WATER REQUIREMENTS OF AN ALFALFA CROP IN CALIFORNIA

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One of the problems facing alfalfa producers today is the maintenance of yields at profitable levels. Adequate supply and proper timing of irrigation water are factors which contribute to a high level of management. For alfalfa grown in the Sacramento and San Joaquin Valleys irrigation water must be supplied throughout the growing season in order to achieve adequate production. The proper timing of irrigation resupply to the soil alleviates the problem of plants being drought stressed or flooded when a set irrigation schedule is followed. A method which may be used by the individual producer then incorporates the use of evaporation of water from an open pan as a measure of the crop water use. This method simply budgets the inputs, irrigation water and precipitation, and the outputs, water use by the crop. Therefore, this method requires a knowledge of soil, crop, and weather data.

Shown in Table 1 are the monthly precipitation and estimated consumptive water use by alfalfa in the Sacramento and San Joaquin valleys. The largest monthly uses by alfalfa are throughout the summer while precipitation is lowest. Therefore in this budget scheme precipitation is a small input while irrigation is a very large input and must account for the difference between precipitation and crop water use. For the San Joaquin Valley this amount is near 50 inches and must be scheduled with the proper timing to achieve the best results.

Table Monthly precipitation and estimated consumptive use of water in inches by alfalfa grown in the Sacramento and San Joaquin Valleys

	Sacramento Valley		San Joaquin Valley	
Month	Precipitation[a]	Water use	Precipitation[b]	Water use
January	3.9	1.0	1.8	1.0
February	2.8	2.0	1.7	2.0
March	2.0	3.2	1.6	3.8
April	1.5	4.8	1.2	5.2
May	0.5	6.3	0.3	7.0
June	0.2	8.3	0.1	8.6
July	0.01	8.4	0.0	9.4
August	0.03	6.9	0.02	8.7
September	0.2	5.2	0.07	5.8
October	1.0	3.6	0.4	4.3
November	2.0	1.9	1.2	2.0
December	3.2	1.0	1.7	1.0
Annual total	17.3	52.6	10.2	58.8
Growing seasonal total[c]	5.4	46.7	3.8	52.8

a. Monthly climatic normals for Davis, California.

b. Monthly climatic normals for Fresno, California.

c. Totals considered to be representative of alfalfa growing season However, exact length of growing season depends on locality.

The values given in Table 1 are for monthly water use, but what is required is a daily estimate of crop water use. One could simply divide the monthly water use by the number of days in the month to determine a daily water use by the crop. However, this may overestimate the water use by the crop in some cases and underestimate in others, and could lead to an improper budget of soil moisture supply and drought stressing or flooding of the soil. Evaporation from an open pan then provides an easy estimate of the daily crop water use.

Soil Factors in Irrigation Scheduling

Soil factors important in proper irrigation scheduling are; water holding capacity of the soil, infiltration rate of water into the soil, and rooting depth of the crop within the soil profile.

Water holding capacity of the soil

The amount of available water in the soil for the crop to extract is dependent upon the soil type. Table 2 provides a guideline as to the amount of water available in a foot of soil. These are presented as representative values and for an individual producer the exact soil moisture holding capacity should be evaluated. Even though this amount of water is available to the crop, resupply by irrigation should occur when approximately two-thirds of the water is removed.

Table 2. Water holding capacity of four soil types.

Soil Type	Available water per foot of soil (inches)
Sand	0.5 -0.75
Sandy loam	0.75-1.50
Clay loam	1.5 -2.0
Clay	2.0 -2.5

Infiltration rate into the soil

To avoid prolonged periods of standing water on the crop, it is best to have a rapid rate of infiltration into the soil. Alfalfa is very susceptible to excess water in the root zone. Saturation of the root zone can cause damage to roots through decreased oxygen supply. Incidence of Phytophora can be decreased if the time which the roots are saturated is kept to a minimum. The conditions necessary for root infection are water in excess of field capacity and temperatures below 85°F. Other diseases associated with flooded roots may also be controlled if time which the roots are flooded is as short as possible.

Root distribution within the soil profile

A proper irrigation scheduling program requires knowledge of the portion of the soil profile which is occupied by active roots. If the roots are only present in the upper two feet of soil then only the water contained in that portion of the soil will be available to the plant. A proper management practice in irrigation is to know if alfalfa is behaving as a shallow- or deep-rooted crop. Under irrigation practices alfalfa can be assumed a shallow-rooted crop. The actual depth to which the roots penetrate can be easily measured by digging down into the soil.

Crop Factors in Irrigation Scheduling

One of the more drought susceptible times for alfalfa is the regrowth after cutting, therefore irrigation scheduling must allow for adequate water to be left in the soil to provide for rapid regrowth. However, the soil must be dry enough for equipment movement during cutting. It is also undesirable to irrigate directly after cutting to avoid germination of grasses and weeds which require light and a moist soil surface to trigger growth.

The alfalfa crop uses water in relation to the soil moisture supply and the atmospheric demand. In irrigation to soil moisture supply is maintained where it is a nonlimiting factor in water use. Atmospheric demand can be equated to the atmospheres thirst for water, on a high demand day, i.e., warm, windy, and clear, the plant will respond by transpiring large amounts of water into the air. On a low, demand day; cloudy, cool, and calm, the plants transpire less water into the atmosphere. Atmospheric demand is also reflected in the amount of water evaporated from an open surface of water. In meteorology, this loss is measured as open pan evaporation and, obviously, a pan of water and an alfalfa crop do not lose the same amount of water each day. There is, however, a direct relationship between water loss from an open pan and the evapotranspiration by a crop. A simple correction factor can be used to adjust the open pan evaporation to estimate that transpired by an alfalfa crop. The monthly crop coefficients (open pan correction factors) for an alfalfa crop in the San Joaquin Valley are given in Table 3.

Table 3 Recommended alfalfa crop coefficients for relating open pan evaporation to crop evapotranspiration in the San Joaquin Valley[a].

Month	Crop Coefficient
January	0.71
February	0.74
March	0.70
April	0.70
May	0.71
June	0.73
July	0.76
August	0.80
September	0.80
October	0.77
November	0.73
December	0.70

Coefficients derived from an open pan site in an irrigated pasture. Corrections must be made if observing site is considerably different from this type of location.

[a]Values taken from Vegetative Water Use in California, 1974, Department of Water Resources, State of California, 104 p.

Using Table 3, then crop evapotranspiration (Crop ET) can be calculated by multiplying the crop coefficient for the appropriate month by the observed daily open pan evaporation (Pan E) using the following equation.

$$\text{Crop ET} = \text{Crop Coeff.} \times \text{Pan E}$$

For example, on August 23 open pan evaporation was observed to be 0.35 inches and the crop coefficient for August is 0.80 (taken from Table 3) then the estimated crop evapotranspiration for that day is 0.28 inches ($0.28 = 0.8 \times 0.35$). This amount of water (0.28 inches) would then have been extracted from the available supply in the soil.

There are other approaches to estimating crop evapotranspiration, however, all of these require numerous meteorological inputs. These inputs include solar radiation, air temperature, relative humidity and a measure of the wind. The evaporation from an open pan integrates all of these factors into a singly observable event. For the individual producer, the pan approach to estimating crop evapotranspiration offers a very simple, easy to use measurement.

Irrigation Scheduling Using Pan Evaporation

This approach to irrigation scheduling can be called the budget method. In balancing the inputs versus the outputs a producer essentially balances the soil moisture content. The steps to implementing this method are:

1) Determination of the water holding capacity of the soil.
2) Determination of the rooting depth of the alfalfa crop.
3) Steps 1 and 2 will estimate the amount of water available to the alfalfa crop.
4) Measurement of precipitation and irrigation water supplied to the field.
5) Daily measurement of the open pan evaporation and related to crop evapotranspiration by use of the monthly crop coefficient (Table 3).
6) Remove the amount of water calculated in step 5 from the amount of water in the soil profile.
7) Add the amount of water from step 5 into the soil profile.

An example of this budget procedure is shown in Table 4 for 10 days in August

Table 4. Sample calculations for irrigation scheduling using monthly crop coefficients and daily open pan evaporation data.

	Inputs		Removal			Soil Moisture Balance[c]	
Day	Irrigation[a]	Precip.	Pan E	Crop Coeff.[b]	Crop ET	Carry-over	Remaining
1	0	0.05	.31	.8	.25	2.01	1.81
2	0	0	.28	.8	.22	1.81	1.59
3	0	0	.35	.8	.28	1.59	1.31
4	0	0	.34	.8	.27	1.31	1.04
5	0	0	.33	.8	.26	1.04	0.78
6	0	0	.36	.8	.29	0.78	0.49
7	0	0	.27	.8	.22	0.49	0.27
8	0	0	.24	.8	.19	0.27	0.08
9	2.00	0	.28	.8	.22	0.08	1.86
10	0	0	.32	.8	.26	1.86	1.60

[a]The amount of water supplied to soi has accounted for the efficiency of irrigation.

[b]Example of month of August using a crop coefficient of 0.80 as shown in Table 3

[c]A clay loam soil with a rooting depth of two feet is calculated to have 2.01 inches of water available when only two-thirds of water is removed.

In this example 2.00 inches of irrigation water were needed on the 9th day to maintain an adequate supply of moisture to the soil. Using this approach, the producer would have more control over when to apply water to the field. The producer would also be able to jduge the amount of water to apply just before cutting to insure a dry field for implement movement and yet still contain sufficient moisture for rapid regrowth.

The crop coefficient for adjusting open pan evaporation to crop evapotranspiration should be reduced for about five days following cutting. Evidence on water use by alfalfa from W. O. Pruitt (Doorenbos, J., and W. O. Pruitt, 1975. Crop Water Requirements, FAO Irrigation and Drainage paper No. 24, 179 p.) suggests that the coefficient be reduced by approximately one-half of the normal value. A bare soil with only a small amount of plant cover will not lose water as rapidly as one completely covered with foliage. This will reduce the amount of water removed from the soil and this adjustment will prevent overirrigation at the next time of application.

This approach to scheduling irrigation by use of open pan evaporation data to predict crop evapotranspiration is new and needs extensive field testing to determine possible changes that may be necessary in the crop coefficients and removal patterns from the soil. The use of pan evaporation method, however, is simple to use and requires only limited soil and crop data and the daily pan evaporation and precipitation. With this data available to individual producers, then he would be able to exercise control over the scheduling of irrigation for the most efficient use of water.