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Forage Production with Limited Irrigation

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By selecting the right forages and using efficient management practices with limited irrigation or drought conditions, producers can achieve reasonable forage production with reduced input costs.

In many parts of Nebraska irrigation water is limited due to declining groundwater, pumping restrictions, and reduced surface water, resulting from prolonged drought. Producers in these areas face the challenge of producing forage under different circumstances than in the past. By answering several questions related to forage production goals, you can determine which forages are most likely to be the most profitable for your individual needs and operation.

Use these questions to help determine which forages may best fit into a limited-irrigation production system.

- When and how much irrigation water is available?
- What is a typical seasonal distribution of precipitation?
- When is the forage needed and what time of year will it be grown?
- What type of forage is needed? Is the forage needed primarily as an energy or protein source?
- How will the forage crop be harvested? Is it for hay, silage or pasture?
- What is the estimated harvest cost per ton of dry matter?
- Is perennial or annual forage to be used?
- Will the forage crop be used in part of a rotation?
- What kind of drought tolerance is needed for the crop?
- What is the soil type and soil fertility where the crop will be grown?
- What irrigation method will deliver water to the crop?

Water-Use Efficiency of Forages

Forages can vary greatly in water-use efficiency, defined as pounds of forage produced per inch of water applied. In addition to forage species differences, the time of year the crop is grown, how much total water is available and the time of harvest can all affect the outcome.

In general, warm-season forage crops are more water-use efficient than cool-season crops and annual forages use water more efficiently than perennial forages. Legumes tend to use water less efficiently than grasses.

When moisture is plentiful, water-use efficiency estimates for warm-season annual grass forages such as foxtail millet, sudangrass, and sorghum-sudangrass hybrids range from 2.5 to 3.5 inches of water per ton of yield. Efficiency for oats, a cool-season annual, is estimated at 4.5 to 5.5 inches per ton, cool-season perennial grasses at about 5 to 6 inches per ton; and alfalfa at 6.5 to 7.5 inches per ton.

Under limited water allocations, forage water-use efficiencies will differ in total pounds of dry matter produced per inch of water applied than when crops have enough water to express full production potential. Use water-use efficiency information as a guide along with establishment, fertilizer, and harvesting costs to determine which forage will most likely be profitable in a specific production system.

Several factors influence how effectively a forage crop converts water into pounds of forage. These include:

- Soil type and water holding capacity
- Available soil water
- Amount of residue and tillage practices
- Weather conditions and rainfall
- Physiological stage of plant maturity
- Yield limiting factors such as stand quality, soil fertility, soil compaction, weeds, and insects

Irrigation Management

Irrigation efficiency and management is critical when dealing with limited water supply. Water-use efficiency in forage production is greatly improved by scheduling irrigation when plants will most effectively use the water. Knowing a crop's water requirements and the growth stage when irrigation is most efficient will help optimize using available water to achieve production goals. Crop water-use estimates over the growing season also should be considered. Estimates for alfalfa and cool-season pasture can be found in NebGuide G1465,

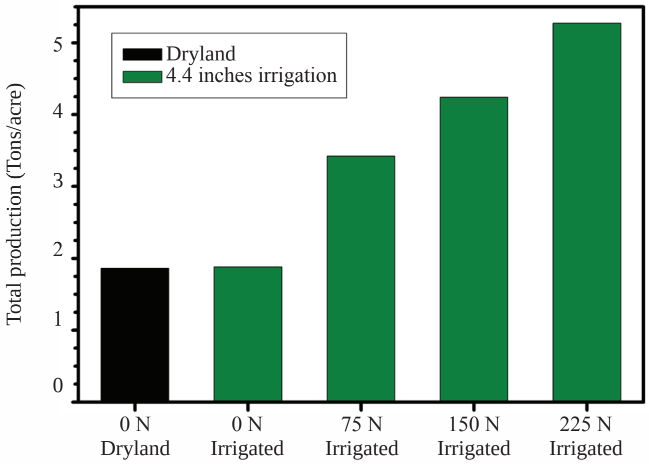


Figure 1. Effect of nitrogen fertilizer rate (lb N/acre) on total forage production of cool-season perennial grasses under dryland or irrigated conditions.

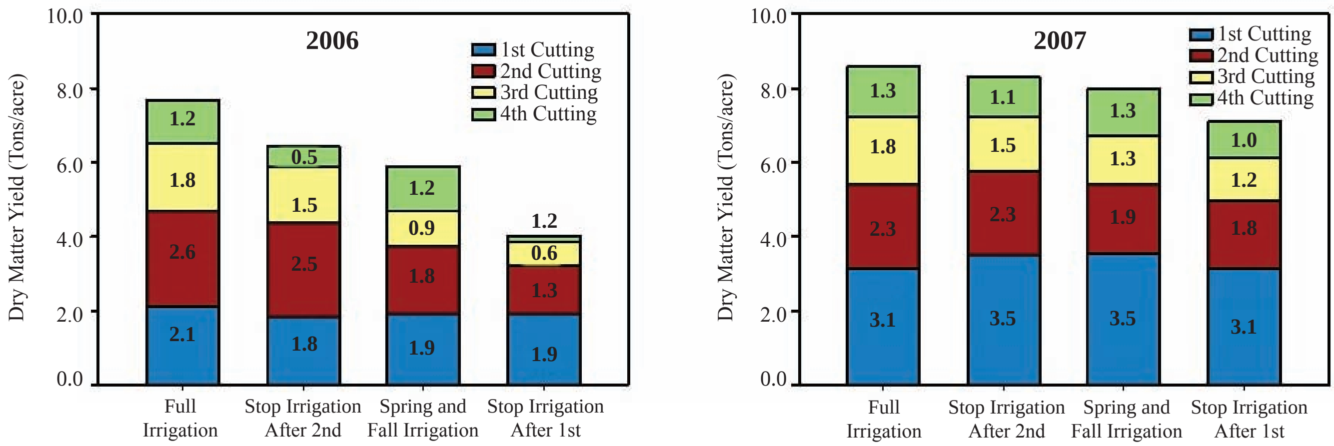


Figure 2. Effect of irrigation scheduling treatment on alfalfa cutting and total yield in 2006 and 2007. (From Lindenmayer et al. 2008)

Crop Water Use in Western Nebraska. Further information on scheduling can be found in EC709, *Irrigation Scheduling: Checkbook Method*.

Table I. Forage yield response of foxtail millet to five irrigation levels, North Platte, 2006.*

Irrigation (inches)	*Total water (rainfall + irrigation) (inches)*	*Forage Yield (Tons/acre)*
0	2.65	0.40
2.22	4.87	2.18
4.62	7.27	3.52
6.23	8.88	3.57
8.03	10.68	3.59

*Foxtail millet was planted July 1 and harvested August 31. Rainfall and irrigation amounts were for that period.

Trial results in *Table I* provide an example of forage yield response to irrigation level for foxtail millet. Yield without irrigation during the droughty two-month growing period was poor (0.40 tons/ac) while yield with 2.22 inches of irrigation water resulted in moderate yields. Applying more than 4.62 inches of irrigation did not increase yield (plants had reached their production potential) and was an unnecessary use of water and expense.

Soil Fertility

Soil fertility greatly affects the pounds of forage produced per inch of water applied. Crops use water most efficiently when grown in soils with adequate fertility. Results from a University of Nebraska–Lincoln trial found that supplemental irrigation water (4.4 inch) did not increase forage production of cool-season perennial grasses grown in a nitrogen-deficient soil *(Figure 1)*. However, production increased when nitrogen was applied along with irrigation. Use soil test results along with crop nutrient and water requirements to determine where dollars will most effectively be spent to produce forage.

Timing of Harvest

Timing of harvest affects both the quantity and quality of a grazed or mechanically harvested forage crop. Forage quality is higher when plants are at a younger growth stage (less mature). Yield, however, will be less than if plants were allowed to reach later growth stages. Plants use water rapidly as they move into a reproductive state and begin to produce seed. The earlier the crop is harvested in that reproductive state, the less total water will be used. Harvesting will temporarily lower perennial forages' water use and drastically reduce water use for annual forages you will only harvest once.

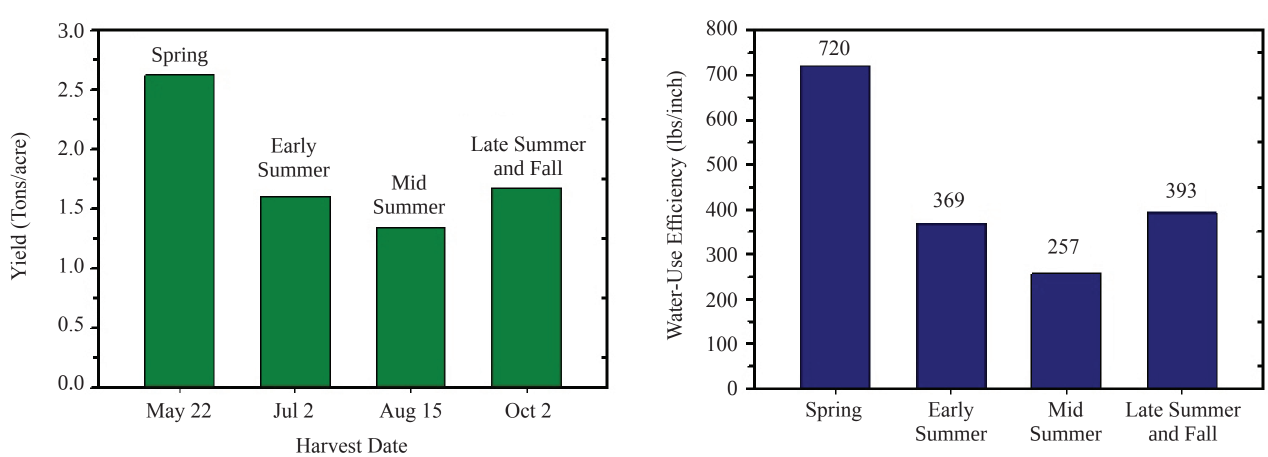


Figure 3. Seasonal yield of irrigated cool-season perennial grasses (left) and water-use efficiency (pound forage/inch of water) (right) during those seasonal periods, North Platte.

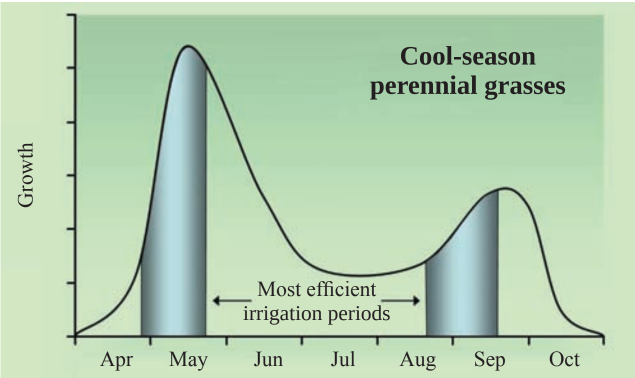


Figure 4. **Typical growth pattern of irrigated cool-season perennial grasses. Shaded bars represent rapid growth phases for these grasses and periods of efficient irrigation.**

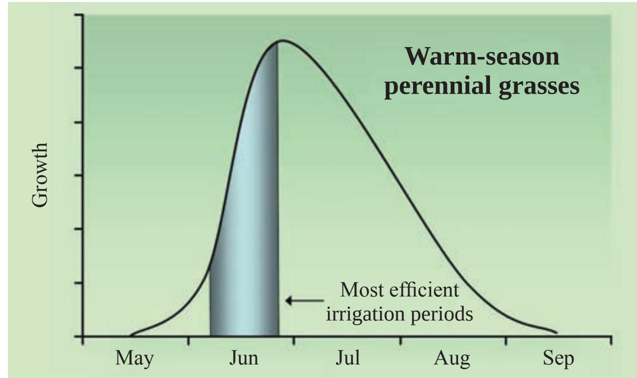


Figure 5. **Typical growth pattern of warm-season perennial grasses. Shaded bars represent rapid growth phases for these grasses and periods of efficient irrigation.**

Forage Response to Limited Irrigation

Alfalfa

Alfalfa can produce very high-quality forage and is very drought-tolerant. However, alfalfa is not one of the more water-use efficient crops in terms of pounds of forage produced per inch of water applied, especially when fully irrigated over the entire production season. Alfalfa is a deep-rooted crop. It can utilize water deep in the soil profile not captured by other crops and will become semi-dormant when water is not available.

Colorado alfalfa research reported yield response to different irrigation scheduling strategies *(Figure 2)*. Although there were differences in individual cutting yield, total yield, and yield between years, water-use efficiency was greater in the partial irrigation treatments. In addition, research concluded that alfalfa does have the ability to recover from drought stress and partially irrigated stands had higher crown and stem densities than fully irrigated stands. Additional information on alfalfa can be found in NebGuide G1778, *Irrigation Management and Crop Characteristics of Alfalfa*.

Cool-season Perennial Grasses

Cool-season grasses such as orchardgrass, smooth bromegrass, meadow bromegrass, creeping foxtail, festulolium, tall fescue, and intermediate wheatgrass begin using water when growth starts in early April. Initial water use is low due to minimal foliage and cool temperatures. During the rapid growth phase in May, daily water use increases until seedhead emergence or until the forage is removed by grazing or haying. The pattern of water use is similar for subsequent regrowth and harvest cycles. The seasonal peak in water use occurs in July and early August when temperatures are warmest.

Cool-season grasses need about 12 inches of irrigation water annually in eastern Nebraska and 14 to 20 inches in the central and western parts of the state for maximum production. Under fully irrigated situations, or when irrigation occurs for selected periods during the growing season, keep soil moisture near 50 percent of the plant-available level.

With limited water, irrigation scheduling is critical for the most efficient use of water, but also consider soil type, field topography, and grazing schedule. For medium- and fine-textured soils, avoid irrigating a currently-grazed paddock to limit soil compaction and potential damage to plants from hoof action.

Research results shown in *Figure 3* show that water-use efficiency (pound forage/inch of water) is greatest during spring.

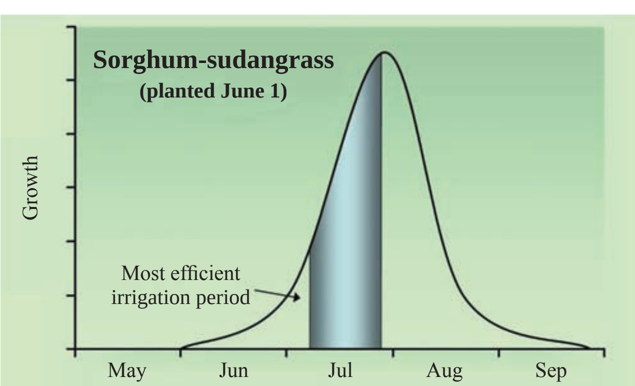
When limit-irrigating cool-season grasses, apply water as needed in the spring and early summer with a smaller amount allocated for the fall, if possible *(Figure 4)*. This timing corresponds to periods when temperatures and day length promote rapid growth. This results in the greatest water-use efficiency as illustrated in *Figure 3*.

Irrigation in late summer and fall will stimulate growth for fall pasture.

An additional benefit of fall irrigation is that new grass tillers will develop and emerge, with many of those tillers resuming growth the following spring. Adequate soil moisture going into winter reduces the potential of winter-injury to plants.

Depending on the amount available, little or no water could be applied during the mid-June to mid-August period. Without irrigation, grass growth will be minimal at this time and, depending on rainfall, the grasses may go into summer dormancy, but will resume active growth in the fall or the following spring when moisture and temperature are more favorable.

There are differences among cool-season grass species and their abilities to grow during the heat of mid-summer. Given adequate water, orchardgrass and tall fescue, for



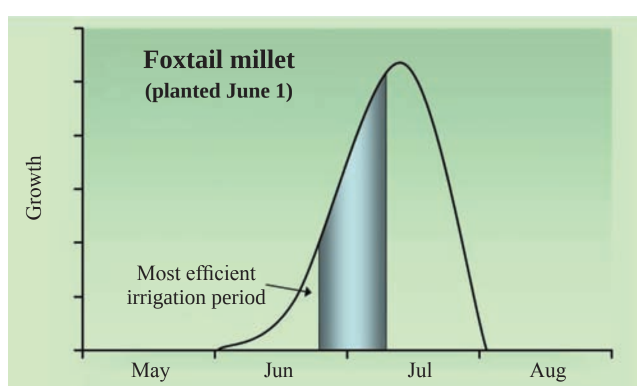
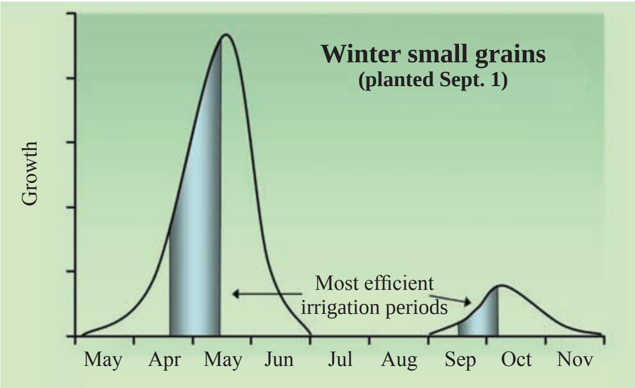


Figure 6. **Typical growth pattern of warm-season annual grasses. Shaded bars represent rapid growth phases for these grasses and periods of efficient irrigation when planted at the indicated dates.**



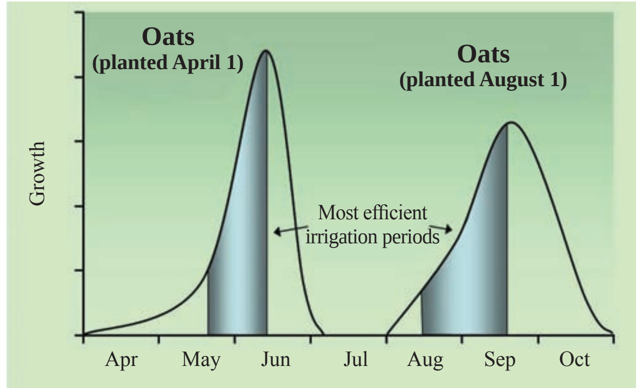


Figure 7. Typical growth pattern of cool-season annual grasses. Shaded bars represent rapid growth phases for these grasses and periods of efficient irrigation when planted at the indicated dates.

example, will maintain moderate growth through the summer. Intermediate and pubescent wheatgrass have excellent spring production but produce minimal summer growth, regardless of the amount of irrigation water applied.

Wheatgrasses are relatively drought-tolerant, making them ideally suited for very limited irrigation situations where water might be applied only during spring, as needed.

Grazing management may also affect irrigation water efficiency. Grazing paddocks to maintain a residual stubble height of 5 to 6 inches will result in less surface evaporation and potential runoff. Additionally, grass regrowth will be faster when stubble heights are at these levels compared to heavy grazing to a 2 to 3 inch stubble height.

Warm-season Perennial Grasses

The rapid growth phase for most warm-season grasses that are used for pasture or hay occurs during June *(Figure 5)*. Irrigation at this time will result in the greatest increase in forage production should rainfall be limiting. Irrigation after grazing or haying in late June to early July will stimulate regrowth of warm-season grasses. Adequate soil moisture is also important for initial spring growth of warm-season grasses, which occurs about mid-May. Late summer irrigation of warm-season grasses has a tendency to promote growth of weedy winter annual plants such as cheatgrass.

Annual Forages

Although warm-season annual grasses such as foxtail and pearl millet, sudangrass, sorghum-sudangrass hybrids, and teff have a relatively high heat unit requirement, they are among the most water-use efficient plants used for forage.

Provide adequate soil moisture during germination and early seedling growth, and irrigate during the species' rapid growth periods for the greatest increase in forage yield *(Figure 6)*. Most warm-season annuals are planted in late May to early June when soil temperatures reach appropriate levels. However, trials have shown that planting them after wheat harvest (mid to late July) may result in forage production of about 2.5 tons/ac for foxtail millet and teff and about 4 tons/ac for sorghum-sudangrass hybrids.

Cool-season forage crops include winter annuals, such as wheat, rye, and triticale, and spring-planted annuals such as oats or barley. Adequate soil moisture during germination and early seedling growth is important for cool-season annuals planted for forage. When grown for grain production, water availability during reproductive and grain-fill growth stages is critical. However, when managed as a grazing or hay crop, place emphasis on meeting the plant's water needs during rapid growth stages *(Figure 7)*. While moderate water stress during vegetative stages can reduce yield, it often leads to improved forage quality.

Oats can also be planted in late July or early August, and have the potential to produce 2.0 to 2.5 tons of forage per acre for fall use. However, water use and irrigation needs during August and early September can be relatively high, reducing production efficiency, especially when compared to spring-planted oats.

Annual species like turnips, forage rape, and other brassicas — either planted alone or in mixtures — have also been used for forage. Adequate water for these small-seeded species is important during germination and early growth because of their shallow planting depth.

Cover crops also used for forage, sometimes referred to as forage cocktails, are diverse mixtures of several cool- and/or warm-season grasses, legumes, and broadleaf plants that are either spring- or summer-planted. The critical period when water is most needed for growth will vary with the mixture, but all mixtures need sufficient moisture to become established.

Whether they are grazed or harvested for hay, drought stress on many cool- and warm-season annuals increases the forage's risk of nitrate accumulation. This risk is increased on fields where excess nitrogen fertilizer or manure has been applied. In all forages, weeds are water-wasters, so early identification and control can save water and increase quality and quantity of forage.

References

Lindenmayer, B., N. Hansen, M. Crookston, J. Brummer, and A. Jha. 2008. Strategies for reducing alfalfa consumptive water use. p. 52-61. *In*: Proc. AGU Hydrology Days. Colorado State University.

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