefinite number of secondary flowering axes appear and mature. Finally development of this type ceases. Nevertheless, the main apical meristem continues to grow and gives rise to the leafy or vegetative spring flush of growth (fig. 12). Each leaf on this upper portion of the main axis subtends an axillary bud which is purely vegetative in character. In a few abnormal cases the primary axis becomes determinate and a flower terminates the growth. Vegetative growth is therefore dependent upon the normally indeterminate condition of the primary axes. Although a group of inflorescences arising from a single winter bud may bear several hundred flowers, in most commercial varieties usually a single fruit matures, or—at best—a very small number. Thus most of the secondary axes or

inflorescences abscise. The primary axes continue vegetative growth, and the fruits that mature are usually borne upon axes of a third or fourth order (fig. 13).



FIGS. 10-13.—Fig. 10, terminal bud just before elongation of secondary axes. Fig. 11, inflorescences expanded and ultimate cymules visible. Fig. 12, flowers and various axes abscising and vegetative growth of indeterminate primary axis developing. Fig. 13, fruit and its relation to secondary or inflorescence axis and to primary axis of winter bud.

## Summary

1. Buds of Lula and Nabal avocado collected during the winters of 1940-41 and 1941-42 at Orlando, Florida, and from the same varieties at Homestead, Florida, during the winter of 1941-42, were studied. In these varieties floral differentiation continued over a period of months during that part of the winter when leaf formation and growth did not take place or were at a minimum.
2. Differentiation began with development of the proximal secondary axes in late October or November. There was a year-to-year variation in the time of this development for a given variety, and between varieties, as well as between trees of the same variety in different sections.
3. The first identifiable flowers appeared on the lowest inflorescences (secondary axes) in the January buds of both varieties in the Orlando district and of the Lula variety in the Homestead district; but in the Nabal variety at Homestead they had not yet appeared on March 10, 1942. Differentiation proceeded distally during the winter, and in the most distal secondary axes it was completed just prior to or during expansion of the bud. Development into complete bloom was not interrupted by a dormant period between the time of initiation and differentiation on the inflorescence and its expansion in the spring.