# IRRIGATION MANAGEMENT STRATEGIES FOR CORN TO CONSERVE WATER


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## INTRODUCTION

In the past, water has been plentiful and relatively inexpensive in most of Nebraska. Irrigation systems and irrigation scheduling equipment/procedures have made it challenging to put on just the right amount of water. Thus, many fields have been managed with the strategy that we will just put on a little extra water to make sure we have enough. In some fields, this has been a lot of extra water.

Today, water supplies are stretched very thin and pumping costs are much higher. In addition, more fields just simply do not have enough water to fully irrigate the crop. With this in mind, water conserving strategies are needed.

Research on conserving irrigation water in west central Nebraska has been underway since the 1920's. This research along with other work from around the world has led to the development of two water conserving strategies--Water Miser BMP and Deficit. Both conserve water by limiting irrigation water applied during the vegetative growth stage and relying upon precipitation and stored soil moisture.  These two strategies can lower evapotranspiration (ET), which can potentially lower yields. In addition, the Deficit strategy lowers ET during the reproductive stages to keep water use down to the quantity available, which will defiantly lower yields. This strategy would only be used if water supplies were inadequate.

An irrigation management strategy, for purposes of this paper, is the plan or philosophy of how to decide the timing and amount of water to apply to the crop and should be developed before the crop is planted. Irrigation scheduling, on the other hand, is the in-season procedure used to carry out the management strategy.

The focus of this paper is on describing three irrigation management strategies for west central Nebraska. They are the traditional fully watered strategy and two that conserve water. Other water conserving practices that are not discussed here should be considered for irrigated corn production. Some practices to investigate include: good weed control, grow crops that need less water, and no-till or other tillage practices that minimize soil drying and leave the residue on the surface.

## SOIL WATER TERMS

Before looking at the strategy in more detail, let's first review a few terms relating to soil water.

Soil holds water somewhat like a sponge. If one places the sponge in a container of water to completely fill the pore spaces with water and push out the air, the sponge would be saturated. This condition in the soil would also be called **saturation**.

The second term is **field capacity**. It describes the soil water content after the soil has been saturated and allowed to drain for about two days. This would be like lifting the sponge out of the container of water and allowing the free water to drain, but of course still leaving a lot of water in the sponge.

The third term is **permanent wilting point** and describes a soil water content that is so low that a plant growing in the soil would not be able to survive. This would be like wringing out all of the water we could get from our sponge. The soil, just like this wrung out sponge, still has some water left in it. This water is referred to as **unavailable water** and can only be completely removed by air-drying in an oven or in the sun.

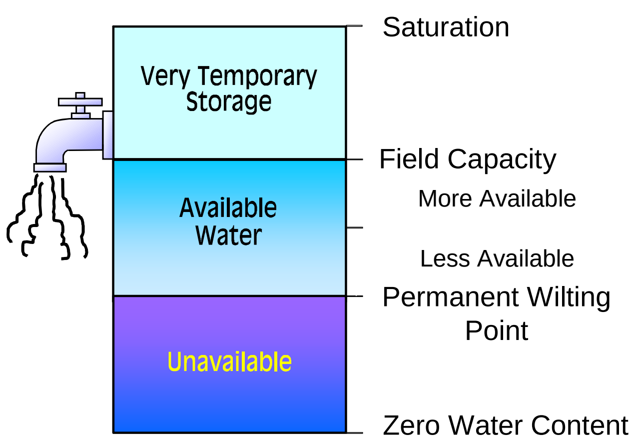

Figure 1. Relationship between different soil water terms. (Watts et al., 1998)

The water that is in the soil between field capacity and permanent wilting point is called **plant available water**. Typical soils can hold between 1(fine sands)-2.5 (loam) inches of plant available water per foot of soil. The quantity of water in the soil that is above field capacity can be used by the crop, but remember this water will drain through the soil in a couple of days. Figure 1 shows the relationship between these terms.

The crop root depth is another important concept to understand that relates to the amount of water in the soil that the crop has access to. At emergence, a corn crop can access water in about the top 6 inches of soil and the roots can grow to a depth of more than 6 feet by the beginning dent growth stage if soil and moisture conditions encourage deeper root growth. Well-watered corn may only root to a depth of three feet. For irrigation scheduling purposes, corn is assumed to have access to the water in the top 6 inches at emergence, three feet by silking and 4 feet by beginning dent. A graphic depiction of these changes over the season is shown in Figure 2. An example, also shown in Figure 2., of this would be if we had corn at the silking stage (three foot root zone) growing in a soil that is at field capacity and holds 2 inches of plant available water per foot. The plant available water in the root zone would be 6 inches.

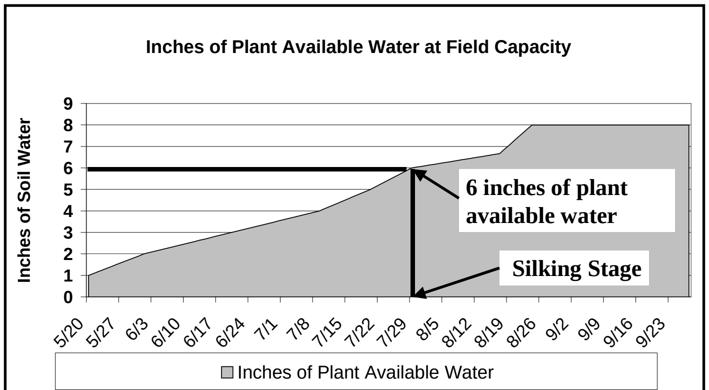


Figure 2. The gray shaded area shows the plant available soils water holding capacity in the root zone for a soil that holds 2 inches per foot of soil and how it changes during a typical growing season in Nebraska.

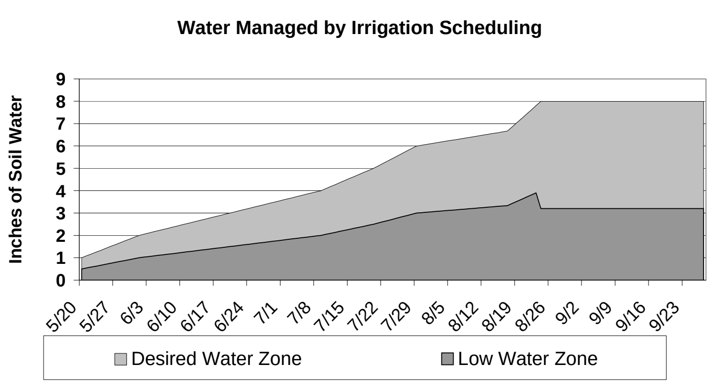


Figure 3. The gray shaded area shows the difference between the soils water holding capacity in the root zone and the maximum allowed soil moisture deficit.

## FULLY WATERED

The Fully Watered management strategy is the traditional Best Management Practice (BMP) that has been around since the 1960's. It focuses on preventing moisture stress to the crop from planting to maturity by maintaining the plant available soil-water (in the active root zone) between field capacity and 50% depletion. Usually the soil in the root zone is kept one-half to one inch below field capacity to allow for rain

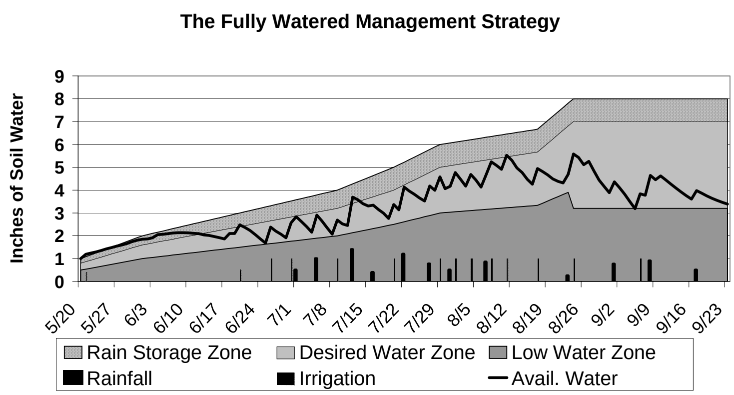


Figure 4. The gray shaded area shows desired water zone for the Fully Watered strategy. The black line showing available water should stay in the gray shaded area to indicate planned moisture level for the crop. Rain may push the line into the rain storage zone.

storage. After the dough stage, the soil is allowed to dry down to 60% depletion.

The strategy can be illustrated by taking the top 50 percent of the plant available water as shown in Figure 3. This zone can be called the desired water zone. The way to tell if the Fully Watered strategy was met is to plot the actual plant available water in the root zone each day as shown in Figure 4. If the black line stays within the desired water zone on the chart, the management objective was met. The vertical lines indicate rain and irrigation applications.

## MANAGEMENT TIPS

The fully watered strategy is the easiest of the three strategies to manage. Management needs to focus on: 1. when to start irrigation for the season, 2. limiting irrigation to keeping the soil moisture below field capacity to prevent water from draining below the root zone and to provide space to store in-season rain, and 3. when to stop irrigating at the end of the season, so the crop can use enough water to dry the field down to the 60% depletion level before it matures.

## WATER MISER BMP

The Water Miser BMP irrigation management strategy focuses on saving water during the less sensitive vegetative growth stages and fully watering during the critical reproductive growth stages. Irrigation is delayed until about two weeks before tassel emergence of the corn, unless soil-water depletion exceeds 70% (in the active root zone). Once the crop reaches the reproductive growth stage, the plant available soil-water is maintained in a range between field capacity and 50% depletion. Usually the soil in the root zone is kept one-half to one inch below field capacity to allow for rain storage. After the hard dough stage, the soil is allowed to dry down to 60% depletion.

The principle behind this strategy has been shown in several research studies over the years. In the 1970's, at the former University of Nebraska's Sandhills Lab, Gilley et al.(1980) used a line-source sprinkler irrigation system to study the effects of water-stress on corn at the vegetative, pollination and grain filling stages. They found no significant yield reduction when the crop was moderately stressed during the vegetative stage. However, significant yield reductions were found when the corn was stressed during the pollination period.

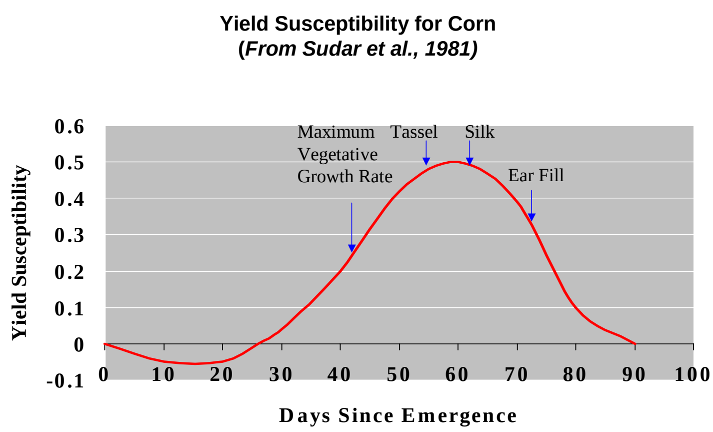


Figure 5. Yield susceptibility for corn.

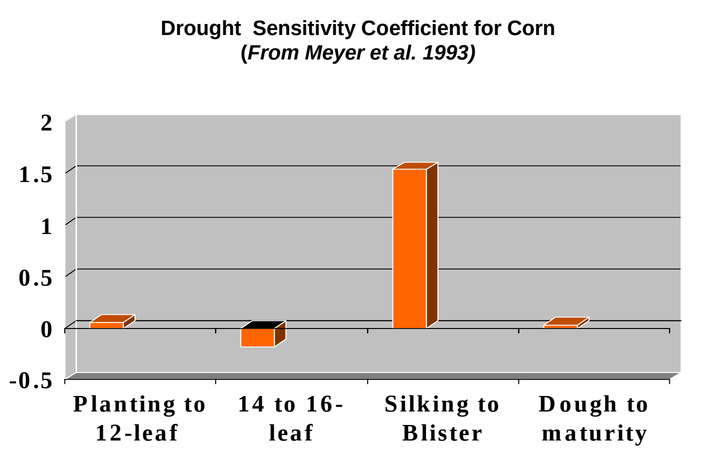


Figure 6. Drought sensitivity coefficient for corn.

The research found that a water savings of more then 4 inches or about 30 percent could be achieved without a significant yield reduction if the water was withheld only during the vegetative period and if the plots were then fully irrigated during the rest of the growing season. On-farm studies have shown that 1-3 inches of irrigation water can be saved as compared to the Fully Watered strategy. However, during springs and early summers with above normal precipitation, no water savings should be expected.

Starting in the early 1980's, this idea was confirmed by further research conducted at North Platte, both using a solid-set sprinkler irrigation system and under surface irrigation. (Schneekloth et al. 1991)

The long and short of it is that corn yields are not very sensitive to moisture stress before the tassel stage or after the dough stage, however, from the silking to the blister stages corn is extremely sensitive. All irrigation strategies should focus on minimizing moisture stress during this time. Figures 5 (From Sudar et al., 1981) and 6 (From Meyer et al. 1993) are examples of two curves that have been developed to show how moisture stress effects corn yields as the crop progress though the season.

The Water Miser BMP allows a 50 percent depletion of the plant available water during the critical growth stages. However, a strong case could be made for only allow a 40 percent depletion during this stage because corn is very susceptible to moisture stress during this time and water use is high, which would make any delay in irrigation cause a significant yield loss. Further support for the 40 percent number is based on the information presented in Figure 7 (modified from Doorenbos et al., 1979). It shows that on lower ET days (0.08-0.12 in/d) the soil can be very dry without having any moisture stress occurring. However, on high ET days (0.35-0.39 in/d) the field can only have 40 percent of the plant available water used or depleted without causing yield loss from moisture stress. Keeping the soil a little wetter during this time should not increase water use as long as the crop is allowed to use the extra water before maturing by cutting back on irrigation in the later parts of the growing season.

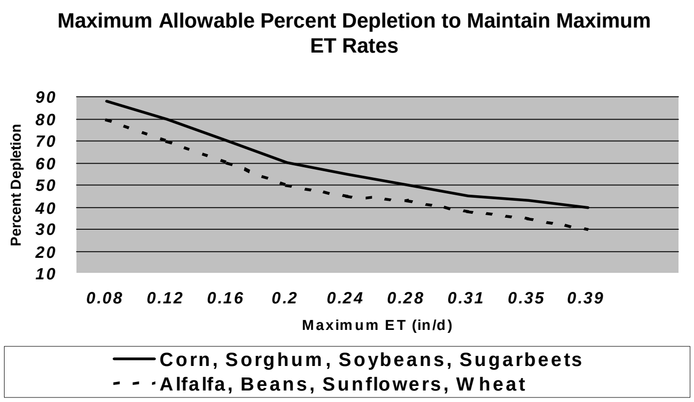


Figure 7. The maximum allowable percent depletion of the soil water that will still maintain maximum ET rates.

Another important point from Figure 7 is that in the early and late parts of the season when ET rates are lower, the soil needs to be very dry to create moisture stress.

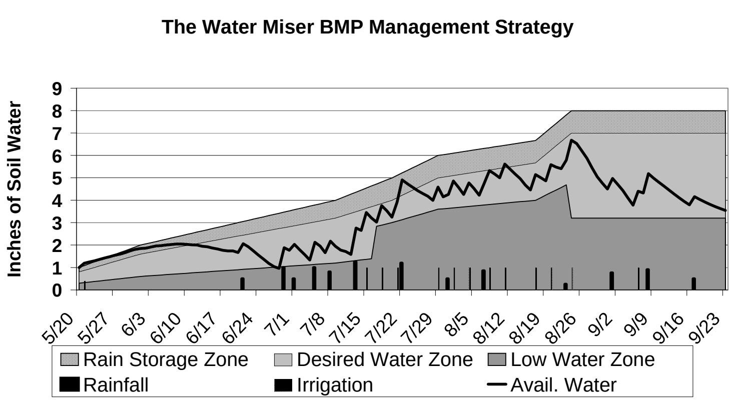


Figure 8. The gray shaded area shows desired water zone for the Water Miser BMP strategy. The black line showing available water should stay in the gray shaded area to indicate planned moisture level for the crop. Rain may push the line into the rain storage zone.

The Water Miser BMP strategy is illustrated in Figure 8. This irrigation scheduling method is sometimes called a crop growth stage irrigation strategy. Irrigation is limited during the vegetative growth stage while full irrigation management is practiced during the critical reproductive growth stages.

## MANAGEMENT TIPS

Managing a field with the Water Miser BMP strategy requires good soil moisture readings and careful timing. The upper three feet of the soil profile should be at or near field capacity in the early part of the growing season so the developing roots can grow in moist soil, thus allowing the stress to come on more gradually. Most fields in west central Nebraska that were somewhat fully irrigated the previous year will meet this condition even with below normal precipitation. If the field is dry, be very careful not to over stress the corn.

The biggest hazard involved with this strategy is not getting the irrigation started soon enough to avoid excessive stress during the pollination period. If soil water reserves are depleted and something occurs to delay irrigation, severe problems could occur during the pollination period. Also, keep in mind that lower capacity systems (less then 5.5 gpm/ac) need to be started sooner, as compared to higher capacity systems (over 7 gpm/ac) which can wait to get more of this benefit, but still needs to be started soon enough to get caught up before the reproductive period starts. The above listed system capacities are net system capacities and would need to be increased by the water application efficiency of the irrigation system. (Kranz et al., 1989)

## DEFICIT IRRIGATION

The deficit irrigation management strategy should only be used if the water supply is short, since it will result in reduced yields. This strategy focuses on correctly timing the application of a restricted quantity of water, both within the growing season as well as over a several year period. The intent is to stabilize yields between years by applying irrigations based on soil-water depletion. The idea is to keep the soil dry enough to significantly reduce ET, but keep it from getting so dry that it substantially lowers the yield potential. Less water will be applied during wetter years, while more will be applied through the drier years, with an average over the years equaling the available quantity of water. The management strategy is to delay the application of water until about 2-weeks before tassel emergence for corn, unless soil-water depletion exceeds 70%. Once the crop reaches the reproductive growth stage the plant available soil-water (in the active root zone) is maintained in a range between 30 and 60% depletion. It is allowed to dry down to 70% depletion after the

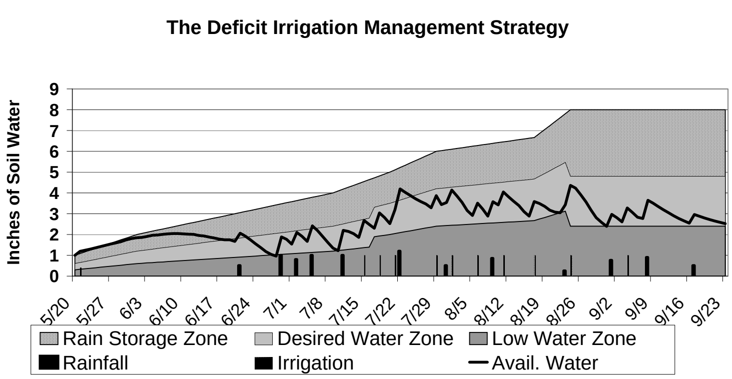


Figure 9. The gray shaded area shows desired water zone for the Deficit Irrigation strategy. The black line showing available water should stay in the gray shaded area to indicate planned moisture level for the crop. Rain may push the line into the rain storage zone.

hard dough stage. The idea is that these depletion numbers should be changed based on the amount of water the producer has to work with. More research is needed to determine guidelines for differing water use levels. Figure 9 graphically illustrates this strategy.

## MANAGEMENT TIPS

The Deficit Irrigation strategy is the most challenging to manage. In fact it may be as much an art as it is science. The challenge is to keep the crop fairly dry to reduce the ET to the desired level, while preventing an extremely hot, dry few day period from significantly impacting the yield potential. Remember this strategy is intended to lower the plant water use to the amount of water available for the season, but as a consequence the yield will be lowered as well. Also, this strategy does not work with low capacity irrigation system. It only works if the restricted quantity of water can be put on the field quickly and at the right time. If the water supplies are very limited, irrigating less acres or growing a crop that requires less water may be a better option.

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