

Avocado Decline Investigations

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In September, 1943, the avocado industry, through the intermediary of General Manager Hodgkin of Calavo Growers, asked the Agricultural Experiment Station to prepare and submit an expanded research program on avocado tree decline. Estimates of the necessary costs were requested.

In October, 1943, such a program was submitted, together with estimates calling for costs of \$3200 to \$3700. The following month, in consultation with the officers and directors of the California Avocado Society, the estimates were adjusted to \$3000 because of some overlapping of these studies with similar work on lemon tree decline supported by donations from the California Lemon Men's Club.

During the following winter and spring, through the intermediary of the California Avocado Society, a campaign of solicitation and collection of funds was conducted. A first payment of \$2000 was accepted by the Board of Regents at its meeting April 28, 1944. This fund was credited to the Divisions of Irrigation and Horticulture (Los Angeles) and Plant Pathology (Riverside) in May and became available for expenditure in June. A second payment of \$500 was accepted by the Board of Regents at its meeting May 26, 1944. This fund was credited to the Division of Agricultural Chemistry (Riverside) in June and became available for expenditure in July. The third and final payment of \$500 was accepted by the Board of Regents at its meeting August 25, 1944. This fund was credited to the Division of Orchard Management (Riverside) in September and became available for expenditure early this month. Secretary Shepherd of the Avocado Society reports that more than 500 avocado growers contributed to this fund, the raising of which constitutes a notable and highly meritorious accomplishment.

General Nature of Research Program

The program was developed by the group analysis and discussion method and was formulated in the descending order of the importance of its constituent parts. It calls for participation by the five divisions of the Experiment Station previously mentioned and assigns responsibility for the work to be done by each. It consists of the following parts:

1. Drainage and soil moisture control trials and studies (Irrigation).
2. Expansion in the studies on possible relationships between soil organisms and tree decline (Plant Pathology).
3. A horticultural field survey, including rootstock relations (Horticulture).

4. Study of possible relations between oxygen deficiency in the soil and nutrition of the avocado tree (Agricultural Chemistry).
5. Continuance for another year of the soil-water relations survey conducted in San Diego County during the winter of 1942-43 (Orchard Management).

Progress Report to Date

Division of Irrigation (Huberty, Pillsbury)

The laboratory studies of the physical properties of soils from declined and non-declined areas (Pore space, permeability, etc., of surface and subsurface horizons) have been continued. Field observations on the effectiveness of surface drains on terraced plantings were made last season and will be continued and expanded. Installations have been made in the Vista area to measure the physical effectiveness of tile drains (rates and quantity of discharge, etc.) Installations have been made to compare the effectiveness of tile drains laid with and without gravel. Soil treatments designed to improve the permeability of poorly drained soils where decline occurs (gypsum, ferrous sulphate, aluminum sulphate, etc.), have been made on the Los Angeles campus. A survey was made in the La Habra Heights area of soil and moisture conditions in healthy and declining orchards following the heavy rainfall of last spring. Surveys have been made in the coastal areas of San Diego County to determine the relationships between soil characteristics and tree health.

Drainage installations to individual declined trees in various stages have been made in the Vista area to see whether decline can be checked and at what stage of development. Others are planned at Vista, La Mesa, and Escondido. Arrangements have been made to cover the ground surrounding declined trees in several areas so as to prevent the accumulation of excess soil moisture resulting from rainfall. An installation has been made in a thickly planted seedling orchard, where decline has been severe, which provides surfaces coverage and subdrainage for part of the affected area. An experimental planting has been made, on various rootstocks, in a shallow, poorly drained hill soil where conditions should be favorable for decline. It will provide suitable materials for more detailed studies (in cooperation with Horticulture). Plans are being made to grow avocado trees in tanks under controlled moisture conditions. A lithographed circular "Drainage of Avocado Orchards on Terrace and Upland Soils" has been prepared and issued. This is available from Farm Advisors.

Division of Plant Pathology (Klotz and Harvey)

Workers in this division have done extensive work collecting root and soil samples from healthy and diseased trees in virtually all avocado districts in the state, including central California. So far samples have been taken from 307 diseased trees and 268 healthy trees. In this survey about 25 different species of fungi have been found, but only 2 were isolated with any significant degree of frequency. The fungus **Phytophthora cinnamomi** (cinnamon fungus) was most frequently found on diseased trees (160 out of 307), and least frequently from healthy trees (46 out of 268). Most of the healthy trees on which the fungus was found were in declined orchards. This fungus was not found in

central California.

The fungus **Pythium vexans** was recovered from 148 out of 307 declined trees; and from 81 out of 268 healthy trees. It seems almost certain that neither of these fungi can be the primary cause of the trouble. It is quite possible, however, that either or both may be important contributory factors. This survey is being continued.

In experiments designed to stimulate renewal of the feeder root system, in three orchards in the Vista area the root systems of declined trees have been injected with various vitamins and hormones; 8 kinds to date. In one orchard the soil in the root zone has been injected with a source of vitamins and hormones.

In experiments designed to destroy or reduce possibly injurious organisms by soil disinfection, 4 orchards have had the soil injected with various disinfectants in the root zone; 5 kinds to date.

In experiments on the use of materials to absorb possible toxins produced in the root zone, the soil in the root zone in 3 orchards has been injected with such substances; 2 kinds to date.

In the laboratory and glasshouse experiments have been carried out on the relation of waterlogging to collapse of avocado seedlings. Waterlogging with stagnant water has been shown to be more harmful than with fresh water. A new experiment has been set up with the following treatments: (a) air bubbled through waterlogged sand, and (b) fresh water constantly flowing through waterlogged sand, and (c) waterlogged sand allowed to stagnate. The cinnamon fungus has been shown to be ineffective except under conditions of waterlogging, but may be effective under such conditions if rootlets are actually inoculated. Waterlogging in the presence of high organic matter content has been shown to cause collapse **without** the presence of the fungus. The cause of this is not known but may be due to lack of oxygen, or injury from nitrites, if present. In all the waterlogging experiments avocado rootlets have been shown to be more sensitive than citrus.

Experiments are now under way to test the tolerance of avocado roots to nitrous nitrogen (nitrites) in various concentrations. It is already evident that they are quite sensitive. Experiments are also under way on the possible pre-conditioning effects of nitrous nitrogen on the susceptibility of avocado rootlets to invasion by the fungi above mentioned, and others. Preliminary results indicate that small concentrations of nitrous nitrogen cause the rootlets to be much less resistant to infection with the cinnamon fungus.

Division of Horticulture (Halma and Eggers)

A general horticultural survey to uncover possible leads as to the probable cause of decline has been conducted, covering virtually all the affected areas. In this invaluable assistance has been provided by the field representatives of Calavo Growers. The general conclusion is inescapable that the trouble is associated with unfavorable soil conditions. Possible solutions suggested are avoidance of planting unsuitable soils; adequate drainage for less favorable soils, and the possibility of finding resistant rootstocks for the latter soils. Especial attention has been given to the possibility of

there being rootstock or rootstock-scion relationships to the trouble. In checking field reports and observations against laboratory identification of rootstock bark samples, it has been found that the laboratory method (developed previously by Halma) has important limitations. It is satisfactory only for **pure** Mexican and **pure** Guatemalan; not for hybrids such as Puerte, Puebla and others, many of which have been used as rootstocks. So far no resistance by Mexican rootstock has been found. However, so far, no decline has been found on Guatemalan rootstock. This may not be significant because of so few orchards on Guatemalan rootstock—only two found so far. Furthermore, thus far no Guatemalan rootstock trees have been found in areas which are going out with decline. It is probable that hybrids are not resistant. Many have been used, and many Mexican progenies contain some hybrids. With respect to varietal resistance, no evidence of such has been obtained thus far.

Trials of Mexican, West Indian and Guatemalan rootstocks are in process of establishment. One planting of Mexican varieties as rootstocks has been made in a declined area at Escondido. Five other similar plantings have been made in non-decline areas in San Diego and Ventura counties. The trees on Guatemalan and West Indian rootstocks will be planted out this summer and the following spring.

Replanting trials are planned to compare the behavior of trees planted in new soil and in soil previously occupied by avocado trees where decline was not a factor. One such planting has been made in Los Angeles county. Other tests are to be made to determine whether trees can be successfully established in soil where trees have declined. One such planting has already been made in San Diego county. None of these trees have grown well, and some have already died.

Agricultural Chemistry (Chapman and Colleagues)

Plans are being developed to study the possible relations between oxygen-deficiency in the soil and nutrition of the avocado tree. It is expected to start this work during the coming winter. Some results of previous work with the avocado and of current work on citrus include the following interesting preliminary results. In laboratory trials it has been shown that while avocados show considerable variation in resistance to waterlogging, they are, as a rule, much more sensitive than citrus. Such sensitivity is accentuated in the presence of high nitrogen content of the soil. Soil from a Vista orchard where trees had declined was taken to Riverside and used for potted avocado seedlings. These seedlings grew vigorously, somewhat better than in Riverside soil. This suggests that no permanently unfavorable chemical condition exists in the soil in question, and no virulent organism.

Preliminary results from nitrite studies under field conditions in citrus orchards treated with various fertilizers show that at no time of year have appreciable quantities been found, except where urea was the fertilizer employed. A rate of application giving 536 pounds of nitrogen per acre—high—has occasionally shown amounts of from 15 to 28 parts per million. Not more than a trace has ever been found below six inches. The maximum occurs within a few days or weeks after fertilizers are applied.

Orchard Management (Parker and Rounds)

Plans are being made to repeat the soil-water relations survey conducted in the Vista area during the winter of 1942-43. The results of that survey strongly supported the conclusion that avocado tree decline is associated with the occurrence of free water in poorly drained soils, largely the result of excessive winter rainfall.

Concluding; Remarks

In connection with this report the shortness of time since the expanded research program got under way must be taken into account. The first allotment of funds became expendable only a few months ago. The last allotment became available only a few weeks ago. Obviously much of the work here reported had to be started before funds were available. Under the circumstances I am agreeably surprised at the amount of work now under way.

The College of Agriculture budget request for the biennium which begins July 1, 1945 includes funds for the continuance of this program. What the outcome will be depends on the generosity of the State Legislature which convenes this coming January.