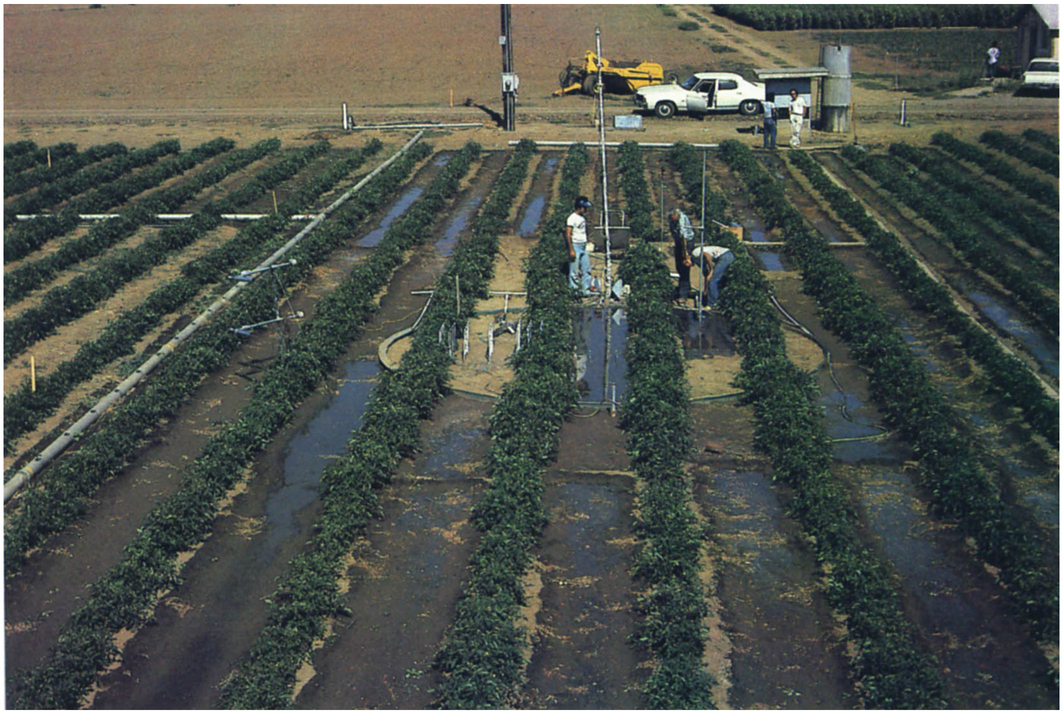

Precise measurement in lysimeters showed that evapotranspiration was essentially the same in furrow- and drip-irrigated tomatoes. Results in adjacent field plots were similar.

# Evapotranspiration losses of tomatoes under drip and furrow irrigation

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Drip irrigation is frequently cited as a technique that can drastically reduce the irrigation water requirements of the principal crops in California. Compared with sprinkler or furrow irrigation, the drip method can result in great water saving during the years trees or vines are becoming established (see article on drip irrigation of almond trees, *California Agriculture*, September-October 1982). However, the potential water saving brought about by drip-irrigating row crops is uncertain.

Water may be lost from an irrigated field through evaporation from either soil or plant surfaces (the latter process called transpiration), surface runoff, or deep percolation below the crop root zone. Under many circumstances, the losses from runoff and deep percolation can be recovered and reused on the farm or within the district or basin, but the losses by evapotranspiration are irrecoverable and are usually considered the net water requirements. Therefore, in developing strategies for water conservation in irrigation, one must first identify the nature of the water saving that could result from adopting such measures.

Drip irrigation of row crops can eliminate runoff and minimize deep percolation, when compared with furrow irrigation, resulting in minimal recoverable losses and high irrigation efficiency. In addition, it is generally assumed that the evaporation loss for the entire soil surface must average less under the localized pattern of water application by drip irrigation than under surface methods, where major portions of the soil surface become wet. This assumption needs to be validated however, especially for row crops, which are irrigated frequently under the drip method, but normally quite infrequently under surface methods.

Current technology does not allow for independent measurement of the evaporation and transpiration components of evapotranspiration, so it is very difficult to evaluate the potential reduction in evaporation from soil brought about by changing from furrow to drip irrigation. Nevertheless, this evaluation is critical, because efforts to conserve water in California agriculture must focus on reducing net water consumption without decreasing crop yield.

We conducted an experiment during the 1979 and 1980 growing seasons comparing evapotranspiration of processing tomatoes under drip and furrow irrigation. We used drip- and furrow-irrigated lysimeters (both 20 feet in diameter) at the University of California, Davis, which allow simultaneous measurement of evapotranspiration to within 0.001 inch under two irrigation methods. We also conducted a replicated trial in an adjacent field to evaluate crop yields and evapotranspiration under the same two irrigation methods.

The tomato crop planted at a standard wide-row spacing was selected for the initial study, both because of the crop's economic importance in California and because any reduction in evaporation would be maximized at that spacing as compared with that in narrow-planted crops.

The two lysimeters and a surrounding area (approximately two acres) were planted to the UC 82 tomato variety in mid-May 1979 and late April 1980. Before thinning, the field was sprinkler-irrigated to ensure plant establishment. A portion of the field was devoted to a study of yield and evapotranspiration with three treatments and four replicates. In addition to the drip- and furrow-irrigation treatments (managed similarly to those in both lysimeters), another treatment of drip irrigation with a plastic mulch to minimize soil evaporation was imposed. The layer of black plastic was covered with about 1 inch of soil so that the plastic would not drastically modify the environment around the plants. Individual plot size was 12 rows, 60 inches apart and 50 feet long. Plant spacing within the row averaged 9 inches after thinning.

The drip-irrigation system consisted of microtube emitters with an inside diameter of 0.035 inch placed every 18 inches on the laterals, each delivering 0.7 gallon per hour. Throughout the 1979 season, several evaluations indicated that the emission uniformity of the system was between 93 and 95 percent. Irrigation frequency was approximately once every 10 days under furrow and daily under drip irrigation.

Each plot was instrumented with four neutron-meter access tubes to a depth of 10 feet, and water applied was measured with water meters. Additionally, flow was measured volumetrically at the gated-pipe outlets in the furrow-irrigated plots. A water balance procedure was used in the field plots to estimate evapotranspiration losses. Detailed micrometeorological measurements were made in the lysimeters to characterize the microclimate of the drip- and furrow-irrigated tomatoes.

The tomatoes were harvested in early October 1979 and early September 1980. A length of 30 feet was harvested from the two center rows of each plot, and tomatoes were weighed after being separated into ripe and green. The entire crop in both lysimeters (314 square feet each) was harvested for yield records.

## Results

Daily evapotranspiration values of each lysimeter were totaled for the entire season, including the periods before the different irrigation treatments were imposed. The results for both years (table 1) show conclusively that, under the row spacing and irrigation scheduling of this experiment, evapotranspiration values for the furrow- and drip-irrigated lysimeters were essentially equal. Immediately after a furrow irrigation, evapotranspiration in the furrow-irrigated lysimeter exceeded that in the drip-irrigated one; however, three to four days later, this trend reversed and remained so for the rest of the cycle (fig. 1). The differences between irrigation methods compensated for each other, resulting in very similar evapotranspiration amounts for the two methods, both seasonally and for the intervals of 10 days or so between furrow irrigations.

In the 1980 season, evapotranspiration in the furrow-irrigated lysimeter averaged 30 percent higher for the first day or two after an irrigation, but, from the fifth day on, it was about 10 percent higher in the drip-irrigated lysimeter (fig. 2). Even though the strip of wet surface soil under the canopy of the drip-irrigated tomatoes was no more than 1 foot wide and was fully shaded, micrometeorological measurements near the soil surface indicated that the dry areas around the localized wet strip contributed significant heat, which substantially enhanced evaporation from the narrow wetted zone.

The estimated evapotranspiration for the field plots was within 8 percent of the measured values in the lysimeters. In 1979, evapotranspiration was 7 percent lower in the drip plot with plastic mulch than in the drip and furrow plots. In 1980, all three seasonal evapotranspiration values for the replicated plot study were essentially equal.

Drip irrigation has been shown to be capable of increasing yields beyond those achieved by surface irrigation methods under some conditions. This was apparently the case in the 1979 field study, when the drip-irrigated plots yielded 19 percent more ripe fruit than furrow-irrigated plots (table 2). Problems in setting up the furrow irrigation system caused the first irrigation to be delayed 10 days beyond the onset of drip irrigation. This delay reduced early crop growth in the furrow treatment and decreased yield. The effects were variable among replicated plots: two furrow-irrigated plots had yields similar to those of the drip plots and the two others had lower yields. The yield differences encountered in 1979 were not statistically significant at the 5 percent level because of the plot-to-plot variability.

**TABLE 1. Seasonal evapotranspiration of processing tomatoes in lysimeters**

| Year | Drip-irrigated | Furrow-irrigated |
|---|---|---|
| | *inches* | *inches* |
| 1979 (5/15-10/8) | 23.9 | 24.2 |
| 1980 (4/23-9/10) | 22.3 | 22.0 |

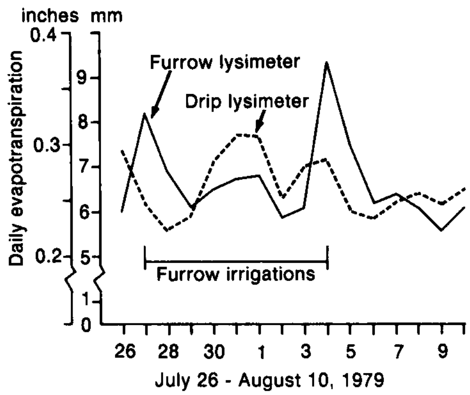


Fig. 1. Evapotranspiration in furrow lysimeter was higher right after irrigation, then dropped below ET in drip plot. (Plant cover: 42% on July 26; 57% by August 10.)

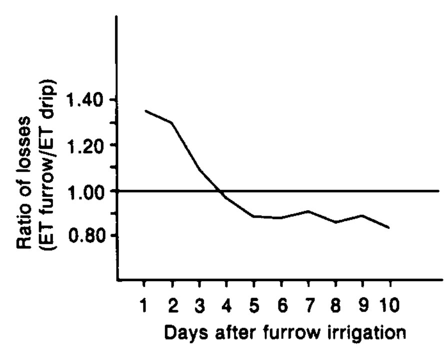


Fig. 2. By day 5, average seasonal evapotranspiration in furrow lysimeter was 10 percent below that in drip lysimeter during 1980. (Plant cover: average of 35% in furrow; 45% in drip.)

**TABLE 2. Marketable yield of processing tomatoes under furrow and drip irrigation**

| Treatment | Yield* 1979 | Yield* 1980 |
|---|---|---|
| | ---- *tons/acre* ---- | |
| Furrow irrigation | 38.4 a | 26.1 b |
| Drip irrigation | 45.7 a | 29.5 b |
| Drip with plastic mulch | 44.1 a | 37.4 c |

* Values not followed by the same letter are significantly different at the 5% level.

In 1980, processing tomato commercial yields were low in the area, perhaps reflecting cool late-spring conditions. As a result, yields for all irrigation treatments were well below those obtained in 1979. Conventional drip-irrigated plots yielded about 13 percent more than the furrow-irrigated ones. The mulched drip plots significantly outyielded the other two treatments, showing greater vegetative growth, particularly early in the season. Apparently the thermal effects of the plastic mulch enhanced canopy growth during the cooler-than-normal May weather, increasing final yields in this treatment.

The results show that, for row crops, the possibility of reducing evaporation losses from the soil by using drip irrigation is quite small, although improvements in buried drip systems that do not wet the soil surface may offer additional savings. The irrigation frequency of the furrow treatment (every 10 days) represents current practice. Soils that require shorter intervals between irrigations may have lower evaporation losses under drip irrigation than under other methods. At the same time, crops in such soils would probably show the greatest response to high-frequency drip irrigation. Also, if those soils were frequently irrigated by surface methods, they would have large recoverable losses and would be likely candidates for drip irrigation.

For most agricultural soils, however, the reduction in evaporation losses alone by changing to drip does not justify the economic investment necessary, because the yield achievable with drip irrigation will not be substantially higher than yield under a well-managed surface irrigation system. Under some conditions, it may be desirable to switch to drip irrigation, but the decision should be based solely on economics and not on the potential reduction in irrecoverable water losses that localized irrigation could achieve in processing tomatoes.

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