Some Anatomical Variations in Relation to Russeting in the 'Golden Delicious' Apple

ROY K. SIMONS[1]

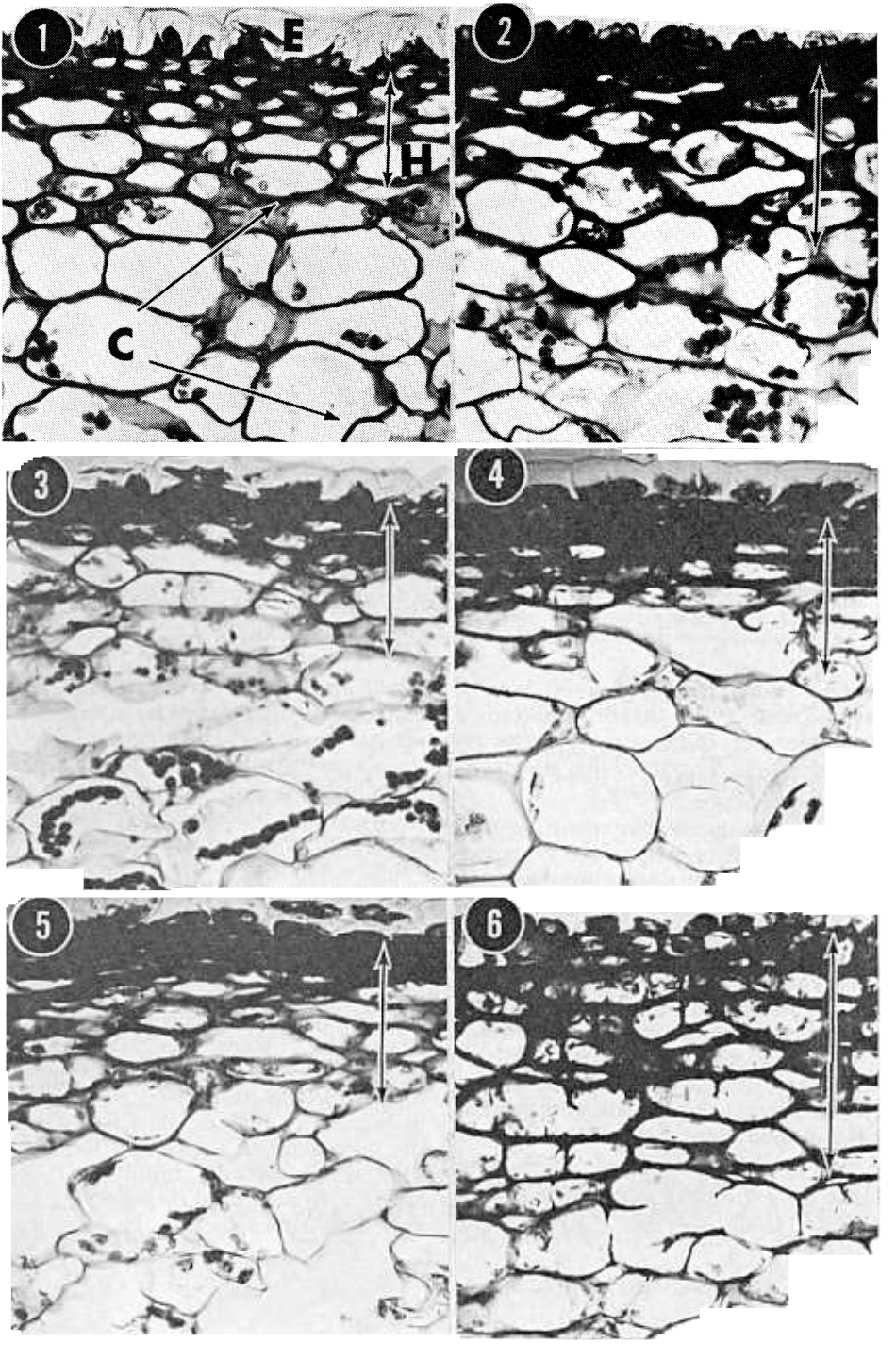
The 'Golden Delicious' apple continues to be accepted by growers as a high-yielding cultivar, and likewise it commands a respectable place on the market. In recent years, many mutations of the 'Golden Delicious' strain have been found, have been tested and some have been produced commercially (1, 3). Some of the strains which have been found in commercial orchards produce more russeting and have variable quality characteristics when compared with the standard 'Golden Delicious'. Variations in russet sports of the 'Golden Delicious' apple have been reported (1, 2, 3, 4, 5, 6).

Some anatomical differences are noted in Figs. 1-6. Cultivars in this study were approaching maturity when collected. However, young developing fruit of the 'Eckert' strain is described for early development of russet. These mutations include 'Blushing Golden' (Fig. 2). 'Gold Spur' (Fig. 3), 'Smoothee' (Fig. 4), 'Starkspur Golden Delicious' (Fig. 5), and 'Prime Gold', a cultivar similar to 'Golden Delicious' (Fig. 6). This fruit was produced in the 1972 growing season at Urbana, Illinois, and some variation of growth would be influenced by the specific growing conditions that occur from year to year. Fig. 1 is a "normal standard" 'Golden Delicious' in which the cuticle and epidermis have not been broken. The cortical cells (C) have enlarged with slight compression of the hypodermis (H) and epidermis (E). If any breaks or mechanical injury occur during the early part of the growing season, the development of cork or russet will persist to maturity. The hypodermal development of the outer protective region is indicated by arrows so that it may be compared with the cell wall thickness in the other mutants. This area of development is significant in russet formation as senescence of these tissues progress, progressive sloughing-off will occur with simultaneous regeneration of the outer cortical cells. It might be pointed out, however, that some of these strains have been observed to produce a better finish than the original 'Golden Delicious'. The quality aspects may or may not be comparable to the "normal" or "standard" 'Golden Delicious'. These new cultivars need to be evaluated as to adaptability to a definite locality and for the growers' market requirements.

'Blushing Golden' (Fig. 2) has a well-defined outer protective region and should have good storage keepability characteristics. 'Gold Spur' (Fig. 3) and 'Smoothee' (Fig. 4) are similar in development of the hypodermal and epidermal cells along with a well-defined cuticle. 'Starkspur Golden Delicious' (Fig. 5) is similar to normal 'Golden Delicious' (Fig. 1). However, compression of the outer hypodermal cells is evident. 'Prime Gold' (Fig. 6) shows a well-defined

Fig. 1-6. The outer protective region of different strains of 'Golden Delicious' and that of 'Prime Gold' at the equatorial axis of the fruit. Fig. 1, normal 'Golden Delicious'. Fig. 2, 'Stark Blushing Golden'. Fig. 3, 'Gold Spur'. Fig. 4, 'Smoothee'. Fig. 5, 'Starkspur Golden Delicious'. Fig. 6, 'Prime Gold'. Arrows denote variations existing in the hypodermal region. All × 160.

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


1
E
H
C
2
3
4
5
6

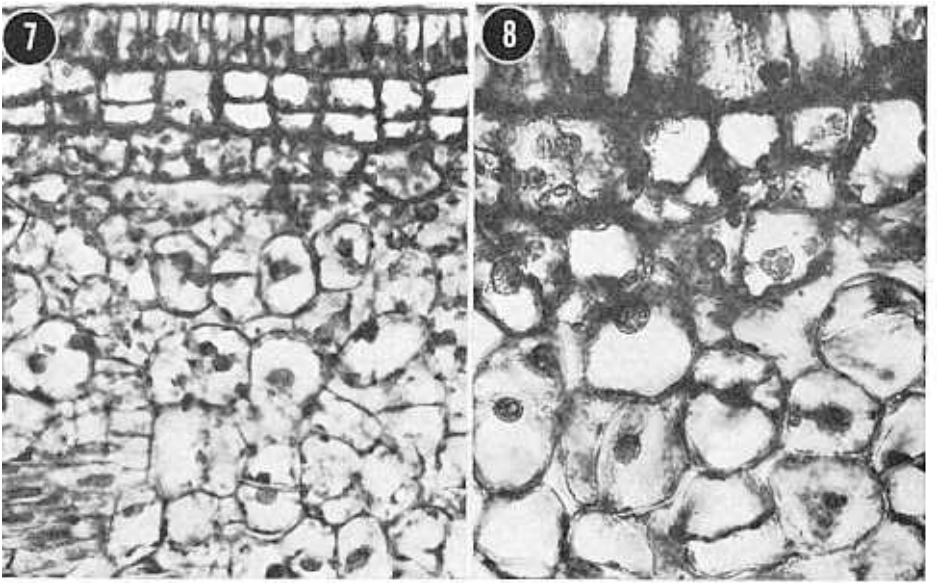


Fig. 7-8. ***'Eckert' russet strain:*** **transverse sections showing fruit development 7 days after fruit-set. Note distinct layers of cells already formed adjacent to the epidermis, Fig. 7. In Fig. 8, the outer cortical cells were nucleated with divisions occurring parallel and at right angles to the surface of the fruit. Fig. 7, × 400; Fig. 8, × 640.**

outer protective region (arrows). Some spur types have exhibited a tendency for russet development on young trees. This may be alleviated when full crops are set.

In contrast, development of the outer protective region of a russet mutant ('Eckert' strain) is shown in Figs. 7-13. Fig. 7 shows periclinal division of 2 cell layers adjacent to the epidermis. Anticlinal divisions were prevalent in contiguous cortical cells. Greater magnification of the abnormal development show cell activity in another area (Fig. 8), with nucleated cells; this development was the beginning of sloughing-off process of the outer protective region.

Russet formation was evident 20 days after fruit-set and 10 days later it was visible over the entire surface of the fruit. Observations of this specific development have been made for several years and the stages of russet development remain constant. Fig. 9 illustrates the fruit 14 days after fruit-set by which time 8-10 layers of cells were well defined in the hypodermis. This activity denotes cessation of growth and senescence of these cells. Continued meristematic activity in the outer cortical region was evident at that time. However, the hypodermal region would not be capable of enlarging as the cortical cells increase in size. Fig. 10 shows the separation of the fruit pedicel (FP) tissue from that of the cortical tissue (C) of the fruit in the cavity region. It is noted that the hypodermal region of the fruit (H) has a definite number of cell layers with periclinal division (P) and anticlinal division (A) in evidence.

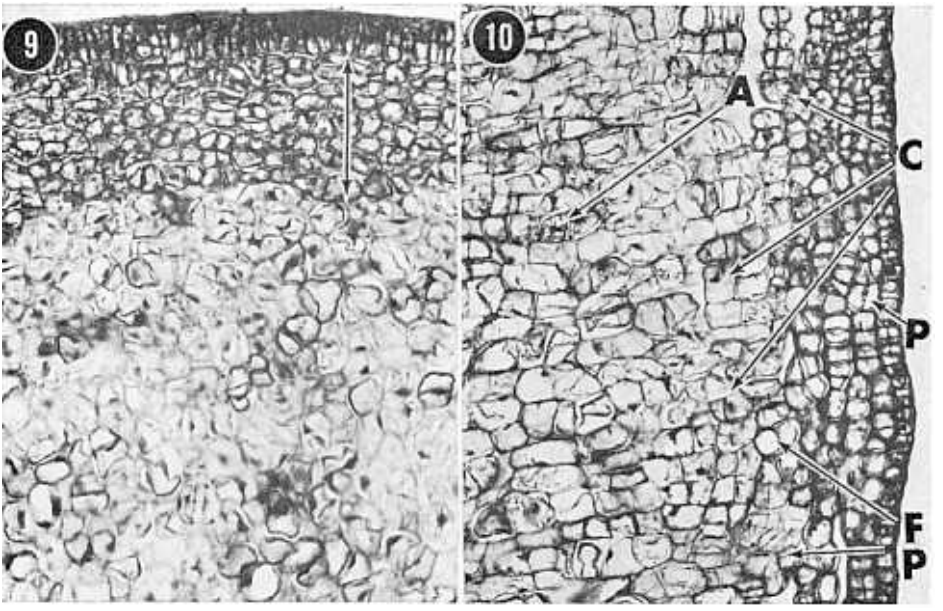


Fig. 9-10. *'Eckert' russet strain.* Fig. 9. Transverse sections of fruit 14 days after fruit-set with 8-10 layers of cells that are well defined in the hypodermis (arrows). Fig. 10. Tissue separating the fruit pedicel (FP) with that of the cortical cells (C) of the fruit. Fig. 9, × 160; Fig. 10, × 128.

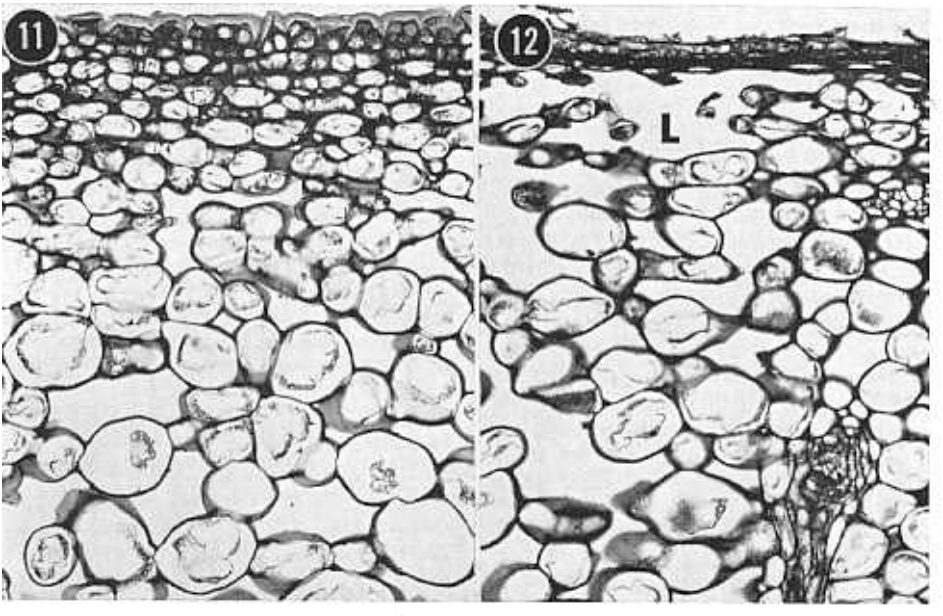


Fig. 11-12. Transverse sections of a "normal" 'Golden Delicious', Fig. 11, 40 days after fruit-set compared with the 'Eckert' russet strain, Fig. 12, on the same date. Note large lacunae (L) with little outer protective region remaining. Fig. 12. Both × 128.

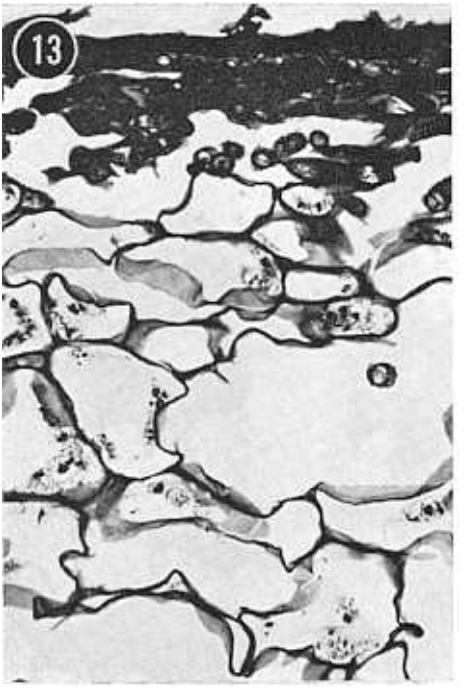


Fig. 13. ***'Eckert' russet strain.*** **Transverse section through the equatorial axis of mature fruit showing large lacunae and disintegration of the epidermal and hypodermal region. × 160.**

A distinct separation of the hypodermal region and that of the cortical region is indicated by arrows.

Fig. 11 shows a "standard" 'Golden Delicious' on June 22 (approximately 40 days after fruit-set) with normal progression of growth in the outer protective region. The cortical and hypodermal cells are enlarging at a constant rate without meristematic activity that occurred in the russet strain. Comparison may be made in Fig. 12 with the 'Eckert' russet strain on the same date. Very little outer protective region is present and the phellogen tissue that has produced cork (phellem) is the only remaining outer protective tissue (Fig. 12). Large air spaces (Lacunae) (L) were evident in this area of activity. Similar conditions existed with mature fruit (Fig. 13) in which the entire fruit surface was covered with phellem (cork) and the meristematic activity of phellogen was lacking at this late date in development. Fruit such as this was extremely difficult to harvest without bruising.

Growers will profit by testing various strains of 'Golden Delicious' in order to determine the one which will be most russet-free and have the highest quality under the existing environmental conditions in which they are grown.

Literature Cited

1. Ballard, Jim. 1973. Apple variety evaluation—a never ending challenge. *Fruit Var. J.* 27(2):30-32.
2. Simons, Roy K. 1960. Developmental changes in russet sports of Golden Delicious apples—morphological and anatomitomical comparison with normal fruit. *Proc. Amer. Soc. Hort. Sci.* 76:41-51.
3. _____. 1962. Spontaneous russet sports of Golden Delicious apples—morphological and anatomical comparison with normal fruit. *Proc. Amer. Soc. Hort. Sci.* 80:79-89.
4. _____. 1962. Some variations in russet sports of Golden Delicious apples. *Fruit Var. and Hort. Dig.* 18(1):9-10.
5. _____. 1965. The origin of russeting in russet sports of the Golden Delicious apple. *Horticultural Res.* 5(2): 101-106.
6. _____. 1973. Some aspects on russeting of the Golden Delicious apple. *Proc. Ohio State Hort. Soc. 126th Ann. Meeting.* p. 95-98.