California Avocado Society 1983 Yearbook 67:123-127

A Possible Association of Stony Fruit of Avocado and *Phytophthora citricola*

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

The appearance in a few orchards in California of avocado fruit with unusual amounts of stone cells in the otherwise soft, uniform pericarp wall has presented some problems of detection, prevention, and explanation of a potentially serious disturbance in avocado fruit production. These aberrant fruits, which show an irregular morphological development of the inner carpellary wall, were first noticed in Orange County in the summer of 1981 when some fallen, mature fruits were collected by orchard workers to make guacamole. The fruits were normal to judge from size and external appearance; but upon cutting, it was noted that a darkened layer of variable thickness and extent near the base of the seed had developed in some fruits. This discolored layer was hard and gritty in texture, suggestive of the stony layer which comprises the thick skin of some fruits of the Guatemalan horticultural race. The stony layer was located very close to the seed with a thick layer of regular soft pericarp tissue between it and the fruit skin. These observations were made on fruits from the Hass variety which was interplanted with Fuerte in a large planting of approximately 1,100 acres in Orange County.

A detailed description of the aberrant fruit and tissue morphology has been published (1). The irregular tissue consists of stone cells of the brachysclereid type which develop in the otherwise soft pericarp tissue. The sclereids, or stone cells, are characterized by distinctively thick layered cell walls which are highly lignified and hard. Many simple pits permeate the thickened cell wall. The cell shape is generally rounded or oval, frequently four or five sided when viewed in cross-section. This differential tissue development is initiated near the apical end of the fruit close to the seed coat. The stony layer may consist of a few scattered stone cells or a small loose group of stone cells. The entire seed, in more severe cases, may be enveloped by a thick layer of densely packed sclereids which become highly lignified. The latter condition results in a structure very comparable to the "pit," or endocarp, of a peach fruit. The stony layer of the abnormal avocado fruit is not necessarily closely associated with the vascular system. The vascular tissue in avocado is prominently developed in the apical end of the fruit. The stony layer actually is separated from individual vascular strands by a layer of parenchyma. It appears that the stone cells do not "invade" the soft pericarp but develop in place by conversion of ordinary thin walled parenchymatous cells into thick walled, lignified sclereids by the initiation of abnormal cell wall thickening and eventually the development of lignification in these thick-walled cells. There is apparently no vascular tissue breakdown associated with the disturbance such as is manifested with some virus diseases. The fact that normal fruit and affected fruit cannot be detected from external appearances makes it difficult to detect and to study the fruit development on the tree. One must cut the fruit in transverse section to ascertain the internal

condition. Moreover, there is no pattern of distribution of abnormal fruit on a given tree. A normal fruit on a given branch may be surrounded by several irregular fruits of various degrees of internal malformation, or the reverse may be found where only a single fruit in several on a given branch will show flesh discoloration and a stony layer at maturity.

Speculation as to the causes of the stony fruit has included several possible conditions or factors such as frost injury, herbicide absorption, mineral toxicity or deficiency, a virus disease, a fungus, or other disease agents. A survey of several avocado plots of Hass trees in the Orange County orchard and in other orchards which were planted from the same propagation sources appears to rule out a possible common virus source which might have been transmitted through clonal propagation. Likewise, trees of the same clone grown extensively under a wide range of low temperature exposures and with a varied history of herbicide exposures during the preceding ten years showed no abnormal fruit development.

The extensive use of herbicides for weed control in several California orchards has suggested a possible uptake and accumulation of plant growth regulator which might have resulted in abnormal fruit development. No evidence could be demonstrated for this assumption in several orchards examined. It is quite feasible to grow callus tissue of avocado fruit pericarp in *vitro* as a tissue culture and to test the effect of specific herbicide molecules on such tissues. A series of experiments incorporating commonly available herbicides in the culture media has provided no specific responses from these herbicides as they might induce cellular differentiation (2). There are many questionable limitations to this line of experimental procedure. The present negative results are not necessarily conclusive.

Some recent field observations relating the production of the aberrant fruit tissue and the presence of *Phytophthora citricola* in the trees have provided a possible lead regarding the causative agent in the production of stony avocado fruits.

The avocado variety Hass is most prominently affected by stony fruit, according to field observations. While trees of the Fuerte variety have exhibited typical trunk cankers associated with *P. citricola,* there has been very little evidence of severe fruit malformation on these trees. Occasionally, fruits of the Fuerte clone from severely affected *P. citricola* trees have shown incipient symptoms in the form of slight discoloration and faint lignification of a few sclereids in the apical region of affected fruit. No extensive, heavy stony layers or sclereid mass have been observed in Fuerte fruits. Similar to the Hass fruit, the abnormal Fuerte fruit could not be detected from external appearances.

The development and spread of a tree decline in avocado caused by the fungus *Phytophthora citricola* has been somewhat restricted for several years, but more recently has been of concern to some growers who have lost several trees to this disease. *Phytophthora cinnamomi,* the cinnamon root rot fungus which attacks the avocado root, is generally restricted to below soil tissues. *P. citricola* appears to be active above the soil line, invading the trunk and larger branches. A common

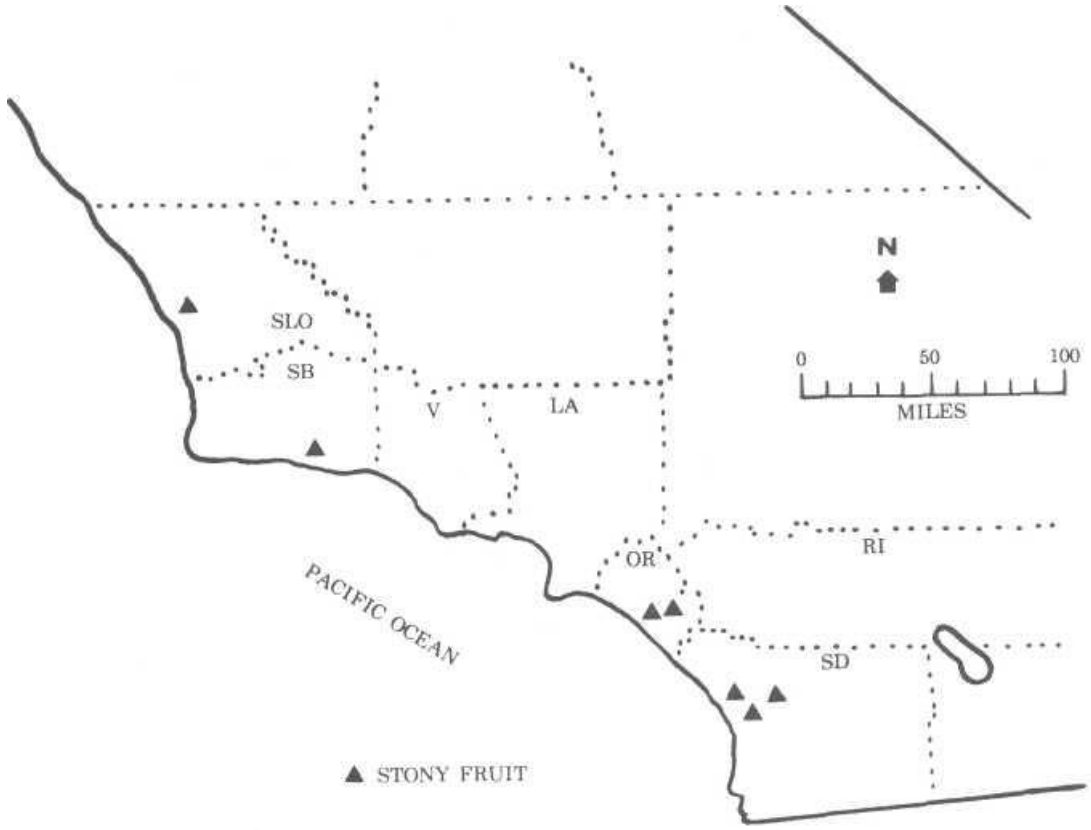
manifestation of *P. citricola* is the development of a trunk canker and subsequent bark breakdown. Sometimes girdling of the trunk results from severe infections.

The specific causative factor or factors associated with stony avocado fruit is not known with certainty at present. Some empirical observations associating the stony fruit with trees which are affected by the fungus *Phytophthora citricola* are highly suggestive that there may be some relationship between the fungus and the abnormal fruit. During a routine survey of a block of trees in an avocado orchard, many of which were eventually noted to be badly affected by *P. citricola,* it was observed that fruits from certain trees showed stoniness whereas the apparently normal healthy trees did not produce stony fruits. Trees with advanced trunk symptoms of *P. citricola,* such as large cankers and bark breakdown, frequently had such stony fruits. Some trees with suspicious trunk symptoms of infection but with an apparent normal leaf and shoot development often did not show a stony fruit from a sample of twelve to twenty or more fruits. Occasionally, apparently healthy trees with no bark symptoms would produce a few to many fruits with stone cells. Some of these apparently healthy trees were surrounded by trees badly affected by *P. citricola.* The association between those trees with obvious or suspected *P. citricola* symptoms and the high number of stony fruits suggested a combination which could be tested in a broader set of conditions. Toward this objective, trees suspected or known to be affected with *P. citricola* were sought and located in such widely separated areas as Nipomo in San Luis Obispo County, Carpinteria in Santa Barbara County, and Oceanside in San Diego County. Several Hass trees in the Nipomo area have died within the last year, and possibly a hundred or more trees in the same orchard are sick, the result of *P. citricola.* A small sample of fruit cut from a few of the more severely affected trees showed the stony condition. About seventy-five miles to the south, in Carpinteria, several trees with distinct *P. citricola* symptoms showed a considerable stoniness in the fruit sampled. Thirty percent of a sample of forty fruits from one tree with stoniness ranged from a trace to a severe condition.

Again, in Orange County, many *P. citricola* affected trees showed a wide range of stoniness in the fruits sampled. A very highly suggestive observation was made in the Oceanside area of San Diego County, where a very large orchard of some 800 trees was under close monitoring for *P. cinnamomi.* The orchard is checked frequently and has been apparently free from the cinnamon fungus. Two apparently slightly sick trees near the middle of the planting have recently been suspected to be affected by *P. citricola.* One tree had a bark canker, the second tree had no surface symptoms. Some fruit cut from both of these trees were slightly to moderately affected with the stoniness.

These observations made on trees widely separated in distance but specifically suspected as carriers of the *P. citricola* fungus showed the stony fruit character to various degrees. Still other observations made in the large orchards in Orange County indicate the stony fruit can be found on *P. citricola* affected trees at distances of one or more miles from the foci of infection where stony fruit was first observed in great numbers.

These empirical field observations which associate the stony fruit with *P. citricola* remain to be confirmed by more observations made on a broader scale and under more varied conditions. The specific causal factor or factors in this case are not known with certainty and must be proven by other acceptable techniques. Attempts are underway to relate the aberrant fruit development with the fungus directly, or with products or by-products of the fungus as these may be conducted to the floral and fruiting structure of the plant. An approach to the problem will be made by the culture of the fruit pericarp parenchyma in *vitro* as a tissue culture in which the fungus *P. citricola* and possibly some of its metabolic products or by-products can be incorporated into the culture media.



Distribution of Phytophthora citricola *infected trees and the presence of stoniness condition in avocado fruit in several counties in southern California,*

It is altogether possible that other causative agents, such as a virus, may be related to the stony avocado. The strong association of virus diseases with vascular tissue breakdown, however, would appear to discredit the virus theory of stony fruit in light of present evidence. There appears to be no vascular tissue collapse or plugging in the stony fruit of avocado.

Literature Cited

SCHROEDER, C.A. 1981. Sclerocarpelosis in the avocado fruit. Calif. Avocado Soc. Yearbook 64: 125-134.

SCHROEDER, C. A. 1982. Progress report on stony fruit of avocado. Calif. Avocado Soc. Yearbook 65: 161-165.