IS ONE SPRINKLER SYSTEM GOOD FOR ALL?

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INTRODUCTION

We often assume that if a system is working for some one else, it will work for us too. Unless all conditions are identical this myth may cause you problems. I will focus on the basic principles that you must consider in choosing the system for your own conditions. Climate, crops, cultural practices, topography, water supply and soils affect the operation of your system. My objective is to make you aware of the many interactions among the basic principles that you must consider and that **not one system** is suitable for all conditions. The variables in selecting a center pivot sprinkler system are system capacity (gpm), length of system, and the type of sprinkler package. Matching the center pivot system with the pumping plant is often neglected, particularly when converting to a new sprinkler package. The pumping plant is the major user of energy and dominates the operational cost of irrigation.

SYSTEM SELECTION

The water supply, system capacity, soil water holding capacity, intake rates, crops and aversion to risk are all important in selecting an irrigation system. Irrigation efficiency is also important in selecting a system and is a function of the system. The irrigation efficiency is the ratio of the water available for the crop divided by the water delivered to the irrigation system. Evaporation and wind drift reduce the efficiency. The other loss considered is due to the nonuniformity of water application. Excess application often percolates below the root zone and is not available for crop production. Deep percolation can be reduced with an uniform irrigation system and proper scheduling. If the system is scheduled for no deep percolation, the nonuniformity of the system will result with less water applied in some areas and stress may cause reduced crop production.

The efficiency is not a constant value each irrigation, even with the same system. The climatic conditions will change the evaporation and wind drift losses. The deep percolation depends on irrigation scheduling and uniformity. Even with perfect uniformity, deep percolation will result if irrigations are applied that can not be stored in the root zone. Don't neglect the savings that can be accomplished with better management. Management could be more important for saving water and energy than converting to a lower pressure system. Irrigation which can not be stored in the root zone is a direct loss of water. The management of effective use of rainfall can also reduce the irrigation requirements.

Capacity

The crop water requirement is an important value to determine the net capacity of the irrigation system. The field size, soil type and the irrigation system efficiency are needed to determine the system capacity. The soil type affects the maximum amount of available water that can be used before you must irrigate. Sandy soils may hold less than 1 inch/ft. in the root zone as compared to 3 inches/ft. on silt soils. The system capacity must be sufficient to supply enough water for peak use of the crop. The peak use rates that must be met by the irrigation system depend not only on the climatic demand but also on the available soil water. The more the available water, the lower the average peak use rate. The peak daily ET rate for one day is higher than for average peak daily ET rates over a longer period.

The system design and sprinkler packages affect the application rate, uniformity and evaporation. The type of system will have a potential efficiency that is needed to determine the capacity of the system. The design is a trial and error procedure, you first select the type system and estimate its performance to calculate the capacity. You must then check whether the water supply and the system application rate is suitable for the soil. If not you will need to consider a different type system. The maximum water used from the soil depends on soil type and management. You must project the maximum available water to be used between irrigations. This is a function of soil type, root depth and risk to deficits in high ET and low rainfall years. The system capacity is usually expressed in units of gpm/acre.

System length

The system length of a center pivot is designed based on the irrigated area of the field. The most common size is a 130 acre circle. The water supply can limit the area and system length that can be adequately irrigated. A limited water supply is probably the most valid justification for converting or installing a LEPA system.

Another important consideration in selecting the length is the intake rate of the soil. One way to prevent runoff is to design the application rate to be less than the intake rate. The application rates under a center pivot system increase from the pivot outward along the lateral. This is necessary since the flow per unit length of the lateral must increase in direct proportion to the area irrigated with the increasing distance from the pivot. It should be emphasized that the efficiency of an irrigation system is a function of the irrigation uniformity. However, this assumes that the water infiltrates at the point where it is applied. Any surface water movement will decrease the uniformity and thus the efficiency.

Runoff does not have to leave the field as a direct loss before it reduces the efficiency. Many irrigators when asked will respond that they do not have any runoff. Their answer means that they don't see any water running out the edge of the field. The following presentation by Duke will examine in detail the effect of nonuniformity on the performance and costs of an irrigation system. The uniformity measured with catch cans will be reduced if there is surface translocation that does not infiltrate at the point it is applied.

Sprinkler package

The type of sprinkler package to select has been confusing to many. There is no simple answer for the appropriate package. The previous information provides the basics that must be considered. The packages available include high pressure impacts (>50 psi), medium pressure impacts (>35 psi), spray nozzles (<20 psi) and LEPA (<10 psi). The pressures are not exact but given as a guide for the type of sprinklers used.

Center pivot sprinklers were introduced with high pressure impact sprinklers with end guns at the outer end of systems and irrigated 132 acres. The pivot pressure was near 90 psi and had capacities of 1000 gpm. The peak application rate approached 1.5 inches/hour at the outer end. These systems performed well and had measured efficiencies of 85%. Even these systems presented runoff problems on many soils. We measured as much as 20% translocation under these systems on silt loam soils. The high energy costs made it desirable to reduce the pressure requirements.

The medium pressure low angle impact sprinklers were quite successfully used as replacements to the high pressure systems. The wind drift from these packages was observed to be less than that of the high pressure systems. The application rate increased slightly but did not cause an appreciable runoff problem. The efficiencies were in the 85 - 90% range with operating pressures decreased to 30-40 psi. Many of these systems are recommended and still in use. The newer systems were often reduced from the 1000 gpm to 800 gpm or less.

Systems with low pressure spray nozzles provide an even lower energy requirement with pivot pressures of 35 psi. With the spray nozzles mounted on drops, 90% efficiency is typical of well designed systems. The application rates are much higher approaching 10 inches/hour depending on the height of the spray nozzle. Even though application rates are higher, the smaller drop size and continuous application has not resulted in as much runoff as one would expect. Simultaneous with the adoption of the low pressure packages, there was an increased awareness of the need to improve the cultural practices that enhance intake rates and decrease the potential runoff.

The LEPA head is a recent package that is used quite extensively. The common LEPA heads are actually operated in several modes. When operated in the irrigate mode, they are similar to the spray nozzle on a drop. These heads operate at 6-10 psi. The efficiency of these systems can approach 95%. When the heads are operated in the LEPA mode, they actually apply a bubble of water in a single furrow. The LEPA technology includes more than just the installation of a sprinkler package. It includes tillage to make small reservoirs to prevent runoff. The water is given time to infiltrate after the sprinkler system has moved on to dry soil. The application rate is very high and is higher than the intake rates of any cultivated soils. They are best suited on very level fields that decrease the potential hazard of surface movement. Fifty percent runoff has been measured on sloping soils without reservoirs. Increased slope decreases the amount of water that can be stored on the soil in the micro reservoirs. More frequent and smaller irrigation depths will need to be applied.

RISK

The system may perform as expected one year but not the next year. The capacity is a function of crop water requirements and precipitation that are not constant from one year to the next. I have calculated seasonal water use to vary from 21 to 26 inches for corn in eastern Colorado . The differences in weekly ET for a given week in the year had a ratio of 2 to 1 for a 10 year period. We all recognize that the rainfall is also highly variable from year to year. I have chosen the week interval since this is the period that is important in determining the irrigation requirements and system capacity for many soils. On sandy soils the irrigation interval maybe even shorter with larger year to year variation.

We have seen many LEPA systems installed with much lower capacities the last few seasons. The phenomenal results reported by some who converted to LEPA with the low capacities may not continue. Rainfall has been adequate to produce excellent crop production the last 3 years with smaller capacity systems. They may face a disaster when we have a drought and increased crop demand. Even one month or 6 weeks of low rainfall and higher crop demands could significantly reduce crop production when using the smaller capacity systems. The increased efficiency of 5 to 10 % for LEPA systems justifies a small decrease in capacity. However this does not justify 30 to 40% decreases in system capacity for converting systems unless they were over sized or of poor uniformity.

MANAGEMENT

It is not just the system selection that is important in having a successful and efficient irrigation system. The tillage and cultural practices can change the intake rates and reduce the potential runoff. The LEPA system technology is not just changing sprinkler package and reducing operating pressure. It includes the addition of micro basins and the recommended planting in circles under center pivots. The uniformity of an irrigation is decreased with surface translocation. You may not see any runoff at the outer edge of the field but could have large amounts of water translocated.

The next paper illustrates that uniformity has a large affect on the volume of water required. Additional pumping adds to the energy costs. The total energy is dependant on the pressure, flow and the number of operating hours of a system. Lower uniformities require either higher flows or more time to obtain the same crop production. The energy saved is less than anticipated. The trade off between reduced pressure and increased volume needs to be analyzed. The extra volume of pumping may negate any savings from converting to lower pressure systems.

Irrigation scheduling is also important in managing a center pivot system. Irrigating when the soil is unable to store the applied water will waste water. Wasted or lost water uses extra energy. Inadequate irrigation contributes to water stress and reduced crop production. Decreased production losses may be less than the cost of irrigation. Deficit irrigation may maximize net returns. Silt and clay soils with larger water holding capacities can often be irrigated without filling the profile. This allows an available storage capacity in the soil to maximize the use of rainfall. The more rainfall that is effectively used, the less energy required to irrigate.

Systems may be designed to irrigate with deficits during years with low rainfall and/or high water use. It may be economical to accept less than maximum production during those years. The long term economics may not justify the additional investment for the increased capacity. The total energy cost for electricity is the sum of a demand charge (kw) and the energy use (kwh). The smaller system has a smaller demand charge but to pump the same amount of water will run more hours. The tradeoff between demand and consumption of electricity must be considered. Don't forget to evaluate the risk. Only then can you make a decision as to the best system and sprinkler package for your system.

SUMMARY

One system is not for all. You must consider your climate, crops, soils, tillage practices, water supply and management effectiveness. We don't all have the same amount of time or ability to manage our systems. Our available labor may constrain our ability to implement the more advanced technology. Don't make a decision without understanding the various factors that determine the success with a new or converted system.