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SOIL STRATIFICATION AND PHYTOPHTHORA ROOT ROT OCCURRENCE IN AVOCADO ORCHARDS

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The quest continues to understand and explain how the Avocado Root Rot disease attacks and kills avocado trees. As with any disease, methods of control can be devised if the conditions which favor or inhibit the organism are understood. This report covers the results of a field experiment in which an additional factor was shown to influence the action of *Phytophthora cinnamomi*.

Since the very beginning of what was then called Avocado Decline, the reports of the Avocado Root Rot disease have shown that in California soil, moisture conditions play a major role in tree death. (2, 6) By 1943 the soil moisture and drainage conditions in diseased orchards were described at length. (4, 3) Many workers have reported that fine textured soils of either the primary type (weathered on bedrock) or old secondary types (terrace clay pan) provide conditions for moisture accumulation in the subsoil which allow the fungus *P. cinnamomi* to kill avocado roots. (14) So called well drained soils were suggested as being safe for planting in the presence of the fungus, (10, 1). However, more recently, orchards on deep, recent alluvial (the so called well drained) soils have been observed to be dying in some cases and not in others.

GROWER SPONSORED FIELD RESEARCH

As a part of an accelerated cooperative field research program, avocado growers' voluntary contributions given through the California Avocado Society were used to obtain tensiometers. These instruments were used to evaluate soil moisture conditions in three Root Rot orchards on deep, recent alluvial soils in Santa Barbara County. The use of tensiometers as instruments to evaluate soil moisture conditions has been well demonstrated. (5)

GOLETA TRIAL

This report is based on one of these tensiometer trials on the Stoddart Ranch in the Goleta Valley, managed by Gordon Troup. The orchard, planted in 1948, was on nearly level Yolo fine sandy loam soil. (7) The San Antonio Creek channel running nearby shows this alluvium to be at least 50 feet deep. The irrigation method was border check since the land was so flat that large heads of water were needed to flush the water through to the end of the run. *Phytophthora cinnamomi* had been accidentally introduced with diseased nursery stock in 1952 at several locations scattered throughout the grove. No tree symptoms of root rot showed until 1957. A survey by soil sampling and culturing snowed that by 1958 the fungus infection was nearly universal in the part of the orchard where the diseased nursery trees had been set and where the irrigation water traveled from these original infection sites.

In surveying the tree top conditions in this infected area since 1958, trees in all stages from complete death to only slight visible symptoms were found. Variation in rootstock resistance (11, 13) could explain only part of this, so it was decided to evaluate the soil moisture conditions in different parts of the orchard.

SAND LENS NOTED

In the areas of the worst tree condition, an examination of the soil showed a pronounced layer of yellow coarse sand, ranging up to 2 inches thick, extending through the profile about 17 or 18 inches below the surface. Other portions of the orchard did not show this sand lens. Table 1 gives the results of mechanical analyses on samples taken from two areas of pronounced stratification and one of no stratification. The sand content ran 11% higher in the lens than in the soil above it and 25% higher than in the soil below. In addition to this difference in sand content, the size of sand particles was larger in the lens and the line between the sand lens and the soil above and below was very pronounced, especially on the upper side.

Table 1.—Mechanical Analysis of Soil in Stoddard Grove, Goleta Valley (Taken April, 1960).

Area		Mechanical Analysis % Sand	% Silt	% Clay
R7 T27	above lens	73	21	6
	in lens	84	14	2
	below lens	59	33	8
R3 T17	above lens	69	26	5
	in lens	80	17	3
	below lens	60	32	8
R10 T12	6-18″	65	27	8

Also noted was that there were no avocado roots, except dead ones, above the lens in the area of Site 1. There were numerous good roots and some dead ones below the lens and some large roots in the sand lens itself. This is illustrated in Figure 1. Figure 2 illustrates the comparative profile without a lens at Site 3.

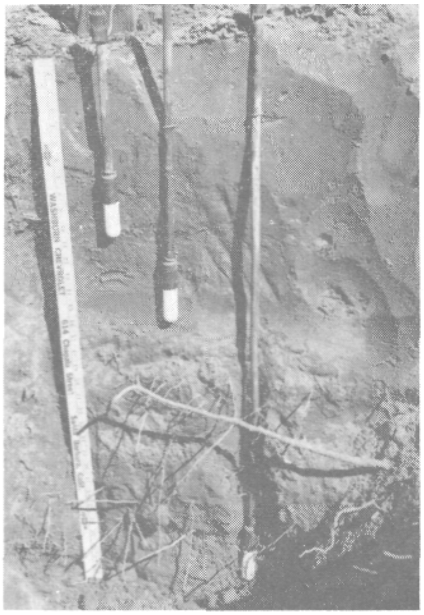

Figure 1. Soil Profile showing sand lens at 17-19 inches below surface and the placement of tensiometers at Site 1.

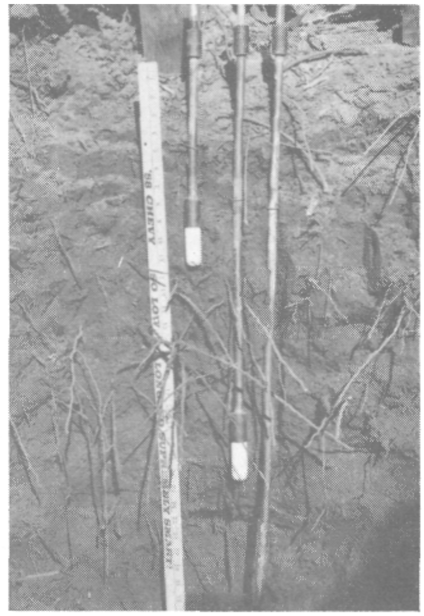

Figure 2. Soil Profile in area of no sand lens showing roots throughout and placement of tensiometer at Site 3.

At the time of the tensiometer installations in March, 1959, soil samples were taken and cultured from the several sites and depths; these results are shown in Table 2. Apparently the fungus prospers in the area above the lens but not below; thus, the laboratory cultures supported our visual observations.

Table 2.—Results of Culture for Phytophthora cinnamomi at Tensiometer Sites, Stoddart Grove, Goleta Valley (Samples Taken at Time of Installation, March 19, 1959).

Tensiometer		P. cinnamomi Culture Results		
Site	Row/Tree	Surface Sample	Above Lens	Below Lens
1—lens	7/27	Negative	Positive	Negative
	7/27 & 28		Positive	Negative
	7/28		Positive	Negative
2—lens	7/24	Positive	Positive	Positive
3—no lens	11/21	Positive		
4—no lens	11/14	Negative		

MOISTURE CONDITIONS MEASURED

Four sites were chosen in the orchard; all subsequently were found to be infected with *Phytophthora cinnamomi*. The sand lens was found present at two sites and not at the others. At each site three mercury manometer type tensiometers were installed at one foot depth intervals. In the lens areas the two-foot instruments were placed at a depth of 17 inches just above the sand lens, but not into it. In Figure 3, the tensiometer records are presented for part of the test period for two sites, both infected. Site 1 record shows a very wet condition, particularly at depths of 12 and 17 inches reflecting the absence of active roots. Note that after each irrigation these two shallower instruments go nearly to zero and in early July they go to zero and stay there several days. The Site 3 record shows the rapid loss of moisture following each irrigation, indicating the presence of active roots. This would be a very dry irrigation record; in fact, these trees showed considerable tip burn, due mostly to salts accumulating as a result of too infrequent irrigation.

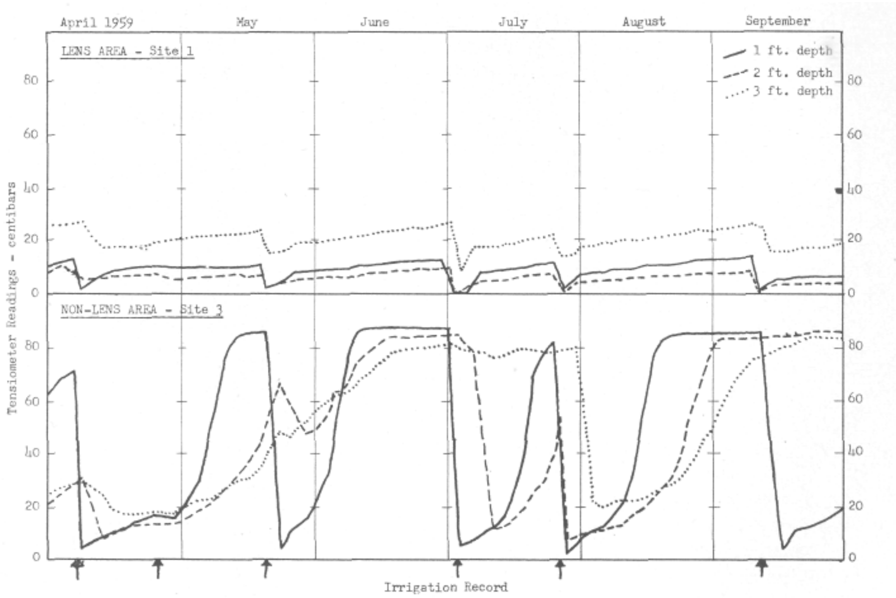

Figure 3. Tensiometer readings and irrigation record from lens area (Site 1) and non-lens area (Site 3), Stoddart Ranch, Goleta.

THEORY OF LENS

Soil scientists have demonstrated that any abrupt change in texture causes impairment of internal drainage. (9) Thus, a sand lens of this nature can create a perched water table above it. Following an irrigation or rain the moisture condition in the soil above the lens must build up to saturation before any water can pass down through the interface. The saturated soil condition above the lens lasts for several days, as illustrated by the at or near zero readings on the tensiometers at the 12 and 17 inch levels at Site 1 in Figure 3.

ROOT ROT DISEASE BROUGHT ON BY LENS

As demonstrated in this trial, sufficient moisture builds up above the lens to bring on the attack of *P. cinnamomi***.** Thus, root rot takes place in an otherwise perfectly drained soil. Based on observations in this grove, the greater the textural differences in the lens with the soil above and below, the greater the effect on the trees, if it occurs within the root zone of the trees.

SUGGESTS DEEP PLOWING

Very little could be done to break up these soil lens or strata in old orchards on alluvial soils since too much of the root zone would be injured and also from the inability to get heavy equipment into most avocado groves.

The real practical suggestion arising from this work is the recommendation to deep plow stratified alluvial soils prior to planting a new avocado orchard.

We have also demonstrated another facet of the relation of the moisture conditions to the occurrence of the Phytophthora Root Rot disease. Low tensiometer readings (0-10 centibars) represent wet soil conditions and appear to be associated with disease damage.

SUMMARY AND CONCLUSIONS

The relationship of *Phytophthora cinnamomi* Root Rot occurrence and soil conditions has been recognized from the beginning. Earlier work had demonstrated that heavy, primary, and terrace soils would allow rapid development of the disease. The so called well drained, recent alluvial soils were suggested as desirable to plant to avocados to avoid the loss of the trees. However, this report shows that stratified alluvial soils, in particular ones with marked lenses, create moisture conditions favorable to the fungus attack and tree death.

Internal soil drainage is impaired by textural stratification. Saturated soil, or perched water table, occurs above a sand interface or lens. This moisture condition can cause tree death in an otherwise well drained soil. Deep plowing prior to new-orchard planting is suggested to eliminate this stratification.

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