Drip irrigation technology imported by UC Farm Advisor Don Gustafson made it possible to convert many acres in the San Diego foothills to avocados. "Drip" has since spread to over 300,000 acres in California. (D. Gustafson photo)

Economic implications of drip irrigation

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The profit potential is greatest on lower quality land

Drip irrigation technology from Israel was introduced into California orchards in 1969. Don Gustafson, Farm Advisor in San Diego County, who initially experimented with drip irrigation of avocados, found that orchards could be planted on slopes of up to 60 degrees and that water savings of 30 to 50 percent could be made. As a result, extensive areas in the San Diego foothills were converted to growing avocados, enlarging the agricultural land base in the area. Bernarr Hall, another Farm Advisor in San Diego, combined the use of drip irrigation with plastic mulching to grow strawberries on marginal land.

By 1974, there were 40,000 drip-irrigated acres in California and, by 1980, 300,000 acres. The technology is used mostly for tree crops (avocados, nuts, grapes, citrus, and deciduous fruits) and high-value row crops (strawberries, fresh-market tomatoes, and melons); some attempts have been made to use it in cotton production.

The adoption of drip irrigation, however, has not been geographically uniform in the state. It seems to be more prevalent in regions with marginal-quality lands and high water costs, and it has been more readily accepted in southern than in northern California.

Advantages and disadvantages

These uneven adoption patterns prompted our study of the economic implications of drip irrigation. To analyze how this technology has spread in California, we developed a conceptual framework based on the premise that drip irrigation increases the value of land as a production input and that the magnitude of this increase varies across lands of different qualities.

Land can be considered a medium for the interaction between variable inputs (such as seeds, fertilizer, and water), resulting in the production of a crop. One important dimension of land quality is the capacity to hold the inputs that are applied and to ensure their use by the plant. In the case of water, this quality is called water-holding capacity. Under traditional irrigation technologies (furrow or flood), large amounts of water are applied in a short period of time. On land with low water-holding capacity, such as sandy soil or an uneven slope, a significant amount of the applied water is not used by the crop because of percolation beyond the root zone or runoff of water from the land.

Modern low-volume irrigation technologies, in particular, drip irrigation apply smaller amounts of water per unit of time than do traditional methods. Modern irrigation methods can thereby reduce runoff or excess percolation, or both, increasing the portion of applied water available to the crop. These methods can thus improve the effectiveness of land as a medium for crop production. This relative advantage of drip irrigation and other modern methods over traditional methods is greater for lower quality land. We developed an economic model for the analysis of crop production in a region with different land qualities and two irrigation technologies — traditional and modern.

Assuming that farmers want to earn as much money as possible, that profits per acre are not related to farm size for the range of farms considered here, and that modern technology costs more per acre, this model indicates that:

□ Under both technologies, better land produces greater yields per acre.

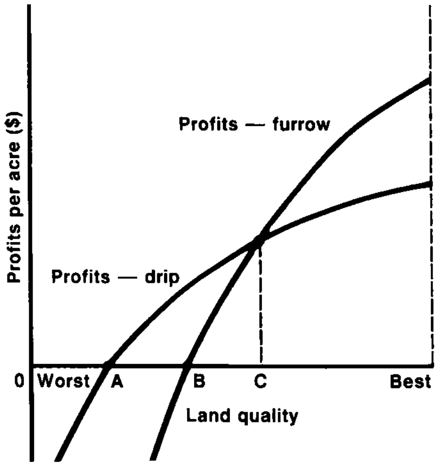

Fig. 1 The most profitable irrigation method depends on land quality. Adopting drip irrigation would make poor-quality land (A to B) profitable; better-quality land (B to C) could be converted to drip irrigation; higher quality land would continue with traditional methods.

On better land, more water is used per acre when an increase in irrigation has a relatively strong impact on yield, whereas less water is applied per acre when the added yield resulting from an increase in irrigation is relatively small.

□ Yields per acre are greater under the modern technology than under the traditional technology. Experiments in Israel have shown increases in production, and work on bell peppers in San Diego County had similar results.

□ Drip irrigation does not necessarily reduce water consumption per acre. Since this method increases water effectiveness, using more water may be justified if it will substantially increase yield. Only when the traditional system obtains most of the crop's yield potential will drip irrigation use less water per acre. The water-use efficiency under drip irrigation will always be better.

□ The modern technology should be adopted and used first on lower quality land, where the profit potential is greater. Later, if the cost of the modern technology declines, its adoption on higher quality land may be profitable also.

High capital expenditures are associated with the use of low-volume methods, such as drip irrigation. The disadvantage of higher costs for the new technology, as compared with costs of traditional systems, would be greater on the better quality land and less on poorer quality land. Terracing a steep slope to flood-irrigate would be too expensive. The profit a farmer can earn with each irrigation system depends on land quality. Since the value of land in its agricultural use is directly related to profitability, its price will depend on the most profitable irrigation method (fig. 1) as well as its quality.

Before introduction of the new technology, it would be profitable to flood-irrigate all land qualities greater than B in figure 1. With the adoption of drip irrigation, more land qualities would become profitable for farming; below a certain land quality, a farmer should change from traditional to drip irrigation methods. Land qualities between A and B would be added to the agricultural land base; those between B and C would be converted from traditional to drip methods; and those greater than C would continue with former methods.

Profitability for each irrigation system obviously changes when economic factors vary. Farmers depending on groundwater are affected by escalating energy prices and a dropping water table. Figure 2 shows the conditions under which a particular farmer would be expected to switch irrigation technologies. Under some circumstances, neither method would be profitable (shaded area). If the farmer had a shallow well (less than 200 feet), energy prices would have to go above 50 cents per foot of lift before a technology change would be recommended. With wells deeper than 500 feet, any energy price greater than 20 cents would prompt a change from flood irrigation to a drip system.

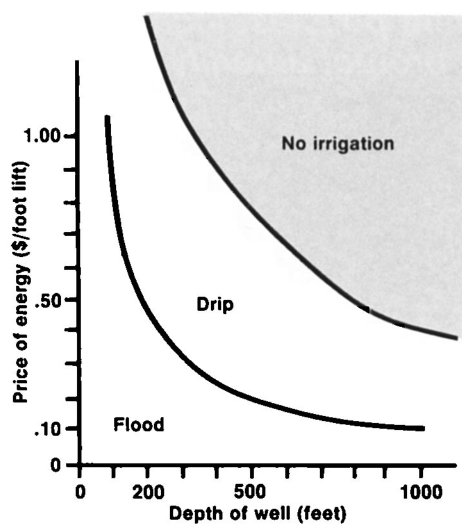

Fig. 2 Rising energy prices and dropping water tables might justify a switch to drip irrigation, but under some circumstances, neither drip nor other types of irrigation would be profitable (shaded area).

Although the land-augmenting characteristic is the most important feature, drip irrigation also reduces preharvest labor, limits weed growth, promotes early and even ripening, and allows irrigation during cultivation and harvesting. All of these advantages have to be considered in the economic analysis for selection of the proper irrigation technique at each location.

Industrywide implications

The introduction of drip irrigation also has implications for members of an industry (or region) as a whole. Farmers may face declining prices for their product as their aggregate output increases. This would be particularly true for growers of specialty crops. They may also face rising water prices as the amount used by the industry increases. If these conditions are true, then the adoption of drip irrigation may affect output or water prices. These price changes, in turn, could have secondary effects on the tendency to adopt drip irrigation.

We analyzed the outcome in these cases and concluded:

The adoption of drip irrigation could increase total production and reduce product price. It would increase total water use and water price when an increase in irrigation had a strong yield effect but might reduce water price and total water use when an increase in application had a relatively small impact on yield.

The introduction of drip irrigation, by lowering crop price and/or raising water costs, would reduce the land rent and value of high-quality land in the region. If owners of the better land had strong political influence and considered drip irrigation to be against their interests, they might object to research and development efforts that would lead to the adoption of such technologies. Therefore, these technologies would be likely to be developed in regions with predominantly marginal land.

Although it is most likely that the introduction of drip irrigation would increase the potential amount of land available for a crop, the long-run effects due to changing prices might, in some-cases, reduce the amount of land used to grow that crop.

California farmers face many difficult decisions in the next few years as a result of population pressures, uncertain water availability, unstable crop prices, environmental constraints, and increases in the costs of energy and labor. This study has indicated several variables affecting profitability. Government policies supporting the adoption of new technology may directly or indirectly change these parameters. Among the new technologies, drip irrigation will have an important effect on California's agriculture in the coming years.

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