COPING WITH LOW WATER YEARS: WHAT STRATEGIES CAN YOU USE?

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ABSTRACT

The evapotranspiration (ET) of fully-irrigated alfalfa ranged from 31.9 inches in northern California to 65.2 inches in desert areas of southern California. During low water years, however, ET may be reduced by limited amounts of applied water. Strategies for coping with limited water supplies include reducing the irrigated acreage, fully-irrigating the earlier harvest periods until the water supply is used up and then no irrigation thereafter, and deficit irrigate the field for the entire season by reducing the water applications between harvests. An evaluation showed little differences in net returns between the first two strategies. Neither option was profitable for a crop price of $100 per ton because production costs were always higher than net returns; positive net returns occurred for a crop price of $200 per tons for water amounts sufficient to satisfy an ET demand of at least 40 to 60 percent of the ET of fully-irrigated alfalfa. The third option could not be adequately evaluated because of the lack of cost data under deficit irrigation. Both surface runoff and deep percolation should be reduced or eliminated to stretch the limited water supply.

Key Words: alfalfa, irrigation, limited water supply, evapotranspiration

INTRODUCTION

Alfalfa is California's single largest agricultural water user due to the amount grown, typically about 1 million acres, and its long growing season. Seasonal alfalfa water applications generally range from 4,000,000 to 5,500,000 acre-feet.

The crop water use or evapotranspiration (ET) is evaporation of water through leaves of the water uptaken by the plant and direct evaporation from the soil. Seasonal alfalfa yield is directly related to seasonal ET. Maximum yield occurs for maximum ET conditions, which depend on the climatic characteristics of a given area. Reduced yields occur for ET amounts smaller than maximum ET. ET is reduced by insufficient soil moisture.

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Drought conditions can limit water supplies to levels smaller than needed for maximum yield. Several strategies are available for alfalfa growers to cope with a reduced water supply, but the bottom line is that yields will be reduced compared to normal water supply conditions.

PROCEDURES

During the past five years, alfalfa ET and yield was measured in commercial fields in California at sites located in the Imperial Valley, southern part of the San Joaquin Valley, Sacramento Valley, Scott Valley (near Yreka), and Tulelake (south of Klamath Falls, OR). These data provided a basis for evaluating strategies for coping with drought conditions.

RESULTS

Evapotranspiration.

Daily evapotranspiration of alfalfa was small, generally between 0.05 and 0.1 inches per day, at the start of the crop growing season, the time of which varied depending on climate characteristics, increased with time of year to maximum values between 0.3 and 0.4 inches per day in June/July, and then decreased to small values at the end of the crop season (Figure 1). For each harvest cycle, small ET values occurred just after cutting, and then increased rapidly to maximum values after the first irrigation between harvests. Seasonal evapotranspiration ranged from 31.9 inches (Scott Valley 2008) to 65.2 inches (Imperial Valley 2008) (Table 1).

Table 1. Seasonal ET of the fully-irrigated alfalfa for the experimental sites.

Site	**Year**	**Seasonal ET (inches)**
Imperial Valley	2007	57.4
	2008	65.2
San Joaquin Valley	2007	56.6
	2008	59.8
Sacramento Valley	2005	50.5
	2006	54.4
	2007	55.0
	2008	50.3
Scott Valley	2007	38.9
	2008	31.9
Tulelake	2007	39.9
	2008	37.9

Yield – ET Relationships.

Cumulative yield of the fully-irrigated alfalfa increased linearly with cumulative ET during the crop season at all sites except for the Imperial Valley (Figure 2). The slopes and y-intercepts of these relationships were statistically similar for all sites.

Strategies for Irrigating Alfalfa with Limited Water Supplies.

Strategies for coping with limited water supplies include:

Strategy 1. Reduce the irrigated acres

- ♦ Fully irrigate the reduced acres for the crop season to obtain maximum yield over the reduced acreage.
- ♦ The amount of acreage reduction depends on the amount of available irrigation water.
- ♦ No irrigation occurs on the remaining acres, which will result in a yield loss on those acres
- ♦ The critical irrigation is the first irrigation after cutting.

Strategy 2. Fully irrigate earlier harvests; no irrigation for the remaining harvests

- ♦ Fully irrigate the entire field staring with the first harvest period until the water supply is used up.
- ♦ No irrigation will be occur for the rest of the crop season, which will result in a yield loss.
- ♦ The number of earlier harvests that can be fully irrigated will depend on the amount of available irrigation water.
- ♦ This strategy will maintain the high yields of the early harvests and will result in no irrigation during the later part of the crop season during which yields and quality normally are smaller compared to the earlier harvests.
- ♦ The critical irrigation is the first irrigation after a cutting

Strategy 3. Deficit irrigate the entire field during the crop season.

- ♦ Irrigate the entire field during the crop season with a reduced amount of irrigation water applied per harvest period.
- ♦ Approaches for reducing the irrigation water per harvest period include applying smaller water applications per irrigation and/or reducing the number of irrigations per harvest period. The first approach is appropriate for sprinkle irrigation, but not for flood irrigation. The second approach can be used by both sprinkle and flood irrigators.
- ♦ Yield loss will occur over the entire field, but the amount of yield loss will depend on the reduction in applied water and the relationship between alfalfa yield and ET under deficit irrigation.

Which Option is the Best?

The best strategy is the one that provide the largest net returns for the irrigator, which will depend on the revenue reduction due to reduced yield and the production costs of a particular strategy. For Strategy 1, maximum yield per acre per harvest of the irrigated part of the field will occur, but little or no yield will occur for the non-irrigated part of the field. However, yield of the first harvest may be similar for both irrigated and non-irrigated parts of the field, depending on the amount of stored soil moisture from winter/spring rainfall. Yields of the Strategy 2 will be maximum for the earlier harvests, but yields of the no-irrigation period may be uneconomical to harvest. Strategy 3 will result in reduced yield per acre per harvest for all harvests except possibly for the first harvest depending on soil moisture from winter/spring rainfall.

Variable production costs include irrigation costs and harvest costs. Variable production costs per acre per harvest will be the same for Strategy 1 as for a fully irrigated field, but because part of the field will not be irrigated, the field-wide production costs will be smaller than those normally incurred. Production costs per acre per harvest of Strategy 2 will be the same as those of a fully-irrigated field for the earlier harvests that are fully-irrigated, but no production costs will occur during the no-irrigation period. Production costs may be reduced for Strategy 3 because of smaller yields per acre per harvest, but the amount of reduction is difficult to determine because the entire field must be harvested. However, irrigation and harvest energy costs per acre should be smaller than those of a fully-irrigated field. It should be noted that the fixed costs such as equipment, buildings, land, insurance, taxes, etc. will not change due to a particular strategy. Also, fertilizer and pest control costs may not change since these costs generally occur early in the crop season.

The relationships shown in Figure 2 were used to evaluate the net returns of the first two strategies for several locations in California. The effect of Strategy 3 was not evaluated because of unknown production costs and the lack of reliable data on the effect of deficit irrigation on yield under commercial field conditions. Production costs data at "http://alfalfa.ucdavis.edu/+producing/index.aspx?/cat=Economics and Marketing" were used for these evaluations. The evaluations were conducted for crop prices of $100 per ton and $200 per ton. Total costs included the production costs, cash overhead costs (taxes, insurance, etc.) and noncash overhead costs (capital recovery costs of land, buildings, equipment, etc.) as defined the cost analysis found in the website.

Little difference in net returns between Strategies 1 and 2 were found. However, in some cases, where the amount of available water could only supply 50% or less of the fully-irrigated ET, the Strategy 1 was slightly more profitable. At $100 per ton, both strategies resulted in negative net returns because production costs were higher than net returns for this crop price. At $200 per ton, positive net returns generally occurred for water supplies that could meet at least 60% of the fully-irrigated ET, although several sites showed positive returns for water supplies providing at least 40% of the fully-irrigated ET. One advantage of the Strategy 2 is that it better guarantees using all of allocated water by applying the water during the earlier part of the crop season. Strategy 1 runs the risk of additional water reductions later in the crop season.

Yield of Strategy 3 will be smaller than the maximum yield for each harvest, except possibly for the first harvest which may not be reduced very much depending on the amount of stored soil moisture from winter/spring rainfall or snowmelt. Numerous studies have shown that yield is linearly related to ET for deficit-irrigation conditions, but these relationships are site-specific. Because of the yield-ET behavior, a 50% reduction in ET generally will decrease yield by 50%.

Both irrigation and harvest costs will decrease for this option, but uncertainty exists in the amount of reduction of costs for a given amount of applied water. One consideration is that for small amounts of applied water per harvest, yields under Strategy 3 may be uneconomical to harvest. A threshold yield value of 0.5 tons per acre generally is considered to be uneconomical.

Improved Irrigation Water Management.

Flood Irrigation

Surface runoff generally is the main loss with flood irrigation. Surface runoff occurs due to the large amount of water ponded on the soil surface during irrigation. After the irrigation water is terminated or cutoff, the ponded water continues to flow down the field. If the cutoff time (time that the application of irrigation water ends) is large, excessive runoff will occur.

Surface runoff can be greatly reduced by cutting off the irrigation water when the water reaches 80 to 90 percent of the field length. An evaluation of a flood irrigation system, showed that surface runoff was reduced from 2.8 inches of water to 0.5 inches by reducing the cutoff time from 800 minutes to 600 minutes for a flood system that required 650 minutes for the water to reach the end of the field (figure 3).

Recovering and reusing the surface runoff should also be considered. This involves installing a tailwater ditch and pond at the end of the field, collecting the runoff in the pond, and then pumping the tailwater back to the head of the field. The pump tailwater should be used to irrigated border checks not be irrigated by the main irrigation water supply. Another approach is to collect the tailwater in a pond and then use the water to irrigate another field.

Sprinkle Irrigation

Surface runoff generally is not a problem with sprinkle irrigation. Thus, the sprinkle irrigation system must be managed to reduce deep percolation. This involves reducing the irrigation set time such that the amount of applied water reflects the amount of soil moisture depletion between irrigations.

CONCLUSION

Strategies for irrigating alfalfa with limited water supplies include reducing the fully-irrigated acres to reflect the reduced water supply (Strategy 1); fully-irrigating the earlier harvest periods as long as possible and then terminating irrigation for the remainder of the crop season (Strategy 2); and deficit irrigating the entire field for the crop season by applying less water between harvests (Strategy 3). Data on yield-ET relationships for fully-irrigated alfalfa developed at various locations in California were used to evaluate the economics of the first two strategies. Economics of Strategy 3 could not be completely determined because of the lack of data on costs under deficit irrigation conditions. The evaluation showed little differences in net returns between the first two strategies.

Stretching a limited water supply requires efficiently using the water by reducing or eliminating surface runoff and reducing deep percolation. Surface runoff can be decreased by smaller irrigation water cutoff times and using tailwater recovery systems. Deep percolation can be reduced by decreasing the irrigation set time.

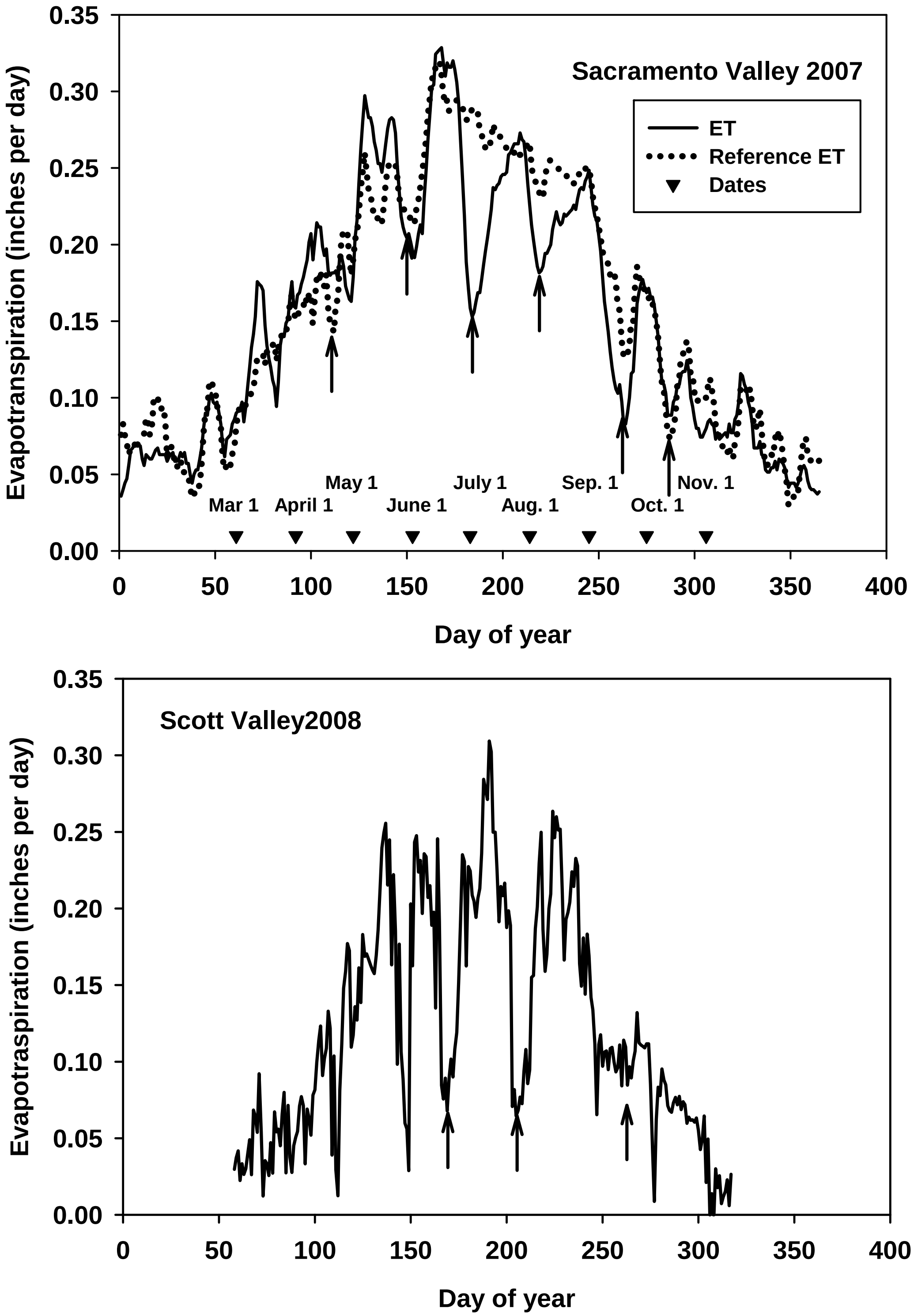


Figure 1. Evapotranspiration of alfalfa for the Sacramento Valley (2007) and Scott Valley (2008). The reference ET is that obtained from the California Irrigation Management Information System. The arrows show the harvest times.

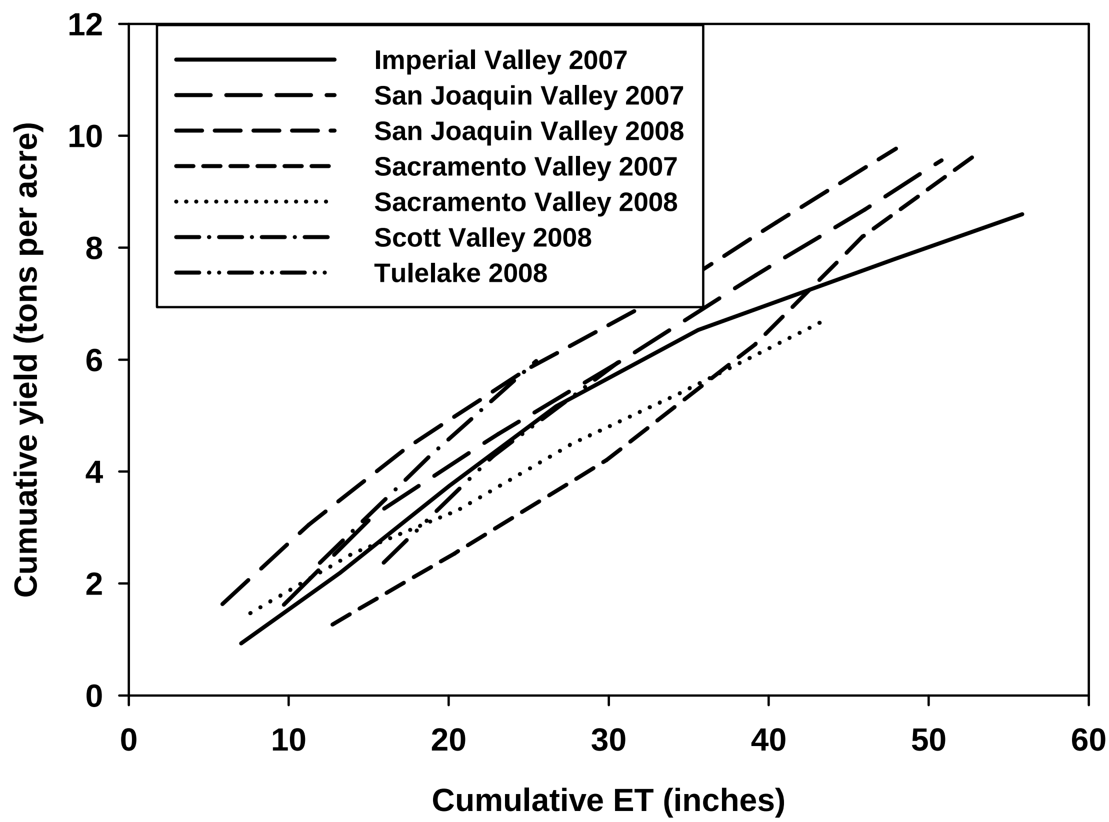
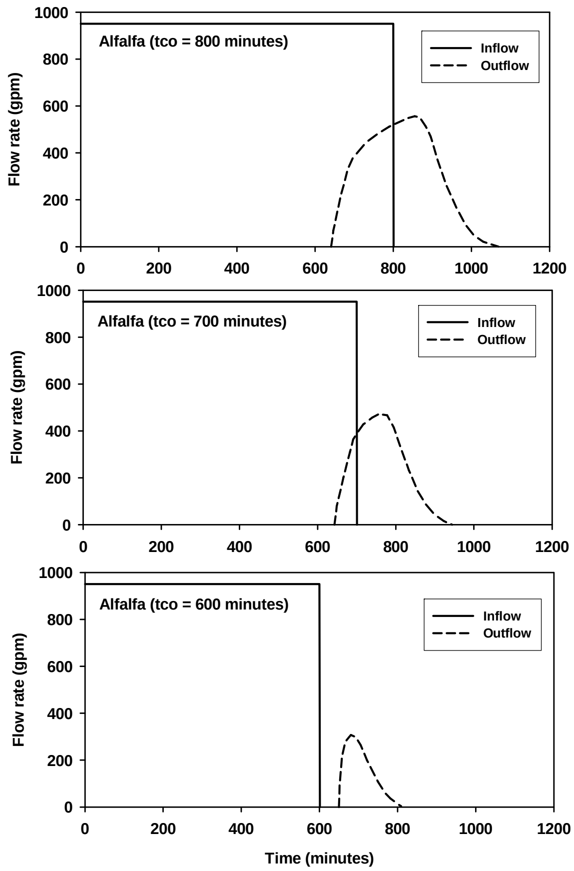


Figure 2. Relationships between cumulative evapotranspiration (ET) and cumulative yield for fully-irrigated alfalfa for seven locations in California.



Cutoff Time (minutes)	Applied Water (inches)	Infiltration Time* (hours)	Surface Runoff (inches)	DU (%)
800	12.8	7.1	2.8	89
700	12.1	5.0	1.6	87
600	11.2	2.7	0.5	82
550	10.7	1.4	0.06	78
500	9.8	0	0	62

* End of check (needed time = 2.6 hours)

Figure 3. Check inflow and surface runoff hydrographs for various cutoff times (time that the application of irrigation water ends). The advance time of water to the end of the border was 650 minutes. The table shows the irrigation system performance characteristics for the various cutoff times.