WATER TASK FORCE
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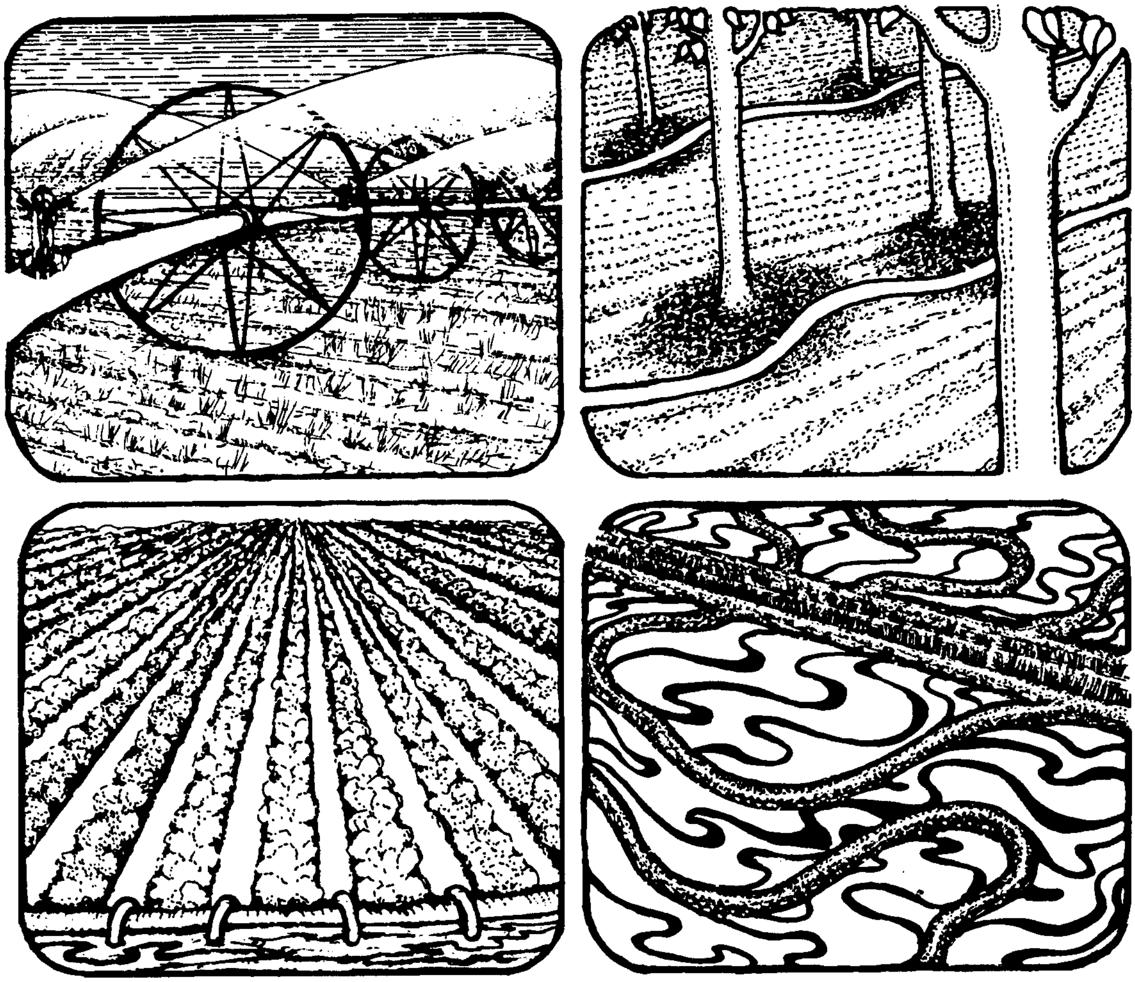
How Farmers Irrigate in California



Cooperative Extension **University of California**
Division of Agriculture and Natural Resources

LEAFLET 21414e
(Scan of Leaflet 21414. No content was updated from the 1986 printing.)

How Farmers Irrigate in California

Most of California's developed water supply—water that is diverted from streams, stored in reservoirs, or pumped from underground—goes to irrigate crops. Californians tend to worry about this arrangement. They ask:

- Why do farmers need so much irrigation water?
- How does a farmer decide when to irrigate, and how much?
- Why are there so many kinds of irrigation?
- What are the roles of new technology and new scientific methods of irrigation?

How much and where

About one-tenth of California, almost 10 million acres, is irrigated farmland. About 85 percent of the state's developed water is used to grow crops on that land. Most of the irrigated acreage is in central California: about 5 million acres in the San Joaquin Valley, and 2 million in the Sacramento Valley to the north. The rest is in valleys along the coast and in southern desert areas.

The crop with the greatest irrigated acreage in California is cotton. All the state's orchards combined, including deciduous fruits, nuts, and citrus, occupy about as much irrigated acreage as does cotton. Other crops occupying large amounts of irrigated acreage are alfalfa, pasture, grapes, rice, corn, tomatoes, and sugarbeets. Also, large acreages of wheat and barley are grown in winter and spring with some irrigation to supplement rainfall.

In an average year, about 36 million acre-feet of water go to irrigate these crops, enough to fill a 1-acre reservoir to a depth of 6,818 miles—almost to China. What happens to all that water? In the process of meeting basic crop requirements, about two-thirds of it changes to water vapor and enters the atmosphere. The other third either percolates down to groundwater or flows out into drainage canals and streams. Some of this return flow serves to flush salts from the soil. Much of it is reused.

How water is applied

California farmers apply irrigation water in a dozen or more different ways. All of these are either surface systems, where water flows across the ground by force of gravity, or pressure systems, where water is pumped through pipes or hoses to sprinklers or emitters.

Surface systems, traditional in California, are used on about 75 percent of the state's irrigated farmland. There are three types:

- Furrow irrigation, commonly used for crops planted in rows, such as corn, cotton, and tomatoes.
- Flood (border) irrigation, used for crops such as alfalfa and pasture, in which parallel strips of land are flooded.
- Basin irrigation, often used in orchards, in which level areas surrounded by dikes are filled with water.

During furrow and flood irrigation, the flow continues until the desired amount of water has soaked into the soil along the entire length of the sloping field. This means that some tailwater generally runs off at the lower end. Also, more water enters the soil at the upper end of the field, where it has been flowing the longest.

CROP WATER NEEDS

Whether it's a clump of grass or a pine tree, every growing plant must have water for two vital functions: transpiration through its leaves and evaporation from its surfaces and surroundings. Together, these functions are called evapotranspiration **(ET).** Plants can survive with less than their full ET needs, but only by slowing growth. Without the growing season's ET requirement, whether from rainfall or irrigation, crop yield will fall.

The actual amount of water used by a crop for ET depends largely on sunlight, temperature, humidity, and wind. On any day at a given location, ET rates are similar for different crops. (Typical rate for a July day in the San Joaquin Valley: 0.3 inches of water.) Season-long ET requirements are something else again; they are low for crops that take less time to mature or that grow during the cool months.

- Wheat and barley (180 days of growth during winter and spring) need about 15 to 20 inches of water for ET, amounting to 9 to 12 gallons per square foot for the growing season.
- Corn (150 days of growth during summer) needs 25 to 30 inches for ET, or about 20 gallons per square foot.
- Alfalfa (spring, summer, and fall growth) needs almost 50 inches, or about 30 gallons per square foot.

Farmers generally apply more water than is needed for ET. This additional irrigation allows for uneven distribution of water in a field and leaching of salts from the soil. Irrigation is considered very efficient if 85 to 95 percent of the applied water is used by the crop. More often, the figure is in the 70 to 80 percent range, which may be the best possible under the circumstances. Below 50 or 60 percent is generally considered poor irrigation efficiency.

Because of this uneven water distribution, surface irrigation systems are often thought to be less efficient than modern pressurized systems. In practice, they may be. However, tests at the University of California and elsewhere have shown that well-designed surface systems *can* be operated as efficiently as sprinkler or drip systems. Particularly where water is scarce and costly, surface systems may be among the best, indicating it is not the system itself but how it is designed and managed that makes the difference. Recycling tailwater, for example, is one way to improve the efficiency of a surface system.

Pressurized irrigation, applying water through sprinklers, microsprinklers, and drip emitters, is now used on about 25 percent of California's irrigated farmland. Sprinklers are the most common, but use of drip systems is increasing rapidly. Still, drip accounts for only a small fraction of the total: about 3 percent of all irrigated acreage in 1980, according to the California Department of Water Resources (DWR).

DRIP: THE MYTH AND THE FACTS

What type of irrigation can be used most easily to apply water efficiently? Probably drip, if the system is well designed and operated.

But drip technology is not, as some have claimed, many times better than other systems—a technological cure for California's water problems. That is because two-thirds or more of all water applied to crops in California goes to satisfy the crop water requirement, the minimum without which plants cannot grow properly. This is true regardless of the type of irrigation system.

With all systems, water is applied in addition to this basic requirement so all parts of the field will get enough water and so salts will leach out. One objective of good irrigation is to minimize this additional application. Drip irrigation makes that easier.

Sprinkler and drip systems have several advantages:

- They make it easier to control the amount of water applied, and to distribute it evenly across the field.
- They can apply water slowly, which is important on tight soils where water infiltrates slowly.
- They can be used on rolling land; in the case of drip, even on steep hillsides.

In other words, applying the right amount of water where and when it is needed is less complicated with sprinkler and drip irrigation. Comparable efficiency is possible with surface systems, but it takes more effort to apply good management.

Sprinkler and drip systems are easier to automate and may save on some aspects of labor. To operate well, however, they must be closely watched and maintained, and that may end up requiring as much labor as surface irrigation.

Sprinkler and drip systems also have some obvious disadvantages. They are more expensive to buy and install, and they require more energy. A particular problem with drip systems is the need for frequent close up inspection to find plugged emitters.

The farmer's decision

Regardless of which irrigation method is used, a grower must make two decisions over and over again: When to irrigate, and how much water to apply. Of course, anybody with a garden, a lawn, or even a houseplant faces the same decisions. But with so much more at stake, how does a farmer decide? The cost of water and other such basic considerations will have an influence. But more specifically, the grower can look at three indicators: the plants, the soil, and the weather.

In practice, many growers go largely by the calendar, basing their irrigation plans on experience and, if they use canal water, on the irrigation district's delivery schedule. Still, most keep a wary eye on at least one of these indicators of crop water need:

The plants. With some crops, such as beans and cotton, experienced growers say they can see the first signs of stress and irrigate in time to prevent yield loss. This is risky. Furthermore, many crops show no visual symptoms until it is too late. Scientific devices are used by researchers to measure a plant's water status, but these are still largely experimental and only indicate when to irrigate, not how much. To determine the amount, it is necessary to look underground.

The soil. The amount of available water in the root zone can be estimated with buried instruments that measure how tightly water is held in the soil (tensiometers and gypsum blocks) or with a device that directly measures water content (a neutron probe). But there's a problem: Each reading reflects conditions in only one spot, while actual conditions in the field may vary widely. The farmer must either install many expensive instruments—generally not practical—or use information from a few to estimate overall conditions. Since at least some guesswork seems to be unavoidable, why not simply use a shovel, a soil tube, or even a steel rod to get some idea of moisture in the soil reservoir? In fact, that old-fashioned approach, properly used, often works well.

THE SOIL RESERVOIR

After irrigation, the amount of water remaining in the root zone and available to the crop depends on the soil's capacity to store water and the depth to which roots have grown.

Sandy soils hold less water than heavier soils. Coarse sands have just enough space between particles to hold about ½ inch of water per foot of soil depth. Fine clays have more, smaller spaces, and commonly store at least 2 inches of available water per foot of depth.

The depth of the root zone also varies: grass roots go down only a few inches; tree roots, 8 to 12 feet or more. Even deep-rooted crops may have their root zones restricted by underground barriers (bedrock, hardpan, soil layers, high water tables).

- A 5-foot root zone in sandy loam can store about 6.5 inches of available water, or 4 gallons per square foot of surface area (1 acre = 43,560 square feet).
- A 5-foot root zone in silty clay *can* store about 10 inches of available water, or 6 gallons per square foot of surface area.

An important point: Plants cannot extract all of the moisture in soil. The portion that *can* be removed by the roots is called available water, but only part of this amount can actually be used in crop production. Some of the available water must stay in the soil to avoid crop stress and reduced yields.

The weather. The actual amount of water used by a crop is determined by still another factor—evaporative conditions, or the evapotranspiration (ET) rate. Rates of ET are generally the same throughout a uniformly planted field, and can be measured fairly easily. This leads to the concept of water budgeting, which many farmers, scientists, and state water officials say is the best broad-based approach to improving irrigation scheduling in California.

A farmer using water budgeting first determines the capacity of the soil reservoir. Second, the farmer decides how much of that soil-stored water can be used safely without decreasing yields. This factor, the yield threshold depletion level, depends mainly on (1) the crop's sensitivity to water stress and (2) root distribution in the soil reservoir. It may be as high as 90 percent or as low as 30 percent of the available water in the root zone.

Third, the farmer keeps a record of the crop's cumulative ET losses since the last irrigation. Then, when the losses approach the yield threshold depletion level, it is time to turn on the water again.

Water budgeting takes into account both soil moisture and the crop's changing water needs. With a reasonable idea of how much soil-stored water can be used safely, and with timely ET readings, a farmer can tell fairly accurately both when to irrigate and how much water to apply.

CIMIS: A new approach

It would help to computerize the process. That is one goal of a new state-sponsored program: California Irrigation Management Information System (CIMIS). Developed by the University of California, CIMIS links a network of more than 40 small, sophisticated weather-sensing stations in various farm areas of the state to a central computer. Day by day, the stations report weather conditions, and reference values for ET are automatically computed. These values are then matched with information on individual fields near each weather station to recommend timing and amount for the next irrigation.

The State Department of Water Resources financed development of CIMIS, and now operates it as a public service. The next step, involving DWR, UC Cooperative Extension, and private irrigation consultants, is to show farmers how to use CIMIS.

But which farmers, and why? Those are not easy questions. Irrigation experts generally agree that:

- Many California farmers already irrigate with reasonable efficiency, so they have little to gain and much to risk from changing their methods.

- In many cases where irrigation is less efficient, the runoff is used by other growers or contributes to streamflow.

But the experts also agree that, overall, there are gains to be made in the efficient use of water on most farms, probably through CIMIS or something like it. In studying the possibilities, UC Cooperative Extension specialists have found that:

- Growers with irrigation problems are more likely to adopt CIMIS.

- Growers who can measure the amount of water they apply are more likely to use CIMIS (most surface irrigators cannot).

- Use of CIMIS is more likely on trees and vines than on annual crops.

- Overall cost of water does not seem to be linked to use of CIMIS, except in some local situations. High power costs for pumping water often do make a difference.

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Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Jerome B. Siebert, Director of Cooperative Extension, University of California.

5m–pr–1/86–WJC/ALS

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Publication 21414e

Previous printing 1986. Digitally re-issued 2002; no content was updated from the 1986 printing.

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Division of Agriculture and Natural Resources

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