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IRRIGATION WATER — A MAJOR SALT CONTRIBUTOR TO AVOCADO ORCHARDS

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Tree fruit crops, in general, are noted for their sensitivity to salts. Among such crops, avocado has the distinction of being the least tolerant to soil salinity. Successful management of avocado orchards, therefore, requires that high priority be given to preventing salts from accumulating to harm tul levels in the soil.

SOURCES OF SALTS

Salts are added routinely to avocado orchards through the application of fertilizers, manures, and irrigation water. The quantity of soluble salt applied in commercial fertilizers, or manures if used, is normally in the order of a few hundred pounds per acre per year. In contrast, the irrigation waters used on avocados in California generally contribute more than that amount of salt with *each irrigation.* Thus, by far the largest amount of salt added to these orchards annually comes from the irrigation water. The total from this source alone is usually several tons/ acre/year.

Taking this into account as well as the fact that avocados are extra sensitive to salts, it becomes clear that growers need to know something about the quality of their irrigation water and the possible problems the waters' salts can cause to plants and soils.

WATER QUALITY FACTORS OF IMPORTANCE REGARDING AVOCADOS

The various kinds of salts present in irrigation water and their concentrations are indicators of the quality of the water. This information is readily determined by chemical analysis which commercial laboratories can perform. A laboratory report of a water analysis contains such a variety of information that it may be confusing to those unaccustomed to such statistics. Only a few of the items, however, need to be considered in evaluating the quality of the water for irrigation of avocados. These include: (1) total soluble salts and (2) certain individual ions; sodium in relation to calcium magnesium; chloride; boron.

Total Soluble Salts

The soluble salts in irrigation water consist mainly of calcium, magnesium, sodium, chloride, sulfate, and bicarbonate. These are present as electrically-charged particles called ions. If these ions are allowed to accumulate in the root zone of avocados, this excess of total salts will prevent normal uptake of water by the roots and plant growth will be reduced. Other problems with plants and/or soil can occur as a result of the accumulation of excessive amounts of certain ions. These problems will be discussed later.

The total soluble salt content of an irrigation water is conventionally determined by measuring the extent to which it will conduct an electric current. Hence, laboratories report this measurement as "Electrical Conductivity," abbreviated as EC. The higher the salt content of the water, the larger will be the EC value. Colorado River water, the source for irrigation water for much of California's avocado acreage, has an EC of approximately 1 *millimho,* abbreviated as mmho. On a lab report this would be shown as "EC x 10^3 = 1." The "10^3" indicates that the EC value has been multiplied by 10^3 or 1,000. This is done by laboratories simply to convert EC values, normally awkwardly small numbers, to numbers of more convenient size. Laboratories have not yet standardized the method of reporting EC. Some report it as EC x 10^3; others report it as EC x 10^6, in which case the EC has been multiplied by 10^6 or 1 million. If Colorado River water is reported as EC x 10^6, the value becomes 1,000 *micromhos.* In order to simplify this discussion of water quality, all references to EC henceforth will be in terms of millimhos (ECx 10^3).

The total soluble salt content of a water may also be expressed as parts per million (ppm). EC values may be converted readily to ppm by multiplying the EC by 640. For example, water with an EC of 1 millimho has a total salt content equivalent to 640 ppm.

The electrical conductivity of waters used for irrigation of avocados in California ranges from less than 0.5 millimhos (or 320 ppm) to approximately 2 millimhos (or 1280 ppm). Even at the upper end of this EC range, the salt concentrations do not exceed the tolerance level of avocado roots. Damage from excess soluble salts does not occur on avocados until the EC of the water surrounding the roots is approximately 4 mmhos (A soil water salt concentration of 4 mmhos is equivalent to a saturation extract salt concentration of 2 mmhos). Thus, we can see that if the EC of the waters applied to irrigate avocados did not increase after application, no salt problems would occur. This, however, is not the case. In reality the EC of water applied to soil does increase after the water enters the soil. The increase occurs mainly because plants absorb large quantities of water and transpire it into the atmosphere without removing much salt from the soil. Evaporation from the soil surface is also responsible for increasing the salt concentration in the soil solution. Other factors which influence how concentrated salts become in soils include temperature, quantity of water used, frequency of irrigation, and drainage.

Under ordinary conditions, it is common to find that the EC of the soil water is 4 to 6 times greater than that of the irrigation water. This degree of concentration of soluble salts in soils, i.e., four to six fold, can be permitted in avocado culture only if the irrigation water EC is not more than about 0.75 mmhos. If irrigation water EC's are above about 0.75, a four to six fold increase in concentration in becoming soil solution will result in excess soluble salt around the roots of avocados. Based on the above reasoning and on general experience of growers, 0.75 mmhos is the upper limit of the EC range for irrigation waters rated as "low salinity hazard" according to the University of California Agricultural Extension system of water quality classification.

It is interesting to note that most of the waters used for irrigation of avocados in California have EC's between 1 and 2 mmhos and, therefore, do not fall into this low salinity hazard classification. Yet many growers use these higher salt waters with good results. Those growers who are accomplishing this have developed, knowingly or not, better than ordinary water management practices. The result is more leaching. More of the water applied is being passed through the root zone and thereby prevents the concentration of soluble salts in the soil solution from increasing to the extent ordinarily found in irrigated soils. With exceptional skill in water management coupled with favorable soil drainage conditions, the concentration of soluble salts can be held to a minimum of about a twofold increase over that of the irrigation water. Under even the best of conditions, then, the upper limit of EC for irrigation waters suitable for use on avocados should be approximately 2 mmhos.

Individual Ions

A second type of salt injury to avocado trees can be caused by individual ions. Absorption of excessive amounts of certain ions (sodium, chloride, or boron) can burn the leaves. Chlorophyll formation and consequently food production is reduced in tip-burned leaves badly damaged by excessive salts. Damaged leaves prematurely drop from the tree, resulting in a progressively weakened tree. Evaluation of water quality for irrigation of avocados, therefore, requires some attention to the concentration of these ions, in addition to the total salt concentration just discussed. Laboratory reports list various ions present in irrigation waters, including the toxic ions, and generally show their concentration in two ways: as parts per million (pnm) and also as milliequivalents per liter (meq/l). In the case of those ions whose concentrations are very low in waters, it is more convenient if the values are expressed as ppm.

In other cases, sodium, for example, it is desirable to have the concentration expressed as milliequivalents per liter. The reason, in the case of sodium, is that the sodium hazard of a water is evaluated by making a calculation that requires an equation (4) in which sodium must be in terms of milliequivalents per liter and not parts per million. Thus, though it may seem confusing to have ionic concentrations of waters expressed in two different ways, there are good reasons for doing so.

Sodium

Among the toxic ions, sodium is unique in that it can damage soils as well as plants. Its excess in soils markedly reduces their permeability to water. A convenient means of determining whether sodium in irrigation water may cause a problem to either soils or plants is by calculating the SAR (Sodium Adsorption Ratio) of the water according to the equation below.

$$\text{SAR} = \frac{\text{Sodium}}{\frac{\text{Calcium + Magnesium}}{2}}$$

With all concentrations in meq./l.

Soils can be expected to be damaged by sodium if the irrigation water SAR is greater than about 10. Plant damage can occur at lower SAR levels. Recent research (1) indicates that avocados will develop severe leaf burn if the SAR of the irrigation water is more than about 6.

Natural Colorado River water has an SAR of about 2. Colorado River water distributed in the L. A. Basin is softened by the Metropolitan Water District. The carefully controlled MWD process raises the SAR to about 6 and sometimes slightly above.

This MWD-softened Colorado River water is marginal in quality for irrigating avocados and other sodium-sensitive plants which include some ornamentals. If marginal-SAR waters *must* be used on sodium-sensitive plants, it would be advisable to broadcast some gypsum on the soil annually as a preventive treatment. The gypsum supplies calcium which can lower the SAR of the soil solution.

Home water softeners, unlike the MWD process, will produce waters with very high SAR's. For that reason, home-softened water should never be used for irrigation.

Chloride

Toxic ion injury in California avocado orchards is most frequently associated with chloride. Several years ago Don Gustafson conducted a study of chloride damage in San Diego County orchards and found that tip-burn on leaves was prevalent in late summer if the chloride concentration of the irrigation water was higher than roughly 100 ppm or about 3 meq./l. (3). Subsequently, research at UCR (2) also indicated that tip burn is likely to occur if chloride in the irrigation water is higher than about 100 ppm. This assumes an average increase of chloride in the soil solution (4 to 6 times higher than the irrigation water) resulting from evaporation and transpiration and influenced by climate, etc.

Better than average water management and drainage conditions will permit use of irrigation water with somewhat higher chloride concentrations as was explained in the case of EC. Under the very best of conditions, though, the upper limit of chloride in irrigation waters for use on avocados grown in California should probably be around 175 ppm. The average chloride concentration of natural Colorado River water has ranged from a low of 83 ppm to a high of 113 ppm during the past 10 years.

Boron

Excessive boron in irrigation waters is a localized problem generally associated with faults where high boron water rises to the surface and contaminates streams. Well waters in such areas may also have elevated boron levels. Avocados show the characteristic boron injury symptoms, interveinal chlorosis followed by tip and marginal leaf burn, when irrigation waters contain more than about 0.5 ppm. Colorado River water has a boron concentration of around 0.1 ppm.

CONCLUSION

Avocado trees are easily damaged by salts, especially chloride, sodium, and boron. The symptoms of salt injury vary, but the overall effect is a reduction in bearing surface as a result of slower growth or early dropping of foliage, thereby lessening the potential of the tree to produce fruit.

Proper irrigation of avocado trees is essential for salinity control. Irrigation should be given first priority on the cultural program of an orchard. There is no substitution for a good irrigation program. Careful consideration should be given to the application of water, both in amount and timing. Water quality should be known. If the amount of chlorides, for instance, goes over 100 parts per million, extreme care should be used in how the water is used.

Time spent on evaluation of an irrigation program, the irrigation system, and using every means to improve the program, will surely pay good dividends in the long run.

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