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Rain and Drought in Avocado Decline

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Soils that support avocado trees in southern California include a good many primary (residual) and old secondary (transported) hill soils. The reasons for occupying these soils with avocado orchards are simple enough. Valley soils were preempted by other crops and, even more important, the steep slopes on which these primary and old secondary soils usually lie provide excellent air drainage that tempers the air on these hillsides on critical winter nights. The doctrine is widely held by horticulturists that western primary soils are, in general, not profitable for tree cropping. Despite this, some primary soils devoted to the avocado have proved themselves well adapted to the tree. Moreover, the financial returns from fruit produced by avocado trees in the better primary soils far exceed those which could be expected from any other system of cropping to which such land can be put. In fact, because of the steep slopes and shallow depth of soil in much of this land (classed as having a primary non-claypan soil), it is virtually unfit for production of any other commercial agricultural crop. Old secondary soils have proved, on the whole, less favorable sites for avocado tree growth and fruit production. The principal difficulty in these primary and old secondary soils that makes some of them unfavorable sites for avocado culture has been the decline that overtakes the trees under certain conditions.

Experiments at Capistrano, California, on hill lands similar to those of the La Habra avocado district, suggest that there are included, even in small areas of land of this character, (1) soils that would not support avocado trees with commercial success under ordinary practice, (2) soils that would support the avocado tree successfully if handled according to good management practices, and (3) soils that because of their depth and physical properties would support successful growth of the avocado tree even under indifferent management. Since, however, the three classes of soil are likely to occur on a single property, the grower is faced with the need to apply the best management practices to the entire orchard planted on this kind of land. A shift to another kind of crop may be indicated on the more difficult classes of land.

The most important physical properties of a soil with respect to decline are its infiltration rate (rate at which water is taken in at the surface) and its permeability (rate at which water can move through the various surface and sub-surface layers). The two properties are interrelated, but it is convenient to separate them because, among other reasons, we can change the infiltration rate rather readily by changing conditions at the surface of the soil, although we have not yet developed techniques to change the permeability of a soil. As examples of the two extremes of soil mentioned in the previous paragraph, we can examine moisture conditions, under identical rainfall, for a Tierra clay (an old secondary soil developed on a tilted terrace) and an Altamont loam (a primary soil that has no well-developed claypan). The soil surface was bare in both cases. Fig. 1 shows the moisture conditions in two plots, one of Tierra clay and the other Altamont loam on March 18, 1941. In the weeks previous to that date, more than 20 inches of rain had fallen. Despite this large total, one of the highest every recorded for a similar period, moisture had penetrated in Tierra clay only to a depth of about 2 feet. At the same time, the upper 6 inches of this soil had an excess of water in it. If one were to walk on the plot in this condition of moisture, it would be found that the soil had the consistency of mud. In the Altamont loam, conversely, water had penetrated to a depth of about 5 feet. Moisture added to this soil by rains is rather evenly distributed over the entire wetted portion. There is no tendency for an accumulation of water at the surface. In walking on the plot when in this moisture condition it would be found that although the soil is obviously damp, it is firm and there is no suggestion of free water. An avocado tree if grown in the Tierra clay would have its roots restricted largely to the upper foot and a half of soil, and here the roots would have been subjected for several months to excess water in a season of heavy rains like those of 1940-41. An avocado tree grown in the Altamont loam would have its roots well distributed through four or five feet of soil. During heavy rains there would be some temporary accumulation of free water in the surface layer, but this condition would last only a short time after rain stopped. Even under the best of management, it would be difficult to grow avocado trees successfully in the Tierra clay, while it could readily be done in the Altamont loam.

Impermeable Subsoil Presents Problems

Although the Tierra clay is not a favorable soil for avocado culture, there are other types of primary and old secondary soils which are even more unfavorable where the profiles are not changed mechanically. In these latter, the topsoil takes in water readily, but the subsoil is highly impermeable. If the thickness of the topsoil is such that artificial drains are feasible, it is possible to remove by lateral flow the excess water that gathers on top of the impervious subsoil. But if topsoil is shallow, say only a foot or so, the unfavorable features are difficult to correct. Sometimes, as in certain soils in Santa Barbara County planted to avocado, the soil profile shows three well-developed layers. At the top is a layer of sandy topsoil generally ranging from a foot to three feet thick. Under this is a dense layer of clay, itself about a foot thick. And under the clay lies the altered sandy bedrock which is fairly permeable. A new type of bench terrace, having incorporated in it a drainage feature, may help to solve the problem in soils that have this threefold layering.

The Bonsall Soil

When the Vista district was first developed about 15 years ago, the rockier soils were usually avoided because it was felt then that cultivation was needed and the rock would, of course, interfere with such cultivation. We know now that much land where rock outcrops are common has proved in the Vista district to be well suited to avocado culture under a system of sprinkler irrigation without cultivation. A more recent development in that district has been the recognition of a soil type called Bonsall. This soil is best developed along the lower parts of slopes, at the boundary of the primary hill soils and the secondary valley soils. The impermeable nature of the Bonsall subsoil seems in part to be due to hydration, and not so much due to the downward movement of the fine soil particles. Avocado decline has been marked on the Bonsall soil. While decline on Bonsall soil is to be reckoned with, at the same time we should be mindful of the presence in the same district of primary rocky hill soils, not fully occupied by trees, that have proved well adapted to the avocado.

Alternate Drought and Saturation Effect

If we turn our attention from those cases of decline attributed by most observers to poor drainage in the soil, there is still a large, though quantitatively unknown, acreage suffering decline in which (1) soil gives no evidence of poor drainage, or in which (2) some trees under one system of culture live and prosper while another set under seemingly identical soil conditions, but under a different system of culture, decline and die.

From surveys made in June, 1943, I came to believe that in the decline in these latter cases (1 and 2 above), the harmful effects were engendered by alternate drought and excess water. Trees in a healthy state that had been sustained by having an adequate supply of water in their root zones and growing in soil that **had not been cultivated**, seem to withstand without harm rainfall heavy enough to injure nearby trees, in the same soil type, that had suffered from drought before the rains came.

Erratic irrigation can likewise set up during the non-rainy season a condition of alternate too little and too much water. Here the effect of too much water may be involved in the general problem of soil drainage. Instances have been recorded in which incipient or moderate decline has been arrested by changing from an erratic irrigation program to one based strictly on the needs of the trees.

While this hypothesis of alternate drought and excess water, which needs further study, may account for cases of decline difficult to explain otherwise, there is an obvious danger in it. Foremost in this danger is the chance that irrigation water may be applied just before a heavy rain in fall or early winter. Evidence bearing on the hypothesis of alternate too little and too much water will be presented in a subsequent report.

Is Increased Runoff An Advantage?

Having in mind the large amount of water that has been taken into some soils during the heavy rains that have been general in southern California in the winter rainy seasons of the past ten years, some observers have wondered if a higher percentage of the precipitation could have been converted advantageously to surficial runoff. In general, conditions favoring increased runoff can be produced by lowering the infiltration rate of the soil and by providing for prompt, safe disposal of such of the rain water as gathers on the surface of the soil.

There are many ways to reduce the infiltration rate of a soil, the easiest of which is to keep the soil bare during rainfall, a practice that may be termed winter-fallow. Possibly in some seasons on some soils the practice of winter-fallow in avocado culture might be beneficial, but it would not usually be so. In a year like 1940-41, it is virtually impossible to keep most soils bare. In 1942-43, while the difference in water intake between bare and mulched plots at Capistrano was large in the first big storm of January 21-23, 1943, the percentages of runoff for the total season were not so greatly different. Differences in soil erosion were, however, extremely large as between bare and mulched plots. Moreover, heavy leaf litter or a thick ground cover not only prevents the loss of surface soil by erosion, but increases moisture loss by evaporation or evapo-transpiration. Such moisture losses may be desirable in seasons of heavy precipitation.

Any contour obstruction placed in such a way that water is dammed temporarily will increase the opportunity for infiltration. In the culture of a great many crops, field crops particularly, increased water intake induced by contour work has been shown to be of great value. But in avocado culture, because of the sensitivity of the roots of the tree to excess soil water, it is good conservation to dispose of surface water as promptly as possible. If water is held too long at the surface, which may happen behind contour work on some soils in which avocados are planted, the soil structure is degraded. Further, ponded rainwater increases the hazard of landsliding. For these reasons, every effort should be made to prevent the temporary impoundment of rainwater at the surface. This impounding can be prevented without in any way interfering with effective erosion control.

Slope No Guarantee of Drainage

Surface intake of water and subsurface drainage of water does not depend primarily on steepness of slopes. It would seem to be a logical assumption that the steeper the slope, the less water will enter the soil from a given rain. This is not the case if the slope is uniform. The intake depends primarily on the type of vegetative cover and the physical properties of the soil. In the same way, the mere fact that the soils lies at a steep angle does not mean that the water moving into the subsurface horizons will readily be drained away. Under natural conditions, the swiftness with which water will move through the subsurface depends, for practical purposes, principally on the structure of the soil, including the subsoil, and on the nature of the underlying bedrock. In artificial drainage, steepness of slopes does affect the rate at which water moves laterally into a tile drain.

Provide For Drainage

In addition to providing for adequate surface drainage by removing obstructions to free flow of surface water, within the orchard, two additional surface drainage measures need attention.

In one, the water that flows onto the orchard from higher land, whether it originates from storm runoff or from uncontrolled irrigation water, should be diverted by a ditch. In the other, all obstructions at the foot of an orchard that tend to back up the water should be removed. One orchard was observed in Ventura County in which tree decline could be unmistakably traced to the effect of a row of closely planted trees at the bottom of the orchard. This row of trees dammed the water back for many feet, causing rapid decline in most of the trees in the area where storm runoff was impounded in the winter of 1943.

Frequently, the shallow gently sloping soil at the top of a hill, often uncultivated and covered with grass or brush, sheds a good bit of runoff that makes its way in part into the somewhat deeper soil that lies just under the shoulder of the hill. Absorption by soils of this extra water from runoff will often set up a state of excess water in the sub-summit areas that otherwise would not take place. This absorption of excess water also greatly increases landslide hazard.

Conclusion

Like a good many other newly established horticultural industries, the California avocado industry may find that it has occupied certain soils not adapted to the avocado tree. At the same time, it seems perfectly legitimate to say that by avoiding negligent care on the one hand, or overzealous attention such as excess cultivation and excess irrigation on the other, the zone of soils now regarded as marginal may be used safely and continuously for avocado production. Research now under way should solidify the use of this marginal zone, and perhaps may extend it into types not now considered adapted to the avocado tree.

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