California Avocado Society 1981 Yearbook 65: 125-132

Sclerocarpelosis in Avocado Fruit

C. A. Schroeder
Department of Biology, University of California, Los Angeles.

A rather unusual case of malformation in avocado fruit has been noted recently. The aberrant tissue structure is not detectable from external examination of the fruit. Upon cutting the mature or nearly mature fruit, the aberrant tissue becomes evident in the form of a stony layer of various degrees of development located in the otherwise soft fleshy pericarp wall. A tentative name of sclerocarpelosis is used to describe this condition. The term *sclero* refers to hardness of the stone cells, or sclereids, which are the basic structural elements involved. *Carpel* refers to the fruit wall, and *osis* implies a disease or disturbance of the plant or plant tissue.

The fruit is sometimes affected to an extent that it becomes inedible. Still other fruits may contain small clusters of stone cells which would not be detected even if eaten. Extremely affected fruits can have a stony layer 1 to 5 mm in thickness completely surrounding the seed. This structure is suggestive in many ways of a peach pit which envelops the peach seed.

The affected fruits have been observed on several trees at various locations in a very large (1300 acres) avocado planting in Orange County, California. The orchards involved are situated on gently rolling hills. The major portion of the trees bearing abnormal fruits are found in low elevations or "pockets" where the effects of local radiation frosts were observed to severely affect the trees during the 1979-80 winter season. Many of the trees exhibited responses to frost injury such as unusual resprouts and development of main structural limbs at points near the soil, severe bark and sunburn injury due to unusual exposure as the result of loss of leaf canopy by frost, and a general weakened appearance of the entire tree in comparison with nearby unaffected trees.

The orchards are planted in alternate rows of Hass and Fuerte varieties. The fruit abnormality has been restricted entirely to trees of the Hass variety. A few abnormal fruits were noted among some fallen fruits in the 1980 harvest season. A considerable amount of fruit damage was noted in the 1981 season when several dozen trees were marked as "unusable," and hence were not harvested because of fruit damage.

Affected fruits cannot be detected with certainty from external appearance. Some persons working constantly among the affected and normal trees have suggested as a symptomatic criterion a red coloration near the stem end of the maturing fruit. This could not be verified in repeated samplings in the 1981 season. There appears to be no correlation between position on the tree and the severity of the internal fruit trouble. Likewise there is no relationship between size of fruit and the amount of stoniness which develops at the time of maturity, which was determined by general dark coloration

of the skin. These general observations are the result of cutting hundreds of fruits from trees known to bear affected fruits.

Internal Symptoms

The general morphology and structure of the avocado fruit has been described in several articles (1, 2, 3). The fruit is generally classified as a botanical berry with a soft, fleshy fruit wall. While some avocado varieties are virtually without stone cells, or sclereids, in this soft pericarp or fruit tissue, the fruits of Guatemalan avocado types may have a few too many stone cells in small clusters located just beneath the epidermis. This sclerenchymatous tissue comprises the "thick skin" of the Guatemalan varieties such as the Hass variety. The fruit disturbance of sclerocarpelosis does not involve the sclereid bearing tissue of the fruit rind, but is manifest in the development of a unique stony layer between the rind and the seed cavity. Moreover, this stony mass is not represented by the internal layer of sclereid cells which forms the internal epidermis of the fruit and lies adjacent to the seed coat. The extreme development within a stony fruit is a layer of very closely packed stone cells somewhat median in location between the epidermis and the seed cavity. This stony layer sometimes envelops the seed completely.

Sclereids are stone cells such as are seen in shells of nuts or endocarp (pits) of stone fruits. These can occur singly, in small clusters, or in large, closely adherent masses such as a nut shell. The form of sclereids is highly variable from those having long extensions in all directions to the simple, isodiametric, short stone cell resembling a typical parenchyma cell but with a thickened cell wall. The secondary wall shows prominent branched pits. The wall thickness may not be uniform within a given sclereid. All of these characteristics are found in the stony avocado fruit.

The stony layer of an affected fruit consists of typical stone cells of the type brachysclereids. These cells are very similar in form to typical parenchymas which comprise the major cell type of the avocado fruit wall. The parenchyma cell has a very thin cell wall of cellulose, whereas the sclereid wall is very prominently thickened and rather highly lignified, a condition commonly observed in stone cells. The very thickened cell wall is permeated by simple branched pits which provide direct connections with adjacent sclereids. Sclereids in various degrees of development are associated with the massive stone tissue in the more advanced cases.

The earliest anatomical manifestation of sclerocarpelosis is the appearance of isolated stone cells in the apical region of the carpel where the vascular bundles of the carpellary wall coalesce and enter the seed coat. The scattered cells with prominently thickened and slightly lignified secondary walls are found among the vascular strands but not intimately associated with the xylem or phloem. The individual sclereid is separated from a vascular strand by a layer of several parenchyma cells. The number of scattered sclereid elements continues to increase, eventually forming a continuous mass of sclerenchymatous tissue. Simultaneously, the cell wall thickness increases and lignification becomes more prominent in this tissue.

The appearance of the stone cell tissue is first evident at the base of the seed as a

small hard mass. This stony mass then spreads basipetally to form a somewhat flattened, cup-shaped tissue permeated by the vascular strands. Development of the stony layer in the form of fingers of tissue continues to extend the sclereid masses toward the stem end of the fruit. There are lateral developments of the stony tissue such that the individual fingers of tissues are connected to form a continuous sheath surrounding the seed base. When viewed in cross section this stony sheath appears as a continuous ring of tissue surrounding the seed. The edges of the stony tissue, seen in cross section, are highly undulating and with perforations of clear areas wherever the vascular tissue permeates the stony layer. The major vascular bundles which parallel the main fruit axis are partially surrounded by stone cells but separated by undifferentiated parenchyma. This arrangement of the buffer zone of undifferentiated tissues gives the stony tissue a scalloped effect when viewed in cross section. There are vascular tissues both inside and outside of the stony layer, which thus becomes a furrowed mass with the furrows running lengthwise within the carpellary wall.

The ultimate arrangement and relationship of aberrant sclereid tissue in affected avocado fruit suggests that there is no invasion of the normal tissue by the development of a meristematic layer or breakdown of vascular tissue, as is noted in some fruit problems in other fruit species. It appears that the pericarp parenchyma become modified in place merely by the increase in thickness and lignification of the cell wall. There is little displacement or translocation of tissues within the pericarp wall. The given parenchyma cells merely develop very thick cell walls by internal growth. The cell size remains constant with that of the surrounding parenchyma, approximately 60 microns (.002 inch) in diameter.

The nature of fruit development in avocado should be noted in respect to this particular problem. Following pollination, most other fruits undergo a period of intense cell division which lasts for approximately three weeks after which time the fruit increases in size primarily by cell enlargement among the cells previously formed. Thus in fruits such as the apple very large cells are found at fruit maturity. A markedly different pattern of fruit development is noted in avocado. Pollination of the avocado pistil initiates a series of cell divisions. Each cell when it approaches a diameter of approximately 60 microns undergoes cell division, which results in a large mature fruit with isodiametric parenchyma cells all of approximately the same size. Thus cell division is continuous throughout the developmental life of the fruit. The larger the fruit, the more cells it contains. Other fruit types, in contrast, develop large fruits because the individual cells become larger. Cell size has many physiological implications in respect to fruit development and metabolic behavior. The fact that the sclereids of the stony layer of avocado do not undergo division may be of significance in evaluation of the disturbance.

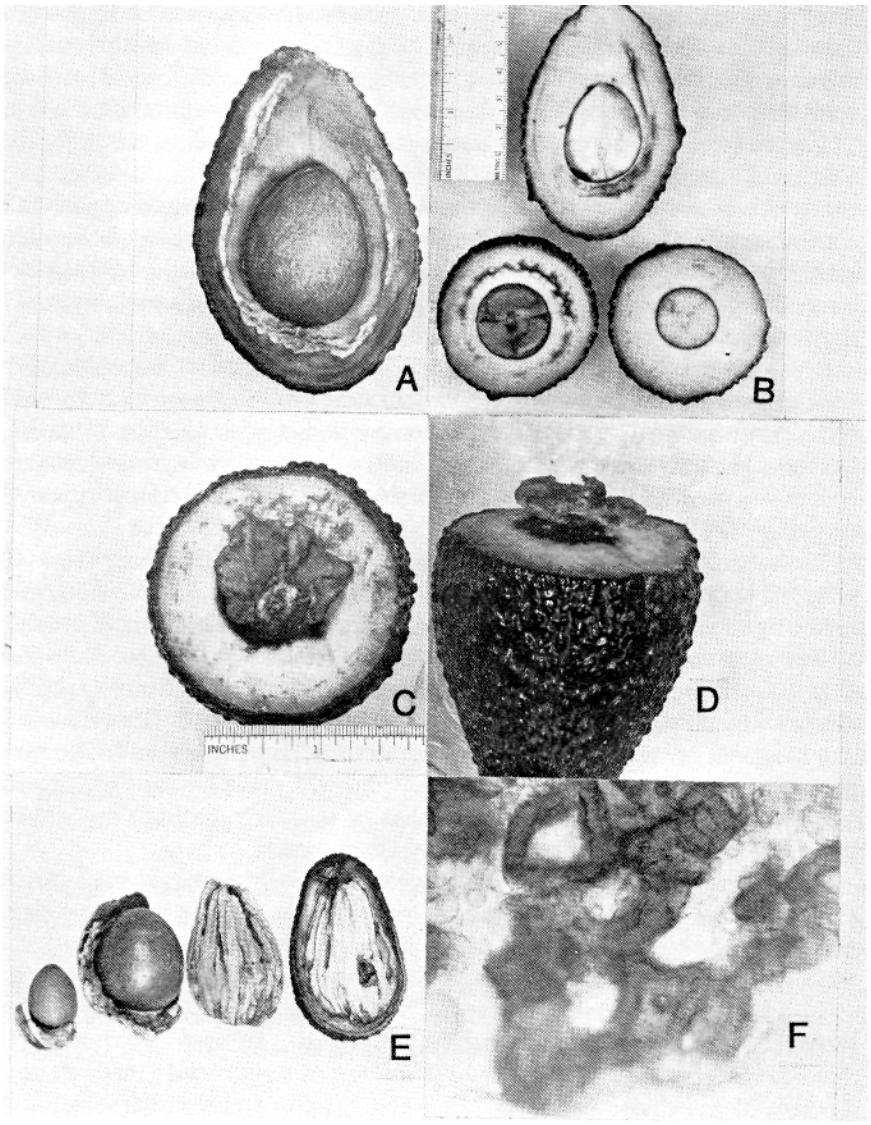

Figure 1. Stony Hass avocado fruits. A—Longitudinal section showing stony layer in otherwise soft pericarp tissue. B—Longitudinal and transverse sections showing discoloration of stony tissue. C—D. View from apical end and side view of same fruit showing stony mass with soft pericarp tissue removed. E—Series of stony masses with soft pericarp tissue removed. F—Photomicrograph of portion of sclereid mass from stony layer.

The physical aspects of sclerocarpelosis are highly variable within fruits of approximately the same age and degree of maturity on a given Hass tree. A series of randomly selected fruit from one tree were examined for the presence of stone cells. The variation in degree of development is depicted by the diagram of tissues in Figure 1. It is noted that some fruits exhibit small clusters of stone cells 1-2 mm (one-eighth inch) in diameter. This stone cell cluster increases in size not necessarily uniformly.

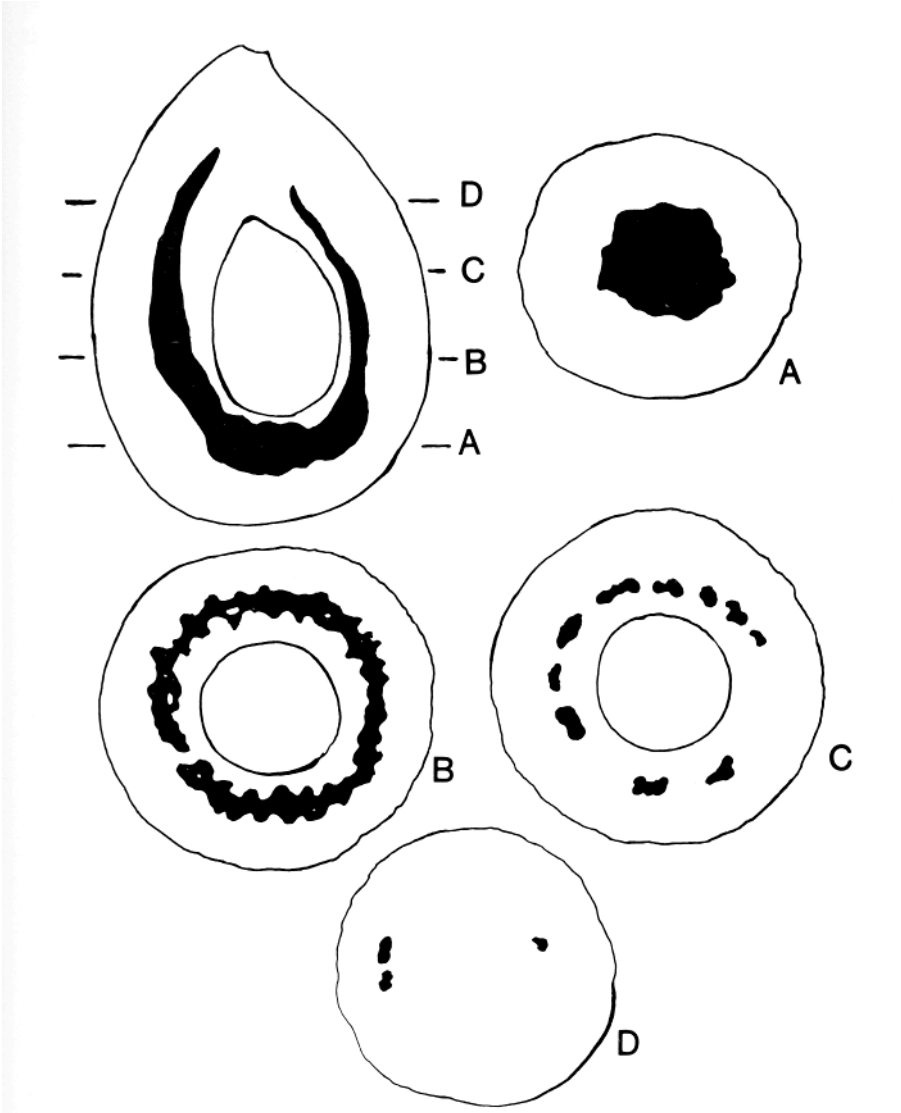

Figure 2. Diagram of Hass avocado fruit in longitudinal section showing distribution of the stony masses at various levels A—D.

Sometimes, a long single finger of cells, or possibly two fingers of cells, will develop from the base of the seed and extend toward the stem end of the fruit. The most extensive case in which the seed is entirely enclosed in a stony layer was noted in several instances.

Fruits affected by sclerocarpelosis are essentially unsuitable for the trade. While those fruits with slight manifestations of a stony layer are probably undetectable in the course of ordinary utilization, those fruits with more extensive sclerification are repulsive to both the eye and to taste in that the affected flesh is slightly discolored to a darkened tan to grey color, and the flesh is gritty to the taste with a consistency much like a sand-pear. One highly developed stony specimen of Hass fruit approximately 4 inches long was determined to have a total fruit volume of 130 ml. The seed volume was 13.5 ml and the volume of the stony layer was approximately 26 ml or 22.3% of the edible portion.

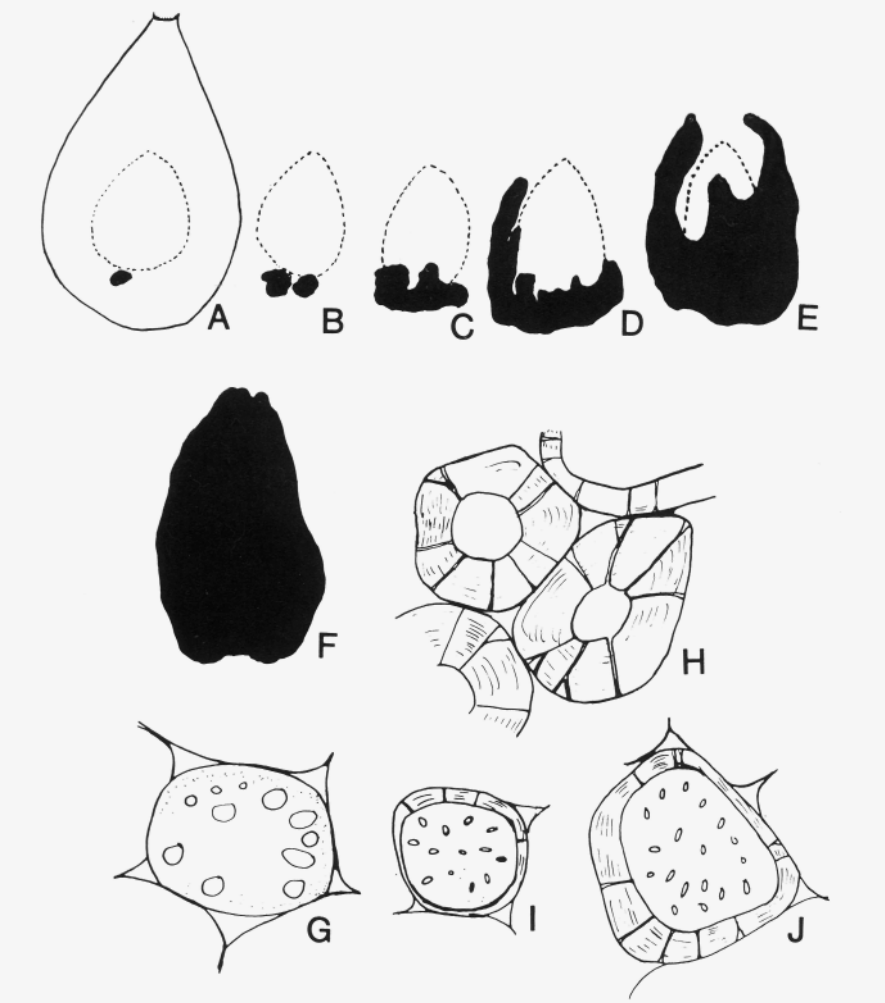

Figure 3. A—F. Diagram of sequential stages of severity in development of sclereid tissue in Hass fruit. G—Normal parenchyma cell of fruit pericarp. H—Ultimate development of brachysclereid with lignified thickened wall, and branched pits. I—J. Developmental stages of sclereids.

The cause of sclerocarpelosis in avocado is not known at this time. It has been speculated that the abnormal fruit has resulted from a disturbance of the tree physiology as the trees were subjected to severe frost two years prior to the season of fruit injury. There is little evidence to support this theory, to judge from the behavior of other Hass trees of comparable age and frost exposure in other parts of the orchard and in other counties. The fact that large blocks of Hass trees were propagated from identical scion sources, and are growing normally and producing acceptable fruit in the same orchard and adjacent orchards, seems to rule out the possibility of poorly selected buds for propagation. Comparable trees of the same origin in other areas such as Ventura and San Diego counties are all growing normally regardless of severe frost injury in some individual trees in these scattered locations.

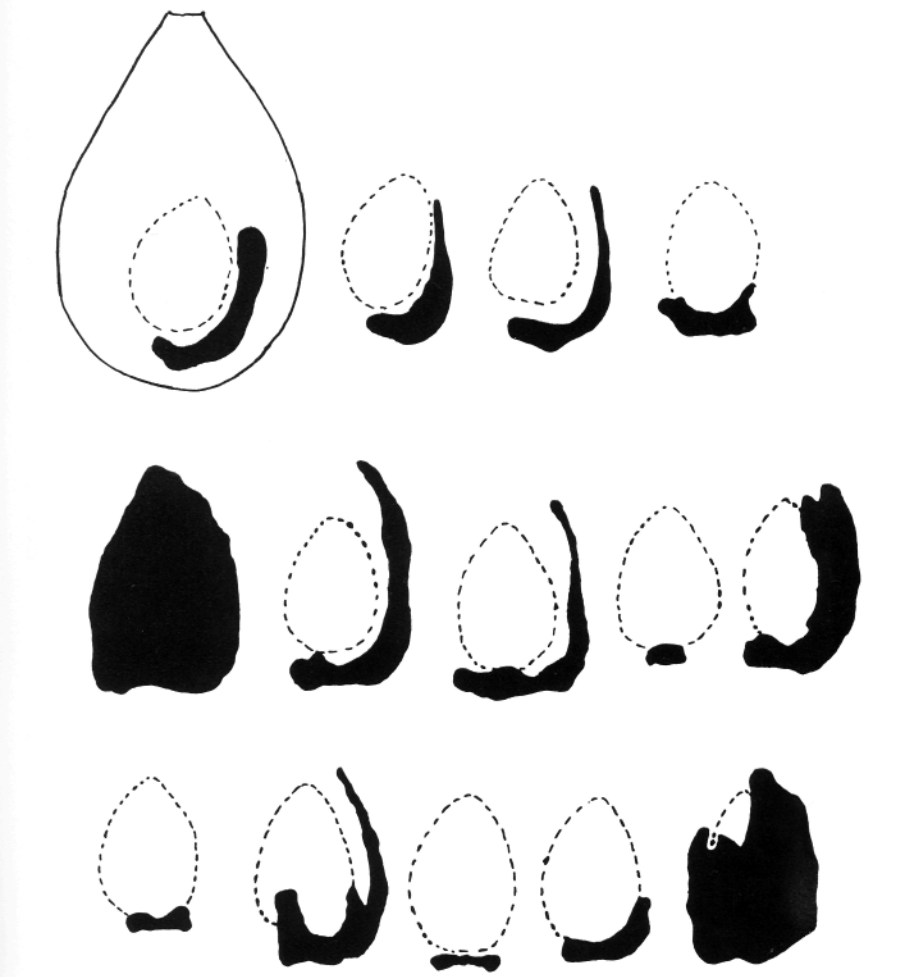

Figure 4. Diagrammatic longitudinal sections through stony Hass avocado fruits. Sample of 14 fruits from one tree indicating range in amount of stoniness in mature fruits.

A second hypothesis concerning the irregular behavior of the affected trees is that of a nutritional nature. Possibly a toxicity or deficiency symptom has been expressed in the fruit. This appears somewhat unlikely, as nearby trees appear normal regardless of block treatment of the ranch in their normal procedures in the fertilization and irrigation management programs.

A third suggestion has been made that the fruit disturbance might result from the use of one or more herbicides or insecticides which could have accumulated in the soil in the "low elevation" areas where the affected trees are generally found.

Still another hypothesis is that of a virus disturbance. Observations on the reappearance or spread of the trouble in future crops may suggest a more careful examination of this hypothesis. Some preliminary evaluations of the virus theory have been initiated.

Presently, there is no confirming evidence for any specific cause of this disturbance in the structural development of the avocado fruit. Preliminary field observations have

revealed no correlations between any factors of the several orchard management programs and the fruit breakdown. Some preliminary experimental procedures have been initiated to investigate the possible relationship of insecticides and herbicides to the problem. There appears to be no simple relationship of any conceivable orchard management or natural factors according to the evidence at hand.

Literature Cited

1.Cummings, K., and C. A. Schroeder. Anatomy of the avocado fruit. California Avocado Society Yearbook 1942: 56 - 64.
2.Schroeder, C. A. 1953. Growth and development of the Fuerte avocado fruit. Proc. Amer. Soc. Hort. Sci. 61: 103 - 109.
3. ---------- . 1951. Structure of the skin or rind of the avocado.
California Avocado Society Yearbook 1950: 169 - 176.