Grapes and Deciduous Fruits

irrigation of deciduous orchards and vineyards influenced by plant-soil-water relationships in individual situations

F. J. Veihmeyer and A. H. Hendrickson

One of the principal cultural practices in deciduous fruit orchards and vineyards is irrigation and its successful accomplishment frequently determines whether the grower makes a profit.

The cost of irrigation—preparing the land for surface irrigation, the labor of applying the water and the cost of the water—may be one of the important items in the production of fruit. Because experience has shown that much time and labor may be wasted, the selection of a rational program of irrigation is of great importance.

Whether to irrigate or not, or when to irrigate, are questions that can be answered only from consideration of the moisture properties of the soil, the kind of plant, its depth of rooting, the kind of root system, prevailing climatic conditions, and whether there is a supply of water for irrigation.

A grower should consider the soil as a reservoir for the storage of water for use by the plants. Therefore, he needs to know how much readily available water can be stored in the soil.

When water is applied to a soil the pore spaces are almost filled with water for a short time to the depth wetted. During this interval the soil is nearly saturated. If drainage takes place some of the water will move downward and, to a less extent, laterally, by gravity. The amount of water held by the soil after drainage takes place is called the field capacity of that soil. For practical purposes a soil has a definite field capacity.

When the moisture content of the soil reservoir is not sufficient to maintain normal growth and vigor of plants, that point is called the permanent wilting percentage and the plants will reach a condition of wilting such that recovery will not take place until water is added to the soil.

The field capacity and the permanent wilting percentage are the only soil moisture conditions of any practical value for consideration in connection with plant growth.

The grower may be able to judge when his trees need water by his daily observation of their condition. When wilting or other evidence of lack of readily available moisture is hard to detect in the trees, the condition of some of the broad-leaved weeds—left as indicator plants in various places in the orchard—will show by drooping that they need water. Generally such weeds are deep-rooted enough to indicate by their wilting a lack of readily available water in the soil occupied by the roots of the trees.

Root Systems

The depth and character of the root systems of trees and vines are important in determining irrigation practices. Deciduous fruit trees and grape vines are in the class of deep rooted plants. Consequently they can be grown sometimes in regions where there is little rain during the growing season, and where evaporating conditions are relatively mild.

Withholding irrigation will not force trees to send their roots deeply into the soil and light irrigation will not encourage shallow rooting; neither will irrigating on one side of the tree only confine the roots to that side.

If soils are wet only to a certain depth, and if the soil below this depth is at the permanent wilting percentage, the roots will be confined within the wetted area. On the other hand, plants which are normally deep-rooted can not be made to keep their roots in the upper layers of soil if those at lower depths have a readily available supply of moisture and if no other adverse condition for root development lies below.

If the soil is wet to the full depth to which the roots would normally penetrate during the growing season, then later applications of water during the summer will have no influence on the extent of the distribution of the roots, unless they be frequent enough to produce conditions unfavorable for root growth. The presence of water in amounts above the field capacity, a condition often called waterlogging, may injure the roots of some trees.

The kind of root system a plant has is a very important item to be considered. Some plants—for a part or all of their life span—seem to have a genetic character of sparse root development. The roots do not thoroughly permeate the soil and consequently there may be parts of soil not occupied by roots. Sampling the soil for moisture conditions under these conditions may not give a true picture of the soil in actual contact with the absorbing portion of the roots. It may, then, be impossible to determine the amount of water available for these kinds of plants at any given time.

Sometimes soils compacted by traffic of field equipment and dense soils such as a clay adobe interfere with root development. Such soils do not permit roots to penetrate into them. Where the roots of plants do not thoroughly permeate the soil, moisture data may be unreliable.

Continued on next page

Graded contour furrows can be used successfully on steep land.

DECIDUOUS

Continued from preceding page

Sprinkling can be used under a great variety of conditions, but is best adapted to steep lands which can not be leveled, terraced or contoured economically.

Study—for many years—of the responses of fruit trees and vines to irrigation has resulted in the conviction that soil moisture, from the field capacity down to the permanent wilting percentage, is readily available to plants and for that reason it is called readily available moisture. Therefore, irrigation is not necessary until the soil moisture reservoir is drawn down to the permanent wilting percentage. In practice, it may be necessary to irrigate before this danger point is reached. Irrigation must be started early enough so the entire area may be irrigated before the trees in the last section suffer.

The growth of fruit is retarded, and other symptoms appear, when the soil containing most of the roots has been reduced to the permanent wilting percentage. The degree of injury depends upon the length of time the soil remains in this condition.

Responses to irrigation may be segregated into two broad classes:

1. Those in which the response is immediate or takes effect in the season when a change is made in the irrigation treatment.

2. Those in which the response appears slowly and is somtimes only apparent after several years of following a given irrigation program.

In general, the beneficial results are chiefly those obtained during several years of good irrigation practice. Immediate results are generally harmful ones that usually follow changes in practice involving neglect or ceasing to irrigate, especially if this occurs during certain critical periods.

Increases in yield, as a rule, are among the benefits that are sometimes slow in appearing, and are the reward for the long, continued practice of keeping the trees supplied with readily available water throughout the year.

Decreased size in many fruits, delay in maturity of pears, and a lowered percentage of well-filled shells in walnuts are some of the results that immediately follow a failure to keep trees supplied with moisture.

Straight furrows on land with a slope of less than 0.15%. Enough furrows between the tree rows are used to wet all of the soil.

Fruit Sizes and Fields

The most sensitive index as to whether the trees have water available to them is the rate at which the fruit grows. Experiments extending over many years and with various kinds of deciduous fruit trees and grapes show that growth of fruit proceeds at a normal rate—irrespective of the amount of readily available moisture in the soil which contains the major portion of the root system—until the soil reaches the permanent wilting percentage, when there is an immediate check in growth.

In some areas—where the winter rainfall is ample and the soil holds a comparatively large supply of moisture—certain early fruits may be grown to maturity without irrigation and reduction in size of fruit. This is because the amount of soil moisture is sufficient to supply the needs of the tree, at least until the crop is mature. When there is a scarcity of water it is less harmful to eliminate irrigation in the late season than in the early part of the summer.

Generally, fruits may be expected to attain normal size if the usual thinning practice is followed and if the soil moisture does not fall to the permanent wilting percentage while the fruits are growing.

The timing of irrigation should not be decided upon because of a certain stage of growth of the trees and vines. The demand for water is dependent upon the size of the plant, sunlight, temperature, humidity, and wind, and not upon the growth stage of the plant.

Highest fruit quality is obtained when trees and vines are supplied with moisture throughout the year.

Experiments with canning peaches

Concluded on page 18

DECIDUOUS

Continued from page 14

showed that maintaining readily available moisture in the soil up to and including harvest time did not injure either the shipping or canning quality. Lack of readily available moisture for several weeks before harvest produced peaches of tough, leathery texture.

Quality in prunes, as measured by the specific gravity, is not greatly affected by the irrigation treatment. It seems to be associated with climatic conditions during the summer. The drying ratios of prunes are not materially affected by the irrigation treatment. They are chiefly dependent on the amount of fruit on the trees. Years of large crops have high drying ratios while those of light crops have low ratios.

Irrigation did not affect the keeping quality, flavor or drying ratio of table and raisin varieties of grapes. Wines produced from the grapes under different irrigation treatments were remarkably similar when the fruit was allowed to reach maturity.

Quality is an intangible characteristic not well adapted to precise measurements but where analyses such as sugar, acid, firmness and storage life can be made, the results have indicated that quality can not be affected by irrigating but it may be adversely affected by withholding water.

Amount of Water Used

Experience with orchards and vineyards in California illustrates the irrigation requirements for these crops.

The maximum use of water per day varies from about 0.1″ in the coastal areas with mild climates to 0.4″, or higher, in the hot portions of the interior valleys.

The actual use of water by the trees or vines will not be increased by increasing the number of applications. Plants can not be made to transpire more water because of high soil moisture conditions than they transpire under lesser amounts of readily available soil moisture. When more irrigations are given than are necessary to assure a continuous supply of readily available moisture, waste occurs by surface evaporation and deep percolation. Where water supplies are cheap, there is a tendency to overirrigate by giving too heavy rather than too light irrigations. Under pumping conditions there is a more conservative practice.

For mature orchards maximum water extraction from the soil may be as high as 36 acre-inches per acre per season. For the average orchard 18–24 acre-inches of irrigation water per acre may meet the demands of the trees in years of normal rainfall. On loamy soils, this amount can be applied in three irrigations. Where the ground water is 12′ or less from the surface, deciduous orchards are able to get a part of their water from that source. The need for winter irrigation should be gauged by soil moisture conditions near the end of the winter season.

Determination of the seasonal water requirements for an orchard or vineyard is only one consideration necessary for successful irrigation. If a grower knows his soil, its field capacity and permanent wilting percentage, he will be able to time his irrigations correctly.

F. J. Veihmeyer is Professor of Irrigation, Emeritus, University of California, Davis.

A. H. Hendrickson is Pomologist, Emeritus, University of California, Davis.

ORNAMENTALS

Continued from page 15

themums may consume as much as 0.35″ of water per day as it reaches maturity.

When water consumption is so great and root systems are limited by the confines of the container, the interval between the time when water is adequately available and severe water stress can be as short as two hours. To avoid any possibility of a water stress developing, ornamental growers usually irrigate when water suction may be relatively low—0.5 atmosphere or less. The tensiometer could serve as a guide to the irrigation of container grown ornamental crops, but it is not widely used. The interval between irrigations under container conditions is likely to be about the same or longer for a sandy soil as for a loam or clay.

Volume Proportion of Water and Air Space in Certain Soils

The volume proportions of air space and available water obtaining when drainage essentially ceases following a thorough wetting in soils of various texture with and without being amended by the incorporation of 50% sphagnum peat moss—volume basis—under both deep and shallow soil conditions. The shallow soil is approximately 8″ deep.

	Available water as percentage of total volume			Percentage of free air space	
	Deep soil	Shallow soil		Deep soil	Shallow soil
Marina loamy sand	6	31	26*	32	7
Marina l.s. + 50% peat	11	48	46	50	13
Diablo clay	17.5	31.5	. . .	20	6
Diablo clay + 50% peat	15.5	52	. . .	49	12.5
Pleasanton silt loam . .	15.5	25	12	11.5	2
Pleas. s.l. + 50% peat	13.5	45.5	33	38.5	6.5
Pleas. s.l. + Krilium . .	12	28.5	17.5	22	5.5

* Volume percentage of water released in range from .01–0.5 atmosphere suction. This is approximately the quantity of water available under shallow soil conditions—soils in a container—if irrigation is effected at a moisture content of 0.5 atmosphere suction.

Because water-holding capacities of shallow soils may be unusually high, there has been considerable apprehension among ornamental growers regarding possible inadequate aeration. To date, research has failed to demonstrate inadequate aeration in container grown carnations or chrysanthemums even when using fine textured soils which would remain approximately saturated after an irrigation. It appears that transpiration losses may induce adequate aeration conditions within a day or two under these conditions. Aeration might become limiting, however, should soils be used in which infiltration was so poor that water stood on the soil surface for prolonged periods.

To assure a free porosity of about 6% or more under container conditions it is the practice for growers to include a coarse organic amendment in a soil mix. Chemical aggregate stabilizers such as krilium are also effective.

One of the significant developments in the use of amendments in recent years has been the use of low-cost bark or wood fragments in place of peat. The use of pine, fir or redwood materials has been quite satisfactory when adequate nitrogen fertilizer has been supplied. These materials may be obtained at about one half or less of the cost of an equivalent volume of peat. Thus the cost of preparing special soil mixes in most cases has declined in recent years.

Irrigation Techniques

Inasmuch as equipment is available to automatically turn on water when needed, the biggest irrigation problem facing the ornamental growers is distribution of water from the supply source to pots, cans or benches. The use of perforated, flexible plastic tubing appears to be a satisfactory solution for irrigation of bench crops. Hand irrigation with a hose costs about 10¢ per square foot per year. At this cost for hand irrigation, plastic tubing approximately pays for its installation in the first year.

The irrigation of potted plants is a more difficult problem. Hand irrigation here costs about 75¢ per square foot per year. Subirrigation appears to be the most satisfactory solution to this problem, although problems of disease control with this cultural practice have yet to be thoroughly evaluated. Plastics are also playing a part in this development by making possible lightweight, economical watertight benches.

The accumulation of salts in pots due to capillary conduction to the surface presents a problem, but it is one which can readily be dealt with if the grower is cognizant of the hazard.

O. R. Lunt is Assistant Professor of Soil Science, University of California, Los Angeles.