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G98-1354 Irrigating Corn

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Irrigating Corn

This NebGuide discusses corn irrigation strategies options and objectives.

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There are over 16 million acres in harvested row crop production in Nebraska. About 8 million of these acres are irrigated. Corn occupies approximately 70 percent of the irrigated acreage, or 5.6 million acres. Given this, improving irrigation management on corn production can have significant positive impacts on the quantity and quality of Nebraska's most precious resource: water.

Soil — plant — water relationships

Understanding the relationships between plants and their environment is essential to irrigated corn management. Plant characteristics important to irrigation management include total seasonal water use, daily crop water use, rate of plant development, critical growth stages for water stress and rooting depth. Important soil characteristics include water holding capacity, water intake rate, and the presence of any restrictive soil layers that might inhibit root penetration and/or water movement. Quantity and quality of the available water supply must be considered. The objective of irrigation management is to enhance growing conditions by providing the water needed to optimize plant growth and yield.

Water use characteristics

Curve A in Figure 1 illustrates an **average** daily water use pattern for corn. This **average** water use

pattern shows typical daily evapotranspiration (ET) throughout the growing season. *Curve B* illustrates the daily fluctuation possible in actual ET values. Evapotranspiration, or crop water use, is the water removed from the soil by evaporation from the soil surface and transpiration by the plant. Evaporation can account for 20 to 30 percent of seasonal ET. Transpiration includes water evaporated from leaf and other plant surfaces. Transpiration is the last step in a continuous water pathway from the soil, into the plant roots, through the plant stems and leaves and into the atmosphere. The magnitude of daily crop water use varies with atmospheric conditions: air temperature, humidity, solar radiation and wind. High air temperatures, low humidity, clear skies and high wind exert a large evapotranspiration demand. Seasonal water use is also affected by growth stage, length of growing season, soil fertility, water availability and the interaction of these factors. Although the total amount of water used by a crop will vary from season to season and location to location, it will generally follow the pattern shown by *Curve A* in *Figure 1*.

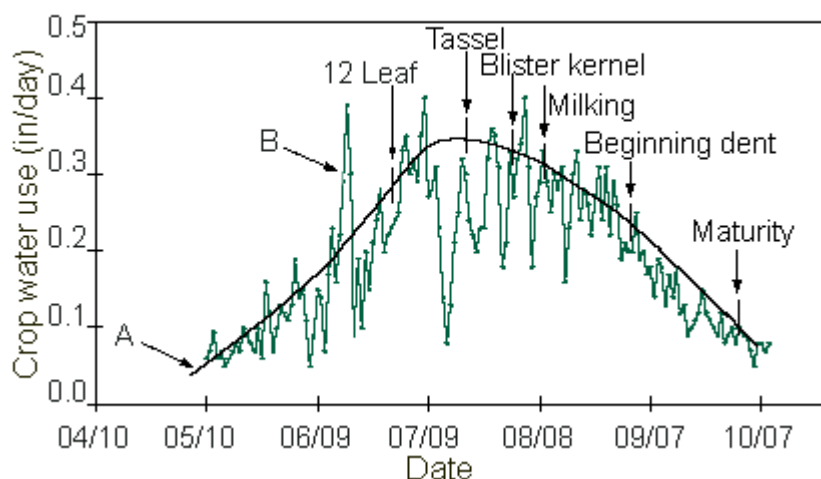


Figure 1. Average and daily crop water use with select growth stages

In Nebraska, total crop water use for corn ranges from 21 inches per year in the west to 28 inches in the east. Water requirement depends both on the previously mentioned atmospheric conditions and crop variety. The relative maturity range of a particular variety has the most impact on seasonal ET. For example, at the same location, a corn variety with a 120-day maturity will use more water than an 85-day variety. Longer-season corn varieties use more water, but they also produce more grain if the heat units and water supply are available. If both varieties are able to mature fully, the grain produced for each inch of ET is approximately equal. The difference in seasonal water use is due to total days of water use, not a difference in daily water use. *Table I* shows average crop water use figures by growth stage for a generic, 120-day maturity variety planted in south central Nebraska.

Corn is more sensitive to water stress than other field crops. For optimum yields, adequate soil water is essential. A full moisture profile in the potential root zone at the beginning of the growing season is desirable for optimal crop performance. In central and eastern Nebraska off-season precipitation is usually sufficient to fill the soil profile. Additionally, topsoil water must be available for the critical germination and emergence periods. Conservation and/or reduced tillage operations that reduce runoff and erosion, increase the amount of off-season moisture stored in the soil profile.

Table I. Average crop water use (ET) by growth stage for 120-day maturity corn grown in south central Nebraska.

<i>Growth stage</i>	<i>Average water use rate (in/day)</i>	<i>Duration (days)</i>	<i>Water needed to reach stage (inches)</i>	<i>Water needed cumulative (inches)</i>
4-leaf	0.10	0-15	1.5	1.5
8-leaf	0.18	15-30	2.7	4.2
12-leaf	0.26	30-40	2.6	6.8
Early tassel	0.32	40-50	3.2	10.0
Silking	0.35	50-60	3.5	13.5
Blister kernel	0.30	60-70	3.0	16.5
Beginning dent	0.24	70-80	2.4	18.9
Full dent	0.20	80-95	3.0	21.9
Maturity	0.10	95-120	2.5	24.4
		Seasonal ET =	24.4	

Corn does not extract water uniformly throughout its rooting depth. Generally, more water is extracted from shallow depths and less from deeper depths. An approximation of the extraction pattern is the 4-3-2-1 rule: 40 percent of the water comes from the top 1/4 of the root zone, 30% comes from the second 1/4 and so on. The 4-3-2-1 rule is illustrated in *Figure 2*, along with the typical development of the corn plant root system. Although corn roots often reach a depth of 5-6 feet, conservative irrigation management assumes that, until late in the season, 3 feet is the effective root zone. Later, when predicting the timing and amount of the last irrigation, the effective root zone is expanded to 4 feet.

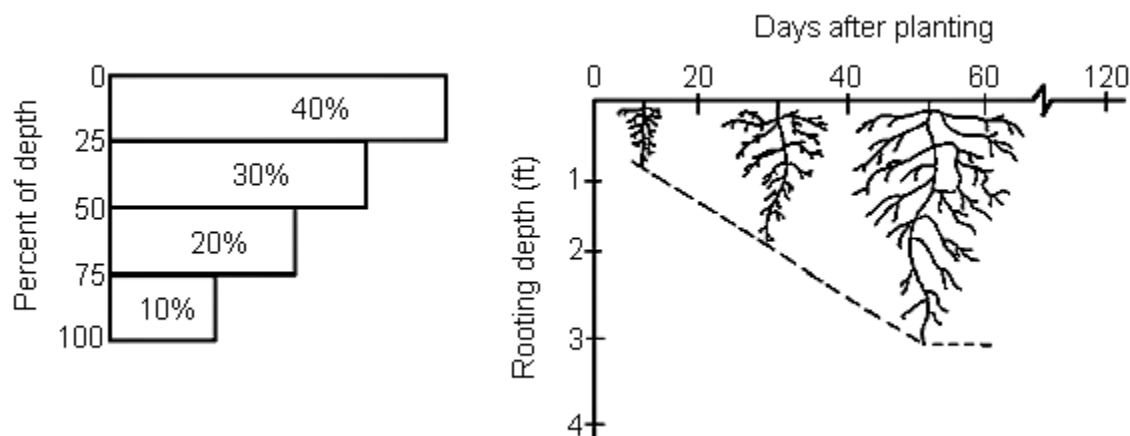


Figure 2. Root zone soils water extraction and plant root development

Matching crop demands with water application

The goal of every irrigator should be to provide enough water to meet the crop's ET demand and minimize water-related, yield-reducing stress. ET is important to irrigation management because crop yield relates directly to ET. If corn doesn't receive adequate water to meet ET requirements, grain yields

are reduced. Applying excess water will not, however, translate into extra yield and can, in fact, depress yields by leaching nutrients below the active root zone and inhibiting soil aeration.

Because there are unavoidable losses with all irrigation systems, it is impossible to convert all of the applied water to ET and ultimately to yield. However, by improving your irrigation system's efficiency, you'll pump less water to produce the same yields. In situations where irrigation water supplies and natural precipitation are not adequate to meet crop ET demands, limited or deficit irrigation can be effective in maintaining yields at acceptable levels. With deficit irrigation, water applications are targeted to critical growth stages, thereby making the most efficient use of the water available.

Growth stages

About two weeks after emergence, the corn plant grows to a height of 6 inches (4-leaf stage). The permanent root system begins to develop from the nodes and growing point during this time. At about 10- to 12-inches (8-leaf), the plant is going through tassel and ear initiation. At this time, the number of kernel rows and kernels in a row is being determined. The plant's roots are in the top 6 to 18 inches of soil. Take care not to over-irrigate at this time. Assuming a full soil profile at the beginning of the season and an effective root depth of 18 inches, the maximum net irrigation application depth at this growth stage should not exceed 1.5 inches on a silt loam soil. On sandy soil, the net irrigation application depth should not exceed 0.75 inches.

For corn, the most critical water period centers on pollination. The highest seasonal water use occurs during these four weeks: two weeks before to two weeks after silking. The reproductive stage is the single most important time to avoid water stress. Moisture stress during silking tends to desiccate the silks and pollen grains causing poor pollination and seed set, resulting in barren ear tips. Water stress during silking will result in the greatest yield reduction.

Water requirements remain high during the early stages of grain development, often described as the blister kernel and milk stages. During this time, grain is developing rapidly and increasing in weight. In fact, corn requires some moisture up to the time of physiological maturity. Since some of the required moisture can come from the soil water reservoir, the last irrigation can usually be applied two to four weeks before physiological maturity, see *Predicting the Last Irrigation for Corn, Grain Sorghum and Soybeans*, NebGuide G82-602.

Irrigation management

Irrigation management includes irrigation scheduling □ deciding when to irrigate and how much to apply. The decision must be based on the available irrigation water supply, the soil's water holding capacity and intake rate and the corn's water needs. Well-timed irrigations scheduled in accordance with crop water use, precipitation and soil water holding capacity can optimize yields.

Soil types

Soils classified as coarse-textured include: fine sands, loamy sands and fine sandy loams. These soils generally have low available water capacities, less than 1.5 in/ft. Some sandy soils in Nebraska have root-restricting layers at shallow depths. The combination of low available water capacity and shallow rooting results in a small soil-water reservoir, creating a more challenging water management scenario.

Light (0.75 to 2.0 in.) frequent water applications are required and there is less room for error in timing irrigations.

Medium- and fine-textured soils generally have an available water capacity of more than 1.5 inches per foot. In the top 3 feet, the available soil water at field capacity can be between 4.5 and 6.0 inches. Because these soil types can store more water, irrigators have more scheduling flexibility. Irrigation scheduling based upon soil water measurements is described in detail in *Irrigation Scheduling using Crop Water Use Data*, NebGuide G85-753, *Estimating Soil Moisture by Appearance and Feel*, NebGuide G84-690 and Extension Circulars EC79-723, *Irrigation Scheduling Using Soil Moisture Blocks in Deep Soil*; and EC84-724, *Irrigation Scheduling Using Tensiometers on a Sandy Soil*.

Irrigation systems

In general, irrigation water supplements off-season moisture captured in the soil profile and any beneficial or effective precipitation that falls during the growing season; irrigation requirement + effective rainfall + soil water consumed = seasonal ET. On average, corn grown on a deep silt loam soil in central Nebraska requires about 10 inches of net *supplemental* irrigation water per year. This water is normally supplied by either furrow or sprinkler irrigation. Conventional gated pipe irrigation with no reuse pit typically has an efficiency of about 50 percent. This means if 10 inches of net supplemental irrigation is required, an irrigator using conventional gated pipe and no reuse would have to apply 20 inches of water to net the necessary 10 inches. With a reuse system the maximum efficiency increases to near 70 percent, and the gross depth required decreases to 14 inches. Under ideal circumstances, surge flow irrigation efficiencies can be as high as 80 percent. *Table II* gives typical net seasonal irrigation amounts and typical soil textures for regions across the state. Compare the average seasonal net irrigation requirement to your yearly application.

When irrigating, it is important to irrigate the entire field quickly. Every-other-furrow irrigation supplies water to one side of each furrow ridge. This technique usually applies water to more area in a given amount of time than does irrigating every furrow. Research indicates every-other-furrow irrigation results in yields comparable to those achieved when every furrow is irrigated. Irrigation water application may be reduced 20-30 percent by implementing every-other-furrow irrigation. Infiltration is not reduced by one-half, compared to watering every furrow because of increased lateral infiltration. With no reuse system, every-other-furrow irrigation is about 60 percent efficient. With a reuse system, maximum efficiency increases to near 75 percent. Surface irrigation management is discussed in detail in *Managing Furrow Irrigation Systems*, NebGuide G97-1338.

Well-maintained and well-managed center pivot and lateral move sprinkler irrigation systems with properly designed sprinkler nozzle packages located near the top of the mature corn plant's canopy can be 80-90 percent efficient. Suppose, again, that net *supplemental* irrigation equal to 10 inches is required. By using a sprinkler irrigation system that is 90 percent efficient, a gross application of 11 inches is required to net the necessary 10 inches. If farming practices are changed to accommodate increased application rates, system efficiencies can be improved by dropping the sprinkler nozzles near the soil surface. A relatively new irrigation system, LEPA (Low Energy Precision Application), can increase irrigation efficiency. Adoption of the LEPA system requires both a change in sprinkler package spacing and placement and a change in farming practices □ planting in circles concentric to the pivot point and providing surface storage through in-furrow reservoirs. Center pivot irrigation system management is discussed in *Water Runoff Control Practices for Sprinkler Irrigation Systems*, NebGuide G91-1043; *Flow Control Devices for Center Pivot Irrigation Systems*, NebGuide G88-888; *Converting Center Pivot Sprinkler Packages - System Considerations*, NebGuide G90-1124; *Water Loss from*

Above-Canopy and In-Canopy Sprinklers, NebGuide G97-1328; and *Application Uniformity of In-Canopy Sprinklers*, NebGuide G97-1337.

Table II. Components of seasonal crop water use for corn across Nebraska.					
	<i>Soil Texture</i>	<i>Seasonal ET</i>	<i>Effective rainfall</i>	<i>Soil water consumed</i>	<i>Irrigation requirement</i>
East	Fine sand	28 in. -	15.0 in. -	2.0 in. =	<i>11.0 in</i>
	Sandy loam	28 in. -	15.0 in. -	2.8 in. =	<i>10.2 in</i>
	Loam	28 in. -	15.0 in. -	5.2 in. =	<i>7.8 in.</i>
Central	Fine sand	25 in. -	10.0 in. -	2.0 in. =	<i>13.0 in.</i>
	Sandy loam	25 in. -	10.0 in. -	2.8 in. =	<i>12.2 in.</i>
	Loam	25 in. -	10.0 in. -	5.2 in. =	<i>9.8 in.</i>
West	Fine sand	23 in. -	6.0 in. -	2.0 in. =	<i>15.0 in.</i>
	Sandy loam	23 in. -	6.0 in. -	2.8 in. =	<i>14.2 in.</i>
	Loam	23 in. -	6.0 in. -	5.2 in. =	<i>11.8 in.</i>

Summary

Proper water management on irrigated corn can enhance yields, conserve water supplies and preserve or enhance water quality. Use crop water use estimates and regular soil water measurements to determine irrigation timing and amount. Consider the irrigation water supply and the system's ability to deliver the water. Work to maximize the efficiency of your irrigation system. A critical concept of any crop production parameter: to manage it, you must measure it. In order to evaluate water use efficiency, all irrigators need to know; how much water has been applied and where it has gone. Water application must be measured and accurate records must be kept.

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