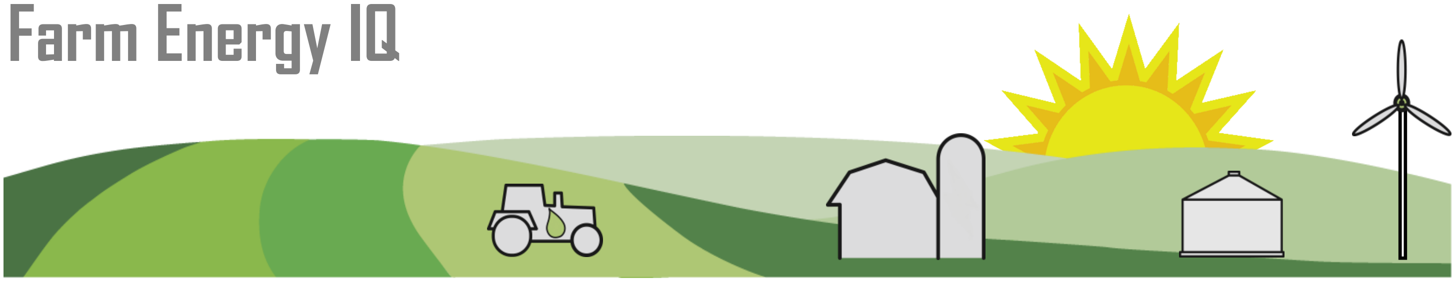

Conserving Energy in Irrigation

INTRODUCTION

In the Northeast, opportunities to conserve energy in irrigation lie primarily in increasing the efficiency of distribution and pumping equipment and limiting irrigation to situations in which an economical crop response is expected.

On most farms, the primary opportunity to increase irrigation system efficiency involves improving the pumps and distribution system. Developing an irrigation master plan allows farmers to forecast future crops and acreage, the spatial layout of crops, and soil characteristics. An irrigation master plan should detail different possible scenarios and define an energy efficient way to address the irrigation needs of each.

This fact sheet addresses the principles of efficient pumping and distribution. In general, the principles are similar to electrical wiring in that the circuit should have little resistance to flow, no sudden changes in any resistance, and as straight and short a path as possible.

Efficient irrigation also depends on good management of the water needs of crops. A common fault of irrigation systems is oversaturation of large portions of the field, causing an inability to absorb any near-term rainfall. Certain common types of irrigation systems do not work efficiently with some crops, but do with others. Designing a system that addresses crop needs throughout the entire crop rotation cycle is important. Soil characteristics are also a significant factor because water holding capacity and mobility within the soil greatly affects irrigation needs and the type of system which can be used most efficiently.

CALCULATING CROPS NEEDS

The place to begin in ensuring water is used efficiently is determining the needs of crops planted. Most crops have significantly higher water needs during certain times of development. A common method of planning for crop water needs is the "checkbook method" of calculating available water. Much like balancing a checkbook, the estimated needs of crops based on estimated evapotranspiration are subtracted from deposits of rainfall or irrigation water into the soil. Plant needs at various growth stages are estimated and, if actual soil moisture is not known, effective precipitation and irrigation can be estimated and counted as deposits. This method gives a rough estimate of the total net irrigation demand and allows for better planning of future irrigation needs.

MEASURING AVAILABLE WATER

Water availability depends on the soil's capacity to hold moisture. Good agricultural soils have a capacity for about 1-in. of water per ft of depth in lighter sandy soils to about 2-in per ft or more in heavier loamy soils with high organic matter. Capacity varies proportionately with the fineness of soil particles and amount of organic matter.

The most basic way to make an initial estimate of soil water availability is the feel method. Simply by the way soil "balls up" when squeezed in the hand, this method can give a rough idea of soil moisture. The USDA (1998) provides a useful chart on how to best determine moisture by the feel method. This method allows quick, cheap evaluation of soil conditions on-the-fly, and can be useful for identifying moisture changes in different parts of the field. However, this imprecise method should not be relied upon to determine irrigation demand.

More precise measurement of soil moisture is usually accomplished by tensiometers and resistance (a.k.a. moisture or gypsum) blocks. Tensiometers, which measure the vacuum pulled on water by the soil, give an indication of how difficult it would be for a plant to pull moisture from that soil. The device uses a container of water that feeds a porous bulb buried in the soil, with a vacuum gauge on the container. The device is designed for lighter textured soils, is relatively inexpensive, and is self-contained. Because the vacuum gauge is placed above ground, the device is vulnerable to damage in the field. Tensiometers are very easy to use to make on-the-spot calculations of irrigation needs, because they directly measure the amount of work a plant needs to do to meet its water needs. Soil moisture can also be measured with resistance blocks. These blocks, usually made of gypsum or some other granulated ceramic, contain an electrode at each end and are primarily used on heavier textured soils. The blocks are buried at various root zone depths and, as the block becomes saturated by water, resistance between the two electrodes decreases. The exact resistance values for particular saturation levels vary between manufacturer and model of the device. The device allows accurate monitoring, and, due to its mostly underground placement, is less vulnerable to mechanical field damage than is a tensiometer. However, unlike a tensiometer, the blocks can only be used for a single season.

PUMP DESIGN AND SETUP

The two pump designs most commonly used in agricultural irrigation are centrifugal and submersed turbine. Centrifugal pumps are used to pump free surface water (ponds/streams) at low suction head, and turbine pumps are used to move water from deep wells at zero suction head and high discharge head. Most centrifugal pumps are driven by electric motors, but diesel engines are sometimes employed in applications in which the pump needs to be moved frequently and having an electric motor at each site is impractical. Although diesel engines are less efficient than electric motors, using a portable pump can nonetheless result in energy savings in situations where different irrigated fields are separated by a long distance and running a main between them is impractical.

Photo by C. McKittrick, NJAES, Rutgers University

The primary energy savings with centrifugal pumps lies within the 10 ft of line nearest the pump, especially on the suction side. Many installations of centrifugal pumps have suction lines with too high a suction head due to poor pickup screen design and induced turbulence. As a general rule, the end of the suction line should be located so that the distance between the bottom of the end and the water body bed is at least twice the diameter of the pipe used. A grate can be used at the entrance to the trench where the suction pipe is located to prescreen water before it reaches the pickup, helping to lessen negative pressure at the pickup. It is a good idea to install a vacuum gauge at the head of the suction line, directly before the pump, so that at every startup any leakage or obstruction will be obvious.

With either type of pump, the discharge line should not decrease in size but, rather, feed into the larger main lines from which laterals can connect with reducers. The ideal fitting to use is a cone-shaped fitting made for the purpose by irrigation equipment suppliers. Most systems should have a fall port gate or butterfly valve that can isolate the entire system from the pump. A good practice is to install a flapper type check valve as well, to prevent loss of the system charge when the pump is shut off. At permanent installations, an electric system which automatically closes the main butterfly valve when the pump is off can lead to energy savings over mechanical check valves. Lastly, consider liberally using relatively inexpensive pressure gauges throughout the system to identify proper operating pressures and hidden blockages or plumbing faults. Operating at too high a pressure increases energy for pumping and may result in fine droplets of water evaporating before hitting the soil surface thus wasting water. Operating at too low pressure may save energy at the pump but distribution patterns will be poor and often insufficient for crop needs.

RUN AND HEAD DESIGN

For most grain crop production in the Northeast, irrigation water is applied with center pivot, or traveling guns. Certain engineering factors must be considered in using these systems efficiently. Nozzles that will cover the field properly need to be selected. In the case of impact heads on center pivots, manufacturers specify a radius that the nozzle will cover, with some degree of overlap necessary to achieve good coverage.

Traveling guns are susceptible to the same problems as impact nozzles, only on a larger scale. They cannot apply a consistent pattern, and are very susceptible to wind drift. When crops can tolerate it, wind drift can be kept to acceptable levels by running irrigation only during times of low wind speed (10mph or less).

Various types of soakers and deflection nozzles, which have become available in the past twenty years, are much more efficient than impact nozzles. Soaker and deflection nozzles may be used on either center-pivot systems or on fixed risers. Both types allow placement closer to the crop, so that a large number of smaller nozzles can be used, leading to better consistency of the spray pattern. Many of these nozzles, particularly of the bubbler type, are very tolerant of pressure variation and may work acceptably without a pressure regulator. With all types of nozzles and application methods it is important to place numerous small containers in the field to measure application amounts and uniformity throughout the field.

Photo by C. McKittrick, NJAES, Rutgers University

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