Drip irrigation saves money in young almond orchards

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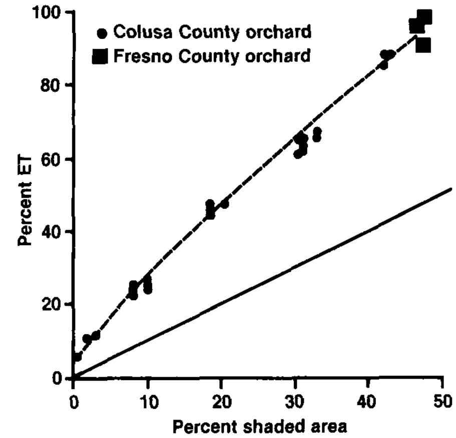
Greatest benefit is in orchard's first five years. Grower may then want to convert to sprinklers.



Relation between percent area shaded by young almond trees in July and percent ET.

Two processes are combined in water use by an orchard—direct evaporation from the soil surface and tree transpiration. Together, the processes are referred to as evapotranspiration (ET), or orchard water requirements. Many studies have been conducted in California to determine the ET of various orchard crops under conventional irrigation techniques. However, this information is not directly applicable to drip-irrigated orchards, because drip irrigation wets only a fraction of the soil volume.

The potential decrease in ET associated with the use of drip irrigation in orchards has been attributed to a reduction in evaporation losses from the soil surface. Thus, the ET reductions in drip-irrigated orchards, when compared with ET of orchards irrigated by other methods, must be a function of tree size, with the highest savings presumably occurring in orchards in the early stages of growth. In drip-irrigated young orchards, water can be restricted to the tree root zone as opposed to wetting most of the soil with conventional irrigation techniques.

To evaluate the potential reduction in orchard water requirements, it is necessary to measure the ET of drip-irrigated trees of various ages, relating development of the tree canopy to the ET rates as young orchards grow. One experiment conducted in San Diego County (*California Agriculture*, May 1978) provides five years of data on water applied to one- to five-year-old avocado trees under sprinkler and drip irrigation.

Information did not exist, however, on ET requirements of deciduous orchards under drip irrigation from the first year to full canopy growth. Therefore, we conducted a four-year ET experiment in a 40-acre orchard of drip-irrigated young almond trees at the Nickels Soils Laboratory, near Arbuckle, Colusa County.

Orchard experiment

The trees used when the experiment started in 1978 were three years old and were irrigated by two micro-tube-emitters per tree. The soil, an Arbuckle gravelly sandy loam over a gravelly clay substratum, has low water storage capacity.

To improve soil physical conditions before planting, a volume of about 6 by 6 by 5 feet for each tree had been excavated, and the soil mixed as it was being returned to the pit. Root development in the excavated zone was enhanced but also largely restricted to that zone. This fact simplified our soil-water monitoring efforts, because we were able to use soil-water balance techniques to evaluate ET losses. A major complication in estimating ET of young orchards from soil-water measurements usually results from uncertainties in determining the extent of the tree root zone.

In 1978, three adjacent trees of the variety Nonpareil were selected; 36 tensiometers and 8 neutron access tubes were installed per tree at depths of 1 to 5 feet and at various distances away from the two emitters. In 1979 one-year-old and three-year-old Nonpareil trees from successive plantings in the orchard were incorporated into the experiment, and three trees per age class were also selected, replicated three times.

During 1979, 1980, and 1981, measurements were then taken on trees that were one to six years old. One-year-old trees had only one emitter: two- and three-year-old trees had two emitters about 18 inches away from the trunk. Two new emitters were installed in the fourth season 3 feet away from the first ones. For the trees instrumented in 1979, neutron access tubes and tensiometers were placed only in the vicinity of the emitter and outside the wetted zones.

Our measurements on trees heavily instrumented in 1978 indicated that the highest rates of soil-water depletion occur a few inches away from the emission point and that they decline with increasing distance from the emitter, becoming negligible outside the zone wetted by the emitters. This pattern results both from the poor physical condition of the undisturbed soil and from the lack of available water. Topographical conditions and the soil intake rate characteristics caused much of the seasonal rainfall (around 16 inches) to run off the experimental area. Soil-water measurements with the neutron probe indicated negligible root activity outside the areas influenced by emitter flow.

Even if the tree root system is restricted to the wetted zones, however, there are still two major limitations to using soil-water balance procedures to determine ET. The first is uncertainty in estimating the deep percolation component of the water balance. We chose to reduce soil-water content of the bottom of the root zone to the point that deep percolation could be ignored. This was achieved by supplying the tree in the spring with less than its required amount of water, depleting soil water in the deeper layers of the root zone. This restricted the measurement periods from early June onwards but improved the accuracy of our ET estimates for such periods.

The second limitation in computing the water used by the trees from soil-water depletion is that, under drip irrigation, both water availability and root density vary with depth and distance from the emitter. It is then very difficult to integrate the observed soil-water changes over the whole tree root zone. By frequent monitoring of soil-water content and tension (every one to two days) and by adjusting the volume of applied water, we were able to identify periods (from one to nine days) when no measurable changes occurred in soil-water content. For those periods, we can then assume that the water applied was equal to the ET of the tree.

Applied water was measured by multiplying emitter flows times the hours of operation as well as by placing water meters at the inlet of drip laterals going to the experimental trees. We found that the most precise method was to measure volumetrically the output of one emitter identical to those used for the experimental trees and located a few feet away from them. All of the emitter flow rates were checked once to twice a week throughout the experimental periods.

Water requirements

The seasonal records of soil-water content and soil-water tension were screened for periods when content changes near the emitters were small enough to be considered negligible. For those steady-state periods, assuming that deep percolation was also not significant enough to affect the water balance (as shown by the low water content and hydraulic conductivity at the 4-foot depth), the water applied would then be equal to the ET. Data for those periods were then related to potential evaporation during the same periods as measured with a standard U. S. Weather Bureau evaporation pan on bare soil outside the orchard. The evaporation measurements were corrected to estimate the ET of a mature deciduous orchard using information developed at U.C., Davis, by W. O. Pruitt.

The graph presents the ET of the experimental trees expressed as percentages of the estimated ET of a mature orchard in relation to the area shaded by the trees. The relation is nearly linear but departs markedly from the one-to-one relationship. Young trees that shaded less than 10 percent of their area at midsummer had more than 20 percent of the estimated ET of a mature orchard. By the time the six-year-old trees shaded around 42 percent, their ET was between 85 and 88 percent of the ET of a mature orchard.

The ET of any crop is directly related to the available energy and to the aerodynamic conditions that prevail in the area. For young trees irrigated by drip, where the soil is partially wetted and the tree canopy shades only a fraction of the total area, horizontal energy transfer (advection) from the dry areas surrounding the trees must increase the transpiration rate above that of canopies where the whole soil surface is frequently wetted by rain or irrigation. This explains why the ET of drip-irrigated young trees is higher than would be expected based on their canopy sizes.

To compute seasonal ET of the experimental trees, we assumed that the relation between tree ET and mature orchard ET during the steady-state periods applies throughout the growing season. Table 1 presents the calculated seasonal ET of young almond trees. The water savings potential of drip irrigation is maximum the first two years of the orchard, then declines as trees grow and probably becomes very limited after the sixth year.

In comparison with an irrigation method that would cover all the soil surface (such as a full-cover, permanent sprinkler system), the accumulated water savings over the first six years of a drip-irrigated orchard would approximate 11.5 acre-feet per acre. On the other hand, some sort of localized irrigation is not uncommon in surface-irrigated young orchards, such as use of only two furrows, one on each side of the tree row. Under those conditions, water savings brought about by changing to drip would be significantly less.

Growers planting new orchards should carefully consider the potential energy savings of using drip irrigation instead of a full-cover sprinkler system in the trees' early years. Such savings could be between $50 and $80 per acre for the first year only, depending on the source of water and the type of sprinkler system. It may be possible to use drip irrigation the first five years of an orchard and then, using the same underground pipe network, convert to sprinkler, if desired.

To provide guidelines for good management of drip systems, table 2 presents the water requirements of young almond trees spaced 24 by 24 feet from year one to six. We assumed an irrigation efficiency of 85 percent, which is characteristic of well-managed drip irrigation systems, except for the first year, where we assumed a 60 percent efficiency. In the first year it is uncertain where the tree root zone is located, and a greater soil volume must be wetted to supply adequate water to the developing root system at all times.

Our results have been partially tested in another experimental orchard in Fresno County, but these results are only preliminary, since they were all obtained in a single location. Until more research is conducted to evaluate ET of young deciduous orchards under the various irrigation methods, it would be advisable to monitor soil moisture as an independent check of the normal water requirements of drip-irrigated trees.

In applying this approach to a specific orchard, one should use locally available climatic data to schedule irrigations. In selecting percent ET from the graph, it is necessary to determine or estimate percent cover or shaded area rather than assuming this information from tree age given in table 1. Trees of similar age are not always equal in size or shaded area.

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TABLE 1. Seasonal evapotranspiration of drip-irrigated almond trees

Orchard age	ET	Range of cover
years	*inches*	%
1	2.0	<1
2	4.5	3-4
3	10.3	8-10
4	18.0	18-20
5	25.3	31-34
6	34.1	40-44
Mature	38.8	>70

TABLE 2. Gross water requirements for drip-irrigated almond trees spaced 24 by 24 feet*

Tree age	Gallons per tree per day							
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1	2	3	6	7	8	7	5	3
2	3	6	7	10	12	10	9	6
3	7	15	16	23	27	24	20	7
4	13	21	33	43	48	41	32	13
5	17	36	40	59	67	58	45	24
6	23	49	54	79	90	78	60	24
Mature	24	54	61	95	102	89	65	35

*Based on maximum evapotranspiration of 0.25 inch in July.