TIME OF FRUIT BUD INITIATION IN DECIDUOUS TREE FRUITS

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FRUIT BUD INITIATION

DASHTPOOR

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Title: Time of fruit bud initiation in deciduous tree fruits.

In order to determine the time of fruit bud initiation of apple, pear, plum, peach, sweet cherry, and sour cherry, a survey was performed at the AUB Agricultural Research and Education Center between July 1 and October 7, 1966.

Samples from different kinds of buds were taken at two-week intervals in a total of eight samplings. Buds were collected, stored, processed, and examined for development of flower buds following standard histological methods.

According to the results the date of the first observed initiation in 1966 was as follows: apple, August 26; pear, July 1; plum, July 29; peach, August 12; sweet cherry, July 15; and sour cherry, July 29.

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I. INTRODUCTION

The appearance of the first anatomical indication of floral parts developing inside the buds of fruiting plants is accepted as proof of "fruit bud initiation". The earliest point at which such a sign can be observed has been termed "the time of fruit bud initiation".

Under normal conditions, initiation of flower parts inside the buds of a deciduous fruit tree starts a few years after the tree has been planted and is repeated every year at a time which is rather specific for the individual variety and the climatic conditions. The period during which most fruit trees initiate their fruit primordia occurs between spring and early fall.

Physiologically speaking, fruit bud initiation is a step following the start of the induction period and has a close association with it.

Although the time of fruit bud initiation is primarily controlled by genetic and environmental factors, many cultural practices, by directly or indirectly affecting the trees can, within a limited range, have an important modifying effect on it.

Anything which encourages vegetative growth of a tree usually postpones the reproductive growth and thus

delays fruit bud initiation (24). Irrigation, pruning, chemical fertilization, defoliation, or injury to leaves by man, insects, caustic sprays, etc .. are all factors which can modify fruit bud initiation. According to many authors (10, 24, 28, 29) the key to the means by which these factors affect fruit bud formation and development is found in their effects upon leaves and specifically upon their ability to synthesize carbohydrates. Gardner, Bradford and Hooker (1952), in a review of the works of Kraus and Kryabill, Klebs, Walster, and others, suggest that the ratio between the carbohydrate and nitrogen contents in plants is one of the main factors influencing the formation of fruit buds. Anything which affects the carbohydrate manufacture or nitrogen absorption will have an effect on the ratio. In addition, there is evidence that growth regulators may play an important role in fruit bud initiation and the site of their formation seems to be leaves. Thus, anything which upsets their ability to function normally may seriously affect fruit bud initiation.

Knowledge of the time of fruit bud initiation can help in orchard management to solve three important problems of fruit production:

1 - How to encourage the formation of flower buds and their development? Knowing the time of fruit bud initiation permits a re-orientation of the time and manner of all the cultural practices of the orchard to ensure a

potentially rich crop of fruit for the following year. Obviously, manipulations using some combination of chemical fertilization, irrigation, pruning, and other cultural practices may be used to encourage fruit bud initiation (reproductive growth) at the expense of vegetative growth.

2 - How to protect the crop from frost injury in early spring? The later the buds mature, the later they enter dormancy and the later they start growing in the following spring. Such late onset of growth may save the crop from being damaged by frost when unseasonally warm weather tends to cause growth to start earlier than normal in the spring. The same management tools as mentioned above may be used for this purpose but in a different direction.

3 - How to predict the crop for the following year? For a good set of fruit, there must be enough healthy fruit buds available on the tree. If there are too few flower buds, no other production factor can compensate for the deficiency. Knowing the potential of the crop in advance permits the orchardist to plan accordingly. By means of a random sampling of the buds in an orchard immediately after fruit bud initiation has taken place, the grower can tell what the potential fruit set is for the following year.

Since no information existed on the time of fruit

bud initiation in Lebanon, this project was undertaken to provide such information under the conditions of the Beqa'a plain at the Agricultural Research and Education Center. As a result, the time of fruit bud initiation as well as the fruiting habits have been determined for apple, pear, plum, peach, sweet cherry and sour cherry.

II. REVIEW OF LITERATURE

Many different factors have been recognized which somehow affect flower bud initiation.

Light, besides functioning in photosynthesis (10, 24) and providing the needed energy for the life of the tree (5, 49), through some photomorphogenic mechanism, directs this energy along the various metabolic pathways which are essential for the life of the tree and the continuity of its species (58). It is suggested that in the flowering process, a time measuring mechanism of the plant functions as the result of the effect of light on a convertable pigment "the phytochrome" (4, 8, 35, 60). The effects of the individual components of light on flowering have been studied by many workers (7, 18, 36, 52, 58).

Heinicke (30) found that increasing light intensity increased the average net assimilation rate (NAR) to a saturating point in the Golden Delicious apple. He found no more than two "light zones" in those trees. This information, combined with those given by Burnside and Bohning (5) and by Kessler *et al.* (34), correlate the effect of light intensity on flowering with the RNA/DNA ratio.

Little information is available regarding the photoperiodic sensitivity of woody plants (16, 24, 25, 44, 57), yet many researchers are convinced that photoperiod has no important effect on the flowering of the woody plants such as is the case in herbaceous plants (12, 16, 25, 44, 57). Gorter (25) stressed, instead, the C/N ratio and Warreing (57) suggested that some internal mechanism was responsible for flowering instead of photoperiodism in woody plants. Gardner et al. (24) on the contrary, suggested that the rather stable time of flower bud initiation of most deciduous trees in the Northern hemisphere is photoperiodic in nature, because it is only the day length that all those different areas have in common. Warreing (57), though he thought there was no photoperiodic sensitivity in woody plants, yet suggests that any general theory must be applicable to both the vegetative and the flowering processes in woody plants. Therefore, the length of the night period (60), the number of light cycles (6), and the temperature coefficient of light through photoperiod may have an important impact on flowering of woody plants.

Though the effect of temperature on normal growth of trees is quite clear (2, 9, 10, 24, 29, 42, 49), there is little information available about the direct effect of temperature on the flower initiation of fruit trees. Nacata and Watanabe (42) suggested that the prolonged

period of low night temperature is a requirement for Litchi chinensis, a woody plant. Hield et al. (31) found that the origin of the floral stimulus in the grapefruit seedling was an internal one and was restricted to shoot terminals and was not related to temperature. On the contrary, Baldwin (2) found that the sum of the daily maximum temperature and the hours of bright sun-shine had important influence on fruitfulness of Sultana grape vines. Furthermore, the thermoperiodic control of flowering of some plants, for example Pharbitis nil, in which temperature acts in similar way to light in photo-period, has been described by Searle (49). However, he considers that low temperature may substitute for darkness and high temperature for light in some plants.

Through a series of experiments, the role of genetic factors on floral initiation has been studied through inactivation of RNA and DNA using pyrimidine 5-fluorouracil (5-FU) or similar materials (3, 34, 47, 59). The conclusions made by Zeevaart (59) are: (a) floral stimuli can be effective in the initiation of floral primordia only in an apex with multiplying DNA, and (b) the genes for flowering must be, apparently, in the process of multiplication in order to become activated by the floral stimulus.

The inhibitive effect of young leaves on flowering has been shown experimentally by Kraus and Kraybill as

mentioned by Gardner *et al.* (24). The observed phenomenon was later attributed to the presence of some hormone-like material. The hypothetical material which induces flowering has been called florigen (49). For the first time evidence of florigen was studied by Hamner and Bonner (27). Later, Lincoln *et al.* (38) extracted a crude substance capable of showing a florigen effect. Searle (49) described flower inducing materials as gibberellin-like compounds of endogenous origin. Smith (50) was convinced that two substances controlled flowering of *Carex*, one prohibitive auxin and the other a substance which could be replaced by Kinetin. Thompson and Guttridge (56) suggested that apices of strawberry were able to produce flowers under any photoperiodic condition yet the inhibitive effect of leaves prevent or control the induction. Moore and Hough (40), on the other hand, suggested that change in auxin levels close to the time of flower initiation was a consequence and not a cause. Similar results were obtained by Cooke (11) and Harada and Nitsch (28). Another idea suggested by Searle (49) is that some inhibitors may prevent flowering by depressing ATP levels needed for synthesis of florigen. Kessler *et al.* (34) suggested that there was a contribution from RNA and protein in the process of flowering which in some way affects the synthesis of hormone which apparently takes place in leaves.

The effect of nutrition, especially as indicated by the C/N ratio, on flowering of fruit trees has been studied by many authors in the past (9, 10, 24). The corresponding effects of late harvesting of fruits (33), the starch content of leaves (42), the ringing of apple spurs (41), defoliation (1), and nutrient compounds (32, 51) have been described. However, there is an observable tendency to re-establish the importance of nutrient effect on flowering (43, 49).

The State of Floral Induction

According to Hartmann and Kester (29) the stage of flower bud induction follows the stage of vegetative growth and precedes the stage of flower bud initiation. The change from vegetative to reproductive growth may come as a response to certain environmental stimuli, particularly photoperiod and temperature, or may be induced in some woody plants by certain horticultural manipulations. The physiological change may be manifested by morphological modifications in some plants.

Popham and Chan (45) observed cessation of cell division and cell enlargement as the first indication of the onset of the flowering condition in the case of Chrysanthemum. For a period of six days, little or no growth occurred and the physiological state of the apex underwent a complex series of chemical changes. In this

stage, in addition to physiological and morphological changes, there was a loss of apical dominance. The mechanism of the phenomenon of apical dominance was suppressed or even destroyed.

Struckmeyer and Roberts (53) investigated the time of blossom induction in Wealthy apple trees and found that induction occurred at least three weeks prior to the appearance of bloom primordia.

Lang (37) refers to the actual flower bud initiation as a process which takes place after, and as a result of, the inductive condition. Floral stimulus, the outcome of such condition, is transmitted from the leaf, as the receptor of the stimulus, to the bud, as the site of actual response (4, 13, 40).

The Bud and its Development

Satina and Blakeslee (48) described the "classical theory" according to which a flower is analogus to a shoot. The characteristics of flower recognizable as shoot characteristics are their growth in length, although restricted, and the foliar nature of their floral organs. This concept, though the prevailing one, is not considered by all to fit with the observations. Gregoire, as described by Satina and Blakeslee (48), and Dermen (15) opposed the classical theory and considered the flower "an autonomus organ" with no foliar origin for

stamens and carpels. This view was based on the fact that the meristem of the floral apex which produces the flower organs lies in the outermost region of the apex, the mantle, and the innermost part of the meristem produces the parenchymatous and inactive part of the apex which does not contribute in the growth of the floral apex.

The concept of the tunica and corpus presented by Schmidt in 1924 has been described by many workers (15, 17, 39, 48). This concept considers that two regions of the shoot apex are the origins of plant tissues; the tunica, responsible for the surface growth, and the corpus, from which the shoot gains growth in volume.

Satina and Blakeslee (48) studied the floral apex of Datura stramonium ontongenetically, using periclinal chimeras. They found that the shoot apex of this plant had three independent "germ layers" designated as L-I, L-II, and L-III. As in the shoot apex, the surface growth was dependent on L-I and L-II, whose cells divided anticlinally. Periclinal division occurred in the L-II layer, only at the initiation of sepal and petal primordia. As in the shoot apex, the growth in volume was dependent on the L-III layer, which acted as a cambium layer and gave rise to the cells of the central core. Furthermore, he observed ascending procambial strands on both sides of the floral receptacle continuing into the floral primordia as they developed. Considering similarities between

chromosomes, arrangement of cells in the layers and central core, and the planes of cell division in shoot and floral apices of Datura plant, Satina and Blakeslee concluded that "there is no essential difference in structure between the shoot and flower apex; another confirmation of the classical theory.

Dermen (14, 15) observed dome shaped apices with a tunica-corpus organization for peach, apple, and cranberry similar to that observed in Datura. In some cases, he observed as many as six or seven apical cell layers. In the cytochimeral plants, he observed that only one of the three layers polyploidized. When the third layer was affected, almost all of the inner portion of the dome was of the same ploidy. He also found that the L-I layer almost always gave rise to the epidermis and the amount of tissue derived from the L-II layer seemed to be variable.

According to McCoy (39), the flower of an angiosperm plant is a determinate stem with appendages which are homologus with leaves. The growing tip is formed of two hystogens: the corpus - a central region made up of parenchymatous cells, capped by the tunica - peripheral tissue of two cell layers. The inner tunica layer occurs as a distinct layer continuous over the tip of floral apex. By periclinal divisions this layer contributes in flower formation as the origin of floral organs.

Griffith (26) recognized in the organization of

apices in some species of Araucaria plants, four zones within the framework of the tunica-corpus theory: (1) The tunica zone, which covers the surface of the bud and whose cells divide anticlinally. (2) Corpus initials, located beneath the tunica at the climax of the apical cone with plane of cell division anticlinal, periclinal, and mostly in irregular directions. (3) The peripheral tissue zone, a peripheral layer over the central core and under the main meristematic area, cells of which divide in an acropetal direction. (4) Rib meristem zone, centered within the peripheral zone and under the corpus initial zone. This zone is produced by mitotic activity of cells at the base of corpus initials.

The development of the apple bud is described in some detail by Fulford (20, 21, 22, 23). Its apical meristem is controlled by the inhibitive effect of adjacent young primordia whose effect is due to their own metabolic activity under the influence of the environment. Therefore, when the environmental factors affect the whole equally, the result will be an increase in the apical meristem activity on one side and an increase in activity of young primordia coupled with an increase in the efficiency of its inhibitive field on the other. Therefore, increase in the activity of apical meristems will be counter-balanced by the increase of the inhibitive fields of adjacent young primordia, a pattern of "control by

negative feed back". Such a balance, according to Fulford, will be disturbed by the formation of new primordia which, due to the strength of the inhibitive field acting on them, may have a short or a long plastochrone. The length of the plastochrone, he suggested, could be used to determine whether the bud is going to be a vegetative bud or a fruit bud. Since in a related experiment he observed no vegetative bud with a plastochrone shorter than 18 days and no flower bud with a plastochrone longer than seven days he concluded that "it seems the ability of a bud to form flowers is associated with the length of the plastochrone".

Struckmeyer (55) observed changes in the stem associated with flowering. She found that the changes in the stem in Xanthium started with the onset of the inductive period. Three days later the flower primordia were present in the plant. She also gave the details of a number of changes in the stem associated with flowering (54).

Some Internal Factors

In addition to external factors, variations in internal conditions cause buds to differ in respect to the time of fruit bud initiation. Varietal differences and differences due to the location of buds, which in turn represent varietal characteristics, are of this kind.

In a review of literature Gardner et al. (24) reported the following:

According to the findings of Bradford, apple varieties Stark, Red Astrachan, and Oldenburg are earlier than Jonathan, Northern Spy, and Grimes in their initiation of flower buds. Furthermore, Magness reported that White Pearmain, Tetofski, and Yellow Transparent were initiated sooner than Lady and Jonathan. Goff found similar differences to exist between varieties of apple, ranging from before August 1 until after September 1.

Bradford reported that in the Yellow Newtown apple the terminal fruit buds on long shoots apparently differentiate at a later period than those on spur. Yet, even in spurs, variations were seen from year to year. Magness reported that differentiation of axial fruit buds occurred about one month later than those on spurs in the Tetofski apple. In the case of stone fruits, Roberts found indications that initiation started both in the basal and the terminal regions of 4- or 5-inch shoots in sour cherries and peaches at the same time.

Time of Fruit Bud Initiation

The interaction of the factors affecting flower bud initiation sets certain time limits within which the process of initiation takes place. The variation in these limits is shown by Gardner et al. (24) who reviewed

the work of a number of researchers located in different parts of the United States of America. The results are summarized in the following.

Species	Variety	State	Time of initiation	Authority
Apple	Oldenburg	Virginia	About June 20	Drinkard
	Hoadley	Wisconsin	June 30	Goff
	-	Iowa	First of July	Kirby
	-	Oregon	First ten days of July	Bradford
Pear	Kiefer	Virginia	Middle of July, later than apple	Drinkard
	Wilder Early	Wisconsin	July 21	Goff
Plum	Rollingstone	Wisconsin	July 8	Goff
	Aitken Plum	Wisconsin	August 9	Goff
	Whitaker	Virginia	First week of September	Drinkard
Peach	Luster Peach	Virginia	First week in July	Drinkard
	Demming's September peach	Georgia	Late in June	Quaintance
	Bokhara	Wisconsin	Middle of September	Goff
Cherries	Louis Philippe (on Morello)	Virginia	June 30	Gardner
	King's Amarelle	Wisconsin	July 11	Goff

III. MATERIALS AND METHODS

A survey was conducted upon six different tree fruits to determine their time of initiation of flower buds during 1966. The trees were in the variety test block in the orchard of the Agricultural Research and Education Center (AREC) of the American University of Beirut, Lebanon. The AREC is located in the North Central part of the Beqa'a plain, Lebanon. The climate of the area is cold and damp in the winter, warm and dry in the summer. Rains occur principally in the winter period and are rare during the summer resulting in relatively short sunshine periods during the winters and long, bright sunshine periods in the summers. Strong winds are common during all months of the year. A summary of the meteorological data for 1966 is presented in Tables 1 and 2.

The soil in the area has a fine texture, is calcareous and alkaline in reaction, and in the test orchard, contains an appreciable amount of gravel (46).

The fruit trees included in the study were sour cherry, sweet cherry, apple, pear, plum, and peach. Starting on July 1, 1966, buds were collected at two-week intervals from a single tree of each type on eight sampling dates. The same trees were used as the source

Table 1. Measures of air temperature, air humidity, and sunshine on a monthly basis in the Beqa'a plain, 1966. Elevation 995 m*.

Climatic factors		Month					
		Jan.	Feb.	March	April	May	June
Air temperature (°C)							
Max.	Highest	16.5	19.6	22.0	27.0	28.0	35.0
	Mean	10.3	11.9	12.8	18.8	22.2	28.6
Min.	Lowest	-3.5	-2.5	-5.0	-3.1	-0.7	6.5
	Mean	1.1	0.8	1.3	4.7	6.7	10.5
Air humidity (relative, %)							
Max.	Highest	97.0	94.0	95.0	95.0	95.0	90.0
	Mean	92.0	92.2	89.8	82.7	76.8	68.1
Min.	Lowest	35.0	29.0	29.0	33.0	24.0	25.0
	Mean	58.5	53.3	46.0	41.5	39.1	38.4
Sunshine (hr. and min.)							
	Mean	4:47	6:12	8:19	9:06	11:02	12:42

* Source: AREC Weather Station.

Table 1 (Continued).

Climatic factors		Month					
		July	Aug.	Sept.	Oct.	Nov.	Dec.
Air temperature (°C)							
Max.	Highest	35.0	38.0	35.5	29.5	26.5	19.0
	Mean	13.69	33.05	28.20	23.11	20.82	11.52
Min.	Lowest	10.5	11.0	8.0	6.5	3.5	-3.0
	Mean	14.00	14.34	12.12	9.15	7.42	3.14
Air humidity (relative, %)							
Max.	Highest	90.0	90.0	92.0	92.0	91.0	93.0
	Mean	69.0	74.0	82.0	83.3	79.7	89.9
Min.	Lowest	27.0	12.0	25.0	32.0	32.0	41.0
	Mean	37.2	33.1	42.3	44.9	46.6	61.0
Sunshine (hr. and min.)							
	Mean	12:49	12:10	10:18	8:49	7:46	5:21

Table 2. Measures of soil temperature, rainfall, and wind on a monthly basis in the Beqa'a plain, 1966.

Climatic factors		Month					
		Jan.	Feb.	March	April	May	June
Soil temperature (°C) at 75 cm depth							
	Maximum	9.1	11.4	13.4	18.7	20.3	22.2
	Minimum	7.9	8.5	10.2	11.5	16.8	20.5
	Mean	8.7	9.4	11.8	14.2	19.3	21.6
Rain (mm)	Total	70.9	68.7	96.7	0	2.6	0
Wind (km/day)	Maximum	449	275	604	382	372	323
	Minimum	41	57	21	84	90	114
	Mean	182.0	158.2	210.3	202.9	199.3	169.4

Table 2 (Continued).

Climatic factors		Month					
		July	Aug.	Sept.	Oct.	Nov.	Dec.
Soil temperature (°C) at 75 cm depth							
	Maximum	25.2	23.9	24.5	21.8	18.6	15.8
	Minimum	21.5	21.6	21.3	18.8	16.0	13.35
	Mean	23.25	22.90	22.57	20.1	17.62	10.7
Rain (mm)	Total	0	0	0.9	28.0	11.0	187.8
Wind (km/day)	Maximum	272	251	245	339	235	392
	Minimum	64	93	110	50	63	50
	Mean	161.7	165.1	170.5	144.4	132.5	182.6

of buds throughout the sampling period. Up to 50 buds were collected from each tree in each sampling; ten buds were selected from each type of bud which is known to become floral. The kind of buds taken from each tree are as follows:

Lateral bud from shoot	Sour cherry, apple, plum, peach
Terminal bud from shoot	Sour cherry, apple, pear
Terminal bud from vegetative spur	Sour cherry, apple, sweet cherry, plum, pear
Terminal bud from fruiting spur	Sour cherry, apple, sweet cherry, plum, pear
Terminal bud from flowering non-fruiting spur	Sour cherry, apple, pear

Information concerning the variety, age, blooming, and yield of the trees are given in Table 3.

A histological examination of buds was used to observe the anatomical changes within the buds and the indications of fruit bud initiation.

The sample buds were killed in vials containing FAA killing and fixing solution having the following formula:

Absolute ethyl alcohol	50%
Distilled water	40%
Glacial acetic acid	5%
Formaldehyde(38%)	5%

The buds remained in the FAA solution until it was convenient to start dehydration. Dehydration was accomplished in an ethyl alcohol/n-butyl alcohol series in eight steps. Buds remained in each solution at least

Table 3. The crops surveyed, their variety, ages, yield in 1966 and date of full bloom in 1966 and 1967, in the variety orchard of the AREC.

Tree	Variety	Age	Crop in 1966		Date of full bloom	
			Date of harvest	Weight of crop kg	1966	1967
Apple	Starking Delicious	11 yr	-	-	Apr. 15	Apr. 28
Pear	Duchess	11 yr	August 5	40.6	Apr. 1	Apr. 19
Plum	Purple Plumcot	11 yr	July 14	63.3	March 30	March 30
Peach	July Elberta	11 yr	-	-	March 25	March 19
Sweet cherry	Gold	11 yr	June 14	16.5	Apr. 12	Apr. 22
Sour cherry	Early Richmond	11 yr	June 2	26.1	Apr. 8	Apr. 28

one hour before being replaced by the next. They remained in 100% butyl alcohol for not less than three days, after which shaved "tissue mat" embedding material was added to the vials and the vials were placed on a slide warmer, adjusted to 50°C, to start the infiltration process. When the tissue mat was completely melted, the mixture was replaced by clean melted embedding material and the vials were transferred to an oven adjusted to 65°C. The old embedding material was replaced every 24 hours by new material until the butyl alcohol odor could no longer be detected.

Twenty four hours after the last renewal of embedding material, the contents of the vials were transferred to paper dishes, the buds were positioned, and the "tissue mat" was permitted to solidify.

The samples were fixed on wooden blocks for sectioning and were soaked in water for 24 hours. Longitudinal section 15 microns thick was cut on a rotary microtome. The serial sections thus obtained were fixed on slides with Haupt's adhesive.

The "tissue mat" was removed from the sections with xylol, the sections were cleared in an alcohol-water series, and were stained in an aqueous solution of safranine O for 16-24 hours and counterstained with Fast Green FCF. Coverslips were mounted with Harleco Synthetic Resin (HSR) in xylol and the slides were permitted to dry.

The slides thus obtained were classified according to the tree and the time of sampling. They were examined for stage of development and flower initiation under a binocular microscope (The Bausch and Lomb Dynazoom Research Laboratory Microscope). Microphotographs were obtained using a Zeiss Photomicroscope.

IV. RESULTS AND DISCUSSION

The results obtained from this study on the time of fruit bud initiation in sour cherry, sweet cherry, apple, pear, plum, and peach in the Beqa'a plain, Lebanon, are shown in Tables 4-10. Photomicrographs of the buds observed in the study are presented as Figures 1-48. Detailed observations of the structure of buds, their pattern of development, and the pattern of color absorption by the parts of the buds are given for each type of bud according to type of fruit plant and by location of bud on the tree. Only those buds suggested by Gardner *et al.* (24, p 545) as having fruiting capability were selected.

Results

Sour cherry

Lateral bud from shoot. As the name suggests, this bud develops along the axis of shoots, excluding terminal point of the shoot. The sections obtained from the earliest part of this study showed that the meristematic cells of the apex of the bud followed a tunica-corpus arrangement. The number of tunica-corpus organized layers was three and a mass of irregularly arranged polygonal meristematic cells had filled the inner curvature of the

layers thus forming the undifferentiated part of the corpus. These two parts absorbed green color mainly. Immediately below the undifferentiated part of the corpus, some scattered cells with purple color were present indicating the trace of differentiation which had already started. About 60 cells below the apex, the beginning of differentiation of vascular bundles could be seen. Usually about seven layers of cells covered the apex of the bud (Figures 1, 2, 3).

The coloring pattern of this bud was:

1 - Green: cell walls and the new mass of meristematic cells on the apex.

2 - Purple: newly differentiated cells, and the content of the older cells.

3 - Reddish purple: the dried or semi-dried parts of the external side of the scales and hairs.

As the season advanced, new scale initials appeared all around the terminal part of the bud and gradually became longer. In many cases the central part which contained the main growing point was no more than 15 cells wide. In some cases, some structures developed on the apex. Though they were similar to fruit bud initials, they never developed into fruit buds. It seemed, however, that apparently some dynamic equilibrium, which was the resultant of the effects of many acting factors, kept the general trend of the development under its own influence.

The potentiality for changing into fruit buds was detectable in many cases.

About July 15, though not showing fruit bud initiation, some buds had a wide apex, indicating that a new trend of development, which topographically was different from before, had started.

Since the sampling method was not a continuous one, i.e., there was an interval of two weeks between each two sampling dates, continuous following of the changes was not possible. However, among the samples taken on July 29, some were containing fruit initials, indicating that between July 15, 1966 and July 29, 1966 fruit bud initiation had taken place in the lateral buds from shoots of the Early Richmond variety of sour cherry (Table 4).

Terminal bud from shoot. This bud was collected from the tip of shoots which existed either as a single bud at the base of a small terminal leaf or among a group of three buds interconnected at the base. The single buds were very delicate and in an immature state.

Similar to others, the layer of procambium divided the main body of the bud into two distinct regions; a central region, and a peripheral one. There was a continuity between the cells of apical meristem with those of central region on the distal part of the bud along which a general increase in differentiation could be observed toward the center of the bud. The disappearing ends of the procambial

Table 4. Number of flower buds initiated in "Early Richmond" sour cherry, 1966.

Date	Number of initiated buds/number of observed buds				
	Lateral bud from shoot	Terminal bud from shoot	Terminal bud from vegetative spur	Terminal bud from fruiting spur	Terminal bud from flowering non-fruiting spur
July 1	0/3	0/3	0/3	0/3	0/3
July 15	0/2	0/2	0/3	0/3	0/3
July 29	1/2	0/2	0/3	0/3	0/3
Aug. 12	1/3	2/4	0/3	0/3	2/3
Aug. 26	2/3	2/4	0/2	2/3	2/3
Sept. 9	0/3	2/4	1/3	0/3	1/2
Sept. 23	3/3	2/3	2/3	1/3	1/2
Oct. 7	3/3	0/2	0/3	2/3	0/3

strands could be seen close to this region. A layering trend similar to those of tunica-corpus organization, consisting of three layers, gradually appeared on the most external part of the apex. From these, the two first ones could be considered as tunic and the inner one as the only organized layer of corpus. These three layers could be seen on fruit primordia when initiation occurred. The apex in the later stages were dome-shaped with cells much smaller than those of central region of the bud. The prominent characteristics of the central region of the bud were the large size of cells, uniformity in shape, and horizontal direction of the cells, thus perpendicular to those of procambium. The cells of procambium were narrow, elongated, and oriented parallel to the main axis of the bud (Figures 4, 5, 6).

The pattern of color absorbing quality was approximately similar to those of the lateral bud from shoot. Meristematic parts, however, were lighter in color. They were more toward light green compared to other parts which tended to be blue in color.

The buds, particularly those single ones which were collected from shoot tips at the base of a terminal leaf, were in an immature condition. The apex in the earlier stage was narrow, not too dome-shaped and was covered rather closely with young scale primordia. Such condition could be seen even on July 15. Later, scale primordia

acquired a rather erect position and the apex became dome-shaped. Gradually, scale primordia of different physiological age could be seen around the apex. Sometimes the strands of procambium tended to go toward the second depression of climax, between the two youngest rings of scale primordia. Furthermore, branching of procambium sometimes took place toward the second depression of the apex but without reaching it.

In the samples taken on August 12, fruit bud initiation had occurred (Table 4). There were two rectangular outgrowths with a rather simple organization on the apex. Only one layer of organized cells similar to a one-layer tunica, or protoderm, and some continuity of cell arrangement either from inside the fruit primordia toward the terminals of procambium strands or from one fruit primordium to the other could be observed as indications of developments. Observation indicated that fruit bud initiation of the terminal bud from shoot belongs to Early Richmond variety of sour cherry occurred between July 29 and August 12, 1966.

Terminal bud from vegetative spur. Buds were not single. They were in groups of two to five. They seemed to be more advanced in their state of development. About five to seven rows of scales had fully covered the apex and two to three rows of less matured ones were present inside the cover, around the apex. The same organization

pattern; a central region, a procambium layer, and a peripheral region existed in this case too. Many cells contained crystals of calcium oxalate in the scale primordia. After August 12, the appearance of new and bigger crystals, stronger procambium and wider surface of apex became more and more prominent toward the time of initiation (Figures 7, 8, 9).

From the beginning of the study until about the middle of August, this bud seemed to be in a very active condition of development. The prominent observable features of such a condition were production of more and more leaf scales and differentiation and distribution of a more developed procambial system. About August 26 a new pattern of development and organization was observed in the bud followed by the appearance of a pair of fruit primordia in the bud samples belonging to September 9 (Table 4). This, however, indicated that the approximate date for fruit bud initiation of this kind of bud was between August 26, and September 9, 1966.

Terminal bud from fruiting spur. Buds were mostly in groups of two to three individuals frequently forming a bunch on the growth of the year before. Inspite of being in a bunch, still the terminal bud had maintained its unique characteristics and made it possible to distinguish between this bud and others in the bunch. General organization of the bud was similar to the others. In

total, five rows of scales, either mature or immature, had surrounded the central part of the apical meristem (Figures 10, 11, 12).

This bud did not seem to be too active in the beginning of summer. However, this condition changed slightly around the middle of July. Observations on July 29 again showed some calmness in the events and activities of the meristematic surface. Samples taken on August 26, showed that initiation had taken place (Table 4). There were two fruit primordia formed in each individual bud. The date of sampling indicated that a period from August 12 to August 26 could be considered as a period during which initiation of terminal bud from fruiting spur took place in the case of the Early Richmond variety of sour cherry in 1966.

Terminal bud from flowering non-fruiting spur. Again in this case, similar to the case of terminal bud from fruiting spur, the buds were either in a group or they were single. When in groups, the number of buds was not more than two to three per group. In the beginning of the summer, the surface of apical meristem contained many scale initials which gradually moved to the sides of it. Five to six scales of different age had covered the bud. Two deep depressions were seen at two sides of the bud on the base. Apex was comparatively wide and calm on July 29, about a week before initiation took place (Figure 13, 14, 15).

The trend of "slow-down" in observable activity of the bud was apparent from the Middle of July. This trend was detectable in terms of scale number, smoothness of the surface of apical meristem, and the width of apex between the youngest scale primordia which had surrounded it. Beginning in the middle of July, it seemed that the bud was not as active as before. Observation on July 29 showed a comparative smoothness of apical meristem's surface which was wider at that time. Observation on August 12 showed a pair of fruit primordia on the apex, an indication of fruit initiation between July 29, and August 12 (Table 4).

Sweet cherry

Terminal bud from vegetative spur. Buds were comparatively large and rather elongated with small compact cells and little effect of crystals. Only a small portion of apical meristem was free and two layers of organized cells could be seen along its outer surface. Thick young scales had covered the apex (Figures 16, 17, 18).

The bud showed more tendency in color absorption toward light blue-green. Dry endings of scales were red.

This bud did not seem to be too active. Yet the development of procambial strands and appearance of some crystals particularly in the central region of the bud were prominent. Samples taken on July 15 showed fruit bud

initiation, an indication of the process taking place between July 1, and July 15, 1966 (Table 5). There were two fruit primordia per bud and the indication of a third one could also be detected. The fruit primordia did not have contact with each other and with the scales. At this stage there were two rows of young scales inside the bud and four rows of matured scales had covered the apex completely.

Terminal bud from flowering non-fruiting spur. Buds were rather large and elongated. Five rows of complete scales had covered them. Apex was dome-shaped with a ring of depression around it. The disappearing end of procambial strands could be seen below the apical meristem (Figures 19, 20, 21).

Initiation of fruit primordia was observed in the samples collected on July 15 (Table 5). There were two fruit primordia per bud. The trend of tunica-corpus organization could be detected below the surface of the initials. The bundles of procambium could be seen distributed between the initials. There were some crystals-containing cells scattered throughout the central region of the bud. At this stage six rows of scales had provided covering for the bud over meristematic initials.

Apple

Lateral bud from shoot. Longitudinal sections of this bud showed an organization similar to those of

Table 5. Number of flower buds initiated in "Gold" sweet cherry, 1966.

Date	Number of initiated buds/number of observed buds	
	Terminal bud from vegetative spur	Terminal bud from flowering non-fruiting spur
July 1	0/3	0/3
July 15	1/3	1/3
July 29	1/3	1/3
Aug. 12	0/3	0/3
Aug. 26	0/3	0/3
Sept. 9	1/3	0/3
Sept. 23	0/3	1/3
Oct. 7	0/3	1/2

cherries; a central region, a layer of procambium, and a peripheral region. The meristematic area at the distal part of the bud seemed to be very shallow compared to what was seen in the case of the cherries. At the level of apical meristem, not many morphologically observable differences could be seen between the cells of meristematic area and the cells just below them in the central region. Apical meristem seemed to be very calm and immature in the beginning. Topographically it was very smooth and rather round. Only one layer of organized cells could be detected on the uppermost part of the apex.

Three to four rows of scales had covered the bud in the beginning of the summer. However, neither the number of organized cell layers nor the number of scales remained stable; the number of organized cell layers reached three on September 9 and the scale numbers showed fluctuation between three to five. Many crystal-containing cells, even in the scales, could be observed (Figure 22). In the beginning of the season this bud did not appear to be active; formation of scale primordia proceeded at a very slow rate and no important change on the smooth surface of apex or in the strands of procambium was observed. Before initiation, however, which was observed on September 23 (Table 6), there were three organized layers of cells present. According to the data, initiation of this bud took place between September 9 and

Table 6. Number of flower buds initiated in Starking Delicious apple, 1966.

Date	Number of initiated buds/number of observed buds				
	Lateral bud from shoot	Terminal bud from shoot	Terminal bud from vegetative spur	Terminal bud from fruiting spur	Terminal bud from flowering non-fruiting spur
July 1	0/3	0/2	0/2	0/2	0/2
July 15	0/3	0/2	0/2	0/2	0/2
July 29	0/2	0/2	0/2	0/2	0/2
Aug. 12	0/2	0/2	0/3	0/2	0/2
Aug. 26	0/2	0/2	0/3	0/2	1/2
Sept. 9	0/2	0/2	1/2	0/2	0/2
Sept. 23	1/2	0/2	2/2	0/3	0/3
Oct. 7	0/3	0/2	2/3	0/2	1/3

23.

Terminal bud from shoot. Although this bud was one of the biggest buds the apical meristem was comparatively shallow. Even about August 26, no important activity was seen in this bud. Meristem was calm and contained not more than two to three rows of scales. The few young scale primordia which were present in the later stage of development did not grow fast enough to provide a good cover for the bud. About September 23, some more activity was seen as increase in the number of young scale primordia and branching of procambial strands which were scattered throughout the central region of the bud. This bud, however, did not initiate fruit primordia (Table 6). On the contrary, when some other buds had undergone inductive changes this bud had newly started forming new scales (Figure 23).

Terminal bud from vegetative spur. These were big buds and were collected from those spurs which had not already produced either flower or fruit. They had at least four rows of scale initials and about two layers of mature scales which had completely covered the bud. They had the general organization of buds, i.e., a central region, a procambium layer, and a peripheral region. Central region was elongated, formed of irregularly arranged cells many of which contained crystals. Procambial strands were similar to two comparatively parallel lines which continued close to the wall of buds with the distal

part disappearing under the apical meristem. Apical meristem was a thin layer of cells covering the distal part of the central region of the bud (Figures 24, 25, 26).

Formation of new scales was continued during the part of development which ended in initiation. On August 12 a small depression on the apex was seen. Nothing was different on August 26, two weeks before initiation. Samples taken on September 9, contained fruit primordia as indication of initiation between August 26 and September 9 (Table 6). Initiated buds had a compound structure. A pyramid-shaped outgrowth was formed on the apex of the bud over which three fruit primordia and eight leaf primordia had developed. Procambial strands had entered the pyramid-shaped outgrowth and were branched between the primordia either leaf or fruit. Many crystal-containing cells were seen in the pyramid-shaped outgrowth. The scale cover was not too strong; about one or two layers.

Terminal bud from fruiting spur. This was a very large bud compared to the others. Much of this feature was due to the contribution of a large and elongated central region, but meristematic area was very shallow. Apex, with one layer of organized cells, was covered by three rows of complete scales. Four rows of young scale primordia were also present; a total of seven layers of scales in different physiological age.

Formation of new scales continued throughout the

summer. The strong strands of procambium entering the scales and the presence of many crystal-containing cells were observed. By September 23, three layers of organized cells were seen on the apex. No further change was observed during the study (Figure 27) and no initiation took place (Table 6).

Terminal bud from flowering non-fruiting spur. This bud in general, was very large due to the length of the central region of the bud. The meristematic area was shallow and was formed of small cells which were in a very latent condition. The central region had many differentiated cells. The scales had densely surrounded the apex although the cover that the matured scales had provided was rather thin (Figures 28, 29, 30).

In the beginning of the summer, formation of new scales continued at a very slow rate. This trend, however, did not last too long, and from the end of July until the end of August it was a very actively developing bud. Samples taken on August 26 contained fruit primordia, an indication that fruit bud initiation had taken place between August 12 and 26 (Table 6). The fruiting cones and fruit primordia were similar to those of terminal buds from vegetative spurs.

Pear

Terminal bud from shoot. The organization of this bud showed three distinct areas in the main body of the

bud; a central region, a procambium layer, and a peripheral region. The meristematic area, covering the distal part of the bud, was a very shallow layer; its thickness did not exceed more than six to seven cells at the apex. Only one or two layers of scales covered the apical meristem. No organized layer of cells was observed in the early stage (Figures 31, 32).

In the beginning of summer the scales had rather bent on the apical meristem, but gradually they acquired an erect and finally a radial position. The number of scales increased to four layers, which covered the top of the bud completely. Other than this, no more activity was seen on the surface around the apex until August 12. During this time, some more crystals appeared in many cells. The samples collected on July 15 showed fruit bud initiation (Table 7). A pyramid-shaped outgrowth similar to those of apple was developed on the apex with three fruit initials and six leaf initials. At this time three layers of scales had covered the top of the bud.

Terminal bud from vegetative spur. Buds collected on the first sampling time, July 1, contained fruit primordia (Table 7). Three fruit and six leaf initials were present on the fruiting cone. Furthermore, three layers of organized cells were clearly observed on the initiated parts and six layers of scales had completely covered the bud (Figures 33, 34).

Table 7. Number of flower buds initiated in "Duchess" pear, 1966.

Date	Number of initiated buds/number of observed buds		
	Lateral bud from shoot	Terminal bud from vegetative spur	Terminal bud from flowering non-fruiting spur
July 1	0/3	2/3	1/3
July 15	1/2	1/2	1/2
July 29	0/2	2/2	1/2
Aug. 12	1/2	3/3	1/2
Aug. 26	1/2	2/2	2/2
Sept. 9	2/2	2/2	3/3
Sept. 23	2/2	2/2	1/2
Oct. 7	2/2	2/2	2/2

Terminal bud from flowering non-fruiting spur. Initiation had taken place in the samples collected on July 1 (Table 7). The type of fruiting cone was similar to that of the terminal buds from vegetative spurs. There were many hollow cells in the central part of the pyramid-shaped fruit-bearing outgrowth. This could be interpreted that initiation had occurred at least two weeks prior to July 1 (Figures 35, 36, 37).

Plum

Lateral bud from shoot. Buds were very small and usually in groups of two or three buds. Cells in outer layers were very small compared to those of the central region. Three layers of organized cells were seen on the apex which was about 20 cells above the endings of the procambial strands. Three rows of mature scales had covered the bud (Figures 38, 39).

This bud had a very good quality of color absorption. Blue and purple colors were dominant. Procambial strands were reddish and the meristematic area around the apex was dark purple. Outer scales were blue and the central region of the bud was light blue to light purple in color.

A continuous formation of new scale primordia was observed clearly and simultaneously, the strands of procambium became more prominent beneath the apex. On August 26, a slight leveling on the apex was observed and finally on

September 9 initiation occurred (Table 8). There was only one fruit primordia per bud.

Terminal bud from vegetative spur. Buds were mostly in groups of three individuals with close structural similarity to lateral bud from shoot. Apex was dome-shaped and very small in size. Three layers of organized cells were present on the apex and apex was surrounded by four rows of scales (Figures 40, 41, 42).

Until July 29, the prominent developmental feature of this bud was formation of new scales, but on July 29, an upward hill-shaped growth on the apex was observable. Samples collected on August 12 contained fruit primordia (Table 8). There were, usually, two fruit primordia per bud and six rows of scales had provided a complete cover for the bud at the stage of initiation.

Terminal bud from flowering non-fruiting spur. Buds were very small, round, and mostly single. The apex was rather dome-shaped and covered by four layers of scales. Two layers of organized cells were observed on the apex of the bud (Figures 43, 44, 45).

This bud was not an actively growing one. Even when initiation occurred there could be observed no other changes in the bud compared to its condition in the start of the study. Samples taken on July 29 contained fruit primordia (Table 8). At this time five rows of scales had covered the bud.

Table 8. Number of flower buds initiated in "Purple Plumcot" plum, 1966.

Date	Number of initiated buds/number of observed buds		
	Lateral bud from shoot	Terminal bud from vegetative spur	Terminal bud from flowering non-fruiting spur
July 1	0/2	0/2	0/3
July 15	0/2	0/3	0/3
July 29	0/2	0/2	1/3
Aug. 12	0/2	1/2	0/3
Aug. 26	0/2	1/3	0/2
Sept. 9	1/2	0/2	0/2
Sept. 23	1/2	2/2	0/2
Oct. 7	2/2	2/2	3/3

Peach

Lateral bud from shoot. Buds were comparatively small and elongated with compact and well-formed cells. Apex was dome-shaped. The strands of procambium disappeared rather far from the apical meristem. Many cells contained crystals and four to six rows of scales had covered the bud (Figures 46, 47, 48). Buds were mostly in groups of three individuals.

The number of scales did not increase prominently in the beginning of the summer but this trend changed later. The apex gradually showed some swelling and finally initiation was observed on August 12 (Table 9). In the first sample of this date only the middle bud in a three-unit group of buds had initiated. Many individual buds contained three fruit initials. Even initiation of sepal and petal could be observed in the samples of later stage.

Discussion

Structure of fruit bud

Observations showed that the same organization which exists in stems of fruit trees under the study, i.e., two main divisions separated by a cylinder of cambium, exists for their buds but in an immature form and with the apical meristem constituting the distal part of it. The strands of vascular bundles, formed of narrow elongated

Table 9. Number of flower buds initiated in "July Elberta" peach, 1966.

Date	Number of initiated buds/number of observed buds lateral bud from shoot
July 1	0/3
July 15	0/3
July 29	0/3
Aug. 12	1/3
Aug. 26	1/3
Sept. 9	1/2
Sept. 23	2/2
Oct. 7	2/3

cells and paralleling the sides of the buds, usually are oriented toward the youngest scale primordia which are mostly present in a semi-circular pattern around the apex. When the apex, the main active part of the bud, is in a latent state it is narrow in width. The disappearing ends of the procambium extend the continuity of the general layer of cambium to just under meristematic zone. As the season proceeds, the apex increases its activity either forming new scales or fruit primordia. Fruit primordia are formed directly on the apex in the case of stone fruits, but on a fruiting cone, extending from the apex, in the case of pome fruits. In either case, procambium establishes its continuity after branching into the individual scales or fruit primordia.

Though the developmental pattern of buds was not followed specifically, in many cases prominent layers of one, two, or three cell thicknesses were observed as the uppermost layer of the promeristem of the apex. The layers were similar to those described for structures having a tunica-corpus organization. The significance of such layering and the interpretation of the developmental pattern of the buds under study based on the tunica-corpus theory calls for a more comprehensive ontogenic study (26).

Time of fruit bud initiation

Due to the differences in environmental factors, no two localities can be expected to have the same time of

starting flower bud initiation for the same variety of fruit tree. In other words, the differences observed in the time of flower bud initiation of similar varieties of fruit trees in dissimilar areas are reflections of differences in climatic and environmental factors. Varietal characteristics, however, set certain limits for such variations.

A compilation of data was made in order to provide a basis for at least a rough comparison between Lebanon and those states of the United States of America whose data regarding fruit bud initiation was given by Gardner et al. (24). According to these informations and those presented in Tables 1 and 2, Beqa'a plain which in this part is referred to as "Lebanon", is drier, more windy, and mostly higher in elevation compared to Wisconsin, Iowa, Oregon, Virginia and Georgia and somewhere between Wisconsin and Virginia in respect to temperature. There are evidences, however, that the general picture of climatic conditions in Lebanon has some closer similarities to those of Wisconsin.

Cherries

As the data show (Tables 4 and 5), buds located anywhere on both sour and sweet cherries could produce fruit buds. However in the sour cherry initiation of floral buds did not occur simultaneously in all localities; the lateral buds from shoots were the first to show initiation on July 29, followed by terminal buds from shoots and from

flowering non-fruiting spurs on August 12, terminal buds from fruiting spurs on August 26, and finally terminal buds from vegetative spurs on September 9. Such a trend shows some common characteristics with that suggested by Childers (10) according to which lateral buds are considered to be the main fruit producing units of sour cherries. The sweet cherry, however, initiated fruit buds simultaneously in terminal buds from vegetative spurs and terminal buds from flowering non-fruiting spurs on July 15.

In Lebanon with July 15 as the starting time of fruit bud initiation, the sweet cherry has shown to be approximately similar to sweet cherries in Wisconsin where the date of flower bud initiation was July 11 for King's Amarelle variety but rather later compared to Virginia with date of initiation June 30. This can be attributed to the rather earlier spring in Virginia, varietal differences, and other differences whose pattern of action is not known.

Apple

In apple, the first buds to show initiation were terminal buds from flowering non-fruiting spurs on August 26, followed by terminal buds from vegetative spurs on September 9, and lateral buds from shoots on September 23. The terminal buds from shoots and terminal buds from fruiting spurs failed to initiate floral parts (Table 6).

As is seen, there is a delay in the time of fruit

bud initiation in Lebanon compared to those of Virginia, June 20 for Oldenburg apple; of Wisconsin, June 30 for Hoadley apple; of Iowa, July 1; and of Oregon, first ten days of July. Such a delay can be attributed to the fact that both Oldenburg and Hoadley are early and hardy varieties and need much shorter time before maturation and before starting dormancy compared to Starking Delicious which has higher requirements of temperature and growing season. It is known that the first two varieties mature their crop from 1.5 to 2 months earlier than Starking Delicious. Therefore, it is logical to expect a somewhat similar trend in their other developmental patterns including differentiation of floral parts. The facts that are additive to the above reasoning is that in Wisconsin, for example, though the growing season is limited by the cool weather of May in the beginning and the early frosts of fall at the end, higher night temperatures and longer day length during summer months meet the thermal requirement within the short period of growing season. This is somewhat different in Lebanon with a longer growing season.

Pear

In the first samples taken on July 1 the initiation of fruit buds of pear had already taken place in terminal buds from vegetative spurs and terminal buds from flowering non-fruiting spurs. Therefore, it is apparent that these

kinds of buds initiate their flower buds in June in Lebanon. Terminal buds from shoots showed initiation later on July 15 (Table 7). These results are in close agreement with those given by Gardner et al. (24) which indicated that the middle of July for the Kieffer variety in Virginia and July 21 for the Wilder Early variety in Wisconsin were the dates of fruit bud initiation. These results, however, suggest that pear must be less responsive to slight climatological variations than apple. This conclusion agrees with descriptions given by Childers (10).

Plum

In plum, terminal buds from flowering non-fruiting spurs were the first to show initiation, on July 29. Initiation in terminal buds from vegetative spurs followed on August 12 and in lateral buds from shoots on September 9.

There is relatively little difference between the time of differentiation of floral parts of plum in Lebanon, July 29 (Table 8), and those of Wisconsin, August 9 for Aitken plum and July 8 for Rollingstone (24). The difference between the time of fruit bud initiation of Rollingstone and Aitken plum in the same state, i.e., Wisconsin, provides a very clear example of the effect of varietal differences on the time of flower bud initiation.

Peach

In this study only one type of peach bud was used since it was known that peach bears most of its fruits on one type of buds, the lateral buds from shoots (24). The study showed that in Lebanon fruit bud initiation starts in peach during the period between July 29 and August 12.

A comparison between the starting time of flower initiation of peach in Lebanon with that of Wisconsin, which is the middle of September for the Bokhara variety (24), shows that initiation occurs 1.5 months earlier in Lebanon. This, in addition to the varietal differences, can be attributed to the nature of the peach tree. According to Childers (10), although peaches can be grown in apple areas, the southern boundary of its distribution is closer to the equator than that of apples. Peach has less requirement for cold and is more tolerant to heat. In addition, peach is frequently injured by the cold winter temperatures in Wisconsin. This is the reason, apparently, that peach growing in Wisconsin is very limited.

The overall picture of flower bud initiation in Lebanon is presented in Table 10.

Table 10. The time of first observed fruit bud initiation in different buds of apple, pear, plum, peach, sweet cherry, and sour cherry in the Beqa'a plain, 1966.

Tree	Variety	Lateral bud from shoot	Terminal bud from shoot	Terminal bud from vegetative spur	Terminal bud from fruiting spur	Terminal bud from flowering non-fruiting spur
Apple	Starking Delicious	Sept. 23	No initiation	Sept. 9	No initiation	Aug. 26
Pear	Duchess	-	July 15	July 1	-	July 1
Plum	Purple Plum Cot	Sept. 9	-	Aug. 12	-	July 22
Peach	July Elberta	Aug. 12	-	-	-	-
Sweet cherry	Gold	-	-	July 15	-	July 15
Sour cherry	Early Richmond	July 29	Aug. 12	Sept. 9	Aug. 26	Aug. 12

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The date of the first observable initiation of fruit buds was measured under the condition of the AREC using the trees of the variety orchard as material. Bi-weekly sampling was made starting July 1, 1966 for each of the following trees; apple (Var. Starking Delicious), pear (Var. Duchess), plum (Var. Purple Plumcot), peach (Var. July Elberta), sweet cherry (Var. Gold), and sour cherry (Var. Early Richmond).

In the apple, terminal buds from flowering non-fruiting spurs were the first to show initiation of flower buds (August 26). Terminal buds on vegetative spurs and lateral buds from shoots started differentiation approximately September 9 and September 23 respectively. Terminal buds from shoots and terminal buds from fruiting spurs failed to initiate flowers.

In the pear, terminal buds from vegetative spurs and terminal buds from flowering non-fruiting spurs had started initiation by July 1, when the first sampling was made. Terminal buds from shoots showed initiation in the July 15 sampling.

Plum initiated floral buds in terminal buds from flowering non-fruiting spurs between July 15 and July 29. Terminal buds from vegetative spurs and lateral buds from

shoots showed initiation in buds collected on August 12 and September 9 respectively.

Peach initiated its flower buds in the first weeks of August in lateral buds collected from shoots.

Sweet cherry flower buds were first seen in terminal buds from vegetative spurs and terminal buds from flowering non-fruiting spurs collected on July 15.

In the case of sour cherry, the first initiation occurred in lateral buds from shoots between July 15 and July 29. Terminal buds from shoots and terminal buds from flowering non-fruiting spurs initiated flower buds shortly before August 12. Terminal buds from fruiting spurs and terminal buds from vegetative spurs showed initiation had occurred in samples collected on August 26 and September 9 respectively.

The primary sites of fruiting of apples, pears, and plums are the terminal buds on spurs which did not flower the previous year (vegetative spur). Peach fruit buds are borne laterally on past season's growths. Fruit buds of sour cherries are borne laterally on shoots of past season's growth, but the experiment failed to identify the major sites of fruiting on sweet and sour cherry.

In general, fruit buds have been initiated by July 15 in pear and sweet cherry, July 29 in sour cherry, August 12 in plum and peach, and August 26 in apple in the primary sites of fruit bearing. After these dates,

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A P P E N D I X

Figure 1. Sour cherry lateral bud from shoot, before flower initiation. Aug. 12, '66 (x270)

Figure 2. Sour cherry lateral bud from shoot, first observed indication of flower initiation. Aug. 12 '66 (x270)

Figure 3. Sour cherry lateral bud from shoot, completed initiation. Sept. 23, '66 (x270)

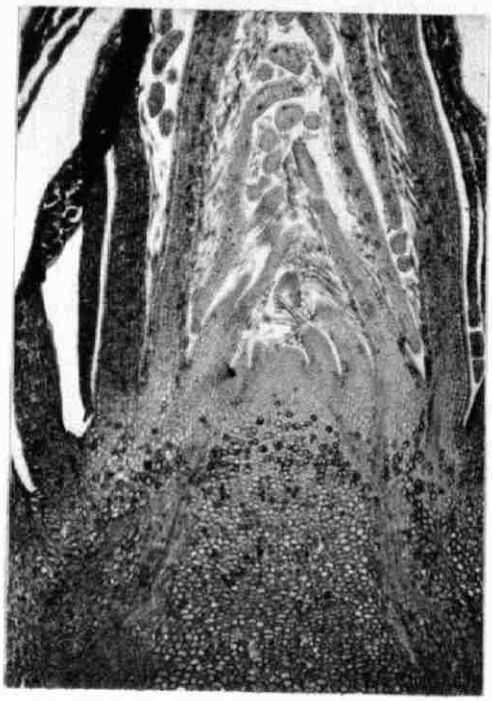

Figure 1

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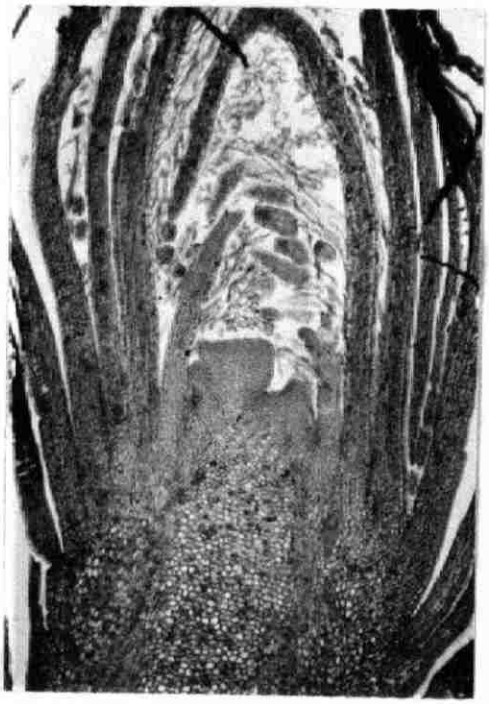

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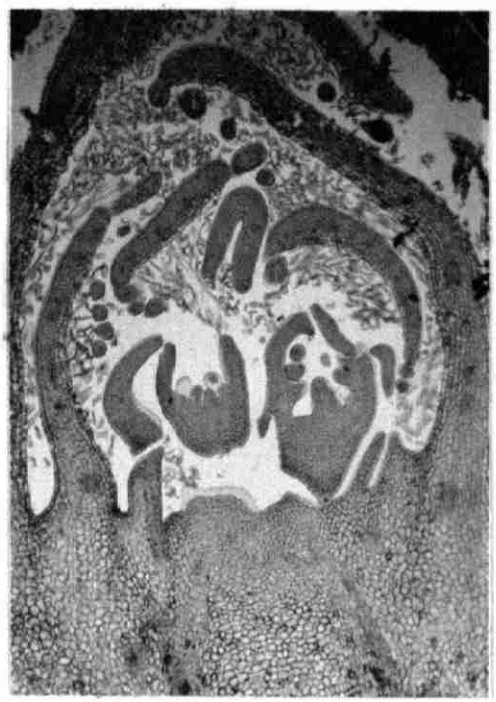

Figure 4. Sour cherry terminal bud from shoot, before flower initiation. July 29, '66 (x270)

Figure 5. Sour cherry terminal bud from shoot, first observed indication of flower initiation. Aug. 12, '66 (x270)

Figure 6. Sour cherry terminal bud from shoot, completed flower initiation. Sept. 23, '66 (x270)

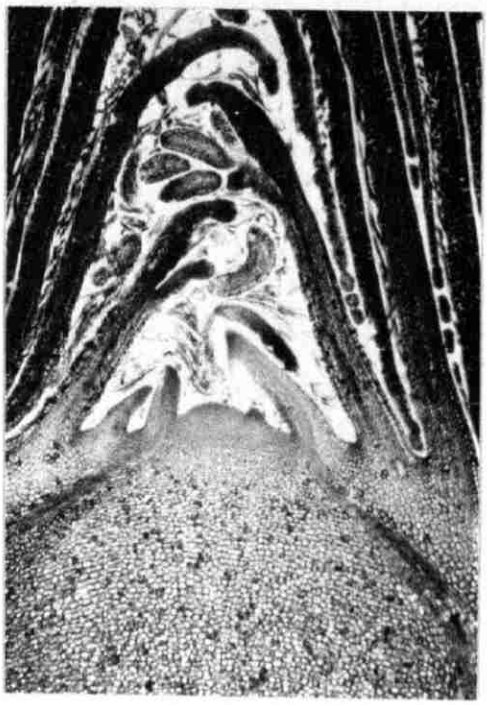

Figure 4

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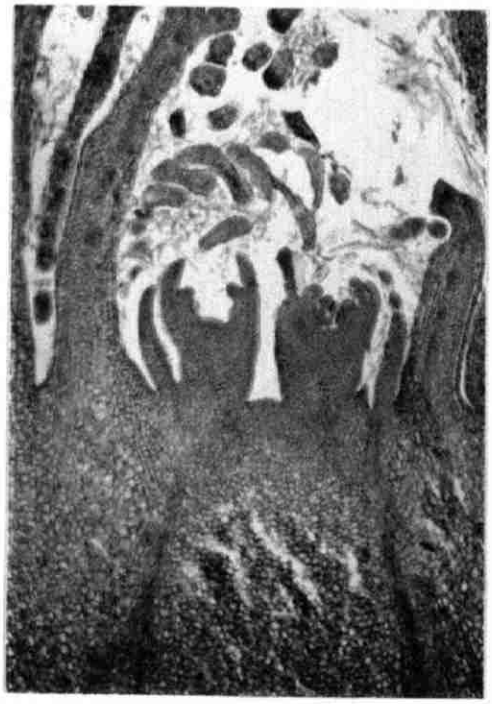

Figure 7.- Sour cherry terminal bud from vegetative spur, before flower initiation. July 15, '66 (x270)

Figure 8. Sour cherry terminal bud from vegetative spur, first observed indication of flower initiation. Sept. 9, '66 (x270)

Figure 9. Sour cherry terminal bud from vegetative spur, completed flower initiation. Sept. 23,'66 (x270)

Figure 7

Figure 8

Figure 9

Figure 10. Sour cherry terminal bud from fruiting spur, before flower initiation. July 29, '66 (x270)

Figure 11. Sour cherry terminal bud from fruiting spur, first observed indication of flower initiation. Aug. 26, '66 (x270)

Figure 12. Sour cherry terminal bud from fruiting spur, completed flower initiation. Oct. 9, '66 (x270)

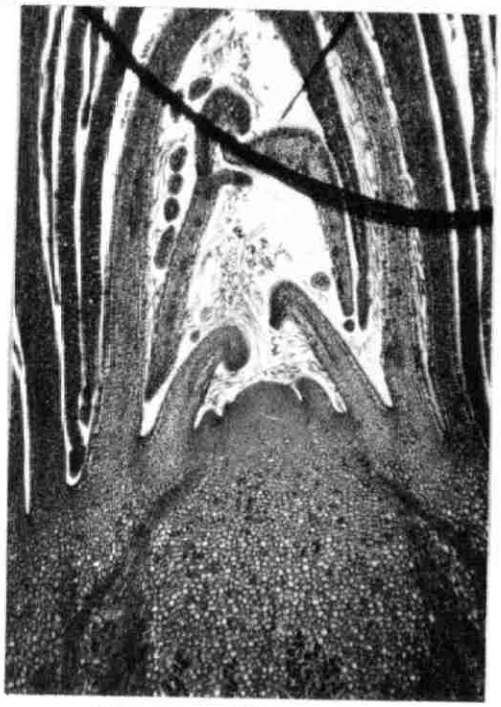

Figure 10

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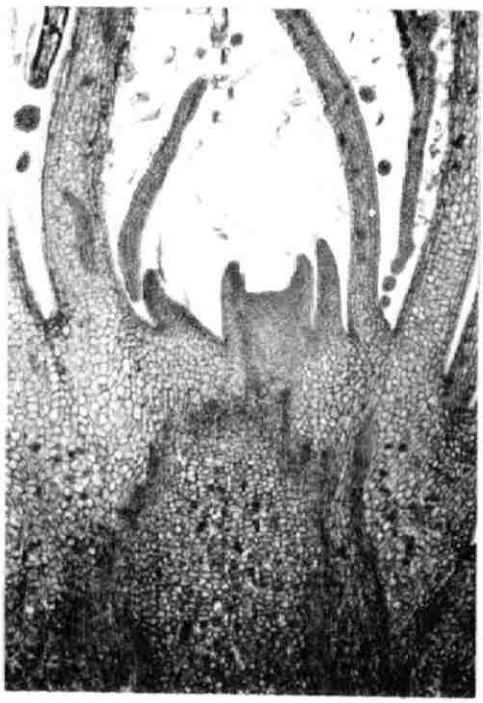

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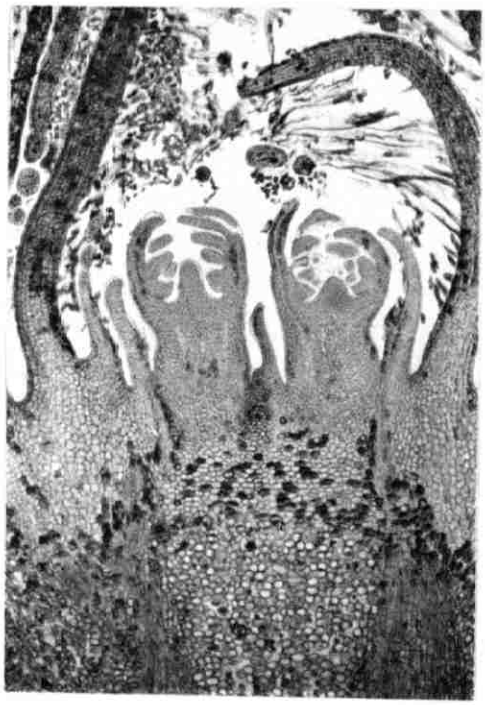


Figure 13. Sour cherry terminal bud from flowering non-fruiting spur, before flower initiation. July 29, '66 (x270)

Figure 14. Sour cherry terminal bud from flowering non-fruiting spur, first observed indication of flower initiation. Aug. 12, '66 (x270)

Figure 15. Sour cherry terminal bud from flowering non-fruiting spur, completed flower initiation. Aug. 26, '66 (x270)

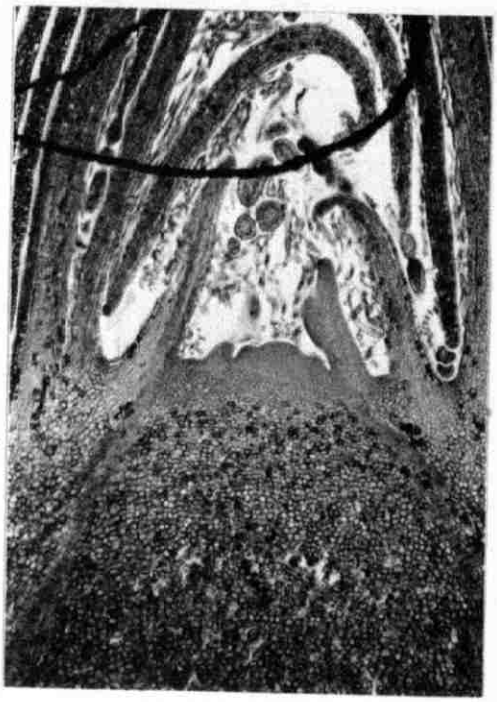
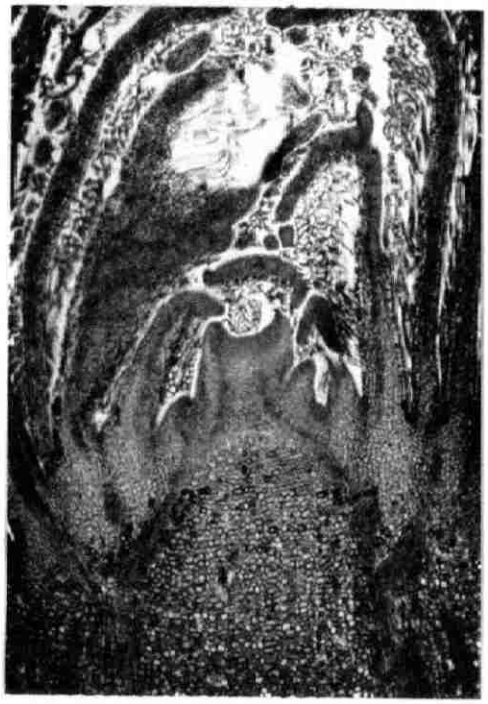


Figure 13

Figure 14



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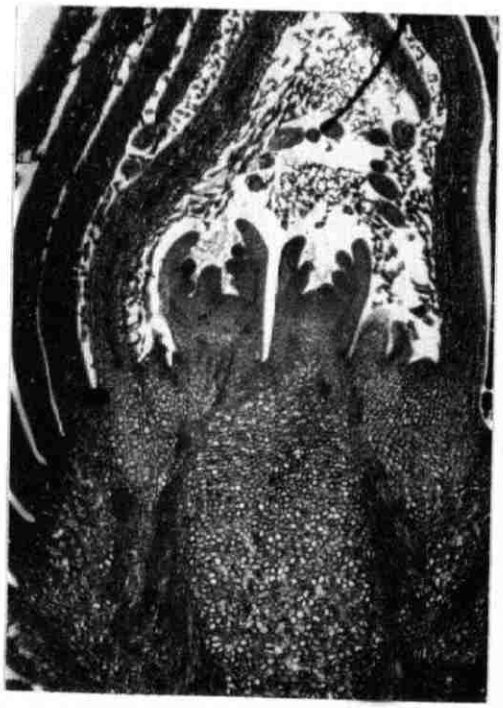

Figure 16. Sweet cherry terminal bud from vegetative spur, before flower initiation. July 15, '66 (x270)

Figure 17. Sweet cherry terminal bud from vegetative spur, first observed indication of flower initiation. July 29, '66 (x270)

Figure 18. Sweet cherry terminal bud from vegetative spur, completed flower initiation. Sept. 9, '66 (x270)

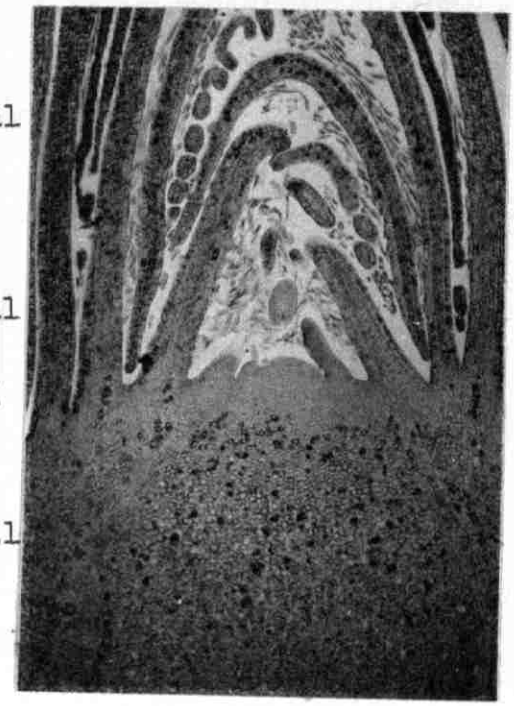

Figure 16

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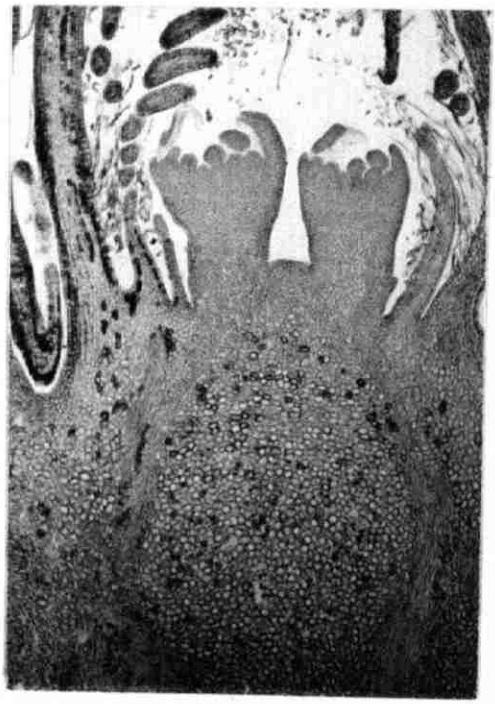


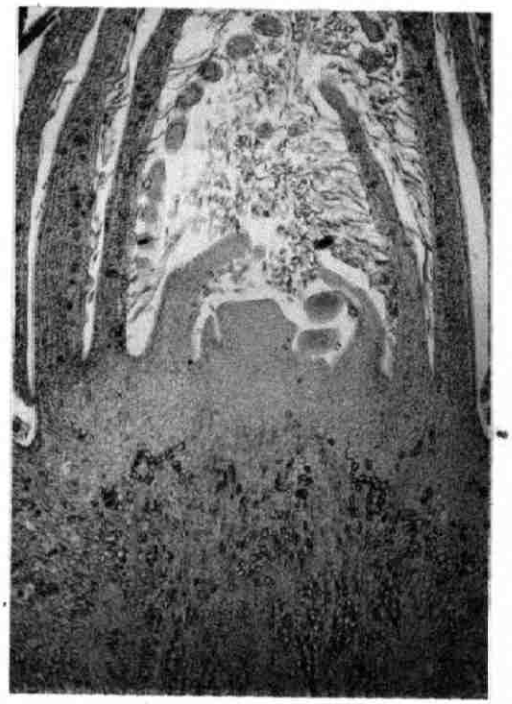
Figure 19. Sweet cherry terminal bud from flowering non-fruiting spur, before flower initiation. July 1, '66 (x270)

Figure 20. Sweet cherry terminal bud from flowering non-fruiting spur, first observed indication of flower initiation. July 29, '66 (x270)

Figure 21. Sweet cherry terminal bud from flowering non-fruiting spur, completed flower initiation. Sept. 23, '66 (x270)

Figure 19

Figure 20



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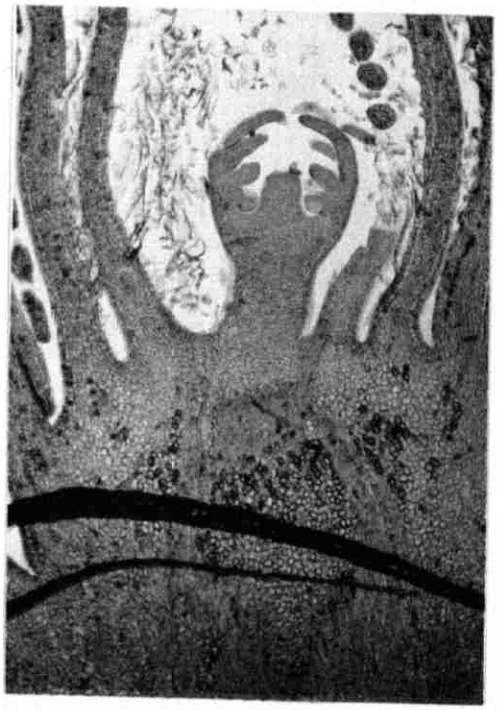


Figure 22. Apple lateral bud from shoot, before flower initiation. July 29, '66 (x220)

Figure 23. Apple terminal bud from shoot, no flower initiation. Aug. 26, '66 (x220)

Figure 24. Apple terminal bud from vegetative spur, before flower initiation. Aug. 26,'66 (x220)

Figure 22

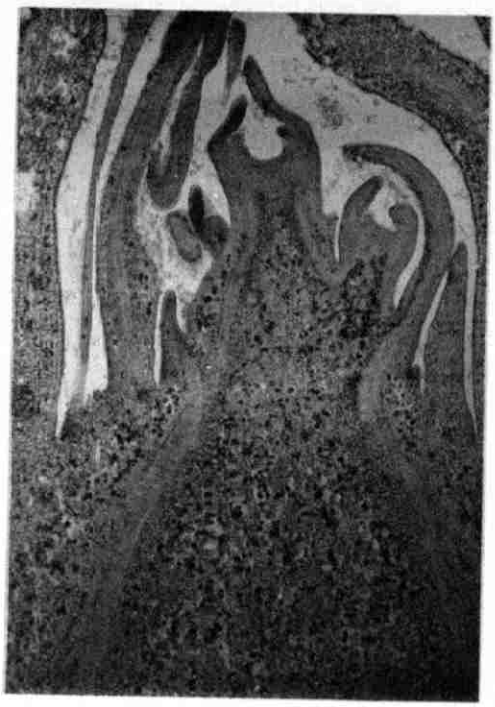
Figure 23

Figure 24

Figure 25. Apple terminal bud from vegetative spur, first observed indication of flower initiation. Sept. 23, '66 (x220)

Figure 26. Apple terminal bud from vegetative spur, completed flower initiation. Oct. 7, '66 (x220)

Figure 27. Apple terminal bud from fruiting spur, no flower initiation. July 15, '66 (x220)



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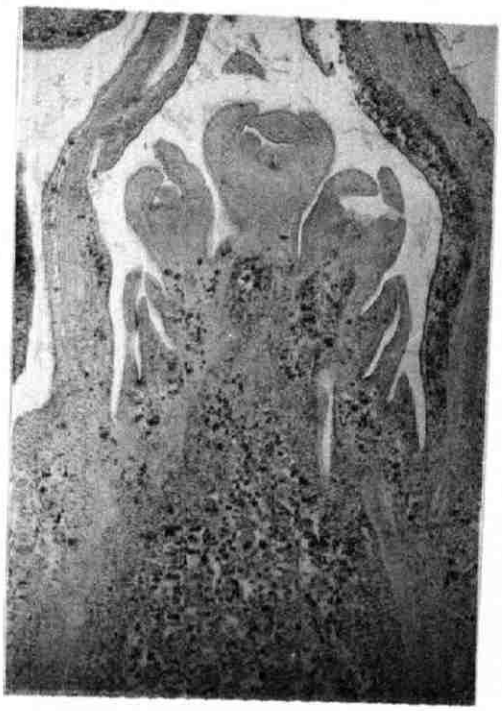

Figure 27

Figure 28. Apple terminal bud from flowering non-fruiting spur, before flower initiation. Sept. 23, '66 (x220)

Figure 29. Apple terminal bud from flowering non-fruiting spur, first observed indication of flower initiation. Aug. 26, '66 (x220)

Figure 30. Apple terminal bud from flowering non-fruiting spur, completed flower initiation. Oct. 7, '66 (x220)

Figure 28

Figure 29

Figure 30

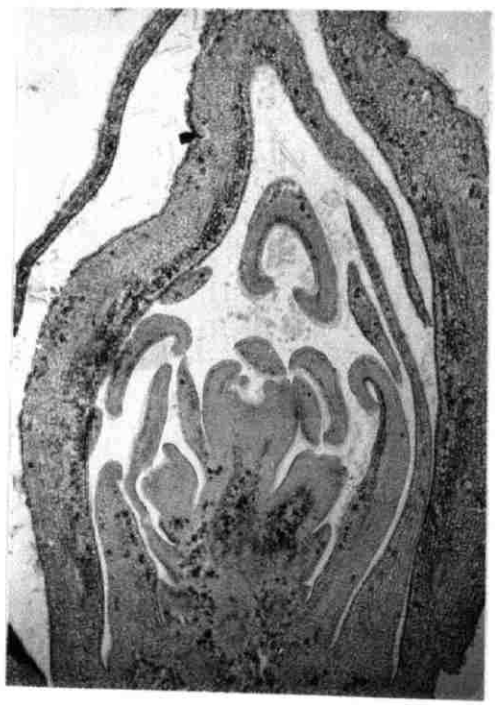

Figure 31. Pear terminal bud from shoot, before flower initiation. July 1, '66 (x220)

Figure 32. Pear terminal bud from shoot, first observed indication of flower initiation. July 15, '66 (x220)

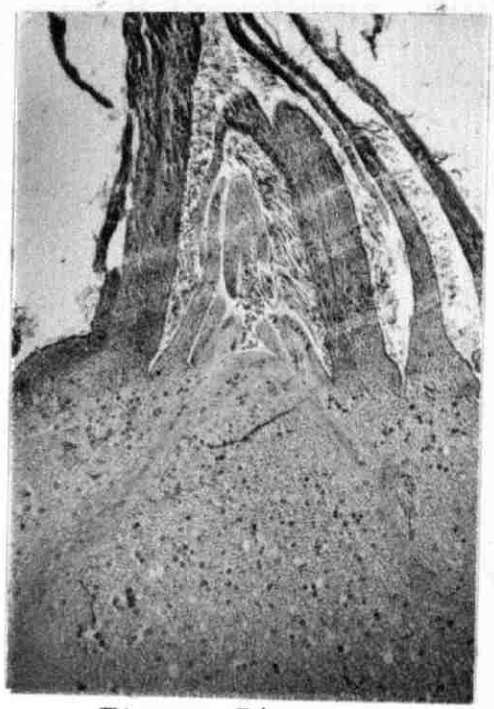

Figure 31

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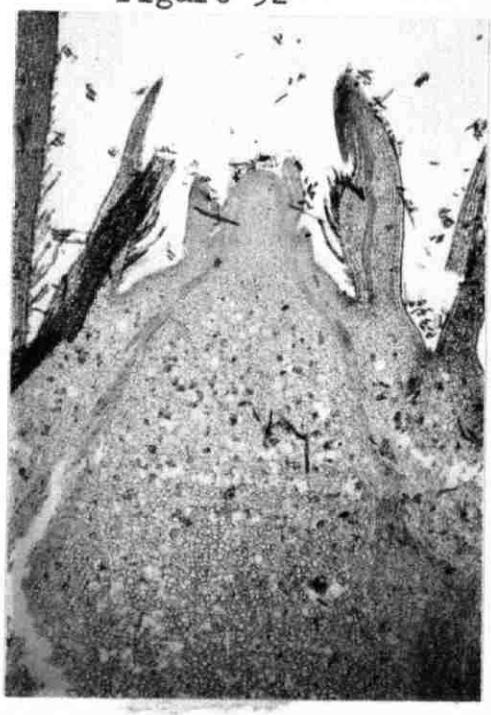

Figure 33. Pear terminal bud from vegetative spur, first observed indication of flower initiation. July 1, '66 (x220)

Figure 34. Pear terminal bud from vegetative spur, completed flower initiation. July 23, '66 (x220)

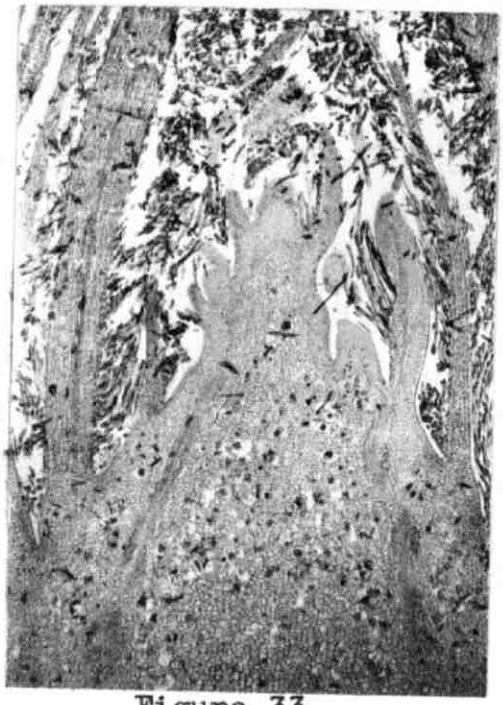

Figure 33

Figure 34

Figure 35. Pear terminal bud from flowering non-fruiting spur, before flower initiation. Aug. 12, '66 (x220)

Figure 36. Pear terminal bud from flowering non-fruiting spur, first observed indication of flower initiation. July 1, '66 (x220)

Figure 37. Pear terminal bud from flowering non-fruiting spur, completed flower initiation. Sept. 9, '66 (x220)

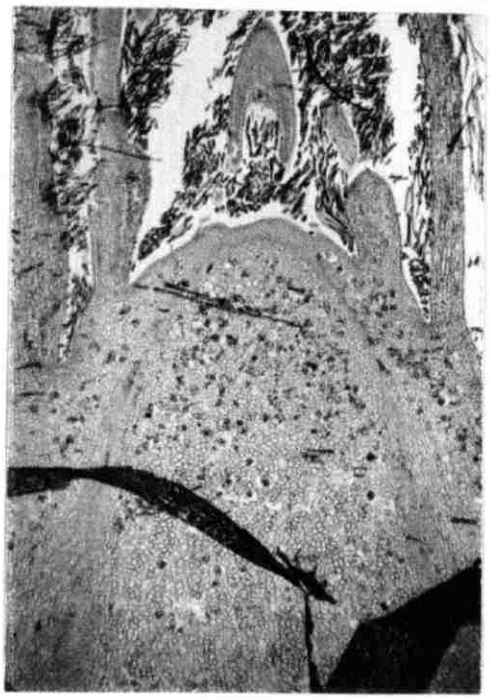

Figure 35

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Figure 38. Plum lateral bud from shoot, before flower initiation. July 15, '66 (x270)

Figure 39. Plum lateral bud from shoot, first observed indication of flower initiation. Oct. 7, '66 (x270)

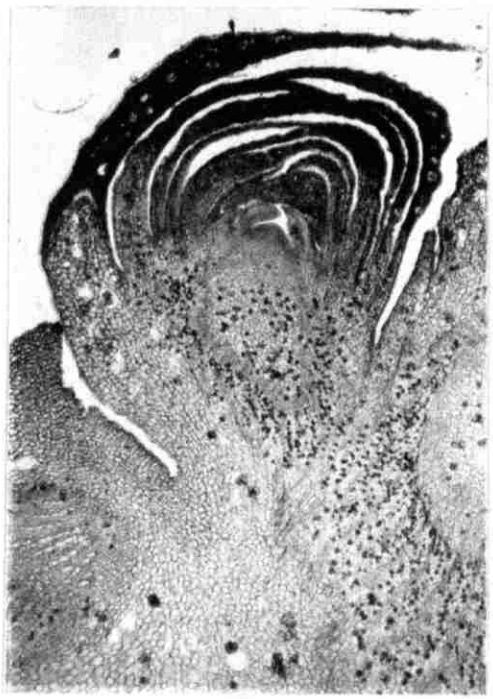


Figure 38

Figure 39

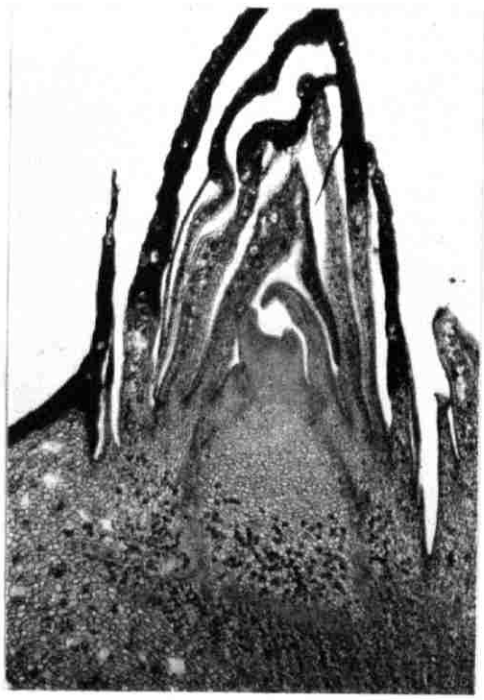
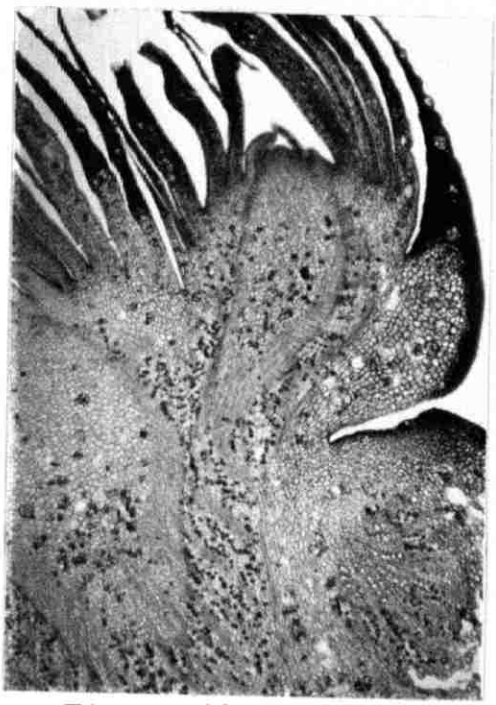


Figure 40. Plum terminal bud from vegetative spur, before flower initiation. July 1, '66 (x270)

Figure 41. Plum terminal bud from vegetative spur, first indication of flower initiation. Aug. 12, '66 (x270)

Figure 42. Plum terminal bud from vegetative spur, completed flower initiation. Oct. 7, '66 (x270)



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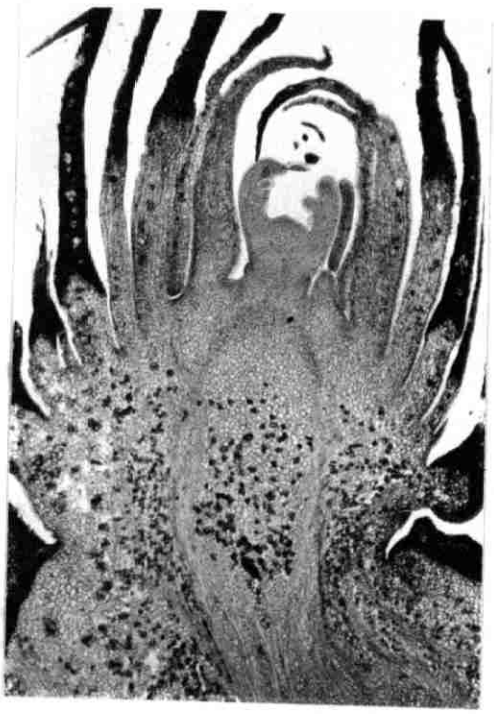

Figure 43. Plum terminal bud from flowering non-fruiting spur, before initiation. July 1, '66 (x270)

Figure 44. Plum terminal bud from flowering non-fruiting spur, first observed indication of flower initiation. July 29, '66 (x270)

Figure 45. Plum terminal bud from flowering non-fruiting spur, completed flower initiation. Oct. 7, '66 (x270)

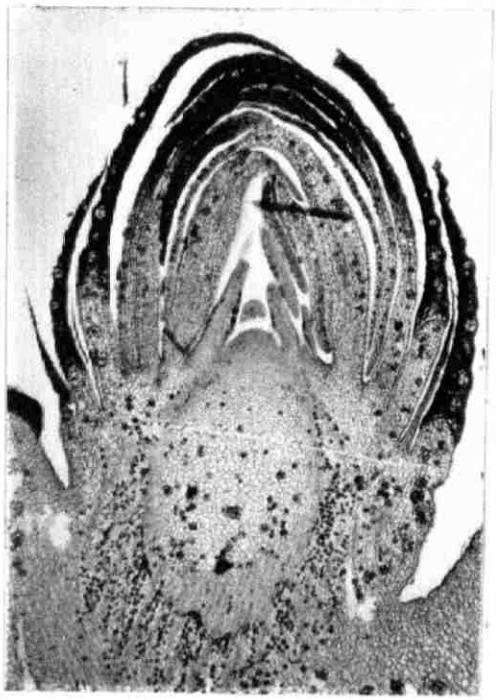

Figure 43

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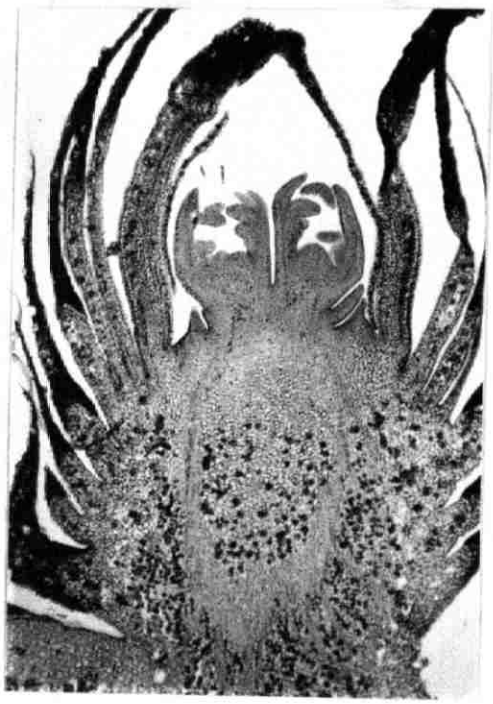


Figure 46. Peach lateral bud from shoot, before flower initiation. July 1, '66 (x270)

Figure 47. Peach lateral bud from shoot, first observed indication of flower initiation. Aug. 12, '66 (x270)

Figure 48. Peach lateral bud from shoot, completed flower initiation. Sept. 9, '66 (x270)

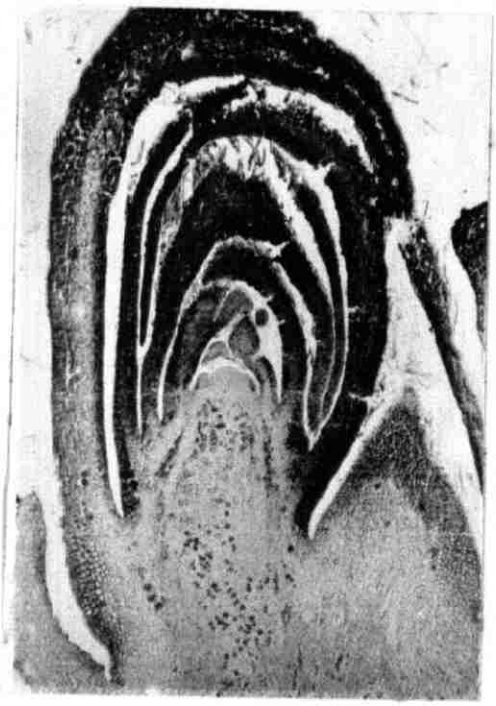
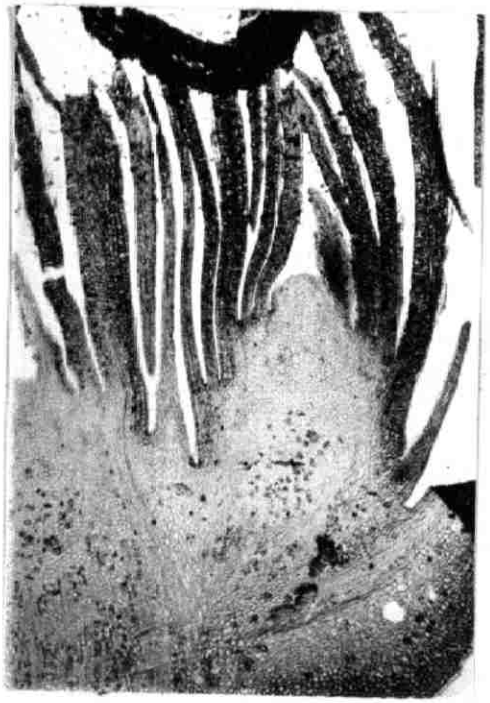


Figure 46

Figure 47



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