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IRRIGATING AVOCADOS

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Irrigation is the avocado grower's most important cultural practice. Adequate irrigation will keep trees from the effects of drought, but only careful irrigation can definitely contribute to the maintenance of tree health and productivity. It all adds up to intelligent irrigation—and that is never accidental.

Under an agriculture such as ours, the water required by crops is furnished by either rainfall or irrigation. The amount that is not provided by rainfall must be supplied through irrigation. Irrigation presents the dual problem of when to apply water and how much to apply. The relationship between the actual requirement of the crop and the water holding and yielding power of the particular soil type becomes involved. An acquaintance with the methods of applying water and of the ways to calculate amounts of water applied can help in attacking the problem. Some special problems, such as drainage, leaching and weed competition, must be taken into consideration. The end result is to arrive at a high degree of irrigation efficiency, or, in simpler terms, to have the trees actually use a large proportion of the amount of water that is applied. At the same time, conditions in the soil must be kept favorable for healthy, normal root activity.

WATER AND SOIL

A very logical approach is to look to the soil. It receives the water and makes it available to the plant. What mechanics or processes are involved? What are such things as "field capacity," "available water?" And above all, what are their practical applications?

When water is applied to a soil, its behavior becomes the result of several forces. The way water moves into the soil and the amount of water that can be given back to the plant are a result of the interaction of some of these forces. The results are somewhat different for each soil type. We want to know and understand the action and properties of water in the soil.

But first a word about the soil itself. It is made up of solid, liquid and gaseous elements. The solid portion consists of rock particles, living organisms and decomposable organic matter. The size and arrangement of the inorganic particles are most significant in soil-moisture relations. Either water or gases occupy the pore spaces between the particles. As water is applied to the soil, it moves into the soil filling most of the pore spaces. The soil is filled from the top down. If we think of soil as a reservoir for water, we must consider it an inverted one, since it actually fills from the top to the bottom.

FIELD CAPACITY

For a short time following an irrigation, part of the water in the soil will continue to move downward by the force of gravity. There will also be some lateral movement due to another force called capillarity. After the force of gravity has had time to exert its full influence on the soil, the soil that has been wet by the irrigation will be at what is called "field capacity." Therefore, the moisture in the soil at this "field capacity" is held or retained by soil particles with a force greater than the force of gravity.

The question of "how much will my soil hold?" then, could be answered by knowing the "field capacity" of your particular soil. For example, a cubic foot of sandy soil can hold about one gallon of water; a loam soil can hold about two gallons. A clay soil will hold about three gallons of water when at "field capacity."

At "field capacity" each particle of soil is surrounded by a thin layer of the water. Most of the water, however, exists in the form of wedges between the soil particles at their points of contact. These wedges of water are very important, for it is from them that the roots derive most of their water. The more particles and wedges there are, the more water that can be held. This explains why the clay soil holds more water. It has more particles and points of contact. The opposite type of soil, the sandy soil, has coarser particles and fewer of them. It holds proportionally less water.

When a soil is wet to its "field capacity," it is not possible to store any more •water in that soil. If any more water is added, it will drain into the dry soil below, with a very small amount moving into the dry soil at the sides. Water that drains into the soil below the root zone is lost because the roots cannot recover it. Water will not rise through the soil by capillarity into the root zone in any appreciable quantity.

AVAILABLE WATER

However, the amount of moisture that a soil will hold is not all that a grower wants to know. Just as important, or even more so, is the amount of water that a particular soil will actually yield or give up to the plant. Obviously, this amount will be some portion of the water in the soil at field capacity. As plant roots gradually reduce the moisture content of the soil, a point is reached where the water is held so tightly by the soil particles as to prevent the roots of the plant from absorbing it rapidly enough to keep the plant from wilting. Very shortly thereafter, the plant cannot obtain any more water. Water remaining in the soil at this point is considered unavailable to the plant. We say the soil is at the "wilting point." Most plants will use water down to the same "wilting point" for any particular soil.

For many soils the available water is about one-half of the amount of water that is in the soil at its field capacity. The farmer wants to know this amount of water. He would like it expressed in inches of water per foot depth of soil. This is the actual amount that must be replaced by irrigation.

The amount of water needed to "refill" depends on the type of soil and the moisture content at the time of irrigation. Assuming the soil is "root dry" or at the wilting point, three-fourths of an acre-inch of water applied will refill one foot in depth on a sandy loam soil. The soil that is medium-textured—more finer-sized particles—will require one and a half inches to restore one foot in depth to field capacity. The heavier clay soil will need 2 1/4 acre-inches to fill one foot.

Under field conditions, the soil is usually allowed to approach the wilting point in the upper foot—the area of most root activity. There is often some available water in the lower root zone area when an irrigation is made. The amount of water needed to refill each foot becomes somewhat less than the approximate amounts listed above.

Then, with plants obtaining their water readily from the soil, the moisture content of that soil will therefore be somewhere between the wilting point and the field capacity. There is no one moisture content that grows plants better than another, as long as it is in that range. There is no optimum soil moisture condition that can be maintained. Trees can obtain water through most of the range between field capacity and wilting point.

OTHER FACTORS

Evaporation of water from the soil might be considered as another factor or force in water and soil relations. Actually evaporation can remove the water only from the surface and top few inches of the soil. The amount lost will depend upon the climatic conditions, the amount of shade and the type of soil. Ground cover of a mulch type will substantially reduce the amount of water lost by evaporation.

It is often thought that cultivation will reduce the amount of water lost by evaporation of the soil. It has been shown beyond all doubt that cultivation is of itself no direct benefit in the soil-water picture. It does, by killing weeds, reduce the competition for moisture that is needed or could be used by the crop.

Water does not penetrate or permeate all soils with equal ease. This brings soil structure, or arrangement of soil particles into the discussion. Surface soil can be sealed by some puddling effect, and water will run off. Soils can be compacted by excessive tillage and heavy equipment so that water movement and root activity is reduced markedly. Very often there are semi- or completely impervious layers underlying the top soil. Such layers may not permit water or roots to penetrate. Under these conditions only enough water should ever be added to wet the soil to the hard or very compactive layer. From a soil viewpoint, sufficient water should be added each irrigation to wet the soil in which there are active roots to the field capacity. This amount can be measured, known and controlled to a very great extent by the farmer.

DRAINAGE CONSIDERATIONS

The word "drainage" when used in connection with avocado soils refers to the ability of water to move directly through the soil. In a "well-drained" soil, water applied either as irrigation or rainfall will move downward into the soil without any marked restriction.

Drainage problems arise where some condition in the subsoil interferes with water movement. Such interference can be in the form of a very impervious hardpan or a dense clay layer. A problem might arise -with merely a change in soil texture through which water must move more slowly than it is being applied to and accepted by the surface soil. In either case the tendency is for the balance of the moisture not readily moving into the subsoil to move down cross slope on top of the subsoil. A water table is thus formed which accumulates in the lower sections and provides conditions ideal for root rot activity.

Drainage problems due to irrigation can be avoided or minimized by very careful irrigation. It means recognizing the soil conditions likely to give trouble and observing the moisture conditions there during the irrigating season using a soil tube or auger.

The grower has little control over the effects of heavy winter rains in this connection. The installation of tile drains in some instances can be effective. Excess water is intercepted by the tile drain as it moves down and across slope.

WATER USE BY TREES

One important factor in irrigation over which man has perhaps the least control is the actual use of water by the plant. Assuming that the soil has been adequately wet to the full depth of rooting of a crop, it is how and at what rate the plant uses this water that is of interest.

The actual use of water by various plants has been studied. The water requirement of the crop is obtained. Once the annual need for water is determined for a crop in a section, it is considered the amount of water that must be furnished a plant either by rainfall or irrigation.

By far, most of the water taken up by the plant's roots is transported to the leaves. Through special cells near the surface of each leaf the water is given off as vapor. It is thus evaporated or transpired. This concept of transpiration of water becomes more significant as the water supply becomes limited.

The rate at which transpiration takes place varies considerably. It increases with temperature. High humidities tend to slow down the rate. At dawn transpiration is practically zero; at mid-afternoon it reaches a maximum. Extremely high volumes of water are needed for transpiration—which is really a cooling process—during our hot summer spells and during our dry windy spells in the fall.

Trees would be expected to use less moisture in winter and such is the case. During five winter months, trees use six to eight acre-inches of water per acre. Cover-crops can use another four or five. Normally this winter requirement of around ten inches is supplied by rainfall. But whenever drought periods of more than six weeks duration occur in winter, irrigation may be necessary.

Summer brings high temperatures. Water use increases more than double. For example, mature avocado trees may actually use around twelve to sixteen acre-inches per acre during the normal irrigation season. Here is where one practical application comes in. Knowing what the tree actually uses and how much is applied, some measure of efficiency can be made. Records indicate that from eighteen to thirty inches are actually applied to our tree crops to furnish a twelve to sixteen inch actual crop requirement. What has happened to the extra amount of water?

Some water is lost through surface evaporation; quite a bit is often used by weeds. Most often the major part of the extra amount of water applied is lost through deep penetration below the root zone.

Application of twenty inches of water to supply a twelve-inch requirement is considered sixty percent efficiency. By minimizing the above-named losses, seventy percent or even higher efficiency can be and is obtained by some irrigators. Average efficiency is around fifty percent.

APPLICATION OF WATER

In irrigation there is the problem of conveying water from a source to where it is needed in the soil. In orchard work, the idea is to get the water evenly distributed to the trees quickly and efficiently. Therefore, the method employed is important.

On medium to heavy textured soils that are quite uniform, the transporting or conveying of water over the land to where it is needed in the soil can often be done by the use of furrows. Where soils are on the sandy side, or shallow, or variable in texture, it becomes desirable to transport the water in closed conduits or pipes. The water is then applied through a distributing device or sprinkler.

Whichever method is employed, the irrigation system should be planned and considered prior to planting. The planting system, grading, location of main and lateral lines, soil variations are but a few items to be considered. The sprinklers or furrows need to be so spaced so that when water movement downward and laterally is completed, a very high percentage of the root zone area has been wet. It is likewise important with avocados not to have some portions of the root zone areas overly wet. Underhead sprinklers can be operated most effectively in this regard, since most of the surface is wetted, and downward movement is the main concern. Attempts at proper distribution of overheads require operation under very calm conditions—usually at night.

LOSSES OF WATER

How the soil type determines the amount of water retained by a soil, and also the amount that is available to the plant has been described. Climatic factors (temperature, humidity, etc.) and tree size (leaf surface) decide the actual amount or water required or demanded. Losses, or water not accounted for by tree use, are due to: (1) deep penetration below the root zone; (2) runoff; (3) evaporation; (4) weed competition. The first three losses can be minimized by improved application practices.

The problem of deep penetration ties directly back to water application. Water permitted to move below the root area is lost to the plant. Uneven distribution is practically unavoidable where water is applied in furrows or basins. For example, in furrow irrigation, one shortcoming is too small a flow of water into the furrow. Water doesn't reach the end quickly. Very deep penetration results at the head of the run. On the other hand, too large a flow will result in ponding at the lower end, and a very deep penetration there. Best penetration is secured by forcing the water to the end of the furrow with a larger flow, then reducing to a flow that is sufficient to just wet the length of the run.

Another factor involved in water loss due to deep penetration is too frequent application.

Water is applied before most of the available water in the root zone has been used up. The existing water together with any dissolved nutrients are thus moved downward, too often below the root zone. For better use of water in this regard, most of the water in the soil should be used before more is added. A satisfactory practice in this connection is some system of alternate row or furrow irrigation.

Runoff is a waste of water rarely, if ever, justified. It means water is being applied faster than the soil can receive it. It could be due to the grading, or flow of water, or type of sprinkler. Perhaps tillage or other cultural practices have impaired soil structure, and permeability has decreased. Certainly steps should be taken to analyze the problem, and take corrective action.

Evaporation is not a significant loss ordinarily. Then, too, it is one over which the irrigator has least control. Loss is chiefly from surfaces wet; therefore, it is greater in sprinkler irrigation than in furrow. Overhead sprinklers would have a greater evaporational loss than underheads, since they wet a much, much greater total surface area. Too frequent irrigation increases this loss, since the same surfaces are wet oftener than necessary. Evaporation directly into the air in sprinkler irrigation becomes significant with overhead sprinklers used on warm or windy days. Underhead sprinklers improperly regulated so as to fog will permit undue evaporational loss.

Weed control is a field to itself. It becomes important aside from actual use of water in that absence of weeds permits better distribution of water. Under furrows and underhead sprinklers weed growth can markedly affect the design or pattern of water distribution and penetration.

Actually there are few set rules or guides pertinent to application of water that hold under all conditions. After consideration of these sources of loss perhaps some gradual changes in practices may be indicated. In other words, a possible saving lies in a thorough check on how well the job of application is being done. The aim is to have the tree actually use a higher percentage of the total water applied.

FREQUENCY OF IRRIGATION

From considering the soil moisture relations and requirements of crops, it may be concluded that an application of water is not needed or economical until most of the soil is relatively dry. As soil moisture is used up, welcome air is brought in. Losses due to evaporation, runoff and deep percolation are automatically reduced by extending the interval between irrigations as far as practicable. The tree size (leaf surface) and weather are the chief factors determining the rate at which moisture is used. Hot, dry or windy weather markedly increase the rate of water use.

This variable weather factor absolutely rules out strict "calendar" irrigation. Any system of irrigating "every two weeks" or "every 20 days" is definitely not consistent with reasonable and wise use of water. It can be satisfactory to think along such lines as a rough or working guide during much of the summer. But the actual "when to irrigate" should be determined by an inspection of soil in an area of good root activity. Also, experience in an orchard over a period of years becomes a valuable aid.

The amount of water a soil can store for use is the next consideration. Since soils vary so in this regard—because of depth and texture—conditions must be known.

By way of example, the loamy sands used for avocados in coastal San Diego County actually hold very little available water—perhaps a half inch per foot of depth. On the shallow sands there, a ten-day interval might be necessary for average summer weather. However, when roots occupy four or five feet of this kind of soil, enough water can be stored to last almost a month. The loam soils with more finely divided particles hold much more water. Two to three weeks or longer are common intervals, depending on the depth of soil and nature of the root system.

Newly planted trees bear watching closely. Five to seven days can be long enough between applications during a hot spell.

As mentioned above, complete irrigations are the rule. Partial irrigations may, in certain places or at certain times, be indicated. The soil with a shallow spot here and there might well use some extra, or spot applications, if such are practicable. During the fall of the year, as tree use of water decreases, and rains are anticipated, short applications are sometimes made. It must be remembered that this is also the time that desiccating winds may occur, and that good practice means keeping adequate moisture available during this time.

There are several instruments available to register soil moisture conditions. However, the use of the soil auger or probe still has the widest application for determining the conditions in several representative areas. The same soil augers and soil tubes can be used to determine the adequacy of any application. This check of the penetration should be made twelve hours or more after the water has been applied. Very often a soil probe is useful in this regard. A light pointed rod is generally used. This will move readily and easily in the wet soil, and will resist entering the unwet portion.

WATER MEASUREMENT

A knowledge and understanding of water measurement can be of help in developing a good irrigation program. Though not an actual essential to good irrigation, the occasional check on the amount applied or to be applied becomes a useful tool.

As a tool in irrigation practice, it can be used as a guide or a check, or both. Actual amounts used become more significant when supplies are short, and when price per unit volume is on the high side. One or both of these factors are rapidly making many growers "quantity conscious."

Briefly, the orchard irrigation practice is reviewed as follows: When the upper foot or so (where most of the feeder roots are) gets on the dry side, approaching the wilting point, an irrigation is due. It should be remembered that, although the upper section is dry, the second foot may have available moisture left, and the third foot may contain considerable moisture. Water is applied to "refill" the soil, where roots are, to field capacity. The upper foot will require considerably more water to accomplish this. The third foot will need very little. Some type of soil probe is the best indicator of penetration. Application is stopped when the proper penetration is reached, remembering that movement downward will continue for a day or two and may wet another six inches or a foot.

Now the amount of water necessary for this irrigation of a given soil can be approximated. For example, that upper foot of a sandy loam will take about three-fourths acre-inch to "refill" it. The true loam may take two and a quarter inches per foot. The amount needed for the second and third foot could be estimated. The total application desired in acre-inches per acre, then, would be the result.

The acre-inch is that volume necessary to cover one acre to a depth of one inch. An irrigation of a certain number of acre-inches is obtained by distributing a set flow of water over some period of time. Units of flow are the gallon per minute, cubic foot per second, and the miner's inch. Meters are used in many districts, registering quantity of water passed. Flow can be determined by timing and indicator hands.

One of the handiest formulas for calculating application of water with a sprinkler system is:

$$\frac{96 \text{ x G.P.M.}}{\text{Sprinkler Spacing}} = \textit{precipitation in inches per hour}$$

Where 96 is a constant factor, g.p.m. is gallons per minute discharge through a single sprinkler. Sprinkler spacing is in feet. For example, Farmer Jones turns on thirty sprinklers. They are spaced approximately 20 x 30 feet. He times the meter for one minute and finds that 45 gallons flowed through. Forty-five gallons divided among 30 sprinklers means 1.5 g.p.m. per sprinkler. The formula becomes:

$$\frac{96 \text{ x } 1.5}{20 \text{ x } 30} = .24 \text{ or approximately } \tfrac{1}{4} \text{ inch per hour}$$

It will, then, take eight hours to apply a good two-inch irrigation.

SUMMARY

Irrigation is necessary as a supplement to rainfall in supplying the water required by the trees. The soil is used as a temporary reservoir. The soil is also the source and storage place for plant foods. Therefore, conditions in the soil must be kept favorable for healthy root activity. Good irrigation is important—particularly in avocado culture—in maintaining the most favorable environment for all root functions.

The irrigator deals directly with the soil. A knowledge of water-soil relationships is basic to developing good irrigation technique. Refinements can result from considering the seasonal tree use of water, sources of water loss or misuse and in knowing the approximate amounts needed and applied per irrigation. The only sure way to know when to irrigate is by a check of moisture conditions using a shovel, auger, or soil tube. There are no shortcuts. Just an earnest desire and intelligent attack on the problem, plus a little work, will do the trick.

EQUIVALENTS, UNITS OF FLOW AND FORMULAS:

1 acre inch = 27,154 gallons = 3,630 cubic feet
1 gallon = 231 cubic inches
1 cubic foot = 7.5 gallons (approximately)
1 acre = 43,560 square feet = 208.7 foot square
1 S.C. miner's inch = 9 gallons per minute
Cubic feet per minute x .83 = S.C. miner's inch

$$\frac{\text{gallons per minute} \times \text{hours}}{450 \times \text{acres}} = \text{acre inches per acre}$$

$$\frac{\text{S.C. miner's inches} \times \text{hours}}{50 \times \text{acres}} = \text{acre inches per acre}$$