ment may be obtained as early as the second growing season. Scepter probably will not produce sufficient quantities of fruit, and Southland is totally unacceptable for this system of management in Maryland.

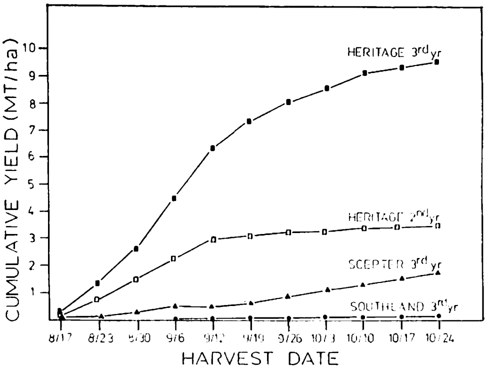


Fig. 1. Cumulative yield of marketable fruit in three red raspberry cultivars during 1977 at College Park, Maryland.

Literature Cited

1. Moulton, J. E. and R. F. Carlson. 1953. Pruning the Durham red raspberry to improve the fall crop. *Mich. Agric. Exp. Sta. Quarterly Bull.* 36:89-93.
2. Ourecky, D. K. 1969. Heritage—a new fall bearing red raspberry. *N.Y.S.A.E.S. Res. Circ.* No. 19:2 pp.
3. ————. 1973. Fall-bearing red raspberries. *Fruit Var. J.* 27:35-38.
4. ————. 1975. Raspberries are "fall-guys." *Am. Fruit Grower* 85:22, 27.

Morphological Characteristics of the Adaxial and Abaxial Surfaces of the Floral Tube in Peach (*Prunus persica* L. Batsch.)[2]

R. K. Simons and M. C. Chu[1]

Abstract

The adaxial and abaxial surfaces of the floral tube of *Prunus persica* L. are characterized by distinctly different epidermal morphology. Stomata on the adaxial surface are dispersed among trichomes from the basal to the distal portion adjacent to the filament base and are partially covered with epicuticular deposits. The abaxial surface is devoid of pubescence and is densely cellular with stomata dispersed over the entire surface.

Development of the peach flower is complex and susceptible to winter and/or frost injury in northern areas. If injury is not present, excess flower production results in heavy fruit-set which is difficult to thin by chemical methods.

During the critical stages of pollination and fertilization J. H. Hale and other varieties of peaches are sensitive to adverse weather conditions (2). When exposed to low temperatures, ice forms within the bud tissues and, upon thawing, the water is reabsorbed.

The flower buds appear to be less hardy than other parts of the tree (11). Monitoring of fruit-bud hardiness in peach and cherry orchards indicated differences in cold hardiness between orchards, perhaps associated with soil type (7). Six deciduous fruit species had similar distribution of mortality with temperature during blossom-bud development from dormancy to post bloom. During this period T_{50} rose to near −3°C. for all species (8). Peach responds to variations in Al in the soil solution, and

[1]Department of Horticulture, University of Illinois, Urbana, Illinois 61801.

[2]This research was supported by the Illinois Agricultural Experiment Station. The authors acknowledge support from the Center of Electron Microscopy, University of Illinois, Urbana.

stomatal aperatures are significantly affected by nutrition (3).

Specificity in the mechanism of supercooling in overwintering peach flower buds has been described (10). Masses of ice formed in the flower bud scales and flower axis, but not in the flower bud primordium. Water appeared to be withdrawn from the bud axis to freeze in preferred sites in the scales. This variation may be due to 1) the cuticle or epidermis which prevents nucleation by ice on the surface of the flower primordium and/or 2) a dry region at the base which prevents an ice boundary from spreading into the flower primordium from the interior of the bud axis. The dry region is formed by water withdrawal into the scales during the initial stages of freezing (10).

Freezing injury to overwintering flower buds of peach was associated with an exothermic process detected on the time-temperature profile (9). This process varied with seasonal fluctuations in the hardiness of 2 peach cultivars and was consistent with the hardiness of 5 cultivars tested on 3 dates during the winter. These findings suggested that flower-bud injury in some *Prunus* species involved freezing of a "bound" or "supercooled" fraction of water. This fraction remained unfrozen in the flower bud until the temperature fell below a critical level which was −27°C. A nucleation barrier (below −10°C) appears to be present, which prevents the spread of ice into the flower primordium from the frozen interior of the flower bud. This nucleation barrier appears to be located at the base of the flower primordium because severing connective tissue in this region destroyed the supercooling capacity (10).

This investigation was initiated to obtain further information concerning variability within the peach flower. Since the peach buds are highly susceptible to cold injury, the purpose of this study was to elaborate on the morphology of the adaxial and abaxial surfaces of the specific sites on the floral tube in relation to abscission and the effect abscission has upon development. The distinct differences existing within the floral tube are recorded.

Materials and Methods

Post anthesis blossoms of Cresthaven, Redhaven, Redskin and Loring (Stage II, development) (5) were placed in 50% ethanol and cut longitudinally to expose both the adaxial (inner) and abaxial (outer) surfaces of the floral tube and fruitlet (Fig. 1). After dehydration through an ethanol series, tissue was dried in a critical-point drying apparatus (1, 4), mounted on aluminum stubs with silver paint and coated with carbon and gold-palladium in a vacuum evaporator. Five samples of each cv. for the adaxial and abaxial surfaces of the floral tube were observed with a Cambridge Stereoscan Mark II scanning electron microscope at 15 KV. For brevity, only the micrographs from Cresthaven and Redskin are illustrated, those from the other varieties being similar.

Observations for light microscopy and histochemistry were made using a freezing microtome at −10°C and sectioning the material at 20 um. Tissue was stained with the periodic-acid Schiff's reagent (PAS) for carbohydrate localization.

Results and Discussion

Floral tube morphology—abaxial (outer) surface. The abaxial surface is illustrated by scanning micrographs in Fig. 2-7. Floral tube abscission (Fig 1) is evident at the beginning of petal-fall (Stage II) (5). The sample showed rapid, progressive development of the ovule, with growth interrelationships between the style and filaments (Fig. 1). Abscission of the floral tube has been described for Stage I and II for the cultivars previously mentioned (6). The same stage of development shown there in longitudinal section is illustrated in this study to show the abaxial and adaxial surfaces.

Fig. 1 shows the abaxial surface of the floral tube where abscission develops (arrow). The site of abscission was apparent as a yellowish-green region around the floral-cup base. Small cracks, slight growth depressions of the abscission zone, and lack of pubescence characterize this region. The young fruitlet was pubescent. Phloem cells at the fruit attachment to the stem apex stained intensely with PAS for carbohydrates. A slight staining reaction occurred distal to the abscission break. Although cells containing carbohydrates and starch were contiguous to the yellowish-orange pigmented cells on the adaxial side of the floral cup (not within the solid pigmentation area), the color was dispersed throughout the parenchyma cells of the floral cup and extended toward the abaxial surface. Carbohydrates were localized with greater intensity proximal to the abscission break as contrasted to distal tissue.

Fig. 2 shows the abscission region across the elongate oriented epidermal cells, emphasizing the distal and proximal areas in relation to abscission. Enlargement of this area (Fig. 5) shows elongated cells from the flower base towards the apex. Cessation of distal growth from the abscission area occurred rapidly. Abscission did not progress as a straight line, and contiguous distal tissues shrivelled.

Stomata on the floral-cup (abaxial surface) proximal to the developing abscission region (Fig. 3) are compared to those on the distal side (Fig. 6). Those on the distal tissue are small, more limited in number, and partially closed. Shrivelled subsidiary cells and collapsed guard cells indicate senescence distal to the break (Fig. 6).

Disintegration was found in the outer-epidermal cells of abscising tissue (Fig. 4). Cessation of distal growth had preceded disintegration.

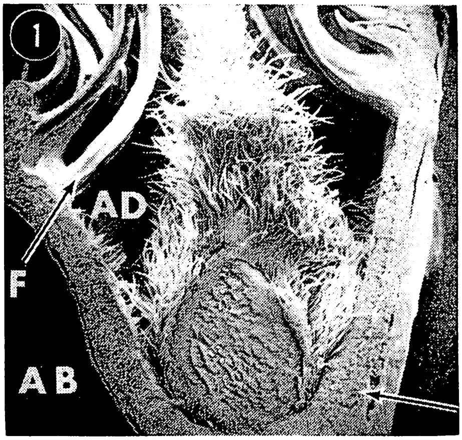
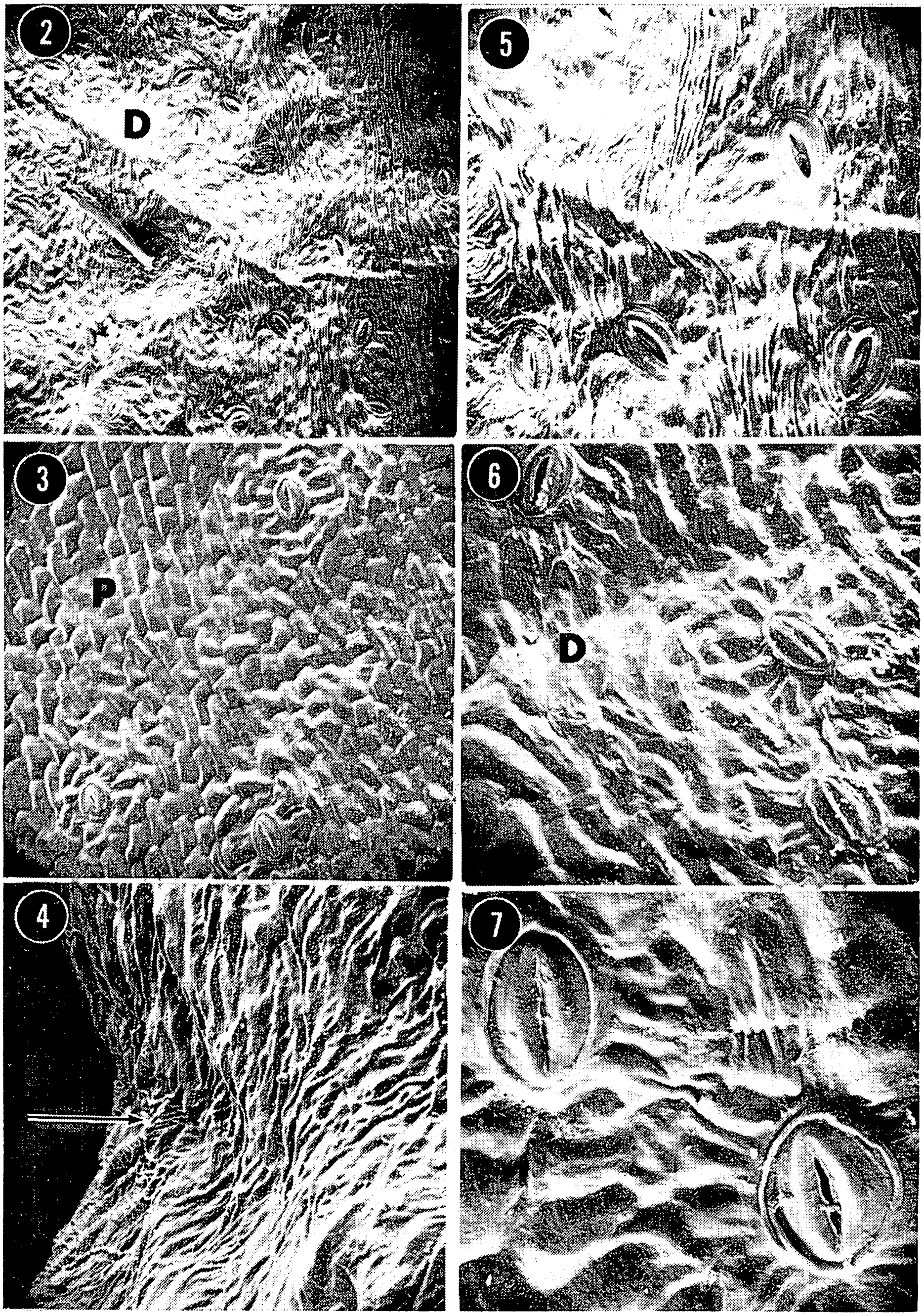


Fig. 1. Longi-sect. of a young Cresthaven peach fruit and accompanying floral organs (Stage II) showing the adaxial (inside) (AD) and abaxial (outside) (AB) surfaces of the floral tube with filaments (F) of stamens at the distal portion. Arrow indicates the area of floral tube abscission. X10.

The collapse of cells was followed by development of regenerative cells proximally. The abscission break progressed through a large expanse of tissue containing shrivelled stomata (compared with normal stomata Fig. 7). The epidermal cells of the abaxial surface were cutinized, smooth and lacked pubescence. The stomatal complex illustrated in Fig. 7 had crescent-shaped guard cells and large subsidiary cells.

Floral tube morphology—adaxial (inner) surface. The adaxial surface of the floral tube had morphologically distinct stomata and trichomes (Fig. 8-16).

The surface of the entire floral tube (Fig. 8) had uniformity of pubescence lining the stomata and contiguous supporting cells which were variable in size and interspersed within loosely-arranged subepidermal cells. Pubescence surrounding the stomata was


2
D
5
3
P
6
D
4
7

variable and partially covered the openings (Fig. 9, 10).

The morphological differences between stomata on the abaxial surface (Fig. 7) are compared with those on the adaxial side (Fig. 9, 10). All the described stomata were located on the proximal side of the floral tube or the basal portion of the flower, contiguous to the abscission area.

Stomata distal to the abscission break were fewer in number, and collapse of the guard cells was evident. Trichomes surrounded the stomata throughout the distal area.

The area of abscission of the floral tube contains trichomes and cuticular deposits (Fig. 11-16). Abscission will occur in the general area originating on the adaxial surface (Fig. 11) with the entire surface covered by thick cuticle Fig. 14). A mass of trichomes in the thick cuticular deposit penetrated the cuticle (Fig. 12, 13).

A trichome base at the juncture with the epicuticular mass (Fig. 15) and further magnified in Fig. 16, indicates that the outer portion is supported by the cuticular mass which has interconnected at the base.

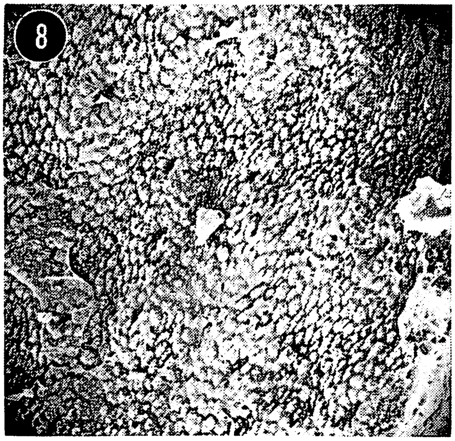
Growth of the floral organs of the peach reveal that varied stages of development occur in rapid succession in relation to fruit set (5). Differences in stomata and cuticular surfaces of the adaxial and abaxial sides of the floral tube may relate to the variable formation of ice in the floral structure (9, 11). This suggests that further studies of bud scales and their function is needed. These could potentially contribute to a better understanding of the physiological processes required for successful flower development and control of abscission.

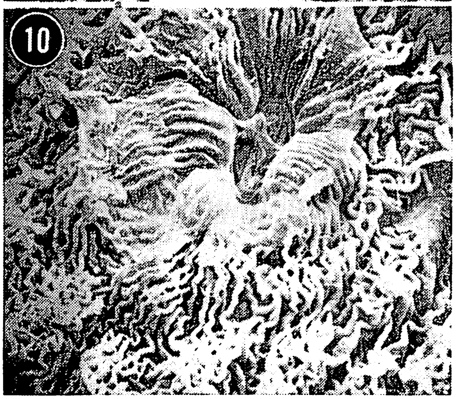
Literature Cited

1. Anderson, T. F. 1951. Techniques for the preservation of three dimensional structures in preparing specimens for the electron microscope. *Trans, N. Y. Acad. Sci.* 13:130-133.
2. Dorsey, M. J. 1934. Ice formation in the fruit bud of the peach. *Proc. Amer. Soc. Hort. Sci.* 31:22-27.
3. Horton, B. D. and J. H. Edwards. 1976. Diffusive resistance rates and stomatal aperature of peach seedlings as affected by aluminum concentration. *HortScience* 11:591-593.
4. Horridge, G. A. and S. L. Tamm. 1969. Critical point drying for scanning electronic microscopic study of ciliary motion. *Science* 163:817-818.
5. Lott, R. V. and R. K. Simons. 1964. Floral tube and style abcission in the peach and their use as physiological reference points. *Proc. Amer. Soc. Hort. Sci.* 85:141-153.
6. Simons, R. K. and M. C. Chu. 1979. Abscission development in the Floral Tube of Peach (*Prunus persica* L.) *Fruit Var. J.* 33:117-124.
7. Proebsting, E. L. 1978. Adapting cold hardiness concepts to deciduous fruit culture. In *Plant cold hardiness and*

Fig. 2-7. Distal and proximal abaxial epidermal surface development (longitudinal orientation) in relation to abscission of the floral tube of Redskin peach. Fig. 2, abscission region transversing the longitudinal epidermal cells showing distal and proximal development. This portion is enlarged in Fig. 5. Fig. 3, characteristics of stomata and epidermal cells proximal to the abscission region. Note senescing epidermal cells and partially closed stomata on the distal side, Fig. 6. Fig. 4, abscission development at the extreme abaxial surface showing large area of affected tissue preceding separation, with arrow indicating direction of abscission. Fig. 7, typical stomata on the proximal side of abscission. D = distal; P = proximal. Fig. 2, X87; 3, 4, 5, X219; 6, X261; 7, X537.

←





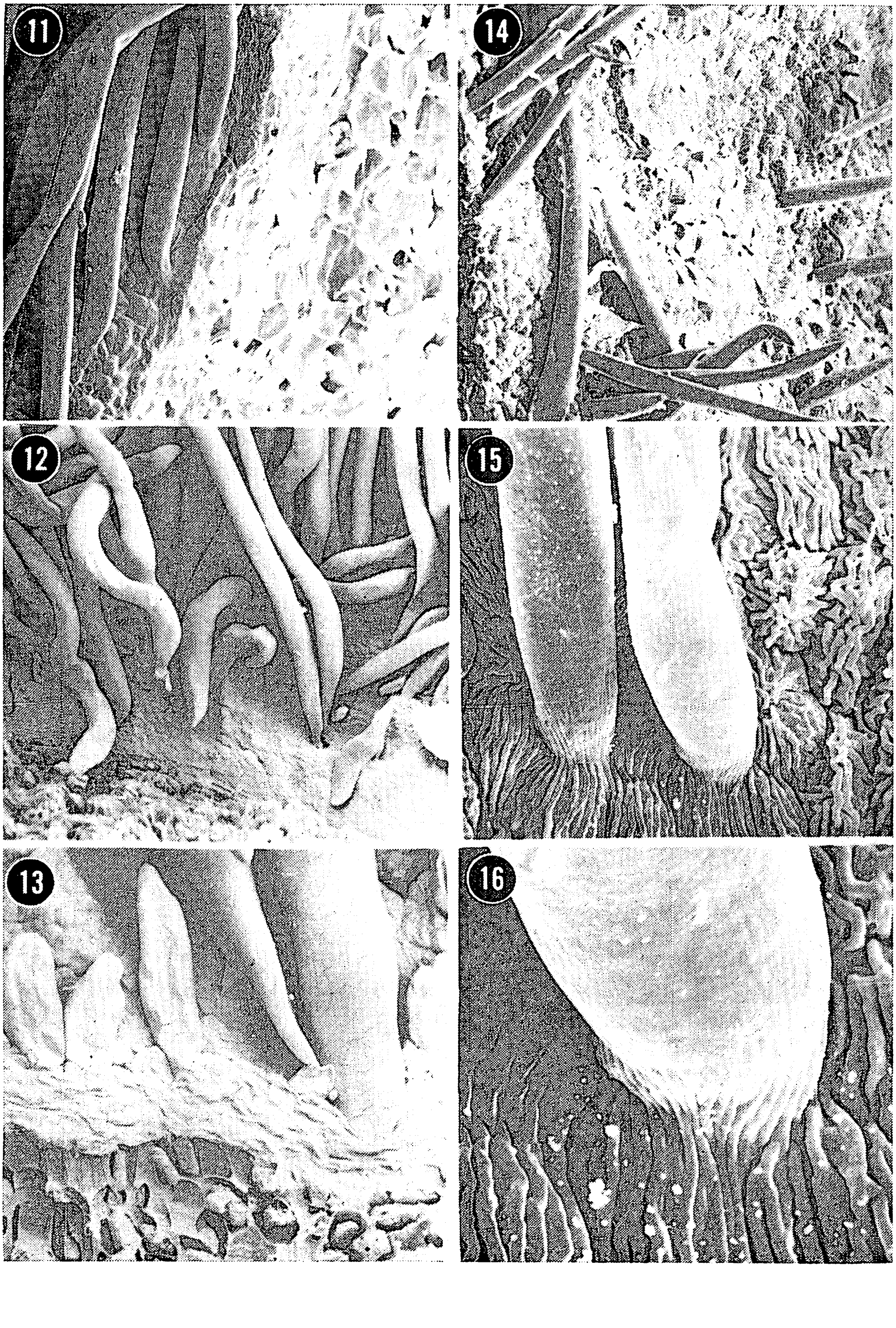
freezing stress, mechanisms and crop implications. 267-279. Li, P. H. and A. Sakai (Eds.) Academic Press, N. Y.

8. ——————. 1978. Low temperature resistance of developing flower buds of six deciduous fruit species. *J. Amer. Soc. Hort. Sci.* 103:192-198.
9. Quamme, H. A. 1974. An exothermic process involved in the freezing injury to flower buds of several *Prunus* species. *J. Amer. Soc. Hort. Sci.* 99:315-318.
10. ——————. 1978. Mechanism of supercooling in overwintering peach flower buds. *J. Amer. Soc. Hort. Sci.* 103: 57-61.
11. ——————. 1978. Breeding and selecting temperate fruit crops for cold hardiness. In *Plant cold hardiness and freezing stress, mechanisms and crop implications.* 313-332. Li, P. H. and A. Sakai (Eds.), Academic Press, N. Y.

Fig. 8-10. Peach development, Stage 1, adaxial (inner) surface of the floral tube showing stomata in relation to entwining trichomes. Fig. 8, Redskin X95; 9, Cresthaven X1100; 10, Redskin X950.

Fig. 11-16. Trichomes and epicuticular deposits found on the adaxial surface of the floral tube of Cresthaven. Fig. 11, trichomes on the epidermal surface in the area of abscission Fig. 12, 13, trichomes embedded in a thick-cuticular mass. Fig. 14, surface view showing trichomes and stomata (compared with the abaxial surface view in Fig. 2-7). Fig. 15, base of trichomes and juncture with supportive tissues. Fig. 16, enlargement of the trichomes base shown in Fig. 15. Fig. 11, X265; 12, 13, X700; 14, X200; 15, X900; 16, X2250.

——→


11
14
12
15
13
16