pH, and total acidity, was as good or better for the LF irrigation treatment as for the HI treatment.

In each irrigation treatment, the maximum yield occurred in the moderately deep soils, where a favorable balance between vine growth and fruit production was most easily attained. The low yields on the very deep soils were attributed to the inability to control excessive midseason vegetative growth. Such growth competed for photosynthates throughout the late summer and resulted in lowered carbohydrate reserves and reduced vigor the following spring. This, in turn, produced low cluster count and poor berry set.

If the soil depth had been uniform across the vineyard for any one of the four depth categories, it would have been much easier to manage irrigations for optimum yield and quality for the entire block. For this reason, growers are advised to plan vineyard blocks and sprinkler irrigation systems to conform as nearly as possible to soil blocks that are uniform in depth and texture. However, even soils with considerable variability can produce better crops if the grower frequently monitors the soil moisture status and schedules irrigation quantity and frequency to maintain soil moisture at desired levels. These levels will vary, depending on the stage of vine growth and crop maturity.

Careful irrigation not only can improve yield and quality, but may also cut down costs. In our experiment, the light, frequent irrigation treatment used significantly less water than did the heavy, infrequent irrigation. In some years the water saving was almost half. In addition, pruning costs were less for the LF treatment, because it reduced excessive vine growth on the deeper soils.

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Drainage problems in the San Joaquin Valley—an interagency approach

Louis A. Beck

The west side of the San Joaquin Valley between Tracy and the Tehachapi Mountains has developed or will develop drainage problems. Ultimately, about 1½ million acres will be affected. Agricultural production could be reduced up to 80 percent in the most seriously affected areas.

The drainage problems are a result of the buildup of perched ground water. Clay layers in the soil and clayey-type soils severely restrict deep percolation in the valley trough. Because of minerals in the soils and in the perched ground waters, it is necessary to maintain salt balance in the root zone by leaching. As the west side has developed firm agricultural water supplies, and irrigation is practiced annually rather than intermittently, the water used for leaching builds up on the restraining soil layers.

This perched ground water usually enters the root zone sometime between 5 and 50 years after annual irrigation is established. Encroachment into the root zone will reduce crop yields. The effect can be so severe in some areas that lands will go out of production unless tile drains are installed to maintain the perched ground waters below the root zone. The waters collected in the tile drains are not usable as agricultural supply water because of their high salt content—5,000 to 10,000 mg/l total dissolved solids (TDS). In some cases, the salt content is so high (40,000 to 80,000 mg/l TDS) that it cannot even be blended to make an acceptable supply water. It is the safe handling and disposal of the salts in the drainage rather than the water itself that is the problem.

Eventually about 600,000 acre-feet per year of this high-salt drainage water will be produced. Most of it will be generated south of Gustine, and about 60 percent of it will be produced during the irrigation season from April through August.

Local areas are developing solutions to the drainage problems that now exist. Areas north of Patterson discharge to the San Joaquin River. A drain being constructed to serve the San Luis service area is authorized to be completed to the western Delta. The Tulare Lake area is constructing evaporation ponds. Kern County is investigating the use of drain water for power-plant cooling. These local solutions, with the exception of San Luis Drain, are not ultimate solutions, because they either discharge salts to surface water or maintain the salts in the valley.

The San Joaquin Valley Interagency Drainage Program (IDP) was established in 1975 to develop a program leading to an ultimate solution. The Interagency Drainage Program is sponsored by the U.S. Bureau of Reclamation (USBR), the California State Water Resources Control Board (SWRCB) and the California Department of Water Resources (DWR). It is a three-year program to be completed in 1978. Its objectives include maintaining irrigated agriculture at its present level and preventing adverse ef-

Barley affected by drainage problems. In the foreground, salt has formed on the soil surface.

fects by any drain facilities.

The IDP is investigating the following basic alternatives: (1) no valleywide action (local areas will develop their own solutions as the need arises); (2) maintain the salts in the valley (evaporation ponds); and (3) discharge the salts to the ocean either directly, or to the San Joaquin River near Mendota, or to the San Francisco Bay-Delta estuarine system.

This investigation of alternatives is being coordinated with several federal, state, local, and private agencies. The USBR is responsible for the economic evaluations. The SWRCB has hired Environmental Impact Planning Corporation and Hydroscience Associates, Inc., as consultants to conduct an environmental appraisal of drainage facilities. DWR is developing a financing program and investigating legal and institutional constraints. The IDP staff is developing evaluation criteria to consider effects of any proposed program.

Two important concepts held by participants in the Interagency Drain Program are that this drain water is a resource and that the implementation of the program must be flexible. The valley is a water-short area, and the drain water must be used to the greatest extent possible before the salts are disposed of. Uses being considered are power-plant cooling, development of marshes for waterfowl enhancement, reclamation of chemical constituents, aquaculture, and salinity repulsion in the western Delta. It is also important that implementation of the recommended program be flexible. The first stage of implementation must allow for changes in the ultimate solution that are required by technological improvement, revision of drainage predictions, or additional reuse.

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Irrigation efficiencies in the Tulare Basin

George V. Ferry

The Tulare Basin, consisting of the southern half of the San Joaquin Valley, is a water-short area, and efficiency of use is quite high.

Water resources within the area are intensively utilized, and importation of water is of utmost importance. Data supplied by the State of California Department of Water Resources (Bulletin No. 198) indicate that 3,166,000 acres received 10,900,000 acre-feet of water in 1972. Even with this large importation of water, an overdraft of 1.3 million acre-feet occurred. Considering the shortage and high cost of water (from $10 to $30 per acre-foot), the growers obviously are interested in efficient irrigation.

Growers are trying to improve on-farm efficiency by employing the best technology available, including proper leveling of land, shortened irrigation runs, various sprinkler application methods, and such low-application techniques as drip irrigation.

Irrigation in the Tulare Basin is estimated to be 82 percent surface application and 17 percent sprinkler application ("Irrigation in California," a report to the State Water Resources Control Board, J. Ian Stewart, University of California, Davis, June 1975). Basin and furrow constitute the major portion of the surface irrigation, and hand-move systems are the most popular type of sprinkler irrigation.

On-farm efficiency

The level of on-farm efficiency is demonstrated by a study made by the Maricopa-Wheeler Ridge Water District, Kern County, of an 11,495-acre area—the Central Wheeler Ridge Front Hydrologic Unit. Approximately 60 percent of this land is irrigated by sprinkler systems and the remainder by surface application. The water has an electrical conductivity (EC) of 0.4 mmho/cm and a leaching requirement of about 10 percent. The table shows the acreage and water needs of the various crops, as calculated by district personnel.

This unit's irrigation efficiency of 77 percent is considered quite good, particularly since its cropping pattern includes such crops as onions, carrots, and lettuce, which require water in excess of the ET to control salinity at the time of germination and to control crop quality. The data indicate that very little improvement can be made in the overall efficiency of this area. (Sprinkler systems are designed for 85 percent efficiency. Surface-applied water systems seldom can compare with this degree of efficiency.) Obviously, the cost of water ($25 to $30 per acre-foot), water shortages and the high cost of energy have already encouraged growers in this area to become efficient.

Crop and Evapotranspiration (ET) Study
Maricopa-Wheeler Ridge Water District

Crop	Net acreage*	ET per acre†	Total water requirement‡
	acres		acre-feet
Cotton	5.367	2.5	13.418
Grain	1.842	2.0	3.684
Sugar beets	1.084	2.7	2.927
Safflower	509	2.0	1.018
Melons	641	3.0	1.923
Almonds	471	2.1	989
Alfalfa	151	3.3	498
Onions	104	1.4	146
Carrots	320	1.4	448
Lettuce	118	2.0	236
Tomato	226	2.3	520
Total	10,833	–	25.807

*Net acreage is gross acreage less roads and ditches.
†From Department of Water Resources Bulletin No. 113.4
‡Total water requirement of crop = net acres × ET per acre
Notes: Additional water requirements for this area would be:

	acre-feet
10% leaching requirement	2.580
5% loss of water in the system	516

Irrigation efficiency for the District area would be:

	acre-feet
Estimated crop ET	25.807
Leaching requirement	2.580
Loss of water in system	516
Total water needed	28,903
Total applied water (District records)	37,406

$$\text{Irrigation efficiency} = \frac{28\,903}{37\,406} \times 10 = 77\%$$

A tail-water return system

Another example of improved efficiency is occurring in Kings County on a 2,400-acre ranch producing field crops in the west side of the San Joaquin Valley. These crops are surface irrigated. In the past, the grower did not have a return-flow system for tail water. This runoff was not wasted but was delivered to a neighboring grower. However, the cost of water and energy encouraged the grower to measure the runoff. He found a 35 percent loss of water through runoff in addition to normal field losses due to irrigation system inefficiencies. The extremely low on-farm efficiency was about 30 percent.

The installation of a tail-water return system will increase this on-farm efficiency to more than 65 percent, which is quite satisfactory. The ranch will be equipped with two tail-water drainage sumps and five drainage water pumps to recirculate the water into the various fields. The tail water is still of good quality and quite acceptable for crop use. Only a slight amount of salts will be added to the water in this operation. The cost of installing the tail-water return-flow system is estimated to be $35 per acre—a small investment in comparison to the savings.

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