South African Avocado Growers' Association Yearbook 1985. 8:27-28

ABERRANT FRUIT DEVELOPMENT IN AVOCADO

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OPSOMMING

Avokadovrugte wat buitengewoon baie houtagtigheid in die pericarp ontwikkel is in Kalifornië waargeneem. Die houtagtige selle word gewoonlik aan die blom-end van die vrug gevindmaar dit brei ook uit na die stingel-end. Die Hass-kultivar word veralaangetas. Die verskynsel word ge-assosieer met ***Phytophthora citricola,*** *'n baskanker.*

SUMMARY

Avocado fruits which develop an excessive amount of stoniness in the pericarp have been observed in California. A layer of stone cells concentrate near the stylar end of the pericarp, but sometimes extend to the stem end. The condition occurs primarily in the cultivar Hass and the condition seems to be associated with ***Phytophthora citricola*** *the cause of a bark canker.*

The avocado fruit is unusual in many of its properties when compared with most fleshy fruits. It is very high in oil and comparable only to the olive in this respect. It differs from most other fruits as it will not soften or mature on the tree. The avocado fruit also differs in its mode of development. Increase in size results primarily from increase in cell number, not by cell enlargement as is common for most other fleshy fruit. The physiology of the fruit is also unique as it exhibits a high rate of respiration and a marked climacteric period associated with the dramatic softening of the flesh. All of these and other properties make the avocado fruit one of interest to the grower, the handler, and the consumer.

The normal avocado fruit develops from a simple pistil as the result of pollination. The young fruit is initiated by a short period of intense cell divisions and some slight cell enlargement. When the fruit is about 3 or 4 millimeters in diameter most of the cells attain a maximum diameter of approximately 60/u before they again undergo division. Thereafter nearly all the parenchyma cells throughout the fruit structure undergo cell division until the fruit attains full size and is removed from the tree. Thus the increase in fruit size of the avocado results primarily from continuous cell division and not cell enlargement of previously formed cells as is the case in most other fleshy fruits (Schroeder 1953). One finds that the large avocado fruits have more cells, not larger cells. An avocado fruit in the stage of active cell division or recent cell division displays juvenile properties such as a high rate of respiration, as is common in young fruits of most species. It is an interesting observation that avocado fruits of nearly all stages of development can be grafted because of the meristematic nature of the developing pericarp. The grafting of avocado fruits may have some value in physiological studies of fruit development and maturation.

The avocado fruit consists primarily of a fleshy pericarp of parenchymatous tissue surrounded by the epidermis and sub epidermal layer of stone cells in some varieties. The endocarp consists of a single fragile layer of sclereids which is difficult to identify in the mature fruit as this tissue becomes closely associated with the seed coat. While some investigators have interpreted the morphology of the avocado as a drupe, indeed the fragile nature of the stony endocarp and the fact that the fruit growth curve is simple sigmoid and not the double sigmoid common to typical drupe fruits would suggest that the avocado should be considered a true berry.

The selection of the avocado fruit for commercial use has given rise to many clones with fruits of

marked deviations in fruit forms can result in problems of variety identification. Climatic effects on fruit form are well known. Off-season avocado fruit frequently differ from the normal fruit in shape. Physiological manifestations such as zinc deficiency or boron deficiency may result in fruit of high modified forms. Zinc deficient Hass fruits are more rounded than normal. Boron deficient Hass fruits are frequently highly distorted with the stem inserted at right angles to the main axis with a tendency for the pericarp to become thin in some areas. In extreme cases of boron deficiency some of the seed may be exposed by a failure in development of the pericarp wall.

Woody avocados are aberrant structures of extremely monstrous fruit-like woody masses which are found occasionally on normal trees (Schroeder 1943, 1954). This woody mass of various size and shape, will develop from a flower segment hence will be suspended by a fruit stem. Empirical observations in the field indicated such woody masses develop from proliferating stamen, and are not the result of modified pistil enlargement. These field observations have been supported by floral tissues grown in vitro in which stamens have proliferated into great masses of irregular shape, whereas the pistil of the given flower did not develop. It is suspected that in nature possibly an insect sting could result in the monstrous wood structures which are observed occasionally.

The occurrence of some avocado fruits which develop an excessive amount of stoniness in the otherwise soft pericarp tissue has been observed in California during recent years (Schroeder 1981, 1983 & 1984). These aberrant fruits are quite normal in external appearance. Upon cutting, however, there is a layer of sclereids or stone cells generally concentrated near the stylar end of the pericarp but sometimes extending toward the stem end of the fruit. In some instances the stony layer may completely envelop the seed. The term sclero-carpelosis has been proposed to describe this condition of the development of excessive sclereids in a tissue which normally is free of stone cells. The sclereids are of the brachysclereid type having a simple thickened, lignified wall and simple, bifurcated pits. These sclereids occur in various configurations from a few scattered sclereids to an extensive layer of closely packed cells. The sclereid masses are separated from the vascular tissue by a layer of parenchymatous cells several cells in thickness, hence are not immediately adjacent to the vascular tissue. The sclereid layer is highly variable in thickness and extent in any given fruit. Early states of the sclereid masses will form a cap in the stylar end of the pericarp. This cap will gradually extend irregularly toward the basal end of the fruit.

The stoniness condition has been observed primarily in the variety Hass, though some evidence if incipient stages have been noted in a few fruits of the Fuerte variety growing in the vicinity of affected Hass trees. The Hass fruit appears quite normal in external characters of size, form and colour, though the internal structure is highly modified. Some trees which appear to be weak may have smaller than normal fruit which tend to show excessive stoniness. Sometimes an unusual red colouration or red blush of the skin has been associated with fruit which contains a stony pericarp but this external symptom is not reliable as a means of detection of the internal trouble. Not all fruits on a given tree will have stony pericarp. Sometimes severa I fruits in close proximity will have stone cells. In other instances only one severely affected fruit may be found in a great number of normal fruits on a given tree.

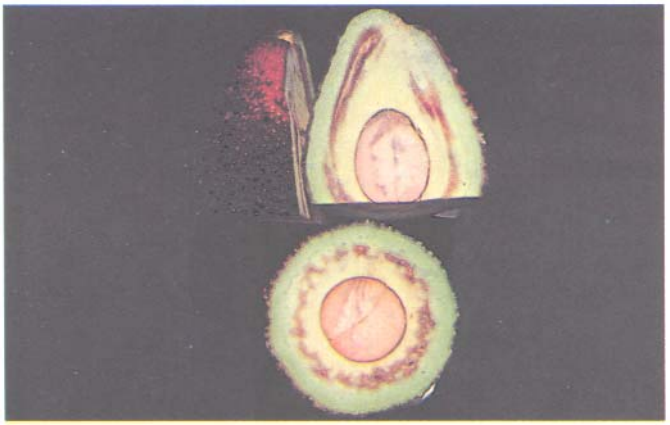
The appearance of stony fruit was noted in a large commercial orchard in Orange County, California in 1981. The stony fruits were numerous on trees which were obviously affected by some physiological problem as was evident by die-back and irregular shoot growth and trunk lesions in 10 year old trees. This abnormal growth was attributed at first to severe frost injury which had affected the trees three years prior to the appearance of stony fruit. A series of systematic observations over a period of two years on a large block of Hass and Fuerte trees led to the conclusion that the occurrence of the stony fruits was associated with many tree= which showed bark symptoms on the trunks. These bark cankers were identified in some cases to result from infection by *Phytophthora citricola,* a fungus which has been reported in California orchards on several occasions in recent years.

Based on the assumption that the fruit stoniness was associated with *P. citricola* infection, several isolated trees suspected to be infected by the fungus were located in orchards widely separated in

exception in detection of stony fruit on trees suspect of infection by *P. citricola* based on bark lesions caused by the fungus. There are some trees which appear to be quite healthy, but show some fruit symptoms regularly or on occasion. This might be explained by the observation that *P. citricola does* not always result in a stem canker above the soil line but occasionally some of the larger roots may show definite bark lesions. One case was observed in which a tree had been cured of a bad bark lesion caused by *P. citricola* by extensive use of Ridomil. Some fruits from this recovered tree did show incipient stoniness.

The relationship of *P. citricola* and the appearance of stony avocado fruits is an empirical observation. These observations are based on a number of trees which are suspected of infection by *P. citricola.* Proof of infection and subsequent confirmation of the sequential development of the stony condition will necessarily require more time. The above observations and associations are presented to cal I attention toa potentially important problem of fruit development.

The problems associated with abnormal fruit development in the avocado have led to some investigations into the normal conditions which prevail in fruit growth and maturity. While the general physical appearance and morphology of the avocado fruit would suggest a rather uniform tissue development throughout, there are several instances where irregular fruit development suggests that physiological gradients of such constituents as calcium (Chaplin 1 983) may account for some aspects the fruit behaviour.



Hass fruit showing distribution of stone cells in advanced stage stoniness.

Preliminary observations on the dry weight of tissues from various portions of the avocado fruit indicate that a great variation does occur which might account for some fruit maturity problems which have been reported. The consistently high oil content of tissue at the stylar end of the seed compared with the low oil content at the stem end can account in part for the advanced stage of softening at the stylar end compared with other parts of the fruit. The assumption is made that the oil content is closely associated with the dry weight of avocado fruit.

Failure of fruit to soften uniformly is a problem which has been reported from California, Israel, South Africa and Australia (Oppenheimer 1960, Sanewski 1984, Schroeder 1983). This irregular maturity of the pericarp is manifested by hand. Lighter coloured tissue masses are generally found near the stem end but not necessarily restricted to that area. Under severe conditions a cone of tissue surrounding the pointed end of the seed remains firm in texture whereas the remainders of the pericarp will soften normally. Cells of the "cone tissue" often will contain less oil compared with the normal high oil content of the other pericarp. The low in oil cone tissue could be considered as less mature than the surrounding parenchyma. Sampling of tissue segments from various points of the pericarp, indicate distinct gradients in oil content. The lowest dry weight (lowest oil content) is found in the "cone area". The highest dry weight is noted on the apical end of the fruit where the vascular bundles coalesce. A

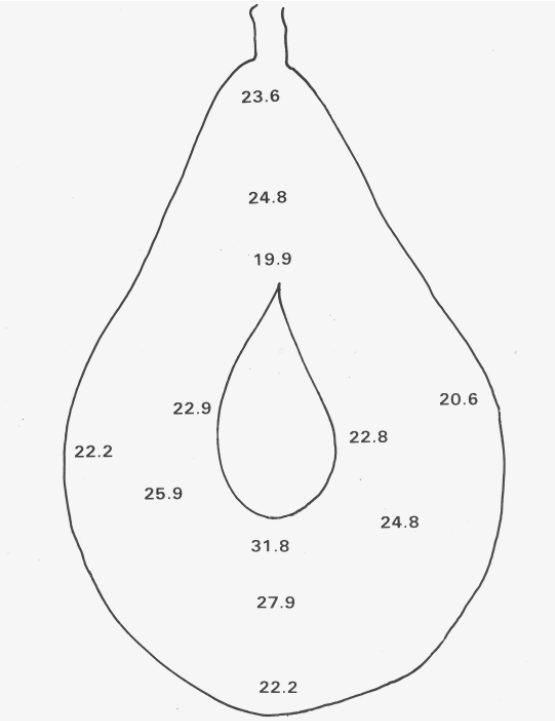


FIG. 1: Percentage dry weight (oil content) at specific points in Hass avocado fruit at maturity.

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