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Concentric cracking of grape berries

by

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Konzentrisches Aufreißen von Weinbeeren

Zusammenfassung. — Bei Traubenbeeren wurden Schrunden („cracks") und Platzwunden („splits") beobachtet, deren anatomische Verhältnisse lichtmikroskopisch untersucht wurden. Die Schrunden bilden sich als feine, konzentrische Oberflächenrisse um den Beerenansatz oder am apikalen Ende der Beere. In diesem Falle sind gewöhnlich nur die Kutikula und die epidermale Zellschicht aufgerissen. Die Platzwunden erstrecken sich dagegen auf Kutikula, Epidermis, Subepidermis und die äußeren Perikarpzellen. In den Zellen unterhalb der Schrunden ließ sich Verkorkung nachweisen, nicht jedoch in den an die Platzwunden angrenzenden Zellen. Mechanismen, die für die Beschädigung der Epidermis verantwortlich sein könnten, sowie das Eindringen von Mikroorganismen werden im Zusammenhang mit dem Auftreten von Schrunden und Platzwunden diskutiert.

Introduction

Splitting of grape berries can take place before harvesting (MEYNHARDT 1964 b, DVORNIC *et al.* 1965) or during storage (RYALL and HARVEY 1959). However, another form of damage occurs as fine concentric surface cracks (subsequently referred to as "cracks" or "cracking") in the berry skin. These cracks may have been observed previously, but to our knowledge no reports describing them have been published.

The purpose of this study was to compare the anatomical structure of cracks and splits, and to establish the extent of damage at the cellular level in each case.

Materials and Methods

Mature berries of grapevine (*Vitis vinifera* L. cv. Sultana) growing in the field were selected and prepared for light microscopy. Small slices were cut from the pedicel end of the berries and fixed in 6% glutaraldehyde (0.025M phosphate buffer, pH 7.0) for 24 hours at 4 °C. The specimens were then dehydrated and embedded in glycol methacrylate (FEDER and O'BRIEN 1968). Sections 2 μm thick were cut longitudinally with respect to the axis of the berry and stained with a) periodic acid — Schiff's reagent (PAS) followed by toluidine blue 0 or fast green FCF as a counterstain, or b) Sudan black B.

Results

Fig. 1 illustrates the external appearance of splits and cracks. A split at the pedicel end of a berry is shown in surface view in Fig. 1a and in longitudinal section in Fig. 1c. In contrast, the berries in Fig. 1b and 1d show fine concentric cracks around the base of the pedicel. Individual cracks do not form an entire circle, but they do overlap and completely surround the region of pedicel attachment. The number of cracks, measured along a single radius from the receptacle, ranged from 1 to 10 on the sample examined. The cracks were not necessarily as uniform and symmetrical as those shown in Fig. 1b. On berries showing the most extensive development of cracks, the radius from the receptacle base to the outermost crack

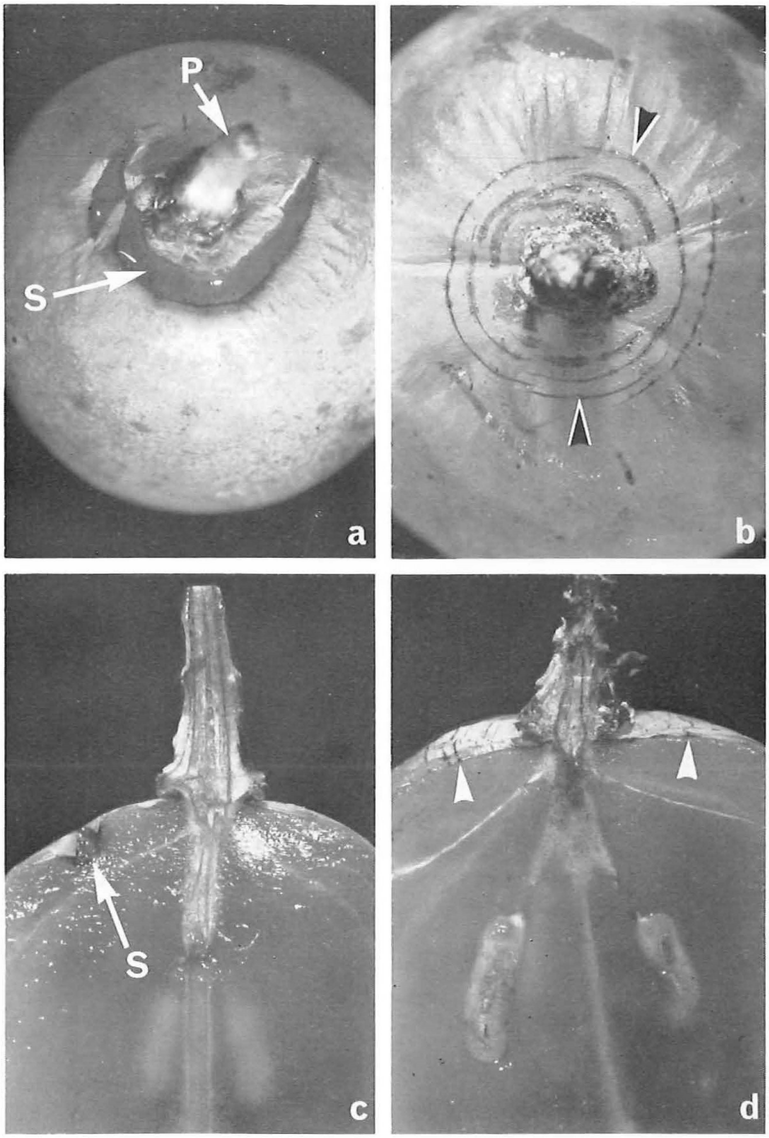


Fig. 1 a—e: The pedicel end of Sultana berries in surface view (a, b, e) and longitudinal section (c, d). Concentric cracks are indicated by arrows. a—d: ×6; e: ×12.
P = pedicel; S = split. Fig. 1 e: see p. 32.

Basales Ende von Sultanabeeren in Aufsicht (a, b, e) und längs geschnitten (c, d). Konzentrische Schrunden („cracks") durch Pfeile gekennzeichnet. Vergrößerung a—d: 6×; e: 12×.
P = Beerenstiel; S = Platzwunde („split"). Fig. 1 e: s. S. 32.

was about 3 mm. Fig. 1 e shows a berry in which a small split has formed near the concentric cracks.

Where these fine surface cracks occurred, skin rupture generally was confined to the cuticle and epidermal layer of cells. Occasionally one or two sub-epidermal

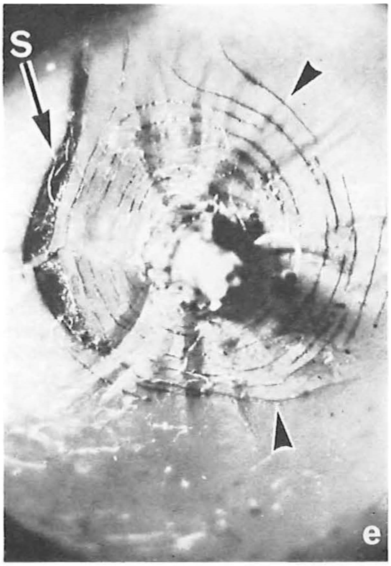


Fig. 1 e

cells were broken also (Figs. 2, 4). The outer cells of the pericarp beneath a crack were compressed parallel to the surface of the berry (Fig. 2). No cuticle was present at the site of a crack, but in some cases a small amount of Sudan-positive material coincided with cell walls immediately beneath the crack (Figs. 3, 5). Fig. 5 provides detail on the distribution of Sudan-positive material around a crack; the cuticle carries wax on its outer surface while cells beneath the crack also show some staining.

In contrast to fine surface cracking, the rupture of cuticle, epidermis, subepidermal cells and many of the large vacuolated cells of the outer pericarp constitutes splitting (Fig. 6). No Sudan-positive material was formed in the cells around such a split (Fig. 7). In Fig. 6 microorganisms have accumulated within the split and have penetrated into those pericarp cells that were not damaged as a result of splitting. The base of the split in Fig. 6 is shown at a higher magnification in Fig. 8. Microorganisms also occurred on the surface of cracked berries (Fig. 4), but no penetration of sub-epidermal tissue was detected.

Discussion

The rupture of epidermal cells which results in the formation of fine concentric cracks, is associated with the compression of sub-epidermal cells in the damaged region (Fig. 2). Internal pressures which lead to epidermal rupture are quite substantial. They have been discussed by Considine and Kriedemann (1972) who demonstrated how pericarp tissue is more viscoelastic than its encompassing epidermal tissue; the present anatomical study of epidermal rupture, with an associated compression of underlying tissue, extends their observations.

Penetration of microorganisms into the berry through the fine cracks was not detected. It is possible that the suberization (indicated by Sudan-positive staining) of exposed cell walls combined with the high phenolic content in sub-epidermal cells proved inhibitory. In the berries examined, suberization under cracks was not as extensive as that under lenticels (Swift *et al.* 1973). The degree of suberization may well be related to the stage of berry development at which cracking occurs.

Splitting, on the other hand, is conducive to berry deterioration because pericarp cells are ruptured and exposed. As no suberin is formed around the split to seal off the damaged cells from the rest of the pericarp, microorganisms can penetrate and become established in the pericarp tissue.

The epidermis may yield to turgor pressure in different ways, depending upon how quickly the pressure builds up; a slow increase in turgor pressure may cause skin "creep" resulting in cracking, while a rapid increase may result in splitting. Splitting occurred on some berries in the region of cracks, but whether cracks constitute lines of weakness where splitting is more likely to occur than in regions where cracks are absent is uncertain. Meynhardt (1964 a) reported that splitting of

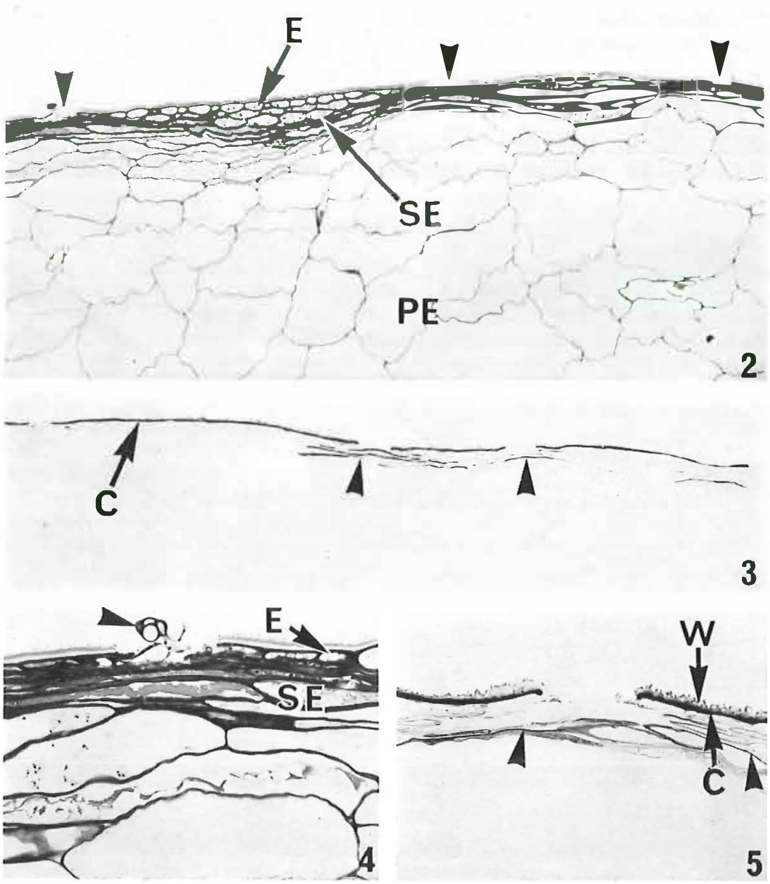


Fig. 1 e.

Fig. 2: Section at the pedicel end of a Sultana berry, showing three cracks (arrows) sectioned at right angles to their long axis. PAS/fast green. ×115.

Fig. 3: Section through a group of four cracks. Sudan-positive material is present in varying amounts under the cracks (arrows). Sudan black B. ×90.

Figs. 4, 5: Views at higher magnification of single cracks. — Fig. 4: Microorganisms at arrow. PAS/fast green. ×310. — Fig. 5: Arrows indicate suberized material in sub-epidermis. Sudan black B. ×200.

C = cuticle; E = epidermis; PE = pericarp; SE = sub-epidermis; W = wax.

Abb. 2: Schnitt durch basalen Teil einer Sultanabeere. Pfeile zeigen auf 3 im rechten Winkel zur Längsachse durchschnittene Schrunden. PAS/fast green. Vergrößerung 115×. Abb. 3: Schnitt durch eine Gruppe von 4 Schrunden. Unterhalb der Schrunden Sudan-positives Material in unterschiedlichen Mengen. Sudanschwarz B. Vergrößerung 90×. Abb. 4, 5: Einzelne Schrunden bei stärkerer Vergrößerung. — Abb. 4: Pfeil zeigt auf Mikroorganismen. PAS/fast green. Vergrößerung 310×. — Abb. 5: Pfeile zeigen Verkorkungen in der Subepidermis. Sudanschwarz B. Vergrößerung 200×.

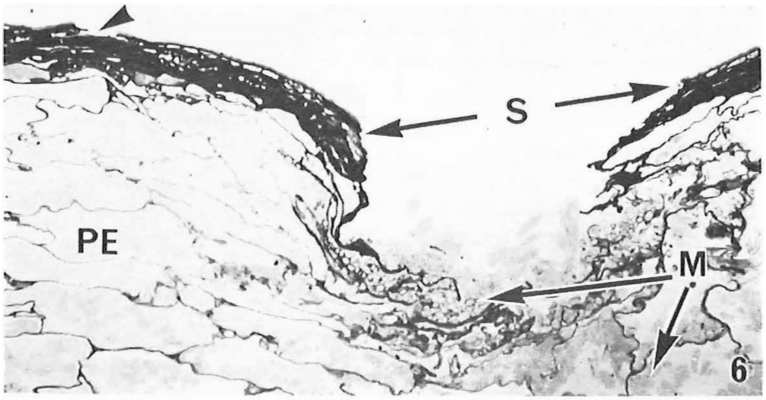
C = Kutikala; E = Epidermis; PE = Perikarp; SE = Subepidermis; W = Wachs.

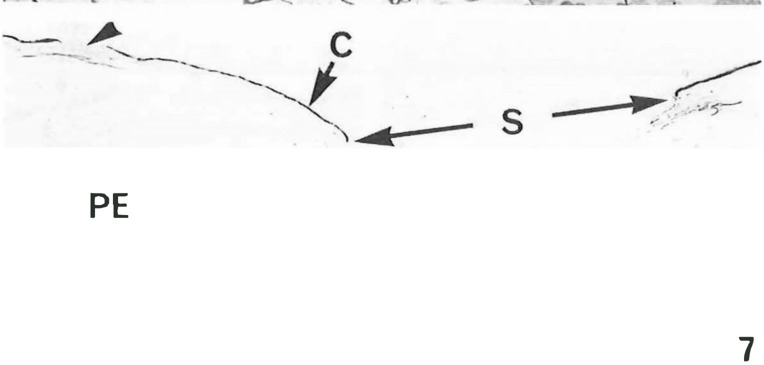
berry tissue was common adjacent to or through cork tissue. He attributed splitting in these cases to uneven stretching of the berry skin caused by the rigid cork tissue.

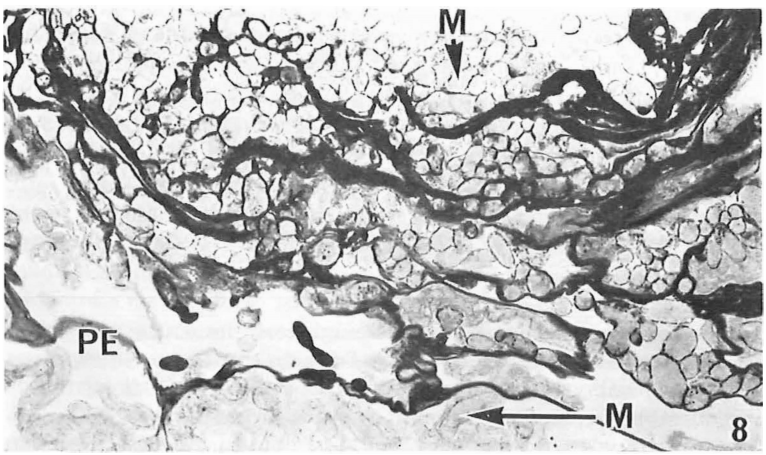
Cracking has not yet been examined extensively in the field, nor have different varieties been compared. Similar concentric cracks have been observed on berries of the variety Trebbiano (syn. Ugni blanc) but in this case they were on the stylar end of the berry. Further study is necessary to establish the factors which lead to the formation of cracks of this nature.

Summary

Light microscopy has been used to study the anatomy of "cracks" and "splits" in grape berries. In cracking, fine concentric surface cracks in the skin are formed







around the base of the pedicel or at the stylar end. Cracks usually involved rupture of the cuticle and epidermal layer of cells only. In splitting, the cuticle, epidermis, sub-epidermis and outer pericarp cells were ruptured. Suberization was evident in the cells beneath cracks, but was not present in the cells around splits. Possible mechanisms of epidermal damage and penetration of microorganisms are discussed in relation to cracking and splitting.

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Fig. 6: Section showing a crack (arrow) and a split. Microorganisms are present in the base of the split and in the cells of the pericarp. PAS/toluidine blue. ×100.
Fig. 7: Adjacent section to that of Fig. 6, stained with Sudan black B. ×100.
Fig. 8: The base of the split shown in Fig. 6 at higher magnification. PAS/toluidine blue. ×360.
C = cuticle; M = microorganisms; PE = pericarp; S = split.

Abb. 6: Schnitt mit einer Schrunde (Pfeil) und einer Platzwunde. An der Basis der Platzwunde und in den Perikarpzellen sind Mikroorganismen sichtbar. PAS/Toluidinblau. Vergrößerung 100×.
Abb. 7: Benachbarter Schnitt des in Abb. 6 abgebildeten Schnittes mit Sudanschwarz B gefärbt. Vergrößerung 100×.
Abb. 8: Basis der in Abb. 6 abgebildeten Platzwunde bei stärkerer Vergrößerung. PAS/Toluidinblau. Vergrößerung 360×.
C = Kutikula; M = Mikroorganismen; PE = Perikarp; S = Platzwunde.