

Fresno County Hay & Forage News

University of California Cooperative Extension

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Alfalfa Management To Improve Water Use Efficiency

The National Weather Service predicts most of the nation's major crop areas will be spared from a repeat of last season's drought conditions, but California might not be so lucky. Although local growers have been notified that they will receive their entire water allotment this year, there is still a need for improving water use efficiency. Management strategies are available to help growers make the best use of limited water supplies for crop production.

Water Requirements

Alfalfa yields are directly related to the soil moisture available for vegetative growth. Water requirements for production vary considerably and depend primarily on climate and soil water supply, while variety selection and management practices have less of an impact.

Normally, 36 inches of water satisfies the irrigation demand during the first year of the stand. First year alfalfa fields may have some remaining deep-soil moisture after harvest because of incomplete root development during the year of establishment. During the second year of growth, soil moisture sampling has shown that alfalfa plants utilized up to 16 inches of moisture remaining from the previous year.

Established stands of alfalfa require roughly 3.5 to 4.5 acre feet of water annually to produce maximum yields. They also require water earlier in the growing season than do annual crops. When temperature conditions are right for shoot growth in the spring, there is a relatively high demand for water by established alfalfa plants with extensive root systems.

Morphological and physiological features allow alfalfa to adapt to a wide

range of soil moisture conditions. Under moisture limiting environments, alfalfa can survive by extracting water from deep within the soil profile or the crop may become semi-dormant. Water stress negatively affects metabolism, development, growth, and ultimately harvestable yield. If the stress has not been too severe or has not lasted for an extended period, the developmental processes can proceed normally once the stress is removed by irrigation or rainfall, although yields are often decreased.

Influence of Water Shortages on Fertility and Nitrogen Fixation

For any crop to produce maximum yields, its root system must grow in a soil environment that has an adequate nutrient supply, good aeration, and suitable water content. Generally, either excesses or deficits of soil moisture limit root growth and function through reduced aeration and nutrient supply.

Soil and plant moisture deficits depress legume symbiotic nitrogen fixation. Nodule number per plant, nodule mass, and nodule size are all reduced by drought. Under extreme moisture stress, nodule shedding may occur. However, nodules subjected to severe water stress resume activity when soil moisture content is restored.

When alfalfa plants run short of water, they begin to lose the tiny root hairs which provide sites for nodulation. Plant growth slows considerably due to reduced availability of nitrogen and water. Root hairs will grow again under favorable conditions, however, potential yield has been lost during the time period required for new root

development. This problem can occur quickly in coarse textured sandy loam soils because of their limited water holding capacity.

Mobile nutrients move within the soil water. This type of nutrient is supplied to the plant primarily by the flow of water through the soil toward the root system which is caused by the roots absorbing water in response to transpiration. Mobile nutrients are swept along in this flow of water toward the root system where they can be absorbed. An example of a mobile nutrient is nitrate nitrogen.

Non-mobile nutrients do not move freely within the soil. They are held by soil particles or exist in the soil with relatively low solubility. Potassium and phosphorus are examples of non-mobile nutrients. As a result of their limited mobility in soil water, the plant must continually extend its root system to come near non-mobile nutrient sites. In a sense, the plant must explore and mine a soil for this type of nutrient.

The key to ensuring that a crop absorbs the greatest amount of nutrients for maximum growth and yield under drought conditions is to develop and maintain adequate soil fertility. When fertility levels are high, plants absorb the greatest amount of mobile nutrients per unit of water taken up, and non-mobile nutrient sites are also at their highest practical concentration.

Obtain maximum use of your limited water supply by optimizing production to increase water use efficiency.

Maximize Production With Limited Water

Alfalfa hay yields are greatest when moisture is readily available to the plant. Water is preferentially taken up by roots from soil layers where it is readily available. However, water is also continually withdrawn from drier soil layers when roots are in the area. Water extracted from drier soil is used less efficiently in dry matter production by the plant. Therefore, it makes sense to fill the effective root zone with water in early spring and keep it near field capacity throughout the growing season.

Dry matter accumulation (hay yield) is relative to the amount of food manufactured through photosynthesis, which increases with the amount of leafy shoot growth. Therefore, to maximize water use efficiency and yield, allow the plants to grow until about 50% bloom before harvesting. This will result in greater yields of somewhat lower quality feed. This practice will also lengthen the stand life of alfalfa plants.

After the last available irrigation water is applied, harvest at about 50% bloom or as soon as the shoot growth obviously stops, whichever comes first. If this growth is not enough to merit a hay harvest, then sheep could be used to remove the top growth. Mature tap roots of alfalfa will go dormant in the dry soil. Small root hairs may slough off, but a good stand of alfalfa will survive a one-season drought if water is applied the next winter and spring.

Determining Crop Water Use Requirements

Optimum production and quality for all field crops requires that adequate moisture be available in the soil. The two questions most often asked by growers are When do I irrigate? and How much water should I apply? Familiarity with the water budget method for scheduling irrigations may help growers answer these questions. The technique works for all crops and is based on crop water use rates and the soil water reservoir. Crop water use refers to the amount

of water lost through evapotranspiration (ET). ET includes water lost through transpiration from plant surfaces as well as water lost through evaporation from the soil surface.

The maximum amount of water that can be stored in the soil and utilized by plants is termed the available water (AW). AW depends on soil texture and is highest for clay soils and lowest for sandy soils. As the available water in the soil is extracted by crops, they begin to suffer a yield-limiting stress. The percentage of the soil moisture which can be removed before the crop is adversely stressed is termed "percent allowable depletion". Yield reductions can be prevented by irrigating when an allowable soil moisture depletion has occurred. The allowable depletion depends on crop type, stage of growth, root depth, and soil type. For example, a deep-rooted crop in a clay soil can tolerate a larger allowable depletion than a shallow-rooted crop in a sandy soil. For alfalfa, the allowable depletion is about 50% of the available soil moisture. Deciding when to irrigate is simply a matter of determining when accumulated ET reaches the allowable depletion.

Determining Soil Moisture Depletion by "Feel"

Efficient irrigation requires reliable and timely estimates of soil moisture depletion between irrigations. One way to check how much moisture has been removed from the soil is by utilizing the "feel" and appearance of soil. A sample of soil is formed into a ball, and then rubbed between the thumb and index finger to "feel" its moisture level. The ability to form a ball and the feel is correlated with a soil moisture depletion for a particular soil texture. The depletion value in inches of soil moisture depletion per foot of depth is multiplied by the depth interval over which the sample is taken. Guidelines for this procedure are presented in Table 1.

Improving Irrigation Efficiency

Irrigation efficiency depends on several factors including the rate water moves down the field, the length and slope of the run, and soil uniformity. It is much more difficult to improve the efficiency of surface irrigation systems as compared to drip or sprinkler systems. With any system, water may be

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Research Results: Evaluating The Effects of Mid-Summer Drought

In a trial conducted by Carol Frate and Bruce Roberts, farm advisors from Tulare and Kings counties, the effects of mid-summer drought on alfalfa were evaluated. Treatments included a standard of two irrigations between cuttings, an "excess" treatment of three irrigations between cuttings, a single irrigation between cuttings, an irrigation cut off in July and August, and a July termination of irrigation until the following spring. Hay yields were greatly reduced by deficit irrigation and cutoff treatments. After two years of differential irrigation, all treatments were irrigated twice per cutting for the third year of production during which all treatments produced as well as the standard.

Quality did not decline significantly until water stress became severe. Quality differences were not evident when the hay was only slightly stressed. There was a trend toward higher quality the first cutting after irrigation was resumed, but it was probably due to delayed regrowth and the subsequent harvest of less mature forage.

Overall, water management affected yield more than quality in this trial. The effects on quality of raking and the conditions at baling are probably greater than those caused by water stress. The alfalfa recovered well after one irrigation following severe drought and there were no long-term effects on yield.

lost during application through deep percolation, runoff, and/or evaporation. Therefore, extra water must be applied with each irrigation to compensate for these losses and for the non-uniformity of water application by the irrigation system.

The amount of water applied per set depends on the flow rate into the field, acres irrigated per set, and set time. The latter values are easy to calculate, but flow rates for surface systems are not so easy to measure. Publications are available for constructing devices to measure flow rates using flumes.

Uniformity

The key to improving efficiency of water use is to increase uniformity by applying the same amount of water to all parts of the field. The more uniform the applied water, the higher the application efficiency by reducing deep percolation losses. Potential benefits from improving uniformity include stretching limited water supplies, reducing pumping costs and fertilizer costs, and reducing subsurface drainage problems. Improvements, however, may require increased capital, maintenance/repair costs, and increased management/labor costs.

The uniformity of surface irrigation systems depends on soil variability and the time required for water to reach the end of the field (referred to as the advance time). Unfortunately, irrigation methods used in hay crops are inherently inefficient due to the time it takes for water to flow the length of the field. More water is applied in the areas where water spends more time. Because of the advance time, infiltration times are greater at the head of the field than at the end. Thus, more water infiltrates at the head, with decreasing amounts infiltrating along the run length (Figure 1). While little can be done to reduce soil variability, design and management changes can reduce the advance time, which will increase uniformity.

Methods for improving the uniformity of surface irrigation systems include:

1) *Shorten run lengths to 600 - 700 feet maximum.* Reduce deep percolation

losses by 50 to 80 percent by cutting the run length in half. This is an extremely effective method of improving the uniformity of surface irrigation systems. However, this measure may require major modifications to an irrigation system due to extra head and tail-water ditches, which may be impractical for border systems irrigating permanent crops.

2) *Increase border inflow rate.* This requires reducing the number of borders irrigated per set.

3) *Convert to surge irrigation.* Surge irrigation involves allowing irrigation water to flow down the run length for a certain distance, and then stopping the flow until water in the furrow or border has infiltrated into the ground. This system can be automatically controlled. Water is then turned back into the furrow/border and allowed to advance down the field for an additional distance and then again stopped. This cycle of on/off times is repeated until the water has advanced to the end of the field. Deep percolation losses can be reduced by 30 to 40 percent on soils with moderate to high infiltration rates. Less water is required for complete coverage of the field compared to continuous flow irrigation.

4) *Convert to level basins or furrows.* Maximum run lengths should not exceed about 1/8 mile. High inflow rates are also desirable. No surface runoff will occur when this modification is made.

Set times must be decreased by an amount equal to the difference between the normal advance time and

the new advance time. For example, if the advance time of the reduced run is 10 hours compared to 18 hours for the original run, the set time must be reduced by 8 hours. Failure to do so will result in excess water applied to the field.

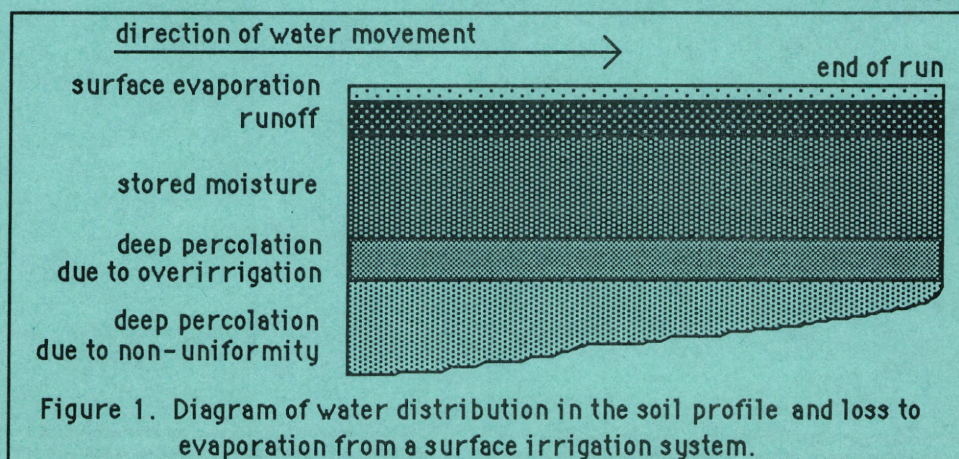
Along with increasing efficiency through reducing the time it takes to get water across the field, tailwater recovery systems should be in place to catch the runoff. The increased runoff due to converting your irrigation system can be easily recovered; water lost through deep percolation cannot.

Finally, check your pump to insure that it is operating at maximum efficiency. Pump wear increases the clearance between the impeller and the pump housing which causes both pump capacity and total head to decrease. Adjustments should be made by the pump dealer! More water is applied when the pump is operating at its highest efficiency, so the the number of hours per set can usually be reduced, which will save energy costs.

Critical Periods

Typically crops are more sensitive to water stress at some growth stages than at others. During these sensitive growth stages, defined as the critical periods, excess soil moisture depletions are the most detrimental to yield. Critical periods depend on crop type, soil, root depth, rate of plant development, evapotranspiration demand, disease, and fertility. Adequate soil moisture should be maintained during critical periods. The critical period for soil water stress for alfalfa hay is just after cutting.

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Other Sources of Information

Apamphlet entitled "Guidelines for Reducing Irrigation Water Use During the 1989 Drought", prepared by the Fresno Area Drought Management Task Force, is now available. This document contains numerous suggestions to assist growers in reducing water use. Suggested conservation strategies are listed below:

1. Limit water application to the crop's actual needs.

- recharge from over-irrigation is not desirable this year
- over-irrigation leaches chemicals and fertilizer out of the root zone, promotes weed growth and causes water logging and potential drainage problems
- forego the normal leaching requirement

2. Avoid run-off.

- confine water application to the cropped land
- provide for recycling of runoff from irrigated fields on adjacent fields

3. Use irrigation practices that control and conserve water.

- match water application to rooting depth and soil moisture deficiency
- avoid 24-hour sets when fewer hours will do the job
- consider night-time irrigation to reduce evaporation loss
- monitor the soil moisture status periodically
- split long runs in half
- re-level the fields
- minimize soil tillage to reduce evaporation
- replace open ditches with gated pipe, buried pipelines, etc.
- leave sandy fields fallow and/or eliminate double cropping

4. Control weeds that compete with crops for moisture.

- mow and use herbicides to control weeds rather than discing to reduce evaporation
- eliminate cultivation between irrigations when ground is weed free

5. Use water conservation practices that are specific to certain crops.

- use deep moisture carried over from previous years and shallow water tables for permanent crops
- consider only one irrigation between cuttings of alfalfa hay
- cut water early on alfalfa hay and allow it to go dormant

Fields which are forced into dormancy by drought during this season, but are intended for 1990 production, should be irrigated as soon as water is available to fill the root reservoir. This will allow root hairs and nitrogen fixing nodules an opportunity to become established early in the spring of 1990.

If these recommendations are followed for more than one year on most western Fresno County soils, a salt accumulation in the surface can be expected.

Hay & Forage News is produced by Shannon C. Mueller, Agronomy Farm Advisor

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SOIL MOISTURE AND APPEARANCE CHART

SOIL TEXTURE CLASSIFICATION

MOISTURE DEFICIENCY IN./FT.	COARSE (LOAMY SAND)	LIGHT (SANDY LOAM)	MEDIUM (LOAM)	FINE (CLAY LOAM)	MOISTURE DEFICIENCY IN./FT.
	(field capacity)	(field capacity)	(field capacity)	(field capacity)	
0.0	Leaves wet outline on hand when squeezed.	Leaves wet outline on hand; makes a short ribbon.	Leaves wet outline on hand; will ribbon out about one inch.	Leaves slight moisture on hand when squeezed; will ribbon out about two inches.	0.0
0.2	Appears moist; makes a weak ball.	Makes a hard ball.	Forms a plastic ball; slicks when rubbed.		0.2
0.4	Appears slightly moist. Sticks together slightly.	Makes a good ball.	Forms a hard ball.	Will stick and ribbon easily.	0.4
0.6	Very dry, loose; flows through fingers. (Wilting point)	Makes a weak ball.	Forms a good ball.	Will make a thick ribbon; may slick when rubbed.	0.6
0.8		Will not ball.	Forms a weak ball.	Will ball; small clods will flatten rather crumble.	0.8
1.0			Small clods crumble fairly easily.	Clods crumble.	1.0
1.2		Wilting point.	Small clods are hard (wilting point).		1.2
1.4				Clods are hard, cracked (wilting point).	1.4
1.6					1.6
1.8					1.8
2.0					2.0

*Adapted from "Field Method of Approximating Soil Moisture for Irrigation," by John L. Merriam, Transactions of the American Society of Agricultural Engineers, Vol. 3, No. 1, 1960.

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