W A L N U T O R C H A R D

I R R I G A T I O N S Y S T E M S

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IRRIGATION SYSTEMS - WALNUT ORCHARDS [1/]

Irrigation of California walnut orchards is practiced to obtain optimum yield of acceptable quality. Irrigation water is applied in varying amounts to supplement water from winter rainfall stored in the root zone.

Walnuts are planted on a wide range of soils with the capacity to store and supply 15 to 50 percent of the seasonal water demand. Irrigation water is applied to meet the remainder of this demand plus that amount of water required to maintain a favorable salt balance. Irrigations should be applied at a time to meet the crop's variable demand and at a location where uptake of water and nutrients can take place easily.

Irrigation systems should be designed and operated to favor optimum crop yields and efficient water use. With this in mind, it must be recognized that other considerations may at times dominate design and operational decisions. Of course, the ultimate cost--both of initial installation, operation, and maintenance --substantially influences the decision of the type of irrigation system.

Many suitable irrigation systems are available for use in walnut orchards. There is not a best system for all situations. Land, water, energy, and labor costs, in addition to soil and plant conditions, vary in each specific case necessitating a complete analysis to select a proper system. The selection of a good irrigation system is the first step toward good water management. Good water management favorably influences not only yield and quality but the mineral nutrition of trees; it minimizes insect and disease problems and makes weed control easier.

Border Irrigation

Border irrigation, a method of flood irrigation, has been successfully used in California for many years. It requires relatively level ground (less than 1% slope) where relatively large flows of water are available. Variations of the

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flood or border system are square basin, contour basin, contour check, and border check--either level or slightly graded. The width and length of these strips, checks and basins are dependent upon slope, soil texture, and amount of water available.

Advantages: The advantages of border irrigation are generally economic. On relatively flat ground it is the least expensive system to install. Earthen open ditches with wooden or concrete turnouts to deliver water into irrigation checks or strips are inexpensive, and even more elaborate systems to deliver water through concrete ditches, pipes, or plastic or fiber asbestos pipelines are available. Labor costs for water control are generally moderate, and maintenance of pipelines is also minimal.

Limitations: Efficient water application with border irrigation is difficult and deep percolation losses can be a serious drawback. Excessive percolation may occur at the upper end of the irrigation run near the turnouts. Soil variability also causes uneven percolation and excessive water losses. Large water flows are required; where water is limited or its cost is high, alternative methods of irrigation may be preferred.

Considerations: On-farm irrigation efficiency varies from 40 to 80 percent with the border system. Tailwater recovery systems can improve on-farm efficiency. Water distribution uniformity throughout the length of an individual strip, even when the land is well graded, rarely approaches 70 percent. Length of the border strip should be carefully calculated to maximize efficiency. If fills from land grading exceed normal discing depth, uniform water movement may be impaired. Cuts and fills often create compaction and interface problems in a soil profile.

Furrow Irrigation

Furrow irrigation is another gravity system which is a variant of the border system. Furrows are formed in a variety of shapes in which water is allowed to

flow down slope. Furrow irrigation is commonly used on lands not exceeding two percent slope when erosion usually becomes a serious problem. Water movement characteristics of the soil must also be considered with this system.

Advantages: The main advantage of a furrow system is the low initial cost of grading lands of one percent or less. The system may use pipeline or an open ditch with plastic or tarpaulin dams; siphon pipes deliver water to each furrow. More sophisticated systems use gated pipe or underground pipes, with short aluminum pipes to supply water to 12 to 24 furrows.

Limitations: Because of losses from deep percolation near the upper end of furrows, and often because of excessive tailwater, the overall efficiency of furrow irrigation in California is only 40 to 70 percent. In areas of high cost water, high water tables, or salinity, furrow irrigation has disadvantages, including high labor costs and need for skilled irrigators.

Considerations: Higher efficiency can be obtained by adjusting length of run, stream size, or by using a tailwater return system. A uniform application of a small amount of water can be more successful than a border system.

Sprinkler Irrigation

Sprinkler irrigation is practiced on unlevel lands or when special soil or water conditions or management requirements exist. Soil problems include excessive or inadequate water intake rates and non-uniform soils. A limited water supply, frost protection, or automation may also encourage the use of this system. The sprinkler system should be energy efficient, utilizing low-pressure concepts, minimizing pumping plant size and friction losses.

Orchard sprinkler systems include portable aluminum pipe which is moved by sets to various locations through the orchard. Hose-pull systems consist of buried lines connected to hose-attached sprinklers which also are moved by sets.

These systems are not used for frost control. Permanent, buried, solid-set systems can be operated by sets, or to apply water over the entire orchard at one time. (Single set systems can also be used for frost protection.)

Advantages: Sprinkling overcomes problems experienced on rough, irregular land where expensive land grading and preparations would be required for surface distribution methods. (Extensive grading often exposes subsoils having physical or chemical deficiencies.) Sprinkling generally avoids excessive losses from deep percolation or surface runoff.

A well designed and managed sprinkler system should give a uniform water distribution pattern, eliminate deep percolation and buildup of water tables, and also minimize drainage problems. Overhead and under-tree sprinklers can also be used for frost protection, chemical injection, and heat suppression.

Limitations: The primary limitations of orchard sprinklers are the initial cost and energy cost which are reflected in high total annual costs. Sprinklers require a dependable source of electrical power or fuel for pressure to operate. Irrigation water must be relatively free of salts, as absorption of salts from water on sprinkled leaves may cause leaf burn. Sprinkling may also encourage and spread certain diseases. The system should be designed and operated to minimize this effect. Low-angle, under-tree sprinklers (maximum height of 4 feet) are recommended in most orchards to minimize leaf-absorbed salinity and disease problems.

Considerations: Selecting and designing an irrigation system to reduce energy consumption is of increasing interest. Until recently, many systems were designed to operate at high pressures and to complete irrigation quickly, thus requiring a large pumping unit and larger piping that may be used less than 25 percent of the time. These systems require higher capital expenditures,

energy consumption, and electric standby charges.

Selection of a system which uses lower operating pressures can reduce the size of the pumping plant, reducing energy-related costs as well as capital cost while supplying the same volume of water. Reducing operating pressure of the nozzle from 50 psi to 35 psi can reduce energy cost for pressure delivery by 30 percent. This savings assumes no other head losses. A reduction at the pump of 65 psi to 50 psi will result in 23 percent savings.

Reducing operating pressure can sometimes result in a poor distribution pattern. This is of greatest concern during establishment of orchards. Older orchards in good condition with more extensive root systems are not as susceptible to the effect of water distribution patterns when applied in a consistent fashion.

Care should be given when considering a low-pressure system on wide plantings (such as 48 x 48). Less pressure can result in less coverage (diameter) requiring closer sprinkler spacing which can result in higher capital costs. Sprinkler head and nozzle design have evolved to improve the performance of sprinklers operated at low pressure and should be considered. Good design and quality installation are essential for long-term performance.

Drip Irrigation

Drip irrigation is a common name for an irrigation method which consists of frequent applications of water to a limited soil volume through small tubes or mechanical devices called emitters. Other systems which fall into this category are misters, spitters, tape, foggers, and mini-sprinklers.

The volume of soil wetted around trees by this method is less than that wetted by other irrigation methods. It has been suggested, although differences of opinion exist, that mature trees require 40 to 60 percent or more of the soil volume as a wetted area (less is required by young trees). Soils which do not have good capillary water movement may require more points of emission to

accomplish the required volume. Mature, larger trees may require up to eight emitters on loamy soil. Micro-sprinklers and similar systems distribute the water over a larger surface area requiring fewer emitters.

A water savings is possible with a properly managed drip system in comparison to other systems. The magnitude of savings depends upon the type of system used for comparison, its design, and level of management. However, there will be some savings due to a reduction in evaporation from the soil and in reduction in deep percolation potential. The amount of savings is greatest in young trees before the orchard canopy is fully developed.

Advantages: Most drip-irrigation installations are made to solve problems such as water supply shortages, water cost, poor or excessive soil permeability, or steep slope of land, but automation and reduced labor and tillage requirements can be factors in the decision. Water savings usually result from reduced runoff, reduced deep percolation, and a reduction of the area of wetted soil surface (conventional methods wet a larger soil area than is needed for young trees).

Because less soil surface is wetted by drip irrigation, total weed growth may be reduced even though weeds may grow vigorously near the emitters--weeds are often difficult to mow in that area, and herbicides may be required for control.

Frequent application also dilutes salts in the soil water more and makes possible the use of more saline water than could be used with other irrigation methods. However, salts may accumulate at the periphery of the rootzone, posing a hazard if not monitored and a leaching program conducted.

Limitations: Clogging of emitter orifices is considered one of the most serious problems in drip irrigation. Clogging can be caused by (a) particulates of sand, silt, or clay; (b) by inorganic chemicals forming precipitates of calcium and iron; and (c) by organic growth carried in the water. When this

occurs, emission uniformity decreases and damage to the trees may occur before clogging is detected.

Considerations: Because most water carries some particulate matter, all drip irrigation systems need an adequate filter. During the irrigation season salts accumulate at the soil surface and toward the fringes of the wetted soil volume. Early light rain may move harmful amounts of the salts downward into the root zone and later cause leaf burn. Drip irrigation should continue during early fall rains to dilute the salts and avoid this problem. If winter rainfall is insufficient, sprinkler or surface irrigation may be needed before spring to remove the salt buildup.

Cultural Considerations

Disease prevention in the culture of walnuts is of prime concern. Saturated soil conditions can enhance disease and should be avoided--this is especially true near the crown of the tree. Soils fine in texture, those with low infiltration rates, or variable in this characteristic are more likely to have problems. Irrigation systems which leave standing water in spots or at the end of the orchard should be modified by a surface drain system or a tail-water recovery system. Irrigation systems which apply water at a distance from the crown (drip, furrow, border with trees on a berm), or apply water at a rate avoiding saturated conditions (sprinkler, drip) should be considered if saturated soil conditions are expected to exist.

Selection and Management

The types of irrigation systems used successfully for the production of walnuts along with their general characteristics are listed in Table 1. Sprinkler and drip irrigation systems are reported to be higher in irrigation efficiency than the other systems, although a properly designed system of the type listed can perform similarly in terms of efficiency. It is important to note that the

best designed and installed system will not function efficiently without the proper management. Good management techniques include estimating crop water demands by the use of predictive methods or actual soil-moisture-monitoring devices, then evaluating the effectiveness of the irrigation after the application of the indicated amount. The potential benefits to the farmer from adequate design and management related to irrigation efficiency can be reduced costs of water, energy, labor, fertilizer, capital, and possibly the lack of a drainage system in the future. In addition to these, there also is the possibility of increased crop yields. Irrigation systems should be monitored and evaluated, especially considering the rapid changing of energy, labor, and capital costs.

TABLE 1

FACTORS TO CONSIDER IN SELECTING AN IRRIGATION SYSTEM
(LIMITATIONS OF SYSTEMS)

Factors to Consider	Sprinkler Systems		Surface Flood Systems			
	Portable	Solid Set	Graded Border	Level Border	Furrow	Drip System
Slope Limitations						
Direction of irrigation	20%	None	0.5-3.0%	Level	2%	None
Cross-slope	20%	None	0.2%	0.2%	6%	None
Soil Limitations						
Intake rate (in./hr.)						
Minimum	0.10	0.05	0.30	0.1	0.1	0.02
Maximum	6.0	6.0	2.0	2.0	3.0	None
Water-holding capacity in root zone (min.)	3.0	None	6.0	6.0	4.0	None
Erosion hazard	Slight	Slight	Moderate	Slight	Severe	None
Saline-alkali hazard	Slight	Slight	Moderate	Slight	Severe	Moderate
Water Limitations						
Quality						
Total dissolved solids (TDS)	Severe	Severe	Slight	Slight	Moderate	Slight
Suspended solids	Moderate	Moderate	None	None	None	Severe
Rate of flow	Low	Low	Moderate	Moderate	Moderate	Low
Climatic Factors						
Temperature control	No	Yes	Yes	Yes	Yes	No
Wind affected	Yes	Yes	No	No	No	No
System Costs						
Capital cost ($/acre)	400-600	700/1200	500-600	500-600	400-500	500-1200
Labor cost	High	Low	Moderate	Moderate	High	Low
Power cost	High	High	Low	Low	Low	Moderate
Average annual cost[1/] ($/acre/year)	100-200	200-300	100-200	100-200	200-300	200-300
Irrigation Efficiency[2/]	70-85%	75-90%	70-85%	75-90%	70-85%	80-90%

1/ Amortized capital cost plus operation and maintenance cost.

2/ $\frac{\text{Consumptive use}}{\text{Applied water}}$ = Irrigation Efficiency, assuming good to excellent management and design.