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A Histological Study of Abscission Layer Formation in Cherry Fruits During Maturation[1]

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Abstract. Abscission layer formation during fruit maturation of sour cherry, *Prunus cerasus* L., occurred between the fruit and the pedicel. No abscission layer was formed between the pedicel and the spur. The abscission layer was first evident 12–15 days before fruit maturity. This layer was composed of 5–8 rows of cells in the transition zone between the fruit and pedicel and was first identified by its low affinity for haematoxylin. Cell separation occurred without rupturing of cell walls. Later cell wall collapse was apparent. Cells immediately distal and proximal to the line of separation were thin walled and prone to separate easily. No abscission layer was formed through the vascular bundles and no cell division was noted during layer formation. Abscission layer formation was observed in detached sour cherry fruit which was histologically similar to that observed *in vivo*. There was a close relationship between abscission layer formation and force required to separate the fruit from its pedicel. No abscission layer was observed, in the transition zone between the fruit and pedicel in the sweet cherry, *Prunus avium* L.

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Introduction

Abscission of cherry fruit is of particular interest for the efficiency of fruit removal by mechanical harvesting machines is related, in part, to abscission layer development. Therefore, there is a strong desire to control the abscission process. Recently, it has been demonstrated that fruit abscission could be promoted in the cherry by chemical means (3). Although considerable research effort is being directed to the control of cherry fruit abscission, no detailed reports have appeared on the nature of ab-

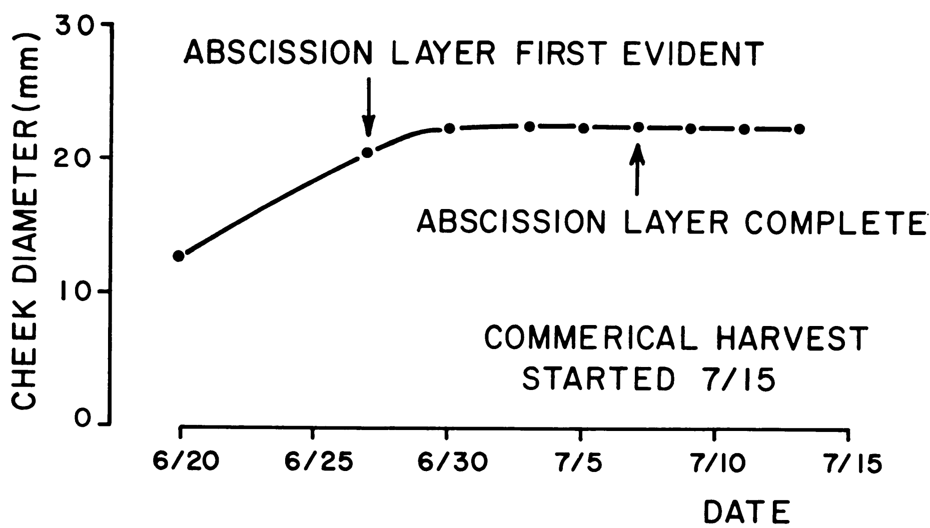

Fig. 3. Relationship between initiation and development of the abscission layer in the sour cherry as related to fruit size, and harvest time.

scission layer development during maturation in this crop and only a few have appeared for other fruits (2, 6, 15). This investigation was undertaken to establish the site of and histological changes associated with abscission layer development in maturing cherry fruit, as a logical basis for further study of the chemical control of fruit abscission.

Materials and Methods

Sour cherry. Fruit samples of sour cherry, *Prunus cerasus* L. 'Montmorency', were collected every 3–4 days from pit hardening to maturity. Two tissue segments were excised, one from the transition zone between the pedicel and fruit and other from between the pedicel and spur. These tissues were fixed in formalin, acetic acid and alcohol (FAA), dehydrated, embedded in paraffin and sectioned at 8–10 μ by standard microtechniques (7). All sections were stained with Delafield haematoxylin which gave better differentiation of cells in the abscission layer than fast green-safranin. These studies were conducted in 1967 and 1968. Each point presented in the figures represents the average of 10 individual fruits.

The force necessary to remove the fruit from its pedicel was determined on a 100-fruit sample collected from the same tree and on the same date as fruits for histological study. Fruit removal force was determined with a Hunter Mechanical Force Gauge (Hunter Spring, Hatfield, Pa.). Cheek diameter was measured on fruits collected for histological studies.

Sour cherry-detached fruits. Uniform immature fruits approx. 1.0–1.5 cm in diameter and in early stage III of development were detached and transferred to the laboratory. The pedicel was cut at 1.5 cm and the detached fruits were set in a moist open chamber at 21°C. The transition zone between the fruit and pedicel was excised from a random sample of 10 detached fruits at daily intervals during a 7-day period. The tissue was processed as described above.

Sweet cherry. Fruit samples of sweet cherry, *Prunus avium* L., 'Napoleon', 'Windsor' and 'Schmidt,' were collected during maturation, fixed in FAA and prepared for observation as previously described.

Results

Sour cherry-abscission zone. The abscission zone of the sour cherry at maturity developed at the juncture of the fruit and pedicel. Fruit separation at maturity did not occur between the pedicel and spur.

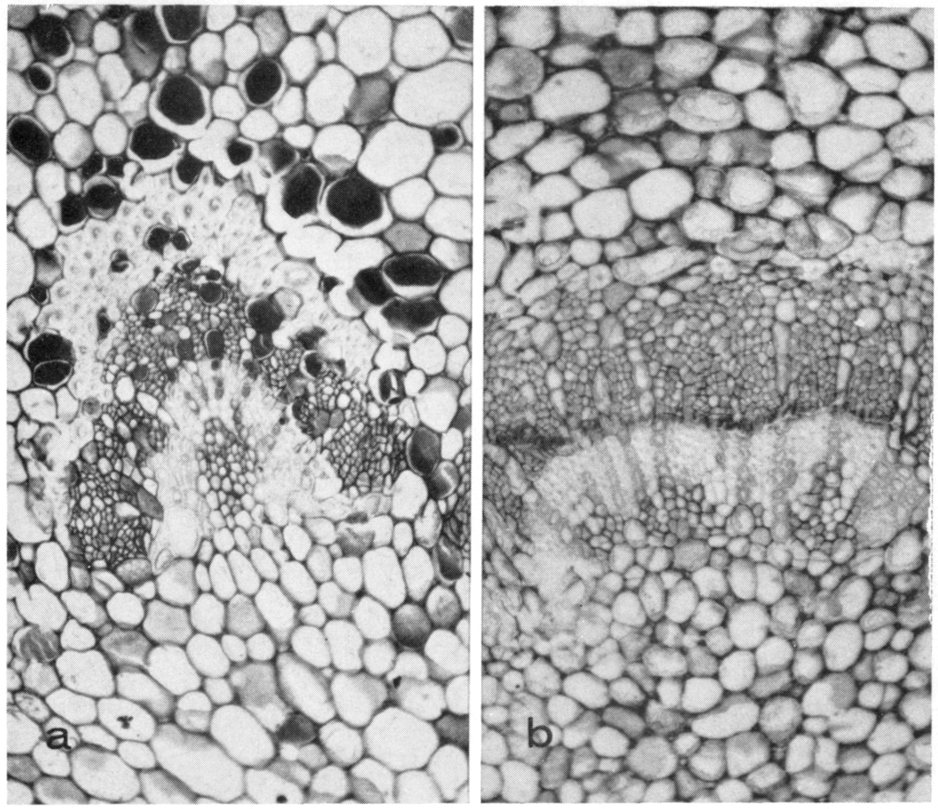

Fig. 1. Photomicrographs of cross sections of the sour cherry pedicel: section through pedicel approximately 5 mm basal to the receptacle illustrating one of the vascular bundles and associated sclerenchyma tissue (a), section at point of juncture of pedical and fruit (b). Both ×288.

The abscission zone may be viewed as a transition region where the cells of the apical portion of the pedicel are contiguous with the larger cells of the fruit. This point of attachment also is characterized by considerable constriction of tissue. The tissue connecting the pedicel and fruit has certain anatomical features, which may influence the separation of the fruit from the stem. The vascular bundles of the pedicel form a circle when viewed in cross-section, and are associated with sclerenchyma elements (Fig. 1a). However, essentially no sclerenchyma is evident in the region where

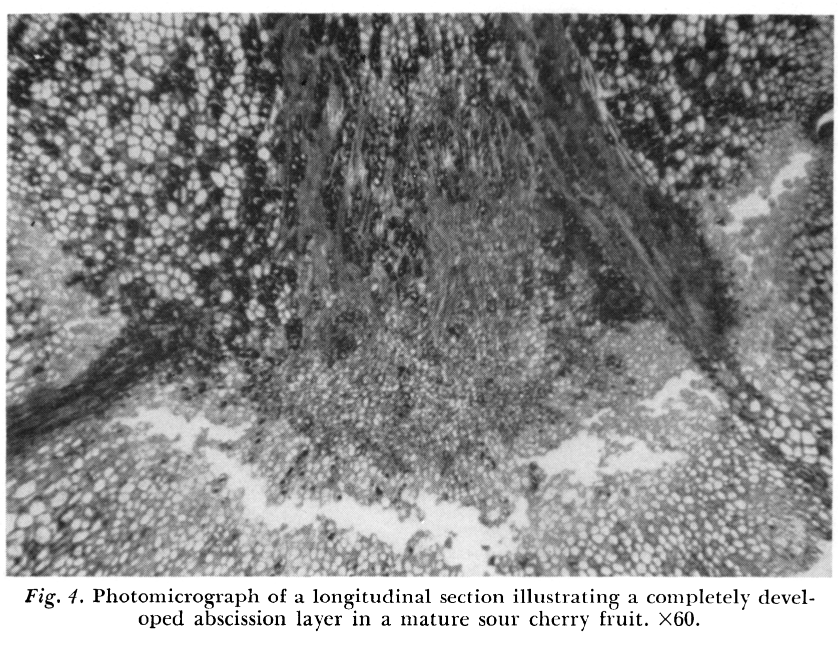

Fig. 4. Photomicrograph of a longitudinal section illustrating a completely developed abscission layer in a mature sour cherry fruit. ×60.

the pedicel enters the fruit (Fig. 1b). The sclerenchyma diverges from the vascular tissue in the apical portion of the pedicel and enters the calyx cup. Sclerenchyma terminates in the receptacle after the calyx is shed. Thus the abscission zone between the pedicel and fruit represents, by nature of its constriction and absence of sclerenchyma tissue, an area of structural weakness.

The cells of the abscission zone, especially those peripheral to the vascular bundles, are usually small and isodiametric (Fig. 2a). Circular dark staining bodies, fat-like in nature, were often present in cells proximal to the abscission layer (Fig. 1a, 2c).

The vascular cylinder branches, after entering the fruit, forming 2 ventral bundles, 1 dorsal bundle, 2 funicular bundles and 10–12 bundles entering directly into the flesh. The ventral and dorsal bundles lie close to the stony endocarp. One of the funicular bundles supplies the growing ovule and the other is associated with the aborted ovule. This vascular distribution is similar to that reported for the peach (10) and plum (12).

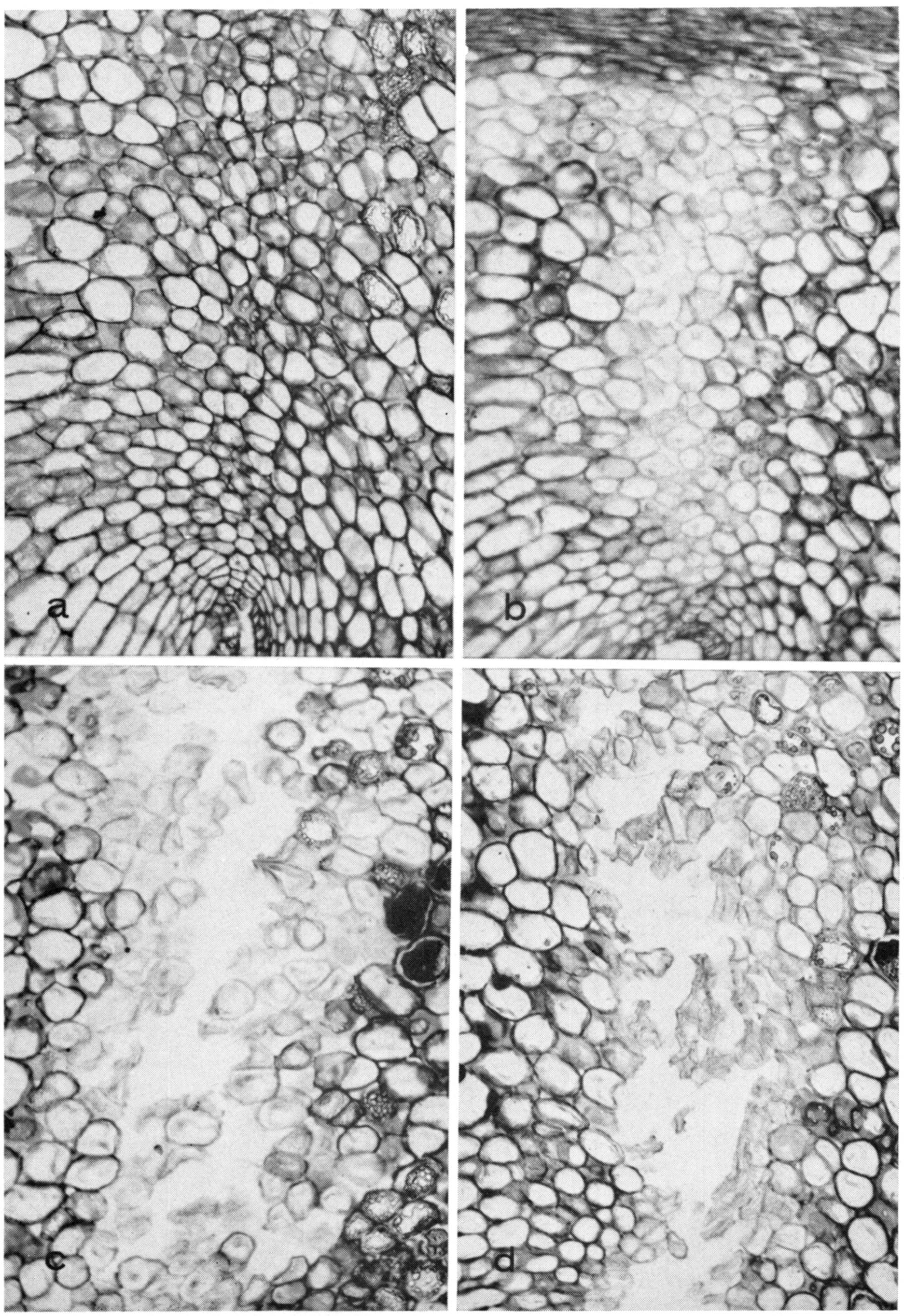

Fig. 2. Photomicrographs of longitudinal sections through the abscission zone of the sour cherry showing various stages in the development of the abscission layer. Abscission zone before initiation of abscission layer (a), early development of abscission layer showing low affinity for haematoxylin (b), cell separation (c), and cell collapse (d). Pedicel tissue is to right of abscission layer. All at ×250.

Sour cherry – abscission layer. In a given fruit sample the beginning of abscission layer formation was first evident, in the abscission zone described above, when the fruit had almost completed enlargement, 12–15 days before maturity, and was complete within 8–10 days (Fig. 3). The abscission layer was composed of 5–8 rows of cells and was first identified by having a lower affinity for haematoxylin (Fig. 2b) than adjacent cells. This layer of cells appeared as a crescent, reaching from the point of juncture of the pedicel and fruit and extended almost to and across the base of the stony pericarp (Fig. 4). No abscission layer was formed across the vascular bundles (Fig. 2b, 4). Progressive development of the abscission layer was characterized by separation of cells, without rupturing of cell walls (Fig. 2c), followed by cell collapse (Fig. 2d). This separation started in the central portion of the abscission zone, generally above the stony pericarp, and progressed toward the periphery. A few rows of cells at the periphery usually did not separate (Fig. 4).

Marked changes occurred in the cells of the abscission layer. The walls of cells in this layer were generally thinner, less rigid, and showed poorer cementing properties than those of cells proximal or distal to the abscission layer. There was no cell enlargement during the separation process as reported for several other plants (4). Further, there was no evidence of cell division or starch accumulation in the abscission zone.

The abscission layer was completely developed at maturity, but the fruit generally did not abscise. This was probably related to the absence of an abscission layer across the vascular bundles (Fig. 2B, 4). Final fruit separation apparently is achieved by mechanical fracturing of the vascular strands.

Abscission layer formation commenced uniformly within a fruit sample; layers were evident in most fruits within 4–6 days after the first layer was identified (Fig. 5). Similar results were obtained in both years of study (Fig. 5).

No abscission layer was formed at maturity in the transition zone between the pedicel and spur.

The relationship between the fruit removal force and abscission layer development, as indexed by per cent of fruits with an abscission layer, is illustrated in Fig. 6. During maturation the force required to separate the fruit from its pedicel decreased markedly. There was a concomitant increase in the number of fruits in which an abscission layer was present. The force needed to remove the fruit after abscission layer formation was complete may represent the resistance necessary to fracture the vascular strands (Fig. 5, 6).

Sour cherry – detached fruit. There was rapid initiation and development of abscission layers in detached cherry fruit (Fig. 7). An abscission layer was present in 40–50% of the detached fruit on the third day and in all on the fifth day after excision. The development of the abscission layer in the detached cherry fruit was histologically identical to that observed *in vivo*.

Sweet cherry. There was no evidence of an abscission layer between the fruit and pedicel in 'Windsor' (Fig. 8) or 'Napoleon' sweet cherries at maturity. Some localized cell separation, apparently not mechanically induced, was observed in mature 'Schmidt' (Fig. 8b) in a region comparable to where the abscission layer formed in the sour cherry; however, a completely developed abscission layer was never found.

Discussion

The site of abscission layer formation varies considerably in different fruits. The pome fruits abscise at the base of the pedicel (6, 8, 9). Plum fruitlets are shed with stems attached in the first and second wave, but without stems in the third drop (June drop) (5). In sweet cherry two abscission zones are known (13). Cherry fruits abscising during the various seasonal drops separate between the pedicel and peduncle or between the peduncle and spur. However, no well defined abscission layer forms at maturity. By contrast, an abscission layer is formed during maturation in the sour cherry between the fruit and pedicel, but not between the pedicel and spur. Fruit separation at maturity also occurs at the base of the fruit in the plum (6), mango (2), avocado (2) and orange (15).

Histological changes associated with abscission layer formation in the sour cherry generally are similar to those observed in other fruits (6, 13, 15) as well as in some other organs (1, 4, 11). The mode of abscission in the sour cherry results in a clear separation without cell division or rupturing of cell walls.

The presence of the abscission layer in the sour cherry at maturity has significance for mechanical harvesting. The force necessary to separate the fruit from the pedicel decreased during maturation, a time during which abscission layer formation occurs. The data presented here imply a close correlation between these 2 parameters. In contrast, no abscission layer was found in the sweet cherry. Even though the fruit removal force decreased with maturation, a much greater force is necessary to effect fruit

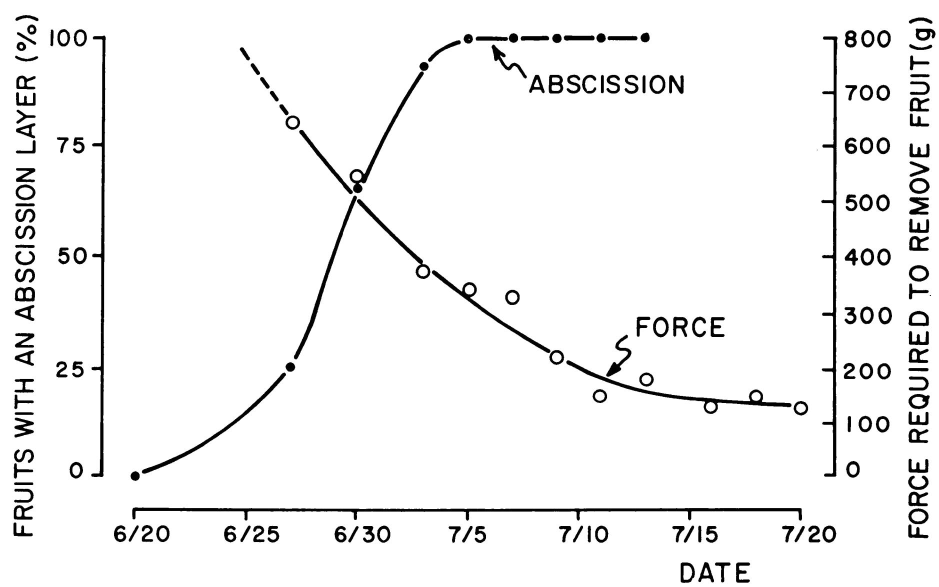

Fig. 6. Relationship between abscission layer development and force required for separation of sour cherry fruit from its pedicel.

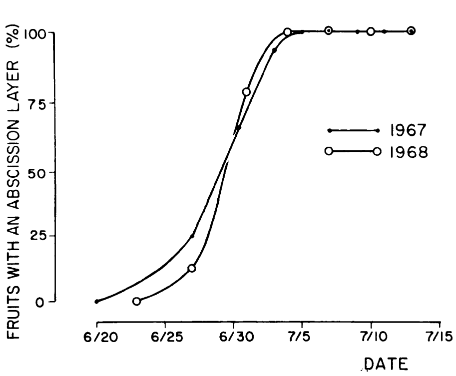

Fig. 5. Time-course of abscission layer initiation in the sour cherry fruit during maturation.

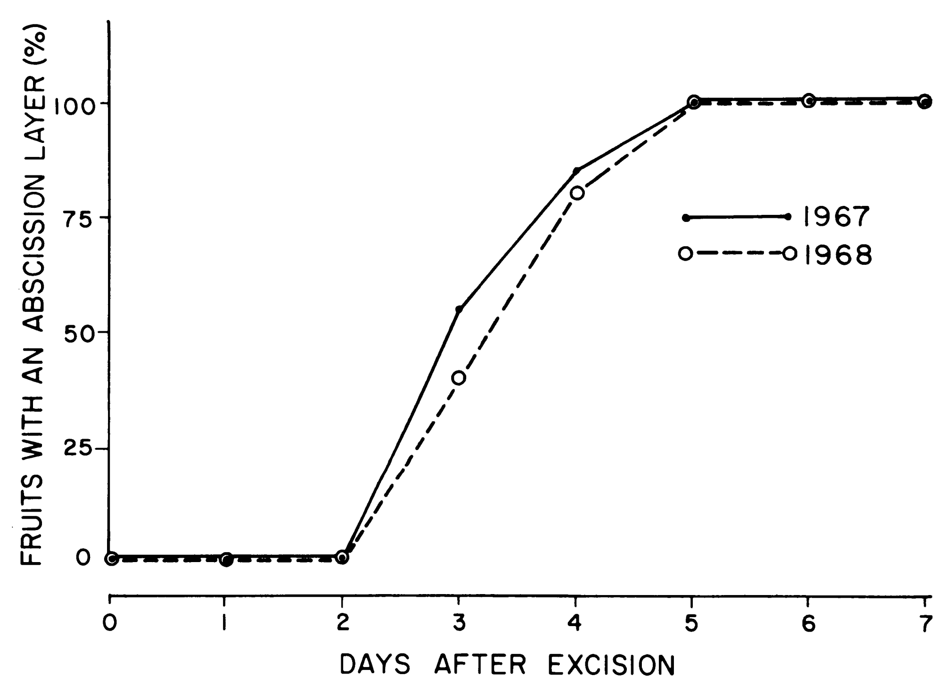

Fig. 7. Time-course of abscission layer initiation in sour cherry fruit explants.

separation and thus generally poorer fruit removal is obtained with sweet than sour cherries (3). Obviously, not all of the reduction in fruit removal force during maturation can be attributed to the presence of an abscission layer, since no layer was found in the sweet cherry and yet fruit removal force decreased with maturation. However, the difference in the fruit removal force at maturity between the sour and sweet cherry (3) may, in part, be related to the absence of an abscission layer in the latter.

The capacity of detached sour cherry fruits to form an abscission layer is meaningful. The observation that similar histological and histochemical changes (14) occurred in walls of cells participating in abscission layer development of both detached and attached fruits suggest that detached fruits might serve as a useful test system for further study of cherry fruit abscission.

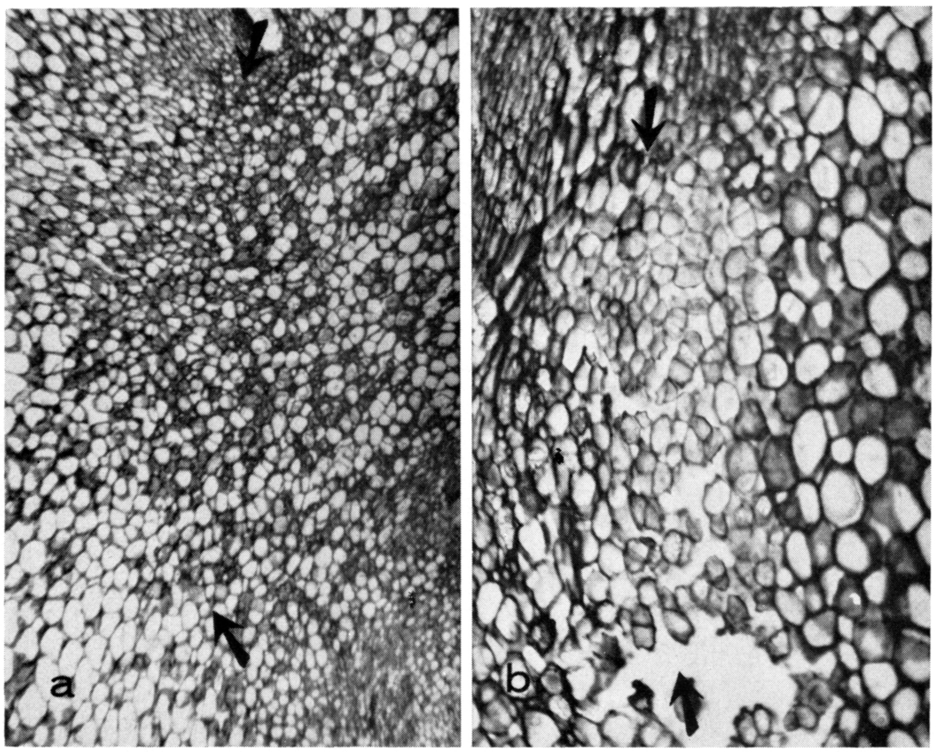

Fig. 8. Photomicrographs of longitudinal sections of the transition zone between the fruit and pedicel of mature 'Windsor' (a) and 'Schmidt' (b) sweet cherry fruits. Note absence of an abscission layer in 'Windsor' (a) and localized cell separation in 'Schmidt' (b). Pedicel tissue is to right of arrows. 'Windsor', ×110; 'Schmidt', ×275.

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