Approximately 400,000 acres in the San Joaquin Valley are classified as drainage problem areas. Levels of soil salinity detrimental to crop yield exist in these areas because of saline high water tables. One water district serving 264,000 acres needing drainage estimated that their production loss caused by drainage problems was about $17 million in 1981.

The traditional way of solving these problems is to install a subsurface drainage system, which removes the excess subsurface water to some disposal facility. Unfortunately, no completely satisfactory method of disposal exists in the San Joaquin Valley. Current disposal methods include discharging drainage water into surface water channels and evaporation ponds. Recommended future plans call for construction of a valley-wide master drain to convey drainage water out of the valley.

Regardless of the disposal method (present or future), growers in problem areas need to reduce the volume of drainage water discharged by means of proper design and management of their irrigation systems. One aspect of management is scheduling of irrigations.

Irrigation scheduling for well-drained soils involves estimating an allowable soil moisture depletion and then irrigating when this depletion has occurred. Methods of monitoring soil moisture depletion include using neutron moisture meters or tensiometers to estimate soil moisture or using estimates of crop evapotranspiration, which are then related to soil moisture depletion. The assumptions behind these scheduling techniques are that all soil water used by the plant is stored in the root zone and that plant stress is primarily caused by soil moisture depletion.

A saline high water table can invalidate these assumptions for two reasons. First, groundwater moving upward into the root zone can contribute significant amounts of the water needed by the crop. A study by UC researchers W.W. Wallender, D.W. Grimes, D.W. Henderson, and L.K. Stromberg, conducted on the west side of the San Joaquin Valley, found brackish groundwater contributing 59 to 70 percent of the total seasonal evapotranspiration of cotton. The electrical conductivity of the groundwater was 6 dS/m (6 mmhos/cm, or about 3800 ppm) and depth to the water table ranged from about 1.7 meters (5 feet) to 2.7 meters (9 feet). Second, plant stress may also be caused by high levels of soil salinity. Soil water salinity just after an irrigation may already be high where saline high water tables exist, and subsequent soil moisture depletion may rapidly increase the concentration of the salts in the water to a level injurious to plants. Thus, to minimize any adverse effects of salinity, irrigations may need to be more frequent than under low salinity.

Traditional methods of irrigation scheduling do not account for these effects. A method that does, however, is basing irrigations on plant response to changes in both soil salinity and soil moisture, since studies have found these effects are additive. Plant stress can be determined by measuring the leaf water potential of leaves with a pressure chamber. The leaf is cut from a plant and placed inside the pressure chamber with the cut stem, exposed to the atmosphere, protruding through a gasket. The chamber is slowly pressurized until sap exudes from the stem. The pressure (expressed as a negative number) at which exudation occurs is assumed to be the leaf water potential.

Research by D.W. Grimes and H. Yamada has provided information on using the pressure chamber for scheduling irrigation of cotton in the San Joaquin Valley. They recommend irrigating when the pressure chamber readings are between 16 and 20 bars. Measurements should be made between noon and 3:00 p.m. on three to five leaves using the third or fourth fully developed leaf from the terminal. Measurements for scheduling purposes should not be made on cloudy days.

We used this technique to develop a scheduling program for a farm of 48 hectares (160 acres) in a saline high water table area. Maximum depth to the water table during the summer was about 1.22 meters (4 feet). The electrical conductivity of the drainage water was about 7 dS/m (about 4500 ppm), while that of the irrigation water was about 0.2 dS/m (about 130 ppm). The soil type mainly consisted of an Armona clay for the top 10 inches. The rest of the soil profile was highly stratified with lenses of sand, silt, or clay. Cotton was grown during the period of this project.

Near the surface, soil salinity levels ranged from 1 to 5 dS/m (740 to 3200 ppm), but with increasing depth (to 1 meter below the surface), salinity levels
Soil salinity (electrical conductivity of saturated extract) at project site increased from 1 to 5 dS/m near the surface to 10 to 12 dS/m at greater depths (1 dS/m = 640 ppm).
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Later than the wet spring of 1982 forced the grower to delay planting until May 1, a month later than the 1981 planting.

Significant differences in cumulative maximum evapotranspiration between 1981 and 1982 existed early in the season, but the difference in seasonal evapotranspiration between the two years was only about 8 percent of the total 1981 evapotranspiration (fig. 2). During the peak evapotranspiration period of July and August, daily rates were about the same in both years.

An evaluation of water content data of both years showed that the increase in irrigation interval resulted in greater soil moisture depletion. The average depletion in 1982 was about 94 mm (3.7 inches) whereas in 1981 it was about 71 mm (2.8 inches). Thus, even though differences in planting days and seasonal evapotranspiration occurred, soil moisture depletion was greater when the pressure chamber was used for irrigation scheduling.

We estimated the contribution of the shallow groundwater to the seasonal crop water use by comparing changes in the soil moisture in the root zone between irrigations with the total evapotranspiration for the same period. The difference between the two is considered the volume of water supplied by upward movement into the root zone. With an assumed root depth of 0.68 meter (27 inches) (based on measurement of the tap root), we estimated that the average contribution from groundwater was about 19 percent in 1981 and 25 percent in 1982. However, we believe that these differences are insignificant.

One aspect to be considered in irrigating under a saline high water table is that of adequate leaching to prevent salt accumulation in the root zone. We believe that pressure chamber measurements made four to six days after an irrigation can be used to detect any increase in the salinity level of the root zone. In 1982, soil moisture in the root zone was approximately the same four to six days after each irrigation in July and August; thus, any significant increases in pressure chamber readings throughout the summer would be due to increases in salinity (excluding any effects of day-to-day variation of climate). Measurements made four to six days after an irrigation showed no significant change in leaf water potential (see table). This would be expected for the short time during which we collected data, if no appreciable increase in soil salinity had occurred.

Since day-to-day variation of the climate, as well as the root zone environment, can affect leaf water potential, we compared pressure chamber readings with solar radiation, maximum daily temperature, average wind speed, vapor pressure between noon and 3:00 p.m., and soil water content. We found little correlation between pressure chamber readings and the climate data, but good correlation between leaf water potential and soil water content. Thus, any day-to-day climatic variation had a negligible effect, but soil moisture changes had a significant effect on leaf water potential.

We believe that the pressure chamber, coupled with the information developed by the other UC researchers, provides a practical means for scheduling irrigations in areas with a saline high water table. In this study, the irrigation interval was increased by about four days during the peak evapotranspiration period and the number of irrigations reduced by one. However, yield at this site was 1,076 kg per hectare (1.9 bales per acre) in 1981 and 1,281 kg per hectare (2.2 bales per acre) in 1982. In our opinion, this yield difference is in part due to the differences in irrigation scheduling.

The need to increase the intervals between irrigations at this site was contrary to what we had expected. Normally, intervals between irrigations under saline conditions should be smaller than those under nonsaline situations to minimize yield reductions. Since we were able to increase the interval, soil moisture rather than soil salinity may have been the controlling factor for scheduling irrigations at that location. Nevertheless, under these conditions, scheduling irrigations at this site, the influence of soil salinity could not have been as readily evaluated.

There is much interest in the feasibility of irrigating with subsurface drainage water. A number of projects are being conducted in California to address this matter. Their main objective is to look at the relationship between crop yield and irrigation water quality. This relationship, however, may depend not only on the water quality, but also on the irrigation schedule. Adjusting irrigation frequency according to measurements of leaf water potential could make a difference in the effects of a particular quality of water on crop yield.

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