

## **The College of Agriculture Avocado Tree Decline Research Program**

A Progress Report

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In September, 1943, through the intermediary of the California Avocado Society, the College of Agriculture was requested to substantially expand its research work on the avocado tree decline problem, currently prevalent and acute and the cause of widespread apprehension and concern. This request led to the development of an integrated research program relating to this problem, involving participation by five divisions of the College on the Riverside and Los Angeles campuses, which program was initiated in the summer of 1944 with financial assistance provided by the industry. The first report on this program, then scarcely under way, was presented in the fall of that year.<sup>1</sup>

A conference of the research workers participating in this program, together with representatives from the Agricultural Extension Service staffs in the counties mainly affected and from the industry, was held recently on the Los Angeles campus. The general purposes of this conference were the following: (1) to present the facts and conclusions resulting from the work done this far so that all concerned with the program might be brought up to date; (2) to disclose leads developed which should be followed up by additional or new work; (3) to bring out facts or recommendations of value to the Agricultural Extension Service, and (4) to stimulate the thinking, planning and work of those participating in this important research program. It was hoped that out of the conference might develop a second progress report.

The conference was well attended, four of the five participating divisions being represented and all but one of the counties where the trouble is of economic importance. The industry representation included Calavo Growers and the California Avocado Society, the two organizations concerned with the initiation and financial support of the expanded research program.

### **Current Status of Avocado Tree Decline**

The first topic discussed was the current status of avocado tree decline as compared with the situation which existed in the summer of 1944, when the expanded research program was initiated.

It was the consensus that in spite of the fact that the past two years have not been characterized by excessive rainfall, such as preceded the widespread increase in tree

decline in 1943 and 1944, this trouble has lessened little if any in extent or importance. Almost without exception, it was reported that in areas affected two years ago it has continued to develop and to spread, both within affected areas and on their margins, though probably not so rapidly as in 1943 and 1944. Some new cases have been found in orchards where there is reason to believe none existed two years ago. In general, however, there was agreement that much the greater part of the decline which developed during the past two years has occurred in areas and orchards where the trouble existed two years ago or earlier and has consisted of its spread within those areas. The rate of development or spread appears to have been highly variable but in general somewhat slower during the past two years.

Among the facts or factors which may help to explain the developments of the past two years with reference to development and spread of the trouble, the following were brought out in the discussion:

1. In many, if not most cases of spread within an affected area or at its margins the primary cause is the progressive extension of a condition of water-logging from a center or centers where it first developed, with resulting tree decline, to surrounding areas which in turn become water-logged and develop tree decline.
2. Some evidence was reported which suggests that the trees become more susceptible to decline as they come into heavy production. Thus far, at least, tree decline has been confined largely to full bearing orchards and not infrequently has seemed to follow a period of heavy production. It was pointed out, however, that new trees rarely, if ever, succeed when planted in declined orchards.
3. The opinion was expressed that in some orchards the development and spread of tree decline have been promoted by the installation and careless use of sprinkler irrigation, which has resulted in water-logging the soil in areas formerly unreached by furrow irrigation.

**Reports of the Several Divisions**—Each of the several divisions of the College of Agriculture participating in the integrated research program was called on for a brief report on the progress of its work to date and future plans.

**Division of Irrigation and Soils (Los Angeles and Riverside)**—Professor M. R. Huberty summarized the work of himself and Professor A. F. Pillsbury.

A study of the irrigation waters used in "decline" areas has shown them to be prevailingly of good quality. A range of soil reaction in affected orchards of from 3.5 (highly acid) to 8 plus (moderately alkaline) in a 1 to 1 suspension has been found, providing no correlation whatever with the occurrence of the trouble. The soils where it is most prevalent are, almost without exception, shallow primary soils and secondary soils with a pronounced B horizon relatively close to the surface. Without exception, a close correlation has been found between unfavorable moisture conditions in the root zone and the occurrence of tree decline. In the vast majority of cases it occurs on shallow soils with poor underdrainage though some cases have been found on heavy soils where water penetration is slow. Excess water in the root zone is invariably

associated with the trouble.

Applications of soil amendments to improve permeability of dense subsoils have thus far shown no benefit. Drains established two years ago in three orchards on shallow soils where decline was prevalent have not had an opportunity to function effectively because of low rainfall. Affected trees have not recovered and there has been no measurable improvement. Indeed, some spread of the trouble has occurred uphill. Surface paper coverings applied in three orchards to prevent excessive wetting from rainfall have stimulated healthy root development near the soil surface but the trees have not improved.

It is clear that irrigations must be light and frequent enough on the shallow soils where this trouble is prevalent to maintain available moisture in the root zone and at the same time prevent its accumulation above impermeable subsoil layers.

**Division of Plant Pathology (Riverside)**—Doctors L. J. Klotz and G. A. Zentmyer summarized their work and that of Dr. J. V. Harvey.

A relatively extensive field survey resulted in the recovery of the fungus. **Phytophthora cinnamomi**, from the roots of approximately 80 per cent of the declined trees examined and from about 20 per cent of nearby presumably healthy trees. The activity of this fungus has been intensively studied under controlled conditions in pot tests in soil, both sterilized and untreated, from areas where trees have declined, under conditions of normal soil moisture and waterlogging and at various soil temperatures. It has been shown that waterlogging alone will cause avocado seedlings to decline provided the period of waterlogging is long enough and the soil or water are not aerated.

Short periods of waterlogging have not caused decline nor has it occurred where the soil or water were aerated. The effects of waterlogging are most rapid and pronounced at relatively high soil temperatures.

Where the fungus is present, however, decline is both more certain and rapid. In all cases, even where decline did not occur, seedlings planted in sterilized soil taken from areas where orchard trees declined have shown much better growth than when planted in the same soil not sterilized. There seems little doubt that **P. cinnamomi** plays an important role in Avocado tree decline in those areas where this fungus is already present in the soil and that the possibility exists that this fungus has been, and is being, spread through the medium of the soil in the balls surrounding the roots of nursery trees.

Extensive field trials with soil nutrients, disinfectants, absorbents and amendments have failed to cause improvement in affected trees. Likewise injections, both in the trees and soil about their roots, with hormones and vitamins have been without effect.

Plans reported for future work included more intensive field survey work on the occurrence of **P. cinnamomi**, studies on the manner and rate at which it spreads in the soil, and experiments to determine the practicability and effects of soil sterilization prior to replanting in "decline" areas. Further work is also planned on the effects of soil aeration and of other possible pathogens and unfavorable soil conditions or influences.

**Division of Horticulture (Los Angeles)**—Professor F. F. Halma reported on his work and that of his colleagues.

Extensive field survey work has resulted in the conclusion that decline is invariably associated with unfavorable moisture conditions in the root zone brought about in nearly all cases by deficient soil depth or faulty structure. No cases have been noted on well-drained and well-aerated soils. The unfavorable moisture condition associated with this trouble may have its origin in winter rainfall, over-irrigation or seepage from above.

Thus far no relationship has been found between rootstock and the occurrence of decline. Much the greater- part of the commercial acreage is on Mexican race rootstock seedlings but the work done to date has failed to reveal evidence on differences in resistance within this horticultural race. Plantings of young trees on Mexican rootstocks of known parentage have consistently failed in "decline" areas.

Only three orchards have been found thus far where it is certain that Guatemalan race rootstocks predominate. Unfortunately for the purposes of this study, no decline exists in any of these orchards irrespective of rootstock. Plantings of young trees on Guatemalan rootstocks in "decline" areas have likewise failed to grow satisfactorily. The same results have followed the planting of trees on a West Indian race rootstock obtained from Florida.

No convincing evidence has been obtained which would support the contention that scion variety may affect resistance to the conditions which result in decline. In all cases brought to light thus far differences in soil depth or structure have been sufficient to account for the differences attributed to varietal resistance.

Fairly extensive replanting trials in declined orchards have, with one exception, consistently failed to give satisfactory results. In one declined orchard a few replants have made good growth whereas most have not. In this case it now seems probable that the good replants occupy spaces where lemon trees had been rather than declined avocado trees. In this connection there seems little doubt that citrus trees generally succeed as replants in areas where avocado trees have declined, and vice versa.

Replanting trials in avocado orchards where old trees were removed because of the sunblotch disease have done well thus far.

**Division of Soils and Plant Nutrition (Riverside)**—Doctor H. D. Chapman reported on the work done thus far and future plans.

In limited pot culture trials in waterlogged soils, the avocado has been shown to be much more sensitive to injury than are citrus seedlings. In soils taken from "decline" areas, avocado seedlings have shown no response to applications of various fertilizers, which suggests that the problem is probably not nutritional in nature.

Preparations are under way for carefully controlled experiments on the comparative oxygen requirements and sensitivity to carbon dioxide of the roots of avocado and citrus trees.

**Division of Orchard Management (Riverside)**—No official report was presented because of the absence of the head of the division owing to illness.

The fact that the past two winters have not been unusually wet made it advisable to postpone the repetition of the soil-water relations survey in "decline" areas conducted in San Diego County during the winter of 1942-43, which established a strong correlation between the presence of unfavorable soil moisture conditions and the occurrence of decline. Indeed, the evidence concerning this relationship is now so overwhelming as to be conclusive, for which reason the decision has been made to abandon further survey work of the type in question and to transfer the funds provided for this work to the Division of Plant Pathology where they can be more effectively used.

### **Suggestions Relating to Future Work**

Among the suggestions relating to future work on this problem, which emanated from the conference, were the following:

1. That more detailed studies be made of the rate and nature of spread of the trouble.
2. That more intensive survey work be conducted to determine the present distribution of the fungus, **Phytophthora cinnamomi**, in both affected and non-affected areas.
3. That efforts be made to determine the origin and means of spread of the fungus in question.
4. That the studies on soil disinfection in affected areas be materially expanded.
5. That experiments be conducted on the effects of decaying avocado roots or root extracts on the growth of avocado seedlings.
6. That the studies on possible relationships between the presence of organic matter and the occurrence of collapse or decline be expanded.
7. That more extensive work be done on possible relationships between nutrient deficiencies and the occurrence of decline.
8. That a field survey be made to determine the possibility of correlation between the soil fertilization program and the occurrence of decline.
9. That more intensive studies be made in non-affected orchards in "decline" areas in the hope that earlier diagnostic methods may be brought to light.

### **Facts and Recommendations**

Among the facts and related recommendations upon which there was virtually unanimous agreement are the following:

1. Avocado tree decline of the type under consideration does not occur except on soils where unfavorable moisture conditions exists in the root zone for considerable periods.
2. In many avocado orchards affected by decline the soil is too shallow for economical or effective drainage.

3. The installation of shallow drains in orchards affected by decline has not prevented its spread during two seasons of low rainfall.

**Recommendation:** Avocado trees should not be planted on soils which have poor drainage or very slow drainage, or are too shallow for economical or effective drainage.

4. Hill lands, even where the slope is considerable, commonly have poor under-drainage.

**Recommendation:** On sloping lands the use of intercepting drains may be helpful. The primary function of these drains is to intercept and carry away seepage from above.

5. On shallow or poorly drained soils, where decline is a potential threat but has not yet developed, it may be possible to delay or even prevent its occurrence by the installation of intercepting drains and special care with reference to soil management practices.

**Recommendation:** Irrigation practice must be such as to avoid creating a saturated condition in the root zone. Frequent and light applications are indicated.

**Recommendation:** To provide for maximum utilization of the limited depth of soil, tillage should either be abandoned or very shallow.

6. No authentic cases of complete recovery from decline have been observed.

**Recommendation:** No permanent benefit is likely to result from pruning affected trees.

7. Replanting "decline" areas with avocado trees has not been successful thus far.

**Recommendation:** The use of other tree fruits or crops is recommended for areas where avocado trees have declined. Obviously, they must be adapted to the climatic and soil conditions.

It is now reasonably certain that in many, if not most, cases of avocado tree decline there is also a biological factor involved, namely the presence and activity of the soil fungus, **Phytophthora cinnamomi**.