# IMPROVING IRRIGATION WATER MANAGEMENT OF ALFALFA

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## Abstract

Efficiently flood irrigating alfalfa is a challenge due to the constraint placed on the manager by alfalfa cutting schedules. The timing of irrigation is set by the cutting schedule rather than being under the control of the irrigation water manager. The additional constraint of needing to irrigate the entire field determines the minimum amount of water which can be applied. Alfalfa water use (evapotranspiration – ET) estimates are available to determine how much water should be applied during an irrigation. If more water is applied than is needed to refill the alfalfa root zone, deep percolation can occur leading to inefficient irrigation. Tailwater runoff which is not reused can also add to irrigation inefficiencies. Techniques to maintain good irrigation efficiencies under the constraints listed above are discussed.

**Key words: irrigation, border irrigation, water management, alfalfa**

## Introduction

The predominant form of alfalfa irrigation in California is surface irrigation, most often border or flood irrigation. Under border irrigation, water is introduced at the head of the field and moves down the field, following the slope of the border check. Once water comes in contact with the soil surface at a location, infiltration begins. Water initially infiltrates at a high rate but this infiltration rate decreases with time until a final, relatively constant infiltration rate is reached (figure 1). The time water is in contact with soil at a field location is referred to as the intake opportunity time. The longer the intake opportunity time at a location, the more water is infiltrated.

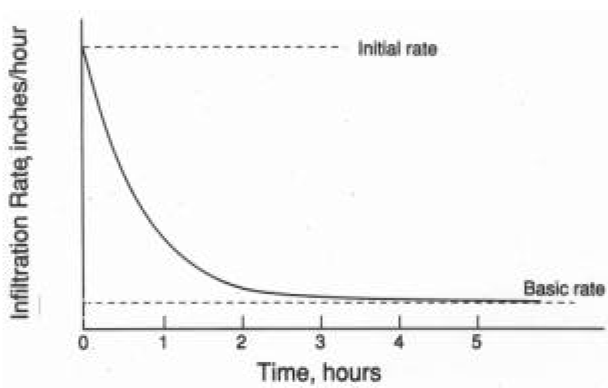


Fig. 1. Typical infiltration rate curve showing the high initial infiltration rate which decreases with time until it reaches a lower, final or basic infiltration rate.

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Initially, water advances down the field rapidly but this rate of advance decreases as the water moves down the field. This is a result of the water infiltrating into the soil all along the field upstream of the advancing front of water. The farther the water advances down the field, the more soil surface there is upstream into which water infiltrates and the slower the water advance becomes.

Depending on how the border irrigation is managed, irrigation water may be shut off before it reaches the end of the field or it may be allowed to reach the field end before it is cut off. Even after irrigation water at the head of the field is cut off, water continues to move down the field. One irrigation water management technique is to time the cut off of irrigation water so that the water just "coasts' to the end of the field, resulting in little ponding or runoff at the end of the border check.

After cut off of irrigation, water on the soil surface will begin disappearing (or receding) from the head of the field first, with this recession proceeding down the field. The time between when water first comes in contact with a field location and when it recedes from that location is the intake opportunity time at that field site. Ideally, each location on the field would have the same intake opportunity time. This would result in all parts of the field receiving nearly the same amount of infiltrated water. Irrigation professionals would call this a uniform irrigation. Unfortunately, the more frequent case is for different field locations to have different intake opportunity times leading to non-uniform irrigation. Often the longer the field, the less uniform the irrigation.

**Irrigation Efficiency**

Applied irrigation water can end up in one of three places. One, it can end up as stored soil moisture which is what we want. Two, it can end up as deep percolation water if too much water is applied and it infiltrates past the root zone. This water is not available to the crop so it is often considered an irrigation loss. It may contribute to groundwater recharge or it may add to a drainage problem. Third, some water may run off the tail end of the field. This is referred to as tailwater runoff. If this water is collected and reused, it is not considered an irrigation loss. If it is not reused, it is counted as an irrigation loss.

To quantify how good an irrigation is, the term Irrigation Efficiency is often used. Irrigation efficiency for a field is defined as:

$$\textbf{Irrigation Efficiency (\%)} = \frac{\textbf{Water beneficially used}}{\textbf{Water applied}} \times 100$$

The major beneficial use of irrigation is the water which is stored in the crop's root zone. Irrigation efficiencies of 75% or higher would be considered good for alfalfa border irrigation systems.

Since it is very difficult to measure the amount of water stored in the crop's root zone, it is usually estimated as the amount of water the crop has used since the previous irrigation. This crop water use is referred to as the crop evapotranspiration (ET). Good estimates are available for alfalfa ET.

Alfalfa water use varies from being low after cutting to highest just prior to cutting. Table 1 shows an estimate of alfalfa crop water use ET) for various location in California. The low to high changes in alfalfa water use between cuttings have been averaged. This makes irrigation scheduling easier and makes an excellent place for alfalfa growers to start with their irrigation scheduling efforts.

Table 1. Estimates of alfalfa crop water use (ET) for various locations in California. Note: table

| | **Alfalfa crop water use (inches per day during period)** | | | | |
|---|---|---|---|---|---|
| **Date** | **Shafter** | **Parlier** | **Davis** | **McArthur** | **Brawley** |
| Jan 1-15 | 0.03 | 0.03 | 0.03 | 0.02 | 0.07 |
| Jan 16-31 | 0.05 | 0.04 | 0.05 | 0.03 | 0.09 |
| Feb 1-15 | 0.07 | 0.06 | 0.06 | 0.04 | 0.10 |
| Feb 16-28 | 0.09 | 0.08 | 0.09 | 0.07 | 0.13 |
| March 1-15 | 0.11 | 0.10 | 0.09 | 0.08 | 0.16 |
| March 16-31 | 0.14 | 0.13 | 0.14 | 0.11 | 0.19 |
| Apr 1-15 | 0.19 | 0.17 | 0.18 | 0.14 | 0.22 |
| Apr 16-30 | 0.20 | 0.19 | 0.20 | 0.14 | 0.25 |
| May 1-15 | 0.24 | 0.22 | 0.23 | 0.18 | 0.28 |
| May 16-31 | 0.26 | 0.24 | 0.24 | 0.19 | 0.29 |
| June 1-15 | 0.27 | 0.26 | 0.28 | 0.22 | 0.31 |
| June 16-31 | 0.28 | 0.27 | 0.29 | 0.25 | 0.32 |
| July 1-15 | 0.28 | 0.27 | 0.29 | 0.27 | 0.31 |
| July 16-31 | 0.26 | 0.25 | 0.27 | 0.25 | 0.29 |
| Aug 1-15 | 0.25 | 0.24 | 0.26 | 0.25 | 0.29 |
| Aug 16-31 | 0.23 | 0.22 | 0.24 | 0.22 | 0.28 |
| Sept 1-15 | 0.21 | 0.19 | 0.21 | 0.18 | 0.26 |
| Sept 16-30 | 0.18 | 0.15 | 0.18 | 0.14 | 0.22 |
| Oct 1-15 | 0.16 | 0.13 | 0.16 | 0.12 | 0.19 |
| Oct 16-31 | 0.12 | 0.09 | 0.12 | 0.08 | 0.15 |
| Nov 1-15 | 0.08 | 0.07 | 0.09 | 0.05 | 0.12 |
| Nov 16-30 | 0.08 | 0.04 | 0.06 | 0.03 | 0.10 |
| Dec 1-15 | 0.05 | 0.03 | 0.05 | 0.02 | 0.07 |
| Dec 16-31 | 0.03 | 0.02 | 0.04 | 0.02 | 0.07 |

**Improving Irrigation Water Management**

Alfalfa irrigation is a challenge because of the constraints of alfalfa cutting schedules. Irrigations must be planned to allow for machinery access for cutting and baling. There may be only time for a single irrigation between cuttings, thus the irrigation frequency is fixed.

Irrigation scheduling, which is determining when and how much to irrigate, is therefore constrained by cutting schedules so the “when” to irrigate is set. This leaves the “how much” to irrigate. By estimating the alfalfa ET since the last irrigation, we can determine how much irrigation water should be applied. It is often not easy to simply apply that amount though since the irrigation system in place may constrain the amount of water applied.

The major constraint for an existing border irrigation system is that the entire field must be irrigated. Enough water much be applied so that the tail end of the field is irrigated. This sounds simplistic but it is a very real constraint. Thus, ensuring that the entire field is irrigated sets a minimum amount of water which must be applied. Ideally, this minimum amount is less than or equal to the amount of water which should be applied during the irrigation. Remember that this amount of water which should be applied is the amount of water the alfalfa has used since the last irrigation. If the minimum amount of water needed to irrigate the entire field is less than the amount we would like to apply to replace the soil water used by the crop, irrigation water can always be run longer to apply more water.

Unfortunately, the minimum amount of water needed to irrigate the entire field is often greater than the amount irrigation scheduling tells us is needed. This is most often the result of fields which are too long. Generally, the longer the field, the greater is this minimum irrigation amount needed to water the entire field.

An example may illustrate this problem.

Example:

30 days between irrigations
Alfalfa ET between irrigations = 7.5 inches
Minimum amount of water to irrigate the entire field = 10 inches

$$\text{Irrigation Efficiency} = (7.5 \text{ inches} \div 10 \text{ inches}) \times 100 = 75\%$$

If irrigation is continued after water has reached the end of the field, more than 10 inches of water could be applied. This may be a benefit in that the tail end of the field may be more fully irrigated, but the price is that: (1) irrigation efficiency would be less, and (2) more tailwater runoff would be generated. If the tailwater is collected and reused, it would not be an irrigation loss.

If the irrigation interval is set by the alfalfa cutting schedule and there is a minimal amount of water required to simply irrigate the entire field, what can be done to improve irrigation water management of alfalfa? Two measures can be taken to make sure the irrigations are as efficient as possible.

First, the irrigation cutoff can be planned to make sure the minimum amount of water necessary to irrigate the entire field is applied. This may entail cutting off the irrigation water before it has reached the end of the field and allowing it to coast to the end of the field. This strategy is best fine-tuned to a particular field since the field slope and field infiltration rate play a major role. One recommendation used in the Imperial Valley is to cut off water when it has advanced 80% of the way down the field. It is expected that the water will continue to advance to the end of the field. This is a strategy to start with but if it doesn't appear that the tail end of the field is being adequately watered, water cutoff should be changed to allow water to run longer before cutoff. This may seem like a trial-and-error method, but considering the complicated physical system being dealt with it is often the best way.

Soil moisture monitoring can prove to be very valuable when evaluating irrigation strategies. Placing soil moisture monitoring devices at locations along the field (e.g. top, middle and bottom of the field) and at various depths can tell you when and where the soil is drying out. It can also tell you to what depth water has penetrated following an irrigation by simply reading the devices before and after an irrigation. Soil moisture blocks have been used successfully as water management tools in alfalfa.

Second, make sure tailwater runoff is collected and reused. This serves a number of purposes. It makes the irrigations more efficient. It also keeps water from standing on the bottom end of the field which is frequently very detrimental to the alfalfa.

Tailwater return does not simply mean collecting water in a pond and allowing it to soak into the ground. This is inefficient use of irrigation water. It can also be a source of groundwater contamination since it has been shown that the tailwater runoff water may contain herbicides, such as hexazinone, which can move from the pond into the groundwater.

Figure 2 shows a tailwater return system which returns water to the head of the field for reuse. This water can supplement the normal irrigation flows. One complication to this method is that if siphons are being used, more siphon pipes may need to be set when the return system kicks in and increases the flow in the head ditch. If this is not done, the head ditch dam may be overtopped. If pipelines with alfalfa valves are being used, this is not a problem.

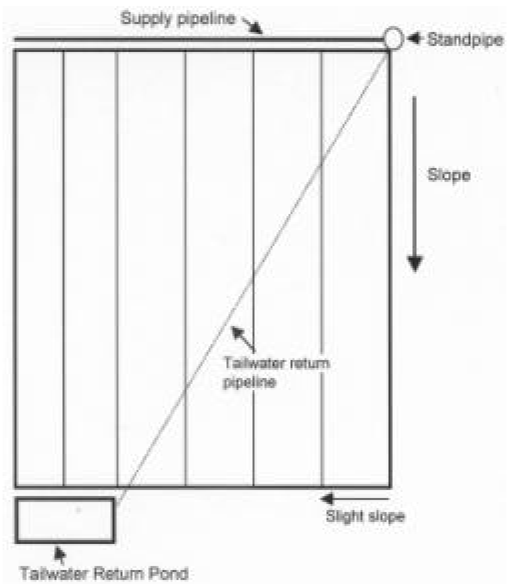


Figure 2. Tailwater return system returning water to the head of the field for reuse.

Tailwater from the pond can also be used to irrigate check(s) on another field. How the tailwater pond is managed should be decided based on how it best fits the ranch's irrigation system. The only criteria is that the tailwater be reused for irrigation.

A change to the irrigation system which may be effective is to increase the flow rate into a border check. For example, this could be done by irrigating two checks instead of three at a time. Increased flow rate into a check will move the water across the field more quickly and often makes for a more uniform irrigation application. It may also allow the check to be fully irrigated with a lesser amount of water. This will also mean that the irrigation set times will be less when the inflow rate is higher. This can be difficult though because set changes may need to be made at times less convenient.