California Avocado Society 1943 Yearbook 28: 34-37

Relationship of Soil Moisture and Drainage Conditions to Tree Decline in Avocado Orchards*

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Calavo Packing-House Park at Vista.
Meeting of Growers, Sept. 29, 1943.

Numerous investigators have called attention to the soil requirements of avocado trees. (3,9) Tree "decline" and "collapse" have frequently been associated with impaired soil drainage and the consequent accumulation of free water in the root zone, particularly during or after heavy rains or excessive applications of water. (2,4,5,6,7,8,10,11) Marked increases in the occurrence and seriousness of decline have been correlated with seasons of heavy rainfall.

An additional study of the relationships between soil conditions and avocado decline was made during and immediately after the heavy rains which occurred in January, 1943. As only a limited area could be studied the observations were confined to previously selected orchards in the Vista area. The soils there have been described by Carpenter and Storie(1), while their percolation capacities have been measured by Huberty and Pillsbury(5). The soils vary greatly, frequently over short distances, particularly as to subsoil characteristics. Individual orchards, and even the separate parts of small orchards, frequently present very different soil conditions.

During the fall of 1942 and the early part of January, 1943, the rainfall at Vista was very light. Starting on January 23, however, a total of 8.56 inches fell during the last nine days of the month, as measured by instruments maintained by the Vista Press. During the next five weeks, 3.16 inches of rain fell in three storms. Such distribution was fortunate for the purpose of this study.

Our first inspections were made on January 26, after 6.2 inches of rain had fallen. Observations were subsequently made at frequent intervals during the remainder of the rainy season and generally until no free water remained in the soil.

1. The relation of free water in the soil and tree condition.

Definite correlations were found between soil conditions, as affecting the accumulation of free water, and the occurrence of tree decline. The situation in one orchard will be briefly described as an illustration. This planting consists of about eight acres of 10-year-old Fuerte avocados, and is located on the lower part of a hillside of varying slope. It is surrounded by non-irrigated land. In the upper part of the orchard the soil is Fallbrook fine sandy loam. It was found that the shallow surface soil was highly permeable to water, but that percolation into the compact clay subsoil was exceedingly slow. Consequently, free water accumulated just above the line of contact between the surface soil and subsoil during the heavy rains of January.

Seepage from the higher brush land adjacent to the orchard occurred at several points. Free water existed in the unirrigated brush land at depths ranging from six inches from the surface to 24 inches from the surface, and therefore was 18 inches in thickness in some places. A spring appeared where a cut had been made at the edge of the orchard during the construction of the irrigation system. Seepage occurred for over four weeks. Our borings and inspection of the topography indicated that an enormous quantity of water moved by seepage from the brush land to the orchard soil. The effect of the seepage from unirrigated lands on the conditions of trees in this orchard was plainly seen. The foliage on the trees in the top row first turned yellow. In a few days the same changes were noted progressively on the second, third and fourth rows of trees. The movement of this seepage water into the orchard could probably have been prevented by the construction of an intercepting ditch, on grade, extending slightly into the clay subsoil.

About eight rows down the hill from the eastern boundary of the orchard the depth to subsoil was found to be correlated with tree conditions. A number of observations were made in a line running parallel to the face of the hill at this point. At one side of the orchard the depth to the clay is only about 12 inches and there the trees were abnormally small, and were affected with decline during the winter. Free water was found to exist on the top of the subsoil for at least four weeks. A part of the free water in the surface soil was attributed to the rain water which fell upon the land at that place and a part to accumulations as a result of seepage from higher land. The depth of the surface soil gradually increases to a point near the center of the orchard, a distance of about 15 trees, where the depth to clay subsoil is about 40 inches. Although about the same quantity of free water was found on top of the subsoil all along this section of the orchard for about the same length of time, tree condition and tree size were observed to

be progressively more normal as the depth of the surface soil increased.

About eight trees beyond the last area referred to, the depth to the subsoil rapidly increases to about six feet. The permeable surface soil is apparently sufficiently deep to hold all of the rain water which fell, at least until the middle of February, as no free water accumulated until three weeks after the first heavy rain. After that time as much as 18 inches of free water formed on top of the subsoil. This water emitted an odor reminiscent of sewer gas and undoubtedly formed as a result of seepage from other areas where the surface soil is shallow and the subsoil is at higher elevations. However, the free water did not come closer than 4.5 feet to the surface and the trees did not show any ill effects of it. They were large and thrifty, the best in the orchard. This area of good trees is only about eight trees long. Still farther along the same row, the trees are small and suffered decline during the winter. In this position the clay subsoil rises to within 20 inches of the surface. The top soil became saturated to within six inches of the surface during the first heavy rain, and free water remained above the subsoil for over five weeks.

Toward the lower side of this orchard the soil gradually changes from Fallbrook to Merriam sandy loam. The latter has a very dense clay subsoil. The surface soil is only 8 to 12 inches deep. The trees in the lower part of the orchard are very small, and all of them suffered with some decline during the period of heavy rains. A number of them collapsed and died. In some places the surface soil was completely saturated with water and surface runoff occurred during the heavy rain storms. This flow continued for about two weeks. The quantity of water which flowed out of this small orchard was surprisingly large.

Similar correlations between soil conditions, as affecting the accumulation of free water, and tree condition were clearly illustrated in other orchards on soils of the Fallbrook, Vista and Merriam series. Where clay subsoils exist, free water was found in the surface stratum above it. Tree decline was associated with the extent to which this free water inundated the root zone and the duration of the free water. In the more shallow soils of this character the effect on the trees was more severe. Where no clay subsoil exists the surface soil rests upon the decomposed granite parent material; the trees were usually in good condition and no appreciable quantity of free water accumulated. Regardless of the ultimate cause of avocado tree decline and collapse in these particular soils, the predisposing cause appears to be the occurrence of free water in the root zone.

In soils having a very permeable surface soil and an impermeable subsoil it would appear that accumulations of free water could be reduced by the installation of adequate artificial drainage systems. A suggestion as to the possible effectiveness of such systems in the Vista and Fallbrook soil series results from the above observations on the lateral movement of soil water in the surface stratum. More value can be attached to the effects of drains which have been installed by a very limited number of orchardists in the Vista area. Although some of these systems are not adequate in their extent or in their design, large volumes of water were removed by their use. In some instances they appear of considerable practical benefit, for the orchards in which they are installed are superior to adjacent orchards. Experimental evidence is not available, however.

2. Surface drainage toward orchards from adjacent lands

The accumulations of water, as a result of heavy rainfall, were found to be aggravated in certain cases when the topography is such as to permit the flow of surface water to orchard areas. This flow came from adjacent lands, roadways, or domestic areas. The effects on the trees were detrimental. The drainage of surface water to the orchards could generally have been prevented.

3. Free water in soil near the tops of hills

In some instances the surface soil at or near the top of rounded hills was found to be partly saturated for a few days after the heavy rains. Tree decline occurred in these cases. In these instances the surface soil is shallow, and overlaid a clay subsoil. The water which was in excess of the normal field capacity of the surface soil had to be removed by lateral seepage.

4. Removal of surface water from orchards

The apparently beneficial effects of the reduction of water infiltration during periods of heavy rainfall by facilitating the prompt removal of surface water was observed. Where broad furrows, having no "crown," were on a uniform grade, and were kept free of weeds or other obstructions, a very large volume of water was removed from orchards. Erosion was prevented by discharging this surface flow into concrete drains at the ends of the furrows. This practice appeared to be beneficial to the trees.

5. Effects of planting in deep tree holes

Declining trees were observed in part of one orchard where the surface soil is 30 inches deep and where large amounts of free water were not found, although a clay subsoil exists there. It was discovered that the tree holes in which they had been planted had been blasted to a depth of about five feet. This operation apparently mixed the clay with the surface soil and compacted it, for basins were found under the trees in which the soil was saturated with stagnant water to within 10 or 12 inches of the surface. A similar condition was observed in several other orchards. It appears obvious that this method of planting avocado trees is detrimental in soils which are not well drained throughout the root zone.

Inasmuch as the variability of the subsurface conditions of the soils of the Vista and Fallbrook series is very pronounced, even over short distances, it would appear desirable for growers to have a detailed knowledge of their own soil conditions in order that they may more effectively prevent or alleviate the accumulation of free water in areas where the drainage is impaired. Observations which are made during and following periods of heavy rainfall appear to be particularly helpful.

*A complete report will be submitted to the American Society for Horticultural Science for publication in its Proceedings

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