further. Therefore, preparation for final separation is due to cellular disintegration in a zone rather than the formation of a discreet layer.

Discussion

The site of separation-zone formation in different fruits varies considerably. Pome fruit abcise at the pedicel base (7, 8). Plum fruit may be shed with or without pedicels (4). Two abscission zones are known in sweet cherry (9). Cherry fruit may abscise between pedicel and peduncle or between peduncle and spur, depending upon time of year. Fruit separation at maturity occurs at the fruit base in mango and avocado (2) and in orange (10).

A morphological and anatomical study of the zone of abscission in the highbush blueberry indicates that the zone has tissue that is both inherently dissimilar to contiguous tissue of the pedicel and the berry and structurally weak. Anatomically, the disc at the point of attachment of the pedicel and the berry was composed of transitory tissue, some of which possessed certain properties of both pedicel and berry as illustrated by differential cell enlargement, sub-epidermal layer differences, and sclerification differences. Separation by cell wall rupture occurs near the distal region of this disc. The initial disruption of tissue integrity in this region was evident at approximately the Green-Pink stage of berry ripeness. Further loss of integrity and eventual separation rapidly developed through subsequent stages of ripeness. The onset of berry coloration (green-pink stage) was also the approximate stage of ripeness at which most berries separated with applied force at the berry/pedicel junction rather than the pedicel/peduncle junction. Therefore, the berry could be loosened from the pedicel when it began to develop red color. In combination with the loss of cellular integrity in the abscission area, added stress is also placed on the structurally weak area by the differential expansion of cells in the transition zone and by the increased point stress due to the increase in fruit weight. Since the structural integrity of the vascular system and the epidermis is apparently not altered, final fruit separation is brought about by mechanical rupture of these tissues. Histological changes in separation zone formation in the blueberry are similar to those in other fruit (9) and other organs (1, 3).

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J. Amer. Soc. Hort. Sci. 105(3):341–346. 1980.

Seedless Fruit in 'Fuerte' and 'Ettinger' Avocado[1]

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Additional index words. ovule degeneration, endocarp, *Persea americana*

Abstract. **Seedless fruitlets of 'Fuerte' and 'Ettinger' avocado (*Persea americana* Mill.) (5 to 20 mm length) exhibited a typical degeneration pattern of the ovule which began at the chalaza and spread toward the micropylar region but stopped when about half of the integument was still intact. Embryo or endosperm or both were found in many seedless fruitlets. Degeneration was found to start at different stages of fruitlet development, from a proembryo to an embryo starting to develop cotyledons. Typical seedless fruit in 'Fuerte' and 'Ettinger' avocado appears to be the outcome of seed degeneration (stenospermocarpy) and not parthenocarpy.**

Seedless fruit (cukes) occur frequently on 'Fuerte' (Fig. 1) and 'Ettinger' trees (3, 7). The number of seedless fruit varies yearly, the amount usually being larger when fruit set of normal seeded fruit is very poor or following girdling which increases the amount of both seeded and seedless fruit (5, 8). Anatomical examination showed that the small body at the distal end of the seed cavity is a partially degenerated seed coat (3). Seedless fruit may be the result of either automatic parthenocarpy or stenospermocarpy (fruit development after embryo abortion). Seedless fruits were examined to determine the type and mode of carpel development in seedless avocado.

Materials and Methods

It is possible to recognize seedless fruitlets on the tree, when they are ⩾20 mm in length by their elongated shape and small size compared with seeded ones. Earlier identification of seedless fruitlets at 5 mm in length could be made by cutting the distal part of the fruitlet, revealing the typical cavity of the seedless fruit. The ovule is degenerated in most fruitlets containing cavity and it is difficult to identify any structure within the ovule. Seedless fruitlets 5 to 20 mm long from 'Fuerte' and 'Ettinger' trees were sampled during April and May from 3 different orchards (Kibbutz Rosh Haniqra, Kvuzat Schiller and the Agricultural Research Organization, Bet Dagan). The

[1]Received for publication September 11, 1979.

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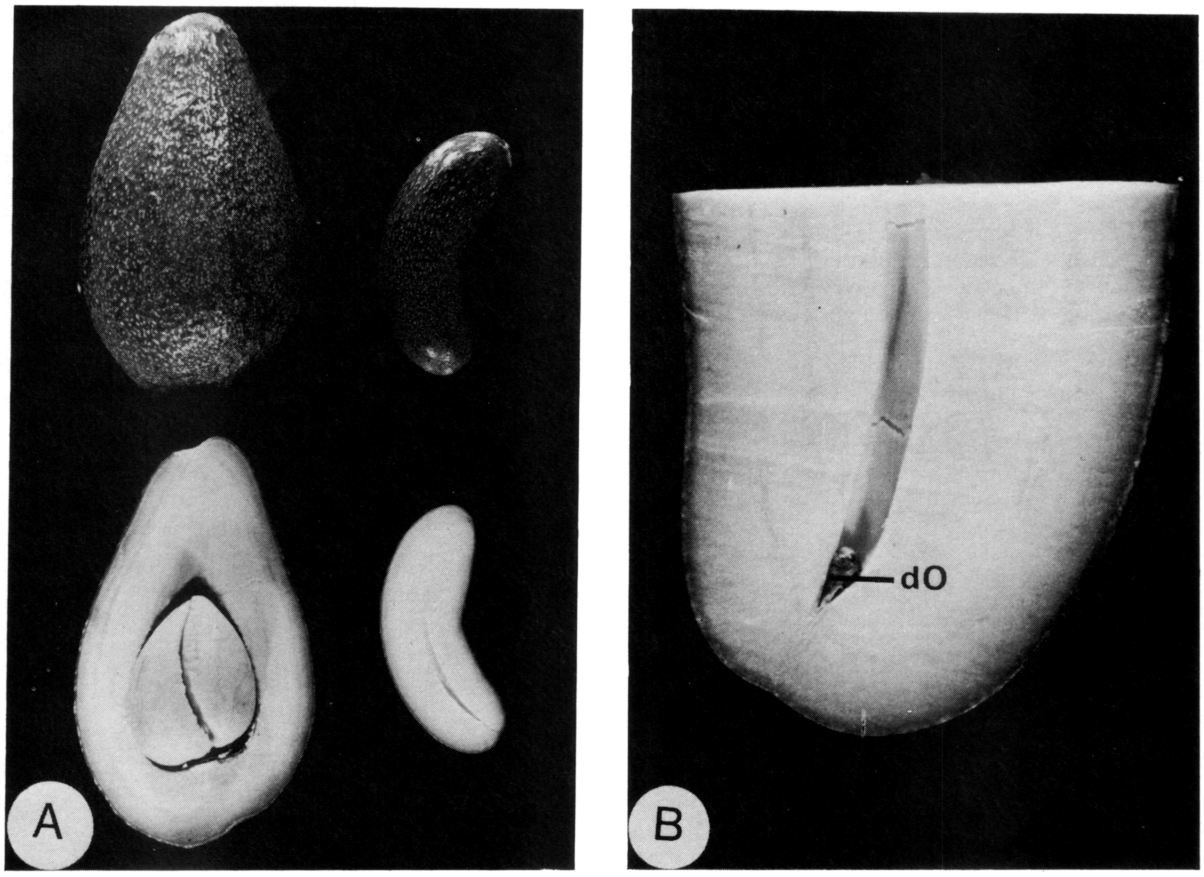

Fig. 1. Macroscopic view of seeded and seedless fruit A) Seeded (left) and seedless (right) mature avocado fruits. B) Longitudinal section of seedless mature fruit. dO = degenerate ovule.

large seedless fruitlets were identified and sampled according to shape and the small seedless fruitlets, after cutting the distal end.

The first discernible stages of seedless fruit development were examined at different ages after pollination from 2 trees known to bear mostly seedless fruits (one 'Ettinger' tree at Kibbutz Rosh Haniqura and a 'Fuerte' tree at the Agricultural Research Organization orchard in Bet Dagan). Samples were fixed in FAA, embedded in paraffin, cut serially at 15μm and stained with safranin and fast green.

Results

No differences were found between the cultivars and the following description refers to both 'Fuerte' and 'Ettinger': The small body at the distal end of the seed cavity of seedless fruit (Fig. 2A) was recognized as a degenerate ovule in fruit of all sizes but advanced deterioration of the ovule in old ones usually prevented clear recognition of the different tissues. Young seedless fruit were always found to have a typical ovule degeneration pattern (Figs. 2A, B).

The anatomical study of fruitlets 5 to 20 mm long enabled us to detect early stages of degeneration and to follow it in the seedless fruit development. The first symptom was the appearance of an open space between the ovule and the ovary indicating the arrest of ovule growth. Symptoms of degeneration appeared at the chalaza, first in the nucellar part and then in the integuments (Fig. 2B, C). Degeneration spread toward the micropylar region, resulting in extensive destruction of the integuments and the nucellus. Degeneration stopped a short distance from the micropylar end, leaving part of the integuments intact without a transition zone, in sharp contrast to the shrunken tissue (Fig. 2D). This intact part of the integuments differed from comparable parts in seeded fruitlets in the proportion of differentiated to differentiating tissue. The outer half of the integument in seedless fruitlets was composed of round, relatively large differentiated cells and the inner half of small, rectangular differentiating cells arranged in rows. Most cells in seeded fruitlets were already differentiated and only a few differentiating. There was meristematic activity at a later stage in young seedless fruit, starting at the proximal end of the intact part of the integuments. Cell division and growth started as a cluster at certain definite locations (Fig. 3A). Eventually the new growth enveloped the chalazal end of the degenerate ovule (Fig. 3B) and the degenerate ovule became visually white all around. Later on, the small ovule shriveled and became brown when the seedless fruit matured.

Eighty-one of 209 seedless fruitlets examined contained an embryo and an endosperm. The embryos were of different size, from proembryos consisting of some ten cells, to large round bodies starting to develop cotyledons (Fig. 3B). Most of the embryos and the endosperms were slightly to severely degenerated in different stages, but a few apparently intact embryos also were observed (Fig. 4). The whole micropylar region of the remaining 128 fruitlets was obscured by heavy deposits of dark red staining resinous substances (Fig. 2A) and it could not be ascertained if they contained a degenerate embryo or endosperm. The presence of an embryo and endosperm or both could always be identified in the first stages of this typical degeneration regardless of fruitlet size.

Seedless fruit lacking an ovule altogether were found on avocado trees that consistently bear only seedless fruit. Such fruit were also obtained by spraying flower buds of normal trees with gibberellic acid (unpublished data).

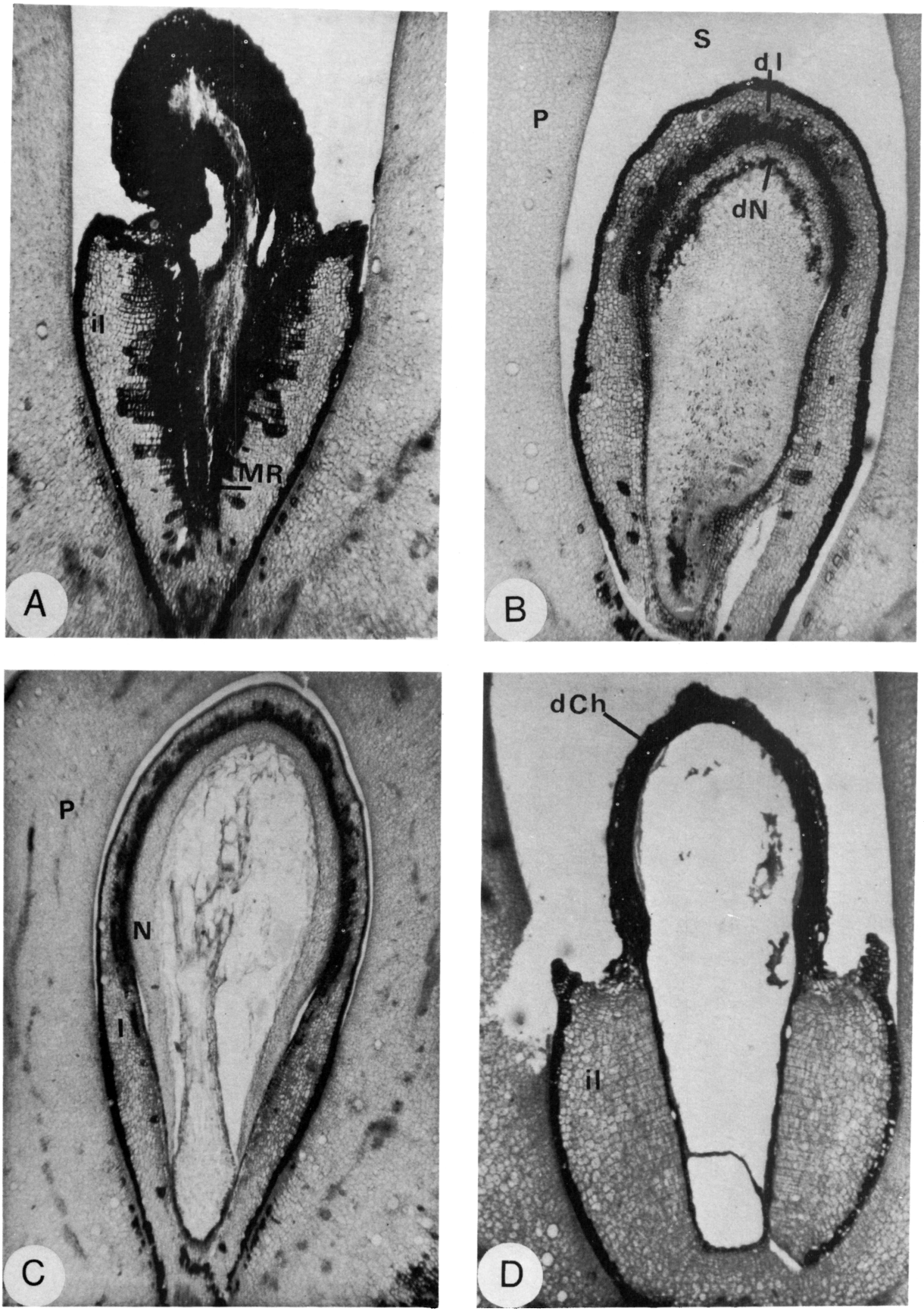

Fig. 2. Stages of ovule degeneration in seedless fruit. A) Severe ovule degeneration in seedless fruitlet (× 300). Note the heavy deposits of dark stained substances at the micropylar region. B) Beginning of degeneration of integument and nucellus at the chalazal end (× 40). Note the space between the ovule and the pericarp. C) Chalazal end of normal fruitlet (× 40). D) The typical ovule degeneration of seedless fruitlets (× 40). Note the intact part of the integument in sharp contrast to the degenerate tissue. M.R. = micropylar region. P = pericarp. dN = degenerate nucellus. dI = degenerate integument. S = space. N = nucellus. I = integument. iI = intact integument. dCh = degenerate tissue.

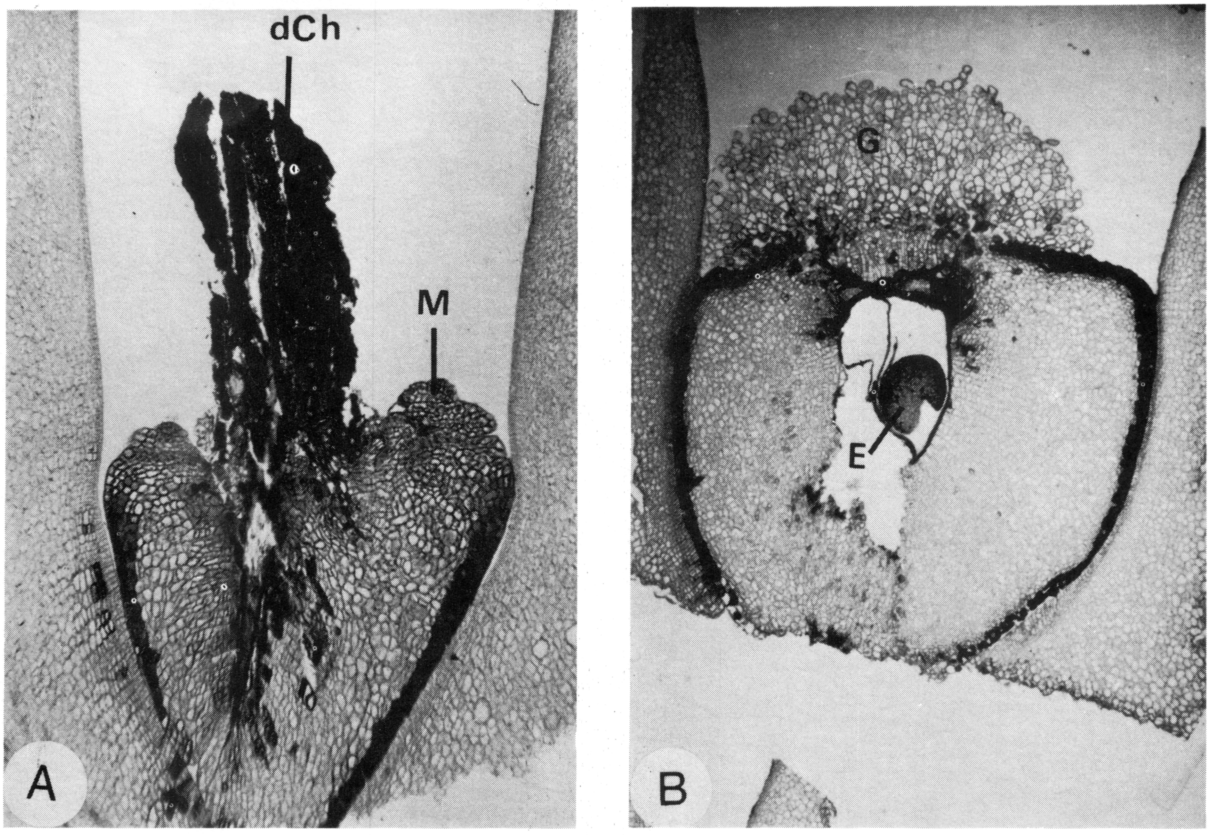

Fig. 3. New growth of the intact integument in seedless fruit. A) Beginning of meristematic activity at the upper end of the intact integument (× 60). B) The new growth envelops the degenerated chalazal end (× 60). M = meristematic activity. dCh = degenerated chalazal end. G = new growth. E = embryo with cotyledons primordia.

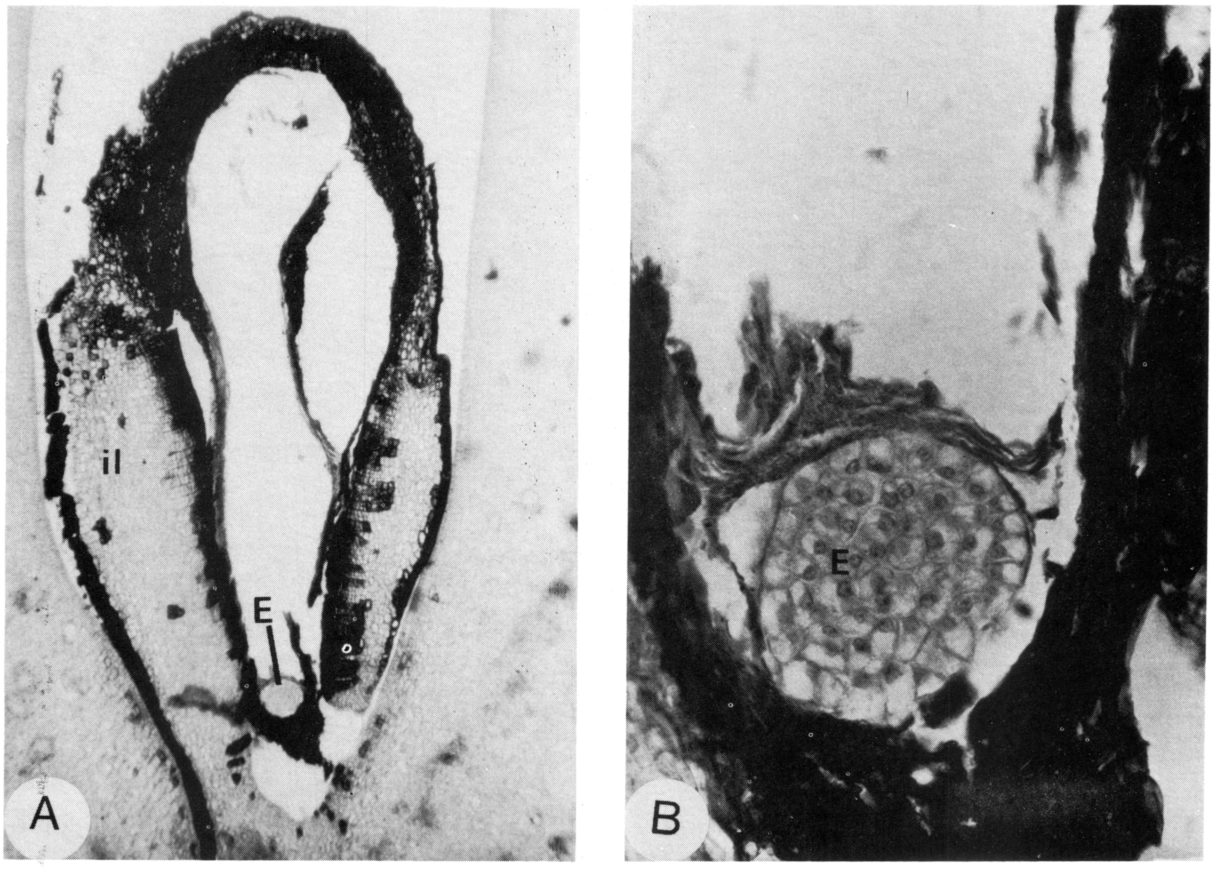

Fig. 4. Healthy embryo in seedless fruit A) × 40. B) × 300. E = embryo. iI = intact integument.

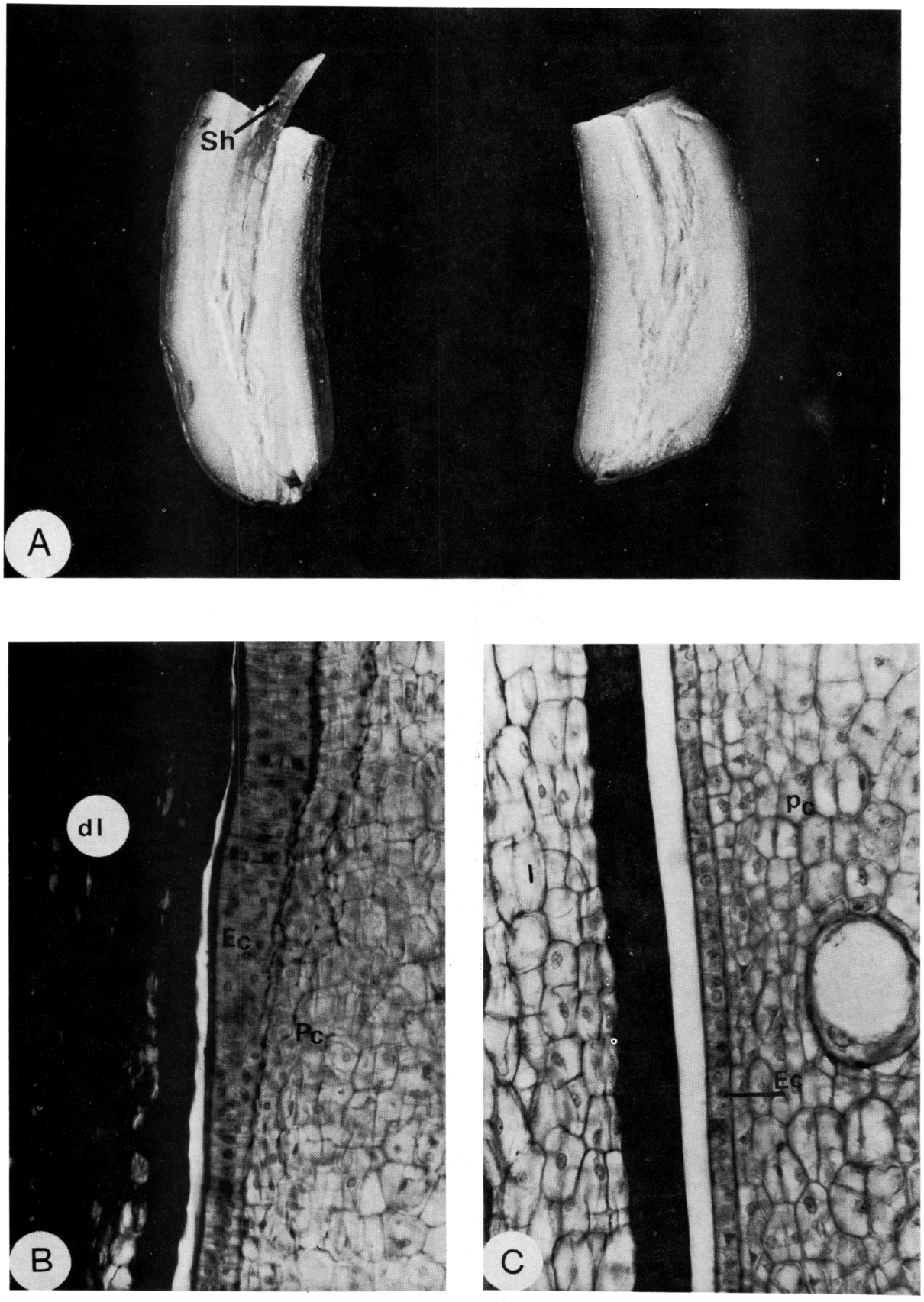

Fig. 5. Endocarp in seedless fruit A) Ripe seedless fruit. Note the large central sheath. B) Endocarp in young seedless fruit (× 300). C) Endocarp in young seeded fruit (× 300). I = integument. Ec. = endocarp. Pc = pericarp. Sh = sheath. dI = degenerated integument.

A long white sheath lining the inner part of the soft seedless fruit (Fig. 5A) enclosed an elongated cavity throughout its length and the remains of the degenerate ovule which are located at its distal end. This sheath is the endocarp, consisting mainly of large sclerenchymatous cells in 1 or 2, and occasionally 3 layers. The sclerenchyma is surrounded by a narrow strand of deformed, small cells. The sheath origin became evident in an early stage of fruit development. Cells of the inner epidermis of the pericarp gradually enlarged, becoming vacuolate, and part of them divided into 2 layers. The walls thickened and lignified (Fig. 5B). The neighboring 1 or 2 layers of very small tangentially elongated parenchymatous cells become compressed and deformed. They remained always adherent to the sclerenchymatous cells.

Development of the endocarp was similar in seeded fruit, but the lignified cells were smaller and consisted of only 1 layer. One or 2 layers of small parenchymatous cells were adherent to the sclerenchyma. The endocarp becomes part of the seed coat and almost inseparable from it (Fig. 5C). Valmayor (1967) described this for other cultivars of avocado.

Discussion

Results of this study indicate that the typical seedless fruit in 'Fuerte' and 'Ettinger' avocado is the outcome of seed degeneration (stenospermocarpy) and not automatic parthenocarpy (6). This conclusion is based on the fact that no fruit were found without an embryo or endosperm in the more than 200 seedless fruits examined. Furthermore, all fruitlets examined at the beginning of seed tissue degeneration, had an embryo or endosperm or both. The set of seedless and seeded fruit was also prevented when pollination was prevented (10).

The facts that 1 tree was found with flowers lacking ovules which produced parthenocarpic seedless fruit and parthenocarpic seedless fruit can be produced by growth hormones (gibberellins) indicate that automatic parthenocarpic fruit will develop under special conditions. Profuse flowering of avocado trees and profuse fruit set at the first fruit development stages lead to competitive conditions which probably eliminate the possibility that automatic parthenocarpic fruitlets will survive. It is known that the avocado seed coat contains a high level of growth hormones (1, 2, 4) that may exert a strong sink effect for photosynthetates. The fact that part of the seed coat in seedless fruit remains viable and even continues to grow might not be accidental.

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J. Amer. Soc. Hort. Sci. 105(3):346–349. 1980.

A Sensitive Method for Measuring Changes in Calcium Concentration in 'McIntosh' Apples Demonstrated in Determining Effects of Foliar Calcium Sprays[1]

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Additional index words. Malus domestica, postharvest physiology

Abstract. **Three different methods of sampling flesh of apple (*Malus domestica* Borkh.) for Ca analysis produced different results due to uneven Ca distribution in the fruit. A sensitive, reproducible method of sampling and analyzing the outer cortex of the calyx half of fruits indicated that Ca concentration in different parts of the fruit changed significantly after harvest, decreasing in the core and increasing in the outer cortical tissues. Massive applications of $CaCl_2$ to trees shortly before harvest increased flesh Ca concentrations and red coloration of the fruit, decreased flesh softening during storage and senescent breakdown after storage, but caused significant injury to the fruit.**

Fruit calcium deficiency is associated with occurrence of some of the most serious apple disorders worldwide (9). Fruit are often too low in Ca to maintain high quality over long storage periods if they have been produced on trees that are quite young, growing on dwarfing rootstocks, or with excessively vigorous vegetative growth, or under moisture stress, or if they are large fruit from trees with a light crop. Soil management practices such as maintaining pH at 6.2 to 6.5, injecting $Ca(OH)_2$ slurry into the soil, and annual applications of gypsum or $Ca(NO_3)_2$ may help maintain adequate levels of Ca in apples under non-stress conditions, but they usually are ineffective in correcting Ca deficiency. For this, the treatment most widely used is the application of 4 to 8 foliar sprays of $CaCl_2$ or $Ca(NO_3)_2$ at intervals throughout the growing season.

Lewis and Martin (4) showed that Ca is not uniformly distributed in apple flesh but ranged from 150 ppm in the stem

[1]Received for publication August 29, 1979. Paper No. 2322, Mass. Agricultural Experiment Station, Univ. of Massachusetts at Amherst. This research supported in part from Experiment Station Project No. 376.

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