California Avocado Society 1946 Yearbook 30: 79-83

Diseases of the Avocado

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Speaking on the general subject of avocado diseases provides me with considerable latitude because, as many of you are well aware, there is a variety of ways in which an avocado tree can look abnormal or diseased. I would like to describe a number of the avocado diseases, give as much information as we have on cause, prevention or control, and briefly outline future research plans on several of the major problems. Some of this may prove to be repetition for some of the more experienced growers, but I hope that they will bear with me.

Perhaps we should begin with what many consider the avocado grower's No. 1 headache—avocado tree decline. In certain areas at least, it is definitely the major problem. Let's see first if we can be sure what we are talking about. The problem is a difficult one to define sharply. The term decline is itself so general that it is likely to lead to including many types of poor trees under the same heading, even though the basic causes for their poor condition may be very different. A much more descriptive term for what is usually meant when we speak of decline would be "poor drainage-itis." Similar appearing trees will result from lack of water, from general neglect, from girdling by gophers or other animals, or from a number of causes. With true decline, however, poor drainage, resulting in the accumulation of excess water in the root zone during periods

of heavy rainfall or over-irrigation, appears to be the factor initiating the trouble. This injury occurs on two main types of soil: 1) Very compact, heavy soils which naturally drain poorly—as in some of the west La Habra heights area for example, and 2) soils with a permeable surface layer but with an impervious layer near the surface, as in parts of the Vista, La Mesa, and El Cajon regions. In either type, drainage of the root zone may be poor and a waterlogged condition will develop if excess water is applied to the soil. Where soil is waterlogged, the oxygen content is low and trouble is likely to occur, particularly with avocados. Abundant oxygen is required for root growth, and in addition, where oxygen is lacking, toxic chemicals are produced by soil fungi and bacteria and accumulate in the soil, injuring the roots.

Most of you are no doubt familiar with the general symptoms of decline— pale, yellow leaves, sparse foliage, wilting of leaves, slight or no new growth, dieback of twigs, and eventually dieback of larger branches and perhaps the entire tree. The first sign, however, is below ground. The feeder roots turn brown or black, die, and rot, so that it is difficult to find a clean normal root under a declining tree. Many of the larger roots may also rot, and show roughened bark.

Dr. Klotz and I have done considerable field work attempting to control decline from the pathological angle—by injecting trees with fungicides, bactericides, hormones, and vitamins, injecting the soil with similar substances, and aerating the soil. None of the treatments has shown any pronounced beneficial effect. We have replanted seedlings in several declining groves, after first treating the soil in various ways. We have used carbon disulfide to remove most of the microorganisms, activated carbon to remove toxic chemicals which may have accumulated in the soil, peat moss to stimulate root growth, and have aerated the soil. It is too early for definite results from these plots, but as yet no pronounced differences are apparent.

We have been carrying on considerable work on the possible role of soil fungi and bacteria in decline. To briefly summarize some of the results: 1) We have taken soil from around declining trees, sterilized it with heat or chloropicrin, and replanted with seedlings in our greenhouse. Much better growth of seedlings has usually occurred in the sterilized than in the non-sterile soil. This indicates that there is a biological factor involved, but does not mean that all a grower has to do to reclaim declined soil is to sterilize it. In the first place, sterilization on a large scale in the field could not be nearly as complete as in our greenhouse pots. In the second place, and more important, even though some initial benefit were obtained, it would be temporary unless something could be done about the basic cause for the trouble in the first place—poor drainage.

We have waterlogged avocado seedlings under varied conditions—in sterile soil and non-sterile soil, in sand, in the presence of various fungi including **Phytophthora cinnamomi and Pythium vexans,** and in their absence, at varying soil temperatures, for varying periods of time. I will not have time to go into all of the details, but briefly the results indicate that: 1) The length of the waterlogging period is very important with relation to decline. If the soil was saturated for short periods, 2 to 4 days for example with our seedlings, no permanent injury resulted. If the soil was saturated with water for 8 or 10 days, 2 weeks or longer, trouble is likely to occur. With a waterlogging period of this length or longer, seedlings were generally severely damaged or killed entirely.

2) There is an indication that, with short periods of waterlogging, presence of certain fungi such as **P. cinnamomi,** may be important. In recent work, short periods of waterlogging in the absence of this fungus did not cause injury, whereas in its presence, injury resulted. With longer periods of soil saturation such as commonly occur under field conditions, however, the presence of such specific fungi is immaterial. Seedlings will decline in sterilized soil if waterlogged for sufficient periods (2 weeks for example), or if the soil temperature is high, seedlings will decline even in sterilized soil with short periods of waterlogging.

3) Adding fungi such as **P. cinnamomi** to the soil has had no effect on decline unless the soil was waterlogged. This is a significant point, indicating which comes first, the water or the **Phytophthora.** Waterlogging is evidently the primary factor.

The effect of soil temperature on growth of avocados might be mentioned. In a recent experiment on waterlogging and decline we have had Mexican seedlings growing in five different soil temperatures, ranging from 13° C to 32° C. Optimum growth of the seedlings took place in the 27° C (approximately 80° F.)

Work along these lines is being continued in the greenhouse, laboratory and field. The role of microorganisms will be investigated further, also the possibilities of replanting. The very important possibility of developing root-stocks more resistant to poor drainage is being investigated at U. C. L. A.

To sum up the decline picture as it looks at present: it is a rather complex one, but speaking specifically, the pathological investigations indicate that the degree or severity of decline depends on the length of the period of waterlogging, relative amounts of various soil organisms present (if the waterlogging period is short), the soil temperature, and probably the condition of the tree. Generally, however, since the primary causal factor appears to be excess moisture in the root zone, the obvious thing to do would seem to be to take measures to prevent or reduce the accumulation of water. This means adequate drainage of the subsoil, removal of excess surface water during heavy rains, and an intelligent irrigation program. In most locations where decline is severe, however, I doubt whether much benefit will be obtained from such a program—it is too late. Permanent and severe injury to the root system has taken place and the soil has been made unfit for good root development because of probably an increase in harmful organisms and accumulation of toxic chemicals. On such bad spots, where drainage is obviously poor, the best thing would be to remove the poor specimens and replant with something besides avocados. Soils on which drainage is poor should be avoided for avocado culture, as they are extremely likely to cause trouble sooner or later. This point has of course been made many times before, but it seems well to emphasize it again. Trees may do well on such soils for a number of years, as they have in many areas now declining, until heavy rains or over irrigation provide waterlogging periods of sufficient length or number to cause real damage to a root system which now extends over most of the available soil, and has a large top to support. Trees may have grown without trouble on these soils when the trees were young because of the small extent of the root system and the fact that it did not extend into the most severely waterlogged zone of soil.

On borderline soils, which are neither very poorly nor very well drained, good drainage

practice and continued careful supervision of the water program is important and may mean the difference between a good grove and a declining grove. Plantings under the most unfavorable conditions will continue to cause trouble in spite of precautions, and in the light of present knowledge should be replanted to other crops.

The No. 2 avocado disease problem, designated as the main problem by some growers, is sun-blotch. This is a disease caused by a virus, and is spread mainly by budding or grafting from a diseased tree. The disease is characterized by light yellow to brownish-red longitudinal streaks in the green twigs or fruit, by rough corky bark on older trees, by a downward growing habit of branches, and occasionally by blotches on the leaves.

For this type of disease, in accordance with our present knowledge, the best control lies in preventive measures. Scions should be taken only from trees known as surely as possible to be free of the disease. The seed source should also be carefully selected for freedom from disease as there is evidence that the disease sometimes may be carried through the seed. Unless there is an insect carrier of sun-blotch, seed transmission definitely takes place. Several nurserymen and avocado growers have reported what appear to be cases of seed transmission. We have observed the disease recently on several unbudded seedlings grown at the Citrus Experiment Station, but the possibility that the seedlings may have been inoculated with the virus by some insect must be eliminated before this can be definitely called seed transmission. The lack of rapid spread of sun-blotch in the field indicates that insects commonly play little or no part in its spread. If sun-blotch were as easily transmitted by insects as are many viruses, the California avocado industry would be severely hit.

Affected trees may outgrow visible symptoms yet still transmit the disease, so a knowledge of the history of trees being used for budwood or seed is essential, plus frequent re-inspections. The disease varies greatly in severity—some trees are badly damaged by sun-blotch, others scarcely affected.

Dr. Wallace, a virus specialist at the Citrus Experiment Station, and I are working on this problem, and quite an extensive program is outlined aimed at developing certified nursery stock, determining susceptibility of various varieties, studying seed transmission and any other form of transmission, to mention some of the lines of attack.

One of the more serious problems of the coastal area is a fruit rot caused by the fungus **Botryosphaeria ribis chromogena (Dothiorella gregaria.)** This is commonly known as Dothiorella rot. This type of trouble is practically impossible to detect and cull out as it does not appear until the fruit softens. The fungus which causes the rot enters the fruit while it is still on the tree and lies dormant beneath the skin until the softening process begins. Then the fungus develops rapidly, causing brown spots with diffuse brownish margins, and imparting an offensive, rancid odor to the flesh. Professor Horne and Mr. Palmer did considerable spraying for control of this disease a number of years ago, and were able to get good control with several applications of Bordeaux-sulfur. The number of sprays required and the difficulties of application, however, make this type of control impracticable, as the above investigators have stated.

We have been working on the problem from the standpoint of developing a treatment which could be used in the packing house to kill out or render the fungus harmless.

Several chemical-impregnated paper wraps, such as those used on citrus, were tried and found to have no effect. Next we tested some 15 new organic fungicides in the laboratory against the fungus growing in petri dishes, and got considerable encouragement. Ten of these chemicals were more effective against **Dothiorella** in the laboratory than was copper sulfate, the active ingredient in Bordeaux mixture. Four of the ten showed control of the fungus at high dilutions—up to or over 1 part of the chemical in 100,000 parts of water. This was encouraging indeed. But next we dipped fruit in these solutions for different periods of time, at different temperatures, and pulled some of the chemicals into the fruit under vacuum, but, I am sorry to report, that absolutely no control of the rot was obtained. Hot water baths and dry heat were also tried, with no success. Even a temperature of 135° C for two hours did not kill the fungus in the fruit, and the resultant fruit were sad looking specimens.

We are continuing work on this problem from all aspects mentioned above, and also plan field trials this year on dusts, and field trials to determine the effect of season of picking on subsequent development of the rot. There have been indications that picking fruit early may result in less rot, but we hope to have some quantitative data on this point next year.

Tipburn is another avocado disease problem; the primary symptom is indicated as a dying of the leaf tips and margins. It is usually caused by an accumulation of salts in the leaves, specifically in most cases sodium chloride. Water with a high chlorine content should be avoided where at all possible. The fungus **Dothiorella** develops abundantly on tipburned leaves, thus providing inoculum for fruit rot.

Mottle-leaf is another nutritional disease caused by a lack of available zinc in the plant. The trouble is characterized by yellowish color between the veins, small leaves, short terminal growth. This is similar to citrus mottle leaf and may be controlled by a spray made up of 5 pounds of zinc sulfate and two and one-half pounds of hydrated lime in 100 gallons of water.

Another nutritional trouble is chlorosis caused by a lack of available iron. This disease is characterized by an even light-yellow color over the leaves, and is common on soils high in limestone. On such soils, control is difficult; where limestone is not extremely high, applications of sulfur or ferrous sulfate to the soil will lower the alkalinity and give some benefit. Excess use of water should be avoided under such conditions of high limestone content, as additional water further increases the alkalinity and aggravates the trouble. Injections of ferric tartrate in the trunk will give temporary relief but are not entirely satisfactory.

There are several fungi which cause cankers of avocado trunks and limbs, including several species of **Phytophthora,** and **Botryosphaeria ribis chromogena**. These cankers are dead, sunken and cracked areas in the bark; often gumming and exudation of white sugary material results. The cankers can be treated similarly to citrus gummosis, by cutting away affected tissue and cutting back into healthy bark for from one-half to one inch and protecting the wounds with Bordeaux paste. Another possibility for destroying affected tissue is careful use of a blowtorch. I have seen a number of trees recently treated by Mr. France with this implement and the method seemed to have given good results. In addition, grass and other debris should be cleaned away

from the trunk, as the fungi causing the trouble are favored by moisture.

There is another minor trouble that might be mentioned before closing. This is a black canker and black spot of fruits, particularly on Anaheim and Itzamna varieties along the coast. **B. ribis chromogena** has been isolated consistently from such cankers and fruits, but its causal relationship has not been demonstrated.