Water Budget Irrigation Scheduling for Alfalfa

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ABSTRACT

The water budget method of scheduling alfalfa irrigation is explained and illustrated. This method of irrigation scheduling relies on estimates of daily crop water use derived from local weather data. This explanation is excerpted from the irrigation chapter of a new comprehensive guide, "Intermountain Alfalfa Management", soon to be published by the University.

Key Words: alfalfa, irrigation, irrigation scheduling, water budget, water use, weather, evapotranspiration

INTRODUCTION

As the term *budget* implies, the water budget method of scheduling irrigations involves tracking additions and losses and balancing them. The losses are those due to crop water use and inefficiencies in the irrigation system. The additions are those due to irrigation and rainfall. The objective of the water budget method is to maintain soil moisture near the optimum level by keeping track of crop water use and then irrigating to replace the water used. Knowing crop water use is essential to using the water budget approach.

Crop water use is also called evapotranspiration (ET). The term evapotranspiration refers to the combined loss of water through evaporation from the soil and from water taken up and evaporated from the plant (transpiration). The rate at which plants use water is determined by the growth stage of the plant and by weather. Small plants use less water than large plants, for example, and all plants use more water when it is hot than when it is cool. Plants use more water on sunny days than cloudy days, and on days with high winds. For these reasons, plants use much less water in the spring and fall than during the long hot days in the middle of the summer. Figure 1 shows how daily water use of alfalfa near Tulelake, California, fluctuates throughout the growing season.

Over the years, irrigation scientists have quantified the effects of weather on plant water use. By using weather data you can predict with reasonable accuracy the water use of alfalfa in a specific region. The data needed include measurements of relative humidity, wind velocity, air temperature, and light intensity. Irrigation science has progressed to a point where such predictions are sufficiently accurate to be used for irrigation scheduling.

Crop water use values for irrigation scheduling may be obtained from several sources. Some local newspapers publish current values. Reference ET values for Tulelake, McArthur, and Alturas are calculated daily by the California Department of Water Resources (DWR) and can be obtained through DWR's California Irrigation Management Information System (CIMIS). You can use ET values for locations in the Intermountain Region by selecting the location with

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weather conditions most similar to those in your area. These reference values are based on pasture use, however. You must modify them to estimate alfalfa water use before using the values for irrigation scheduling. UC Farm Advisors can assist you with the conversion. In most situations, historical long-term averages of water use by alfalfa suffice for irrigation-scheduling purposes. Table 1 shows average long-term water use values for Tulelake. Adjust long-term averages to reflect current weather conditions, since weather can vary significantly from year to year and there is no such thing as an "average" year. For example, contrast the daily water use shown in Figure 1 with the long-term average daily use.

At the start of the production season (preferably), the soil profile is filled with water from rainfall or irrigation. From that point on, the grower tracks daily crop water use and keeps a running total of it. Once total crop water use, or total soil water depletion, equals or approaches the allowable depletion, the field should be irrigated. After irrigating and refilling the soil-water reservoir, daily crop water use is again calculated and added to the total water use to date. Another irrigation is scheduled when soil-water depletion since the last irrigation approaches the allowable depletion.

The water budget theory of irrigation scheduling is relatively straightforward, but alfalfa production practices complicate putting the theory into practice. For example, cutting affects water use by alfalfa. Generally, water use is near zero immediately after cutting and rises slowly after a few days, as the crop begins to grow. After about 10 days, alfalfa regrowth fully covers the ground and full crop water use resumes. A grower must compensate for this reduction in water use after cutting or he or she will overirrigate. Sophisticated methods for calculating the reduction are available, but a practical method is to consider alfalfa water use to be zero for 5 days after cutting. After 5 days switch to full-use estimates until alfalfa is cut again. (See Studying a Practical Example, later in this chapter, to understand how this rule of thumb is applied).

Harvesting and curing operations also complicate irrigation scheduling. Water cannot be applied too close to a cutting because irrigation wets the soil. On wet ground, harvest equipment may get stuck and is more likely to cause wheel ruts and compaction. Also, alfalfa that is cut and laid on moist soil to dry will cure very slowly. The preferred interval between irrigation and cutting depends on soil type. It may be as short as 2 days for sandy soils and as long as 10 to 15 days for fine-textured clay soils. Furthermore, fields obviously cannot be irrigated while alfalfa is curing, which typically requires from 5 to 8 days.

Because cutting delays irrigation, fields usually need water as soon after cutting as possible. Alfalfa is most sensitive to water stress when regrowth begins after cutting. When irrigation is postponed after cutting, dramatic yield reductions can result. So, fields should not be irrigated too close to cutting, and fields should be irrigated as soon as possible after the hay has cured and removed from the field.

An example should help clarify the preceding discussion on practical irrigation scheduling. To follow along with this example, refer to the accompanying water use table, table 2, and to the graph of soil-water depletion, figure 2. This example regards a healthy, well-established alfalfa field on sandy loam soil in the Tulelake region.

On May 12, the field was given a 12-hour irrigation that supplied 2.4 inches of water (net). This irrigation completely refilled the soil profile, so the soil-water depletion on this date was 0.00 (see point A on the table and graph). For 6 days, the crop was assumed to use water in amounts typical for the region (table 1 supplies this information). The average crop water use was added each day to the soil depletion balance. On May 18 the field received 0.50 inch of rain, so 0.50 inch of water was subtracted from 0.96, the soil depletion balance. The daily crop water use, 0.20 inch, was then added. So, soil-water depletion on May 18 (point B) was calculated to be 0.66 inch (0.96 - 0.50 + 0.20 = 0.66).

After May 18, average crop water use figures were again added each day to the soil-water depletion balance. On May 26 (point C) the accumulated depletion totaled 2.29 inches. Because this soil depletion approximated the net amount applied in a 12-hour irrigation, the field was irrigated the next day, May 27. On that day, the 2.4-inch application of water was subtracted from 2.29, the soil depletion balance; 0.21 inch of average crop water use was added, resulting in a net soil-water depletion of 0.10 inches (point D). Important note: The 2.29 inches of soil-water depletion that occurred before the May 27 irrigation was less than the 3 inches of allowable depletion for this sample sandy loam soil. Therefore, no yield reduction occurred due to moisture stress prior to this irrigation. The irrigation occurred 7 days before the first cutting, on June 3, allowing ample time for the soil to dry for harvest.

As explained earlier, it is acceptable to assume that for five days after cutting, crop water use is zero. After that time switch to using full-use estimates. In this example crop water use was estimated as zero, from June 4 to June 8 (period E). On the sixth day following cutting, June 9, the use of full-use estimates resumed.

After soil-water depletions totaled 2.33 inches on June 11, irrigation was applied on June 12 (point F). This allowed ample time for the hay to cure after cutting on June 3. In a similar manner, normal irrigations were scheduled for June 21 and 30 and July 8 (points G, H, and I). Irrigations were more frequent during this period because of the increased water demand of midsummer.

On July 13 (point J), an early irrigation consisting of 1.2 inches, half the normal amount of water, was applied. If this irrigation had been delayed until 2.4 inches of water had been depleted, the irrigation would have been too close to the second cutting, on July 17. The early, partial irrigation was scheduled to carry the alfalfa through the postharvest period without a water deficit. Again allowing for zero crop water use for 5 days after cutting (period K), the next irrigation was scheduled for July 25 (point L).

Figure 1. Comparison of daily water use by alfalfa: 1993 season and long-term average.

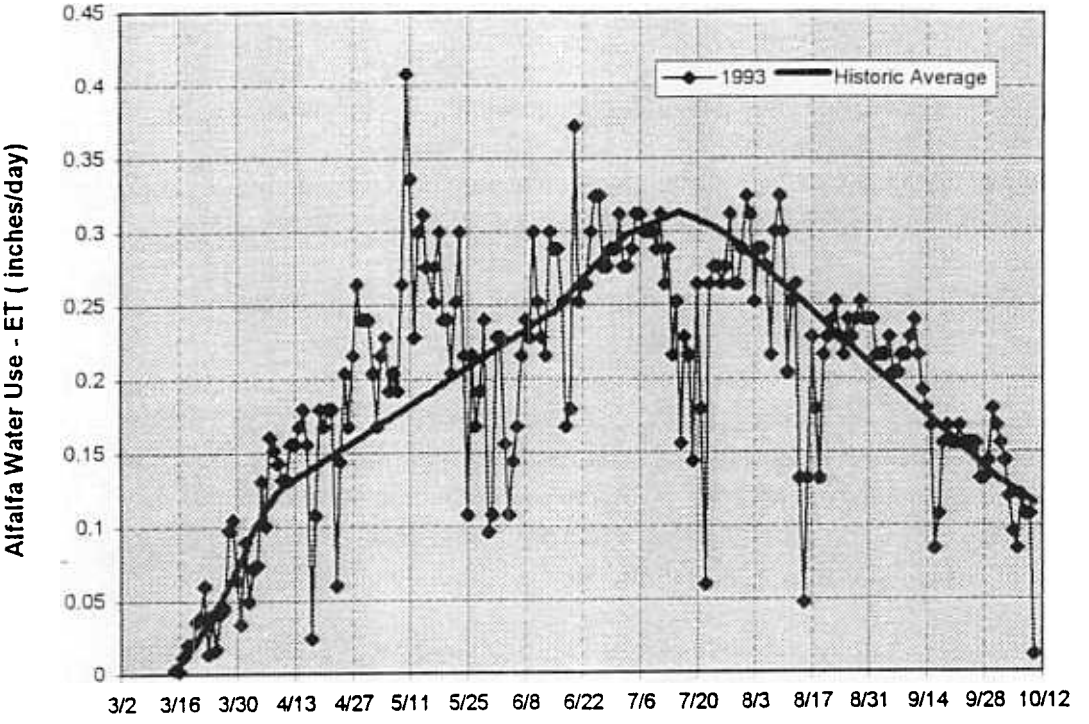

Figure 2. Soil-water depletion in sample alfalfa field, Tulelake area.

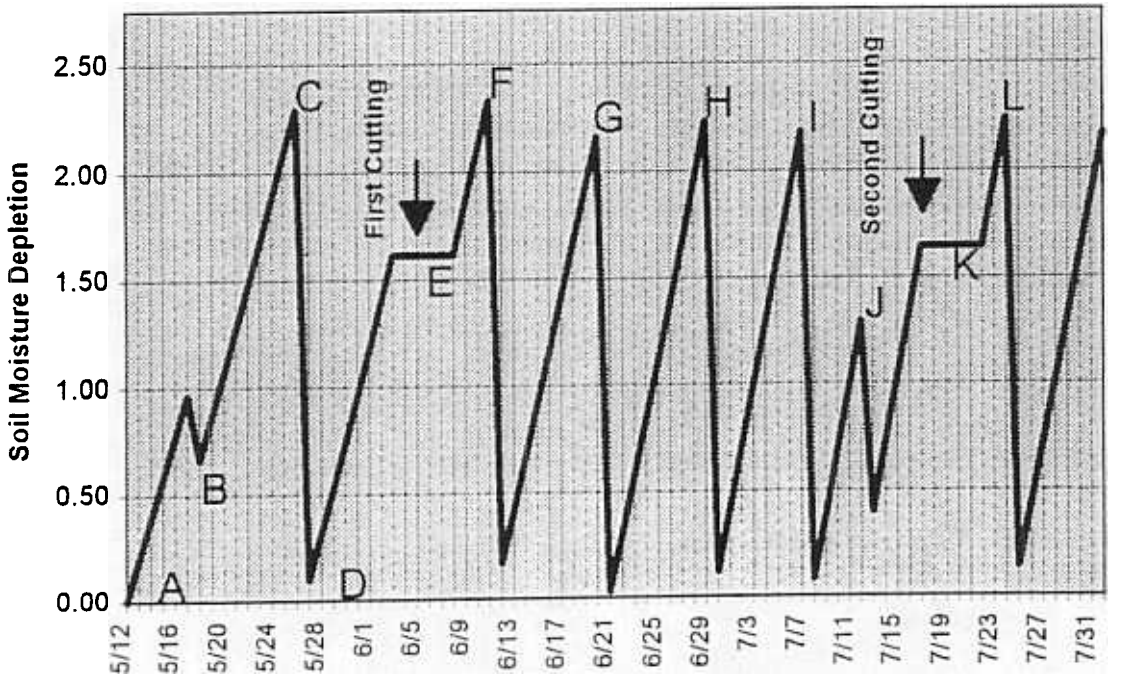

Table 1 Average weekly and daily water use by alfalfa in the Tulelake Basin

Week Beginning (mo and day)	Weekly Total (in.)	Daily Average (in.)
3–15	0.10	0.01
3–22	0.32	0.05
3–29	0.59	0.08
4–05	0.83	0.12
4–12	0.95	0.14
4–19	1.04	0.15
4–26	1.13	0.16
5–03	1.22	0.17
5–10	1.30	0.19
5–17	1.39	0.20
5–24	1.48	0.21
5–31	1.57	0.22
6–07	1.66	0.24
6–14	1.76	0.25
6–21	1.91	0.27
6–28	2.05	0.29
7–05	2.13	0.30
7–12	2.18	0.31
7–19	2.14	0.30
7–26	2.05	0.29
8–02	1.93	0.28
8–09	1.81	0.26
8–16	1.69	0.24
8–23	1.56	0.22
8–30	1.44	0.21
9–06	1.33	0.19
9–13	1.19	0.17
9–20	1.07	0.15
9–27	0.95	0.14
10–4	0.85	0.12

[1] Based on long-term average weather data

Table 2. Water use table for a sample alfalfa field, Tulelake area.

	Date	Crop Water Use (inch)	Rain or Irrigation (inch)	Soil Water Depletion (inch)	Event
A	5/12	0.19	2.4	0.00	12 hour irrigation
	5/13	0.19		0.19	
	5/14	0.19		0.38	
	5/15	0.19		0.57	
	5/16	0.19		0.76	
	5/17	0.20		0.96	
B	5/18	0.20	0.5	0.66	1/2 "rain
	5/19	0.20		0.86	
	5/20	0.20		1.06	
	5/21	0.20		1.26	
	5/22	0.20		1.46	
	5/23	0.20		1.66	
	5/24	0.21		1.87	
	5/25	0.21		2.08	
C	5/26	0.21		2.29	
D	5/27	0.21	2.4	0.10	12 hour irrigation
	5/28	0.21		0.31	
	5/29	0.21		0.52	
	5/30	0.21		0.73	
	5/31	0.22		0.95	
	6/1	0.22		1.17	
	6/2	0.22		1.39	
	6/3	0.22		1.61	First cutting
E	6/4	0.00		1.61	
	6/5	0.00		1.61	
	6/6	0.00		1.61	
	6/7	0.00		1.61	
	6/8	0.00		1.61	
	6/9	0.24		1.85	
	6/10	0.24		2.09	
	6/11	0.24		2.33	
F	6/12	0.24	2.4	0.17	12 hour irrigation
	6/13	0.24		0.41	
	6/14	0.25		0.66	
	6/15	0.25		0.91	
	6/16	0.25		1.16	
	6/17	0.25		1.41	
	6/18	0.25		1.66	
	6/19	0.25		1.91	
	6/20	0.25		2.16	
G	6/21	0.27	2.4	0.03	12 hour irrigation

	Date	Crop Water Use (inch)	Rain or Irrigation (inch)	Soil Water Depletion (inch)	Event
	6/22	0.27		0.33	
	6/23	0.27		0.60	
	6/24	0.27		0.87	
	6/25	0.27		1.14	
	6/26	0.27		1.41	
	6/27	0.27		1.68	
	6/28	0.29		1.97	
	6/29	0.29		2.26	
H	6/30	0.29	2.4	0.15	12 hour irrigation
	7/1	0.29		0.44	
	7/2	0.29		0.73	
	7/3	0.29		1.02	
	7/4	0.29		1.31	
	7/5	0.30		1.61	
	7/6	0.30		1.91	
	7/7	0.30		2.21	
I	7/8	0.30	2.4	0.11	12 hour irrigation
	7/9	0.30		0.41	
	7/10	0.30		0.71	
	7/11	0.30		1.01	
	7/12	0.31		1.32	
	7/[redacted]	0.31	1.2	0.43	
	7/14	0.31		0.74	
	7/15	0.31		1.05	
	7/16	0.31		1.36	
	7/17	0.31		1.67	Second cutting
K	7/18	0.00		1.67	
	7/19	0.00		1.67	
	7/20	0.00		1.67	
	7/21	0.00		1.67	
	7/22	0.00		1.67	
	7/23	0.30		1.97	
	7/24	0.30		2.27	
L	7/25	0.30	2.4	0.17	12 hour irrigation
	7/26	0.29		0.46	
	7/27	0.29		0.75	
	7/28	0.29		1.04	
	7/29	0.29		1.33	
	7/30	0.29		1.62	
	7/31	0.29		1.91	
	8/1	0.29		2.20	