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Irrigation Scheduling for Alfalfa Hay in Southern Alberta

Irrigation management is about controlling the rate, amount, and timing of applied irrigation water in a planned and efficient manner. With good irrigation management, an alfalfa hay crop can have high yield and quality potential.

Irrigation management

The goal of irrigation management is to use available irrigation water effectively in managing and controlling the soil water environment of crops to do three things: promote the desired crop response, minimize soil degradation, and protect water quality.

Proper irrigation management requires a good understanding of a number of factors:

- soil fertility (crop nutritional requirements)
- soil-water-plant relationships
- crop type
- crop sensitivity to water stress
- crop growth stages
- availability of a water supply
- climatic factors that affect crop water use such as rainfall, temperature, humidity, wind speed, and net radiation
- irrigation system capabilities and limitations

Equipped with such knowledge, an irrigator can develop a workable and efficient irrigation scheduling program.

Depletion of soil water to less than 60 per cent of available can result in reduced alfalfa hay yield and quality.

Strategies

A workable and efficient irrigation management strategy should be crop-specific. Crop-specific irrigation management strategies mean available water is used efficiently to meet a specific crop's water requirements for maximum water productivity.

Generally, the goal is to ensure that water is available at germination and in early development by applying light, frequent irrigations (if there is no rainfall). This method promotes vigorous growth for a healthy crop stand and replenishes and increases available soil water content in the entire root zone during the establishment year.

In the following years of production, applying full irrigations to maintain adequate soil water content is essential for promoting vigorous growth, high yield, and a desirable hay quality. The aim of this irrigation strategy is to replenish and increase available soil water content in the entire root zone starting as early as possible in spring and throughout the growing season.

Such a strategy will allow modern sprinkler irrigation systems to keep up to crop demand during the peak water-use period, which typically occurs during the early bloom growth stage in late June (for the first cut), early August (for the second cut), and after a killing frost in the fall (for the third cut).

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Crop-specific irrigation management strategies are usually applied to adjust for the following differences among crops:

- effective root zones
- sensitivity to water stress
- types (cool versus warm-season)
- vulnerability to diseases at various crop growth stages
- response to soil fertility levels
- plant population/densities
- physiologic maturity (timing of last irrigation)
- potential income

Alfalfa hay water needs

Alfalfa is a high water use forage crop because it has a deep perennial root system, produces a substantial amount of above ground biomass, and has a longer growing season compared to other irrigated crops grown in southern Alberta.

In addition to requiring adequate soil water, alfalfa is more productive when it is grown under optimal conditions: well inoculated with appropriate nitrogen-fixing bacteria (*Rhizobium meliloti*), well fertilized, pest-free, seeded in a soil with adequate internal drainage, seeded using a proper seeding rate for optimum and uniform canopy, and adequate day length and temperature.

The water requirement or evapotranspiration (ET) for alfalfa hay depends on cultivar selection, growth stage, canopy density, harvest date, climatic conditions, and irrigation and crop management. Alfalfa uses water for growth and cooling purposes.

Alfalfa grown under optimal conditions requires 540 to 680 mm of water per growing season in southern Alberta. It is estimated that irrigated alfalfa uses about 100 to 125 mm of water for every ton (907.2 kg or 2,000 lb) of hay produced.

Alfalfa is relatively drought tolerant, but its growth depends on the availability of water to the roots. Water is needed for germination and early seedling growth. If available soil water is kept between 60 and 100 per cent, alfalfa will germinate and grow rapidly into a full stand in the year of establishment.

Adequate water and fertilizer are essential for alfalfa to emerge quickly from dormancy in the spring and reach the first-cut peak daily water use of nearly 9 mm in late June, the second-cut daily peak water use of nearly 8 mm in early August, and the third-cut peak water use of nearly 7 mm in late September (Figure 1). Because alfalfa is a cool-season crop, the greatest percentage of the seasonal yield (nearly 40 per cent) comes from the first cut, which also has the highest water use efficiency of the three cuts.

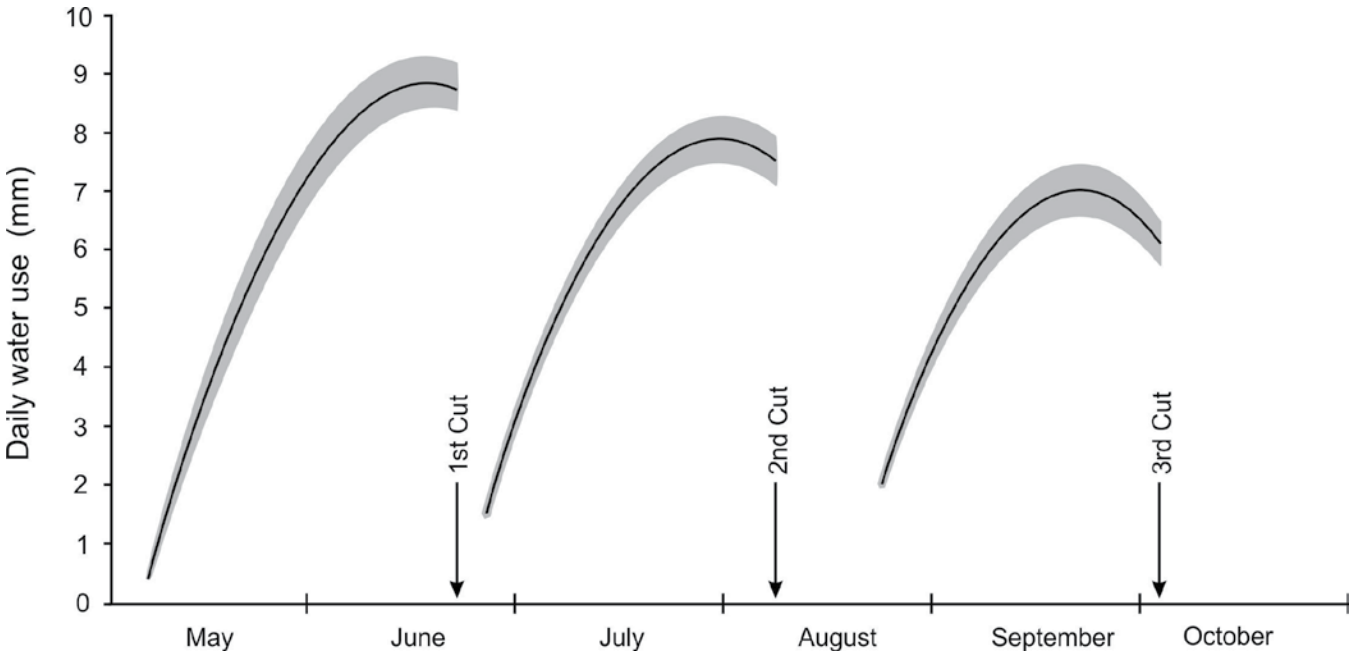

Figure 1. Daily water use for the first, second, and third cuts during different growth stages of irrigated alfalfa hay in southern Alberta. The shaded area indicates variation in alfalfa water use depending on cultivar, plant density, age, and climatic conditions. Differences among cuts reflect differences in climatic conditions such as photoperiod and temperature (ambient and soil).

Typically, the roots of a well-irrigated alfalfa plant grow to an effective water extraction depth of 120 cm in a well-developed soil profile. Root distribution is concentrated near the surface; hence, alfalfa obtains nearly 40 per cent of its seasonal water from the upper 30 cm, 70 per cent from the upper 60 cm, and 90 per cent from the upper 90 cm of the 120-cm active root zone in the production years.

Since only 10 per cent of seasonal water use for alfalfa is extracted from the 90 to 120-cm depth increment, it is essential for irrigators to pay more attention to the water status in the top 90 cm of the active root zone. The active root zone changes from a few millimetres at emergence to a maximum depth of 120 cm at the end of the establishment year.

The roots of non-irrigated alfalfa (particularly taprooted varieties) penetrate deeper than 120 cm (adaptation to stress from water deficits) and reach maximum depths in the third year of the stand.

Irrigation scheduling strategy

The availability of adequate soil water for emergence, stand establishment, and achievement of maximum, high-quality yields is crucial for producing a profitable alfalfa hay crop.

Establishment year

The establishment of a high-yielding, pure alfalfa stand requires careful attention to fertilizer, weed control, and effective irrigation water management. Effective irrigation management for alfalfa uses soil water levels in the root zone as a measure for starting and stopping irrigations to maintain adequate soil water content.

Irrigation can be used most effectively in promoting germination and emergence by wetting the soil profile to field capacity before seedbed preparation and the seeding operation. Avoid irrigation just after seeding because it may cause seed washing and crusting of some soils and reduce plant population and stand uniformity.

After emergence, the alfalfa seedling roots require ample water for rapid growth. To ensure that ample water is available to the young roots during the early seedling and vegetative growth stages (unifoliolate, cotyledonary, and trifoliolate leaf buds formation), and contractile (crown development) growth stages (i.e. the first 10 weeks), light and frequent irrigations (15 mm per irrigation event) should be applied to maintain soil water in the 0 to 30-cm depth at greater than 60 per cent of available in the establishment year.

Irrigation water applied during the early growth stages should meet crop water requirements and build up soil water to near field capacity in the 30 to 120-cm depth for later crop use after the contractile growth stage. To prevent runoff, irrigation water application rates should not exceed soil intake (infiltration) rates.

The practice of withholding irrigation following emergence for the purpose of increasing root penetration is counterproductive because early water stress (available soil water less than 60 per cent) will suppress seedling root growth more than shoot growth for alfalfa. Water stress decreases stem number and diameter, internode numbers and length, and leaf size; hence, stand vigour and health.

If alfalfa is seeded in spring and the stand establishment is good and healthy, the initial cut may occur in the first or second week of August (16 weeks from seeding) after the contractile growth is complete, followed by a full irrigation to fill up the 120-cm root zone. Availability of water to the roots enables the crop to recover quickly from defoliation stress and rapidly grow to a full stand prior to winter.

As the ambient and soil temperatures cool down, the day length shortens, and the soil water is depleted by the growing alfalfa crop in the fall, the taproots start to enlarge and extend into deeper soil horizons. These roots store carbohydrates produced by photosynthesis. Stored carbohydrates provide energy for re-growth after cutting, winter survival, and initial spring growth. Soil water should be monitored so that the crop goes into winter when the available soil water is about 70 per cent. Available soil water greater than 70 per cent (near field capacity) contributes to increased alfalfa winterkill or winter injury.

Production years

Effective first-cut, second-cut, and third-cut alfalfa irrigation scheduling uses soil water levels in the 120-cm root zone as a measure for starting and stopping irrigations. Adequate soil water, coupled with a balanced and adequate fertility program, is critical for alfalfa growth for high yield and quality.

A well-fertilized and pest-free alfalfa stand will reach maximum yield and quality if ample water is available in the root zone during production years. To ensure that ample water is available to alfalfa roots, available soil water should not be depleted to less than 60 per cent in the 120-cm root zone.

Irrigations should be scheduled to fill the entire root zone to 100 per cent of available soil water, especially during dry and hot periods in July. The last irrigation before cutting should be far enough in advance that the available soil water is nearly 70 per cent during harvesting and should be timed with the proper application amount within a week after cutting.

Full irrigations should always be applied immediately after the first and second cut to maintain high alfalfa water

productivity. Irrigation management for the third-cut alfalfa hay crop should be designed to encourage the accumulation of carbohydrates in the roots to provide energy for re-growth after cutting, winter survival, and spring growth.

Soil water should be monitored so that the available soil water in the root zone is at about 70 per cent when the third cut is completed, typically after a killing frost in early October (Figure 1).

Soil texture

The irrigation amounts required to replenish the 120-cm root zone once the allowable soil water depletion level is reached (available water at 60 per cent) will vary with soil texture (Table 1).

Conclusion

Using suitable irrigation strategies with alfalfa can mean a healthy hay crop with high yield and quality potential. In addition to ensuring that the alfalfa hay crop is well fertilized and well protected from pests, growers are encouraged to manage irrigation properly by regularly monitoring soil water to ensure that the availability of water does not become a limiting factor in producing a high yield and the desired quality of the alfalfa hay crop.

Applying irrigation just before the available soil water is depleted to 60 per cent and replenishing available soil water to near field capacity in the appropriate root zones will greatly assist in achieving a healthy stand during the establishment year and in producing a high-yielding and high-quality alfalfa hay crop.

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Table 1. Soil texture-based estimation of total available water and water amounts per irrigation event for alfalfa during the alfalfa growing season in the hay production years

Soil texture	Total available water in a 120-cm root zone (mm)	Water required to replenish soil to field capacity at 40% allowable depletion (mm)
Loamy sand	136	54
Sandy loam	168	67
Loam	216	86
Sandy clay loam	182	73
Silt loam	240	96
Clay loam	240	96
Silty clay loam	264	105
Sandy clay	206	82
Silty clay	254	101
Clay	230	92

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