

IRRIGATION WATER MANAGEMENT OPTIONS FOR ALFALFA

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ABSTRACT

All types of irrigation systems, including border strip flood systems, various types of sprinkler irrigation systems, and subsurface drip irrigation systems, are used to irrigate alfalfa. They all face challenges in irrigating efficiently while still economically producing high-quality, high-yielding alfalfa. This paper discusses techniques and approaches to improving alfalfa irrigation water management.

Key words: irrigation, border strip irrigation, sprinkler irrigation, drip irrigation

INTRODUCTION

Irrigated alfalfa is grown under all types of irrigation systems. Border strip irrigation is widely practiced on alfalfa, especially where land can be easily leveled and inexpensive water is available. Sprinkler irrigation is also practiced widely, especially where land is not easily leveled. While center-pivot irrigation and wheel-line sprinkler systems are the most common, hand-move and solid-set sprinklers are sometimes used. Alfalfa drip irrigation is not yet common, but it is being used more frequently as water cost and scarcity increase.

IRRIGATION SYSTEMS USED WITH ALFALFA

Border Strip Irrigation

Border strip irrigation, sometimes referred to as flood irrigation, entails continuously releasing water at the head of the field and allowing it to flow down the sloping field. The water is contained on both sides of the border “check” by earthen berms. The field is carefully leveled so the water covers the entire check as it flows to the tail end of the field. Water is most commonly supplied to the check with either an underground pipeline and valve system, a ditch with siphons system, or a ditch with gates system. Depending on conditions, water is shut off before or when irrigation water reaches the end of the field.

The alfalfa border check system’s irrigation efficiency is dependent on its design and the field’s soil conditions. Particularly if the flow rate to the check is correct and the field is of an appropriate length, border check irrigation can be quite efficient. Unfortunately, often the check

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length is too long, and the inflow rate and slope of the check are not appropriate to give high irrigation efficiency. The inefficient irrigation can be a result of excessive tailwater runoff, deep percolation losses, or both.

Very good yields of high-quality alfalfa are grown under border strip irrigation. The deep rooting characteristics of alfalfa make it appropriate for the infrequent, deep irrigations provided by border strip irrigation.

Once the field is leveled and the water supply system is installed, border strip irrigation is a low labor, low maintenance, inexpensive irrigation system. Growers with an existing alfalfa border strip system are often reluctant to change their irrigation system unless water scarcity or cost issues drive them to it. Because of this, the first step in improving irrigation water management in border strip systems should be improving the management of the system.

Sprinkler Irrigation Systems

A well-designed sprinkler irrigation system should be capable of high irrigation efficiency with little runoff and of providing high-yielding, high-quality alfalfa. The two issues that most commonly cause poor performance of an alfalfa sprinkler irrigation system are poor management and inadequate maintenance. The poor management most often entails not matching irrigations to the alfalfa water needs. Inadequate maintenance can show up as sprinklers not working properly, replacement sprinklers not matching the original design, and leaks. The more complex the sprinkler system (e.g. center pivots are complex), the more important quality maintenance becomes.

While sprinkler irrigation systems make very good alfalfa irrigation systems, they can be expensive to purchase and their energy requirements may make them costly to operate.

Drip Irrigation Systems

Alfalfa drip irrigation is almost exclusively subsurface drip irrigation in which drip tape is placed below ground, at a spacing and depth selected by the grower and designer. The spacing between lateral lines is chosen based on the ability to irrigate the alfalfa, ability to irrigate other crops in the crop rotation, and the cost of the irrigation system.

The depth of tape placement is influenced again by the ability to irrigate the crops, installation issues, and the requirement to do field cultivation or other cultural practices above the tape. Some SDI user's choice of tape depth is even influenced by gopher or other rodent activity, and the belief that increased tape depth results in less rodent damage.

A well designed SDI system can be highly efficient, but is also an expensive system. Maintenance of SDI systems is a major issue and will be discussed later.

IMPROVING IRRIGATION WATER MANAGEMENT

It is common, especially when irrigation water is in short supply or when the price of water has gone up, for growers to look at improving their alfalfa irrigation water management. Alfalfa is a large water user, with a long growing season, and often the target of those critical of agricultural water use. For more discussion on this topic, see:

http://alfalfa.ucdavis.edu/+symposium/2012f/files/talks/12CAS-2%20Putnam_IrrigationStrategies.pdf

In the search for improved alfalfa irrigation water management, issues need to be examined to determine where limited resources and time should be focused. The following identifies some of those issues, organizing them by irrigation systems.

Management Practices Common to All Irrigation Systems

Irrigation water management cannot be improved unless the alfalfa water needs are determined and the amount of water being applied can be accurately measured. These two pieces of information are critical for irrigation water management, no matter whether border strip irrigation, sprinkler irrigation, or drip irrigation is used.

Measuring the applied water can often be a challenge, especially if water is delivered in a ditch or canal. It becomes easier if the water is in a pipeline where a flow meter can be used for measurement. Accurately knowing how much water is being applied is critical for two reasons. First, comparing applied water to the alfalfa water use provides a good idea of how much water could be saved. What if it turns out the alfalfa is being under-irrigated? Solving an under-irrigation problem may mean using more water but it may significantly improve alfalfa yield or quality.

Secondly if it is decided to switch irrigation systems or practices, knowing how much water was being applied with the “old” irrigation system compared to the new one indicates the effect of the change. Bottom line is that quality irrigation water management can’t be done unless the applied water is known. For more information on measuring agricultural irrigation water see:

<http://anrcatalog.ucdavis.edu/Details.aspx?itemNo=21644>

Equally important is determining when and how much water to apply, often referred to as irrigation scheduling. Alfalfa irrigation scheduling is most frequently done by soil moisture monitoring or by estimating alfalfa water use (evapotranspiration–ET). Both approaches can work well when done correctly, but it is often easier to use estimates of alfalfa ET to determine the amount of water to be applied. Previous alfalfa symposium articles have detailed alfalfa evapotranspiration estimates.

http://alfalfa.ucdavis.edu/+symposium/2012f/files/talks/12CAS-7_Sanden_%20IrrigationManagement.pdf

http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/pdfs/UCAlfalfa8293Irrigation_free.pdf

Improving Irrigation Water Management of Surface Irrigation Systems

Once the amount of water applied with the current system is quantified, a plan for improving irrigation water management can be developed. If the correct amount of water is already being applied to match alfalfa ET, water will not be saved by changing the irrigation system or management practices. It may still be possible to increase yield and quality by changing to sprinkler or drip irrigation systems that apply water more frequently, potentially decreasing water stress which may occur under the “feast and famine” soil water conditions of surface irrigation. Soil moisture monitoring information can be extremely useful here. For more information on monitoring soil moisture in alfalfa systems, see:

http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/pdfs/UCAlfalfa8293Irrigation_free.pdf

If it is determined that there is under-irrigation, can the problem be corrected with a border strip irrigation system? For many growers, irrigation frequency (e.g. one irrigation between cuttings) may not be adjustable, but it may be possible to adjust the set time to get more water into the soil. If a longer set simply generates more tailwater runoff, improved water management is not accomplished. This could happen if the soil infiltration rate drops off during irrigation until the soil seems to “seal”. Again, soil moisture measurements are very helpful here. If it is determined that surface irrigation practices can’t be satisfactorily improved, switching to another irrigation systems should be considered.

If over-irrigation is occurring, what can be done? First, it should be determined where the extra water is going. Over-irrigation water will either be contributing to deep percolation (sometimes called drainage) below the crop’s root zone or to tailwater runoff.

Dealing with excess tailwater runoff

If there is over-irrigation due to excess tailwater, there are a couple of approaches to solving the problem. The solution may be as simple as changing irrigation sets sooner. Turning off the water to a border strip too late means that excess water either accumulates at the end of the check or it flows off the end of the field as tailwater. In general, water should be turned off to a border check before it reaches the end of the field. The exact timing is influenced by the field slope, soil type, inflow rate to the check, and other factors. Some field management trial-and-error will be required to pinpoint the correct shutoff point.

When the conditions are right, it may be possible and desirable to automate the flow control to border checks. Automation may include automating the gates providing water to the field border checks as well as using a field-monitoring system to change irrigation sets when water has advanced a determined distance down a check.

Excess tailwater may still be generated, even when more attention is paid to controlling water to a border check. Under that condition, a tailwater return system that collects and reuses the tailwater should be seriously considered. For more information on tailwater return systems, see:

<http://anrcatalog.ucdavis.edu/Details.aspx?itemNo=8225>

One of the advantages of tailwater return is that the water is reused, increasing on-farm irrigation efficiency. For some growers, tailwater may simply go to a drain or to a ditch supplying downstream users. This may seem like a good reuse of the tailwater, but water quality is an issue. Any problem constituent (e.g sediment or pesticide) that is in the tailwater leaving a grower's field is the grower's responsibility. Collecting tailwater and reusing it on the ranch mitigates this water quality concern.

Dealing with Deep Percolation Losses

Deep percolation losses occur when more water is applied than the alfalfa root zone can hold. Frequently, this over-application is not uniform along the length of the field. The amount of water infiltrated at any location down the field is controlled by the soil infiltration rate and the length of time water is at that location. For simplicity and because we can hardly do anything else, we assume the infiltration rate is the same along the entire check length. This leaves us trying to control the time the water is at a location, often called the infiltration time, as a management strategy.

Excess water application can be due to two causes. First, it can be caused by too long a set time. A border check irrigation set time that is too long can result in deep percolation, but more closely monitoring irrigation sets and turning them off at the correct time may solve the problem. As it was with controlling excess tailwater runoff, under the right conditions it may be possible to automate the border check irrigation system.

A second cause of deep percolation loss is that it takes too long for water to reach the end of the border check. This is a common problem since farming large fields is more convenient and less expensive. It must be emphasized that the first rule of any irrigator is that the entire length of the border check be irrigated. This requirement sets the irrigation set time (and therefore the irrigation amount), not the time (or amount) to refill the water depleted from the root zone.

The solutions to over-irrigation due to water taking too long to reach the end of the field are: (1) move the water faster down the check, or (2) shorten the field length. Two potential changes that can be made to move water faster down the field are to increase the flow rate to the border check and to increase the slope on the field. Increasing the flow to a check may be accomplished by something as simple as running only 2 checks at a time versus 3 checks, diverting all the available irrigation water to the 2 checks. For more information on the impact on irrigation efficiency of increasing flow rate to border check, see "Improving Irrigation Efficiency of Border Irrigation" at: <http://calasa.ucdavis.edu/files/126189.pdf>

Increasing field slope requires a re-leveling of the field. There will be limits to potential slope increases imposed by the infrastructure (roads, ditches, pipelines, valves, etc.), and there is a cost associated with the re-leveling, but once it is completed irrigation practices are not greatly changed except for shorter set times.

Shortening the field length is the most effective way of reducing the amount of water applied to a field during an irrigation. It is easy to determine how much water can be saved by following the procedure and analysis outlined at:

http://cetulare.ucanr.edu/newsletters/Field_Crop_Notes48141.pdf

The disadvantages to shortening field lengths are that it is costly, often requiring an additional head ditch or source pipeline, an additional tail ditch, and likely an additional road to access the new pipeline or head ditch. All these changes require investment and take land out of production. In addition, shorter fields are more difficult to farm, requiring more equipment turns or the more frequent lifting and lowering of equipment when working the field.

Improving Irrigation Water Management of Sprinkler Irrigation Systems

A key to the efficient irrigation with any sprinkler system is determining the sprinkler application rate. Factors such as the sprinkler discharge rate (impacted primarily by operating pressure and sprinkler orifice size), sprinkler overlap, and in some cases by sprinkler travel speed all affect the application rate.

Application rate (inches/hour) information should have been provided by whoever designed and sold the sprinkler system, but frequently this information is lost over the years. In addition, sprinkler systems may change as a result of maintenance, repairs, and even attempts to “improve” the sprinkler system. An additional complication that is common is for the sprinkler system to be operated at a different pressure than it was designed for. This impacts the application rate but it can also impact the sprinkler irrigation uniformity.

Determining the application rate of an existing sprinkler system is best done by performing a field catch can evaluation in which containers are placed in the field, the sprinkler system is operated, and the water collected in the containers is measured. This information allows the determination of the sprinkler application rate as well as providing information on how evenly water is applied (often referred to as irrigation uniformity). While it is possible for a grower to do a catch can evaluation, it is probably better if a consultant or mobile irrigation evaluation team does the evaluation. There is equipment required and a steep learning curve to do irrigation evaluations so hiring someone who is familiar with them is often the most efficient.

With quality information on sprinkler application rate and uniformity, the grower can manage the system optimally. This primarily means matching irrigations to the alfalfa water demands (alfalfa ET). If irrigation uniformity is lower than desired, an irrigation professional can recommend improvements.

The last step, if improvements in management or physical changes in the sprinkler system do not achieve the desired level of irrigation efficiency or crop response, is to switch irrigation systems. For example, switching from side role sprinklers to a center pivot sprinkler system. It could also mean switching from sprinkler irrigation to drip irrigation.

Improving Irrigation Water Management of Drip Irrigation Systems

Drip irrigation of alfalfa is almost always subsurface drip irrigation (SDI) in which drip tape is placed below ground, at a drip tape lateral line spacing and depth selected by the grower and

designer. The spacing between lateral lines is chosen based on the ability to irrigate the alfalfa, ability to irrigate other crops in the crop rotation, and the cost of the irrigation system. Greater spacing between drip tape lateral lines is less expensive but may not adequately irrigate the crop due to insufficient lateral water movement.

The depth of tape placement is influenced again by the ability to irrigate the crop, installation issues (deep installation is more difficult than shallow installation), and the requirement to do field cultivation or other cultural practices above the tape. Some SDI user's choice of tape depth is even influenced by gopher or other rodent activity, and the belief that increased tape depth results in less rodent damage.

The SDI system's application rate should have been provided by the irrigation designer/supplier. If it wasn't or has been lost, the application rate can be estimated if the tape specifics (e.g. manufacturer, emitter spacing, tape diameter, etc.) and the operating pressure are known so that the tape discharge rate (gpm/100 feet) can be determined. Combining tape discharge information with tape lateral line spacing determines the application rate.

Field evaluation of a SDI irrigation system to gather information on irrigation system application rate and irrigation uniformity is extremely difficult and seldom done. It is often just assumed that the system was designed to operate at high irrigation uniformity. The real challenge with SDI systems is making sure they continue to operate as designed. Preventing clogging can be a challenge, particularly if the water quality is problematic, but there are resources available to help with maintaining microirrigation systems:

see the publication "Maintaining Microirrigation Systems" at
<http://anrcatalog.ucdavis.edu/Details.aspx?itemNo=21637>

or

the website at <http://micromaintain.ucanr.edu/>

as well as consultants and services that will do maintenance for a fee. Most SDI maintenance tasks are manageable with a willingness to be diligent, or to pay someone to take on maintaining the system.

Currently, the greatest challenge to alfalfa SDI systems is rodent damage. While rodent damage is an issue with all SDI systems, alfalfa poses particular challenges since gophers are extremely fond of alfalfa as a food and habitat, alfalfa has a full canopy making spotting of gopher mounds difficult, and alfalfa is a multi-year crop during which there is no cultivation.

The bottom line is that gophers have to be controlled if alfalfa SDI is to be used successfully. If the gopher population is not controlled, the leaks caused by gopher strikes on the tape will far exceed the ability to repair the damage. It is not uncommon for alfalfa SDI systems to be abandoned due to gopher damage.

Recently, a chemical that can be injected through the SDI system to repel gophers has reached the market. Since it is relatively new, issues such as its cost and affordability, its effectiveness, and its effective life are still being investigated. Such a product could be a very useful tool in combating gophers in alfalfa SDI systems.