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When is the Best Time to Stop Irrigating?

The last watering of the season can be as important as the first. To ensure optimum yields, adequate soil moisture must be available to crops until they are physiologically mature. Applying excessive irrigation water to the root zone beyond maturity can result in reduced profits. For management decisions on final irrigation, you will need to know the current moisture condition of your soil and the amount available for crop use. Both soil texture and effective root zone will determine the amount of water that can be stored for crop utilization.

Stage of crop maturity and weather conditions will affect the period when the crop continues to use water prior to maturity. Know the signs and symptoms of physiological maturity in crops you are irrigating. Both the extra savings of irrigation and peace of mind that the crop is safe from frost are worth knowing.

Some crops, such as corn, can endure an increased soil water deficit as the crop nears maturity, while others, such as potato or alfalfa, should continue to be irrigated until harvest, maturity or frost.

Corn should be irrigated until sufficient soil moisture is available to ensure that the milk layer of the kernel moves down to the tip of the kernel or black layer formation (physiological maturity). If the milk layer is a third to halfway down the kernel no additional water application is needed. Physiological maturity is reached about 55 days after 75 percent of the plants have visible silks. The grain moisture may range from 32 to 40 percent at the time depending on the hybrid. Yellow dent corn is usually well dented at physiological maturity. Once corn is physiologically mature, the drydown rate is approximately 0.5 percent moisture loss per day.

Dry edible bean: The last irrigation should occur when the first pods are filling, or irrigation stopped when 50 percent of the leaves are yellowing on the plants. When over watered, indeterminate varieties (pinto) may continue to vine and set flower with delayed maturity. For navy bean, physiological maturity is reached when at least 80 percent of the pods show yellowing and most are ripe, with 40 percent of the leaves still green. Pinto beans are physiologically mature when 80 percent of the pods show yellowing and mostly ripe and only 30 percent of the leaves are still green. Beans within pods should not show evidence of any green. If the beans have begun to dry, irrigation will not be needed because the beans no longer are removing much water from the soil profile.

Soybean should be irrigated until sufficient moisture is available to allow full bean development and pod fill. This stage is when leaves are yellowing (75-80 percent) and all pods filled with lower pods just starting to turn brown. At physiological maturity, pods are all yellow and over 65 percent of the lower pods have turned brown. Beans within pods should have little evidence of green color and should be shrinking. Studies do show that yellow pods sprinkled with brown are the best clue of physiological maturity. Usually if one or two pods show this symptom on the upper two or nodes of the plant the plant has reached P.M. The soybeans also should be tolerant of a killing frost at this time also.

Sunflower should be irrigated until sufficient moisture is available for the sunflower achenes (seeds) to fill. This is when the back of the head turns from a lime green to yellow-green color and ray petals are completely dried.

Potato will utilize soil moisture until harvest. Maturation stage begins with canopy senescence as older leaves gradually turn brown and die. Research has shown final irrigation can be used to reduce bruising during the harvesting process. On sandy soils, soil moisture content between 60 to 80 percent of field capacity (40 to 20 percent moisture depletion) provides conditions for a desirable soil load into the harvester with optimum separation of potatoes and soil. This soil moisture level also minimizes physical tuber damage. If soil is dry before harvest, a final irrigation should be applied at least one week prior to harvest to raise the soil moisture level and raise the tuber hydration level.

Alfalfa should be irrigated to maintain active growth until growth is stopped by hard frost. Alfalfa going into the winter with adequate soil moisture has a much better chance of little or no winterkill.

Small grains should be irrigated until adequate soil moisture is available to bring the crop to the hard dough stage.

Sugarbeet will utilize moisture until harvest time. Irrigation is usually terminated seven to 14 days before harvest to allow the soil to dry.

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Determining Rental Rates for Irrigated Land

Rental rates are ultimately determined by negotiation between landowner and tenant. The landowner needs to know his costs as well as returns from alternative uses for the land. To determine the minimum acceptable rental rate. Presumably, the landowner will not be willing to rent out the land and irrigation system for less than the variable costs associated with it. Or to accept a lower return than could be earned if those resources were used differently. The more informed you are regarding costs and returns, the more likely you are to be satisfied with the resulting agreement.

The following investment figures are used for illustrating the landowner's annual costs.

Center pivot	$39,000
Well	$10,500
Pump, motor and electrical	$16,000
Pipe	$4,500
Land preparation	$4,000
Total investment	$74,000

The landowner's total costs include depreciation, interest, repairs, taxes and insurance.

Depreciation: This should reflect the total useful life of the equipment. Do not use the depreciation schedule set up for tax purposes as that reflects less than full lifetime. Salvage value is assumed to be 10 percent of original investment.

Center pivot:
$39,000 less $3,900 for 15 years — $2,340

Well, pump, motor, piping, electrical and land preparation:
$35,000 less $3,500 for 20 years — $1,575

Interest on investment: This is the opportunity cost of having money invested in the irrigation system rather than the next best alternative. Assumed salvage value equals $7,400.

Average annual investment equals beginning value plus salvage value divided by two.
($74,000 + 7,400)/2 = $40,700 x 6 percent = $2,442

Repairs: Repairs are generally regarded as variable expenses. However, repairs tend to occur sporadically. If a system is rented for only a portion of its life, the repairs that occur during that period are not likely to reflect that portion of use. Therefore, it is better to allocate an average annual repair cost based on the total life of the equipment.

$74,000 x 2 percent — $1,480

Taxes: Refers to property taxes that do not apply to North Dakota.

Insurance: One-half percent of investment — $395

Total annual ownership costs — $8,232

Annual cost per acre at 130 acres per system – $63.32

In addition to the cost of the system, the landowner has the investment of the land itself. After separating the cost of the system from the land, the annual charge for the land should be the equivalent of the typical land rent for that type of land as non-irrigated cropland. As an example, the average 2001 cash rent for non-irrigated cropland in Kidder County as reported by the North Dakota Agricultural Statistics Service is $23.40. A rental rate for irrigated land subject to these costs and conditions of $86.72 per irrigated acre would recover the owners investment in irrigation as well as the opportunity cost of the land as non-irrigated cropland.

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Renovating an Old Irrigation Well

Groundwater is the major water source for irrigation development in North Dakota. In any given year, an irrigation well operates for only a short time. However, down in the well, biological activity and chemical actions continually take place, even through the winter months. If performance is important to you, you need to check your irrigation well on a regular basis. Below is an account of a situation we experienced at the Carrington Research Extension Center (CREC) earlier this year.

The irrigation well

There was a need to demonstrate various types of microsprinkler systems and to study plant diseases by misting the plants with a microspray system. The system capacity we wanted varied from 20 gallons per minute (gpm) to as high as 60 gpm for any one zone. The desired operating pressure was about 30 pounds per square inch (psi) at the microsprinkler and microspray watering systems.

Before we laid out our plans for the plot sizes and selected the microirrigation system components, we needed information about the performance of the pump and well. This was an old pump, and we needed to know the pressure versus flow rate relationship. We discovered that these two pieces of information, the records for the construction of the well and the specifications of the pumping plant were not retained. The pump and well had not been serviced in the last 10 years. We physically determined that the pump installed was a submersible pump and the outlet pressure was controlled with a pressure relief valve that recirculated excess water back into the well.

We searched for the pertinent records concerning the pump and well from many sources. The North Dakota State Water Commission (SWC) records revealed that the 4-inch diameter well was constructed during 1965 and was drilled to a depth of 97 feet. From records retained by a well driller and pump installer, we also recovered additional information that the original pump installed was a high-pressure turbine pump driven by an electric motor. The original pumping plant was replaced with a submersible pump in 1991. The 7.5 HP submersible pump had 18 stages, designed to deliver 75 gpm at a total head of 110 psi.

We performed a pump test to determine the flow rate and pressure developed by the pump. We found that the flow rate measurements obtained with the relief valve operating were not accurate. A repeat test after the relief valve was disconnected showed that the pump vibrated violently at a total head of 100 psi and delivered only about 20 gpm when the pumping water level was about 60 feet below the surface. At that point, we were certain

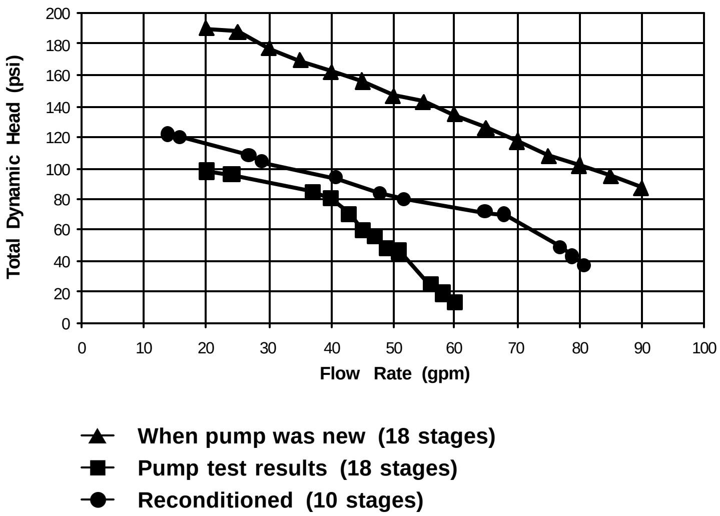

Figure 1. Comparison of pump performance characteristics of irrigation pump 3, Carrington Research Extension Center, North Dakota.

that we had a problem well and a pump that was not performing adequately. The diagnosed pump performance level did not match the manufacturer's pump curve. Therefore, we decided to recondition the well and pump to try to accomplish the following objectives:

1. Raise the production capacity of the well.
2. Renovate the pump to operate at optimum flow rate at the desired pressure regime.
3. Design microirrigation systems to match pump flow rate and pressure characteristics.

The reconditioning process

The reconditioning process involved the following:

1. Redevelop and clean the well with acid.
2. Remove eight stages from the 18-stage pump and reset it with 10 good impellers. This action was taken to reduce the pressure to microirrigation systems.
3. Reinstall the reconditioned pump with standard valves and a pressure gage.

The submersible pump was found to be in fair condition. Several holes in the pump riser pipe and incrustations in the pipe were found. The well was acid treated and redeveloped with a compressed air jetting tool. The reconditioned pump with new riser pipe was installed with the necessary valves and gages. A test was conducted to verify the performance of the reconditioned irrigation well. The test results are shown in Figure 1. The pump flow rate has significantly increased and is operating at the desired working pressure.

We will present the lessons learned from our experiences with the well reconditioning process and the benefits derived from the microirrigation systems in October 2001 article of the Water Spouts.

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Drainage — Myths, Legends and Reality

I have lived in North Dakota since 1994. When I moved here, I was told it was dryland country, and I suppose for most of pioneer history until now it was. Every year, it seems that North Dakota is more and more like Illinois — more corn, more soybeans, more water, and more talk of tile and drainage. One has only to fly around the state briefly to look at what excess water can do to a region that has no effective drainage strategies. Land that was cropped in the 1980s now has some of the best northern pike fishing around. The low, black fertile ground is now covered with cattails. Areas with no salt 10 years ago now grows kochia and little else and is surrounded with still more white crusty land. Irrigators have a special challenge. Many pivots are on sandy ground, interspersed with low lying areas with clay that collect water runoff and shallow groundwater flow. These areas quickly become problem areas for crop growth, particularly with soil-borne diseases such as late blight and root rot.

Drainage can be approached two ways. Get rid of the surface water as soon as possible and/or install drain tile to move water slowly from the land. This allows the surface to dry enough between rains so that surface flooding from already saturated soils is not as severe.

With high clay soils, like those within five miles east and west of the Red River Valley, we are stuck with the first option. This option distresses most urban people within the region, because with more surface drainage, water moves more quickly to the river and causes higher crests. Tile drainage is possible in clay soils, but the distance between the tile lines must be very close, perhaps 40 to 50 feet. The cost of achieving this drainage is very high. The other consideration in clay soils is that the immediate benefit from having removed free water from the upper 18 inches of soil or more is not as great as in soils with higher permeability. Drier surface soils may allow another ¼ inch of rain to penetrate the soil, but movement downward is so slow that runoff potential is still very high.

In medium and moderately fine textured soils, tile drainage makes more sense than surface drainage. It results in slower release of water to swollen streams and rivers, and because the loss of water is continuous for a long period, it keeps streams and rivers flowing, perhaps during times that they normally would not. The spacing between lateral tile lines within fields will normally be between 80 and 150 feet. This makes the cost of installation far less expensive than in clay soils, although in many cases it might cost as much as a person paid for the farm originally to install them.

Tiling does not eliminate all water from the soil; it only gets rid of free water to the depth of the tile. Most plants use only a small amount of free water, since roots of our normal crop plants also need oxygen to grow and do not grow into saturated soils on purpose. Tiling will lower the water table, cause salt problems to diminish, and provide a more stable moisture environment for crops. Fields can be seeded earlier in the spring, and harvest rains are not as devastating, because tile helps to dry the fields out even when crops are not using water anymore.

Practical considerations must be addressed before tiling. First is where the outlet might be. Many areas in the state are essentially land-locked to drainage. In other areas, the drop to a ditch or stream might be too shallow. There might be neighbors whose land must be crossed to reach an outlet. In states where drainage is a way of life, there are drainage districts established where there are agreements regarding who has rights and who does not. This helps

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solve these social issues with limited hard feelings. However, working with neighbors is an important issue and may often restrict what can be done. Many people want to get rid of their water but do not want anymore upstream water if they can help it.

The second issue is regulatory. Before going too far into the process, wetlands are protected. There are firm guidelines, mostly defined by soil series and soil development under these areas, of what a wetland is and is not. Working with NRCS, there may be ways to mitigate certain lands to create wetlands somewhere else and allow drainage of large parts of fields through the original wetland.

The third issue is cost. Drainage is not cheap. If we knew the current wet period (I dislike the word cycle — every year is different, not a repeat of another time) would last for another 50 years, we would see more tiling. However, might our climate revert to dryland next year? There is no way to know. So to spend $500/acre on tile drainage might be what keeps someone in business in a highly profitable way, or it could hasten a farm sale. Under irrigation, the cost is more justifiable, because if irrigation is scheduled correctly, there should usually be some amount of groundwater to move away from sensitive land. The cost of disking under a quarter of potatoes is enormous, making the cost of tiling a reasonable cost of doing business.

The fourth issue is environmental. Currently, areas of the U.S. with tile drainage experience large fluctuations of nitrate in surface waters. Low rainfall and slow tile drain activity result in reduced surface water nitrate. However, when rainfall is high, the soil is "flushed out" of nitrates, because all the soil pore space is filled with water and the concentration of nitrate in water increases greatly. It would be more difficult in tiled fields to predict nitrate levels based on our fall soil testing. It might push us to use more spring soil testing or pre-sidedress testing for row crops. With increased tile drainage, nitrate levels in surface waters might increase. There is already activity at the Federal level to limit N rates in some parts of the country. With increased nitrate in our water supplies, those coming regulations would surely be applied to our region as well. Adding a wetland between the tile outlet and a surface water body has been shown to be effective in cleaning the water of nitrates. Such a system should be considered when tiling in the state to keep our surface waters low in agricultural pollutants.

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