SELECTING SPRINKLER PACKAGES FOR SPECIFIC CONDITIONS

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INTRODUCTION

Sprinkler package selection in the early 1970's was quite simple because there was only a handful of options to choose from. Since that time the number of different options has increased to several hundred. This increased flexibility carries with it a need for more care when making the final selection. Irrigators cannot afford to install a sprinkler package based upon pumping costs alone. Crop requirements, wind drift, runoff potential and special system capabilities may be significant factors affecting the actual operating efficiency of the system. Further, some sprinkler packages may require alteration in crop row orientation or field tillage practices. This paper will discuss services which are typically provided by sprinkler sales representatives, how sprinkler package operating characteristics vary and how special field conditions can be matched by sprinkler packages.

DEALER SERVICES

Sprinkler package selection assistance varies among dealers, however, most dealers provide many of the services described below. Questions which need to be answered and potential use of the responses are:

1. Question: Is there a particular pattern to the field's topography?

   Answer: This information can be used to design special drive tower locations and in particular, identify field slope conditions for areas of potential runoff.

2. Question: What is the pump flow rate and operating pressure?

   Answer: Used to match sprinkler package output to an existing pumping plant. For a new installation the irrigation system should be designed and then select a pumping plant which matches the irrigation system's inlet requirements. Also used to size pivot lateral or pipeline. Best estimate provided by a pumping plant test.

3. Question: What soil textures are represented in the irrigated area?

   Answer: Used to match soils with the water application rate and water droplet characteristics of the sprinkler package.

4. Question: Are there any obstacles which the system must operate around?

   Answer: Used to identify system control requirements for sprinklers and center pivot.

5. **Question:** **Do you intend to chemigate?**

Answer: **Used to identify the most appropriate sprinkler package for application uniformity. Also used to determine irrigation system coating.**

Still other questions are best verified by an on-farm visit to the field area in question. Field dimensions, field elevation changes, acres irrigated and other field layout conditions are easily accounted for and may have been overlooked by the irrigator. Supplying accurate answers to these questions are key to making an appropriate sprinkler package selection.

The final question should be how much is the system going to cost new or converted? Since the answer to this question is typically a long term decision, fixed and variable costs of the system should be accounted for. It is particularly important that differences in total cost of the irrigation system be evaluated.

SPRINKLER PACKAGE CHARACTERISTICS

Understanding "characteristics" of a sprinkler package is an important part of the process of selecting sprinkler packages. It is very important to keep all characteristics in mind because it is inescapable that one characteristic will require priority over other characteristics during the selection process. Table 1 may help to keep some of the characteristics in mind. Seven generalized sprinkler packages are shown. Combining options for regulators, drop tubes, pad assortments and mixtures of the seven packages, quickly shows that actually hundreds of sprinkler packages are available to obtain the results necessary for various field conditions. Included in Table 1 is a column for LEPA. LEPA systems are more closely related to flood irrigation since under all conditions the water application rate exceeds the soil infiltration rate. Special management practices are required and are covered in other parts of this meeting.

Average Application Rate

Water application rate by a center pivot/lateral system varies as the system passes over a given point in the field. Figure 1 shows water application patterns for five sprinkler types. If the amount of water applied (in inches) and the time of application (in hours) are recorded, dividing the water application amount by the elapsed time provides a good estimate of the average water application rate. The average application rate for a lateral or linear move system is constant from one end of the system to the other. However, the average application rate for a center pivot increases with distance from the pivot point with the highest application rate being near the distal end of the pivot pipeline. Table 2 presents a relative rating of average water application rates excluding the LEPA system. The average application rate establishes how fast the soil must take in water. Thus some sprinkler packages can be eliminated from consideration if the average application rate exceeds the soil infiltration rate by a significant margin.

Instantaneous Application Rate

The instantaneous water application rate is the rate water is supplied to the soil at some point in time and at some point in the field. Table 2 presents a relative rating of instantaneous water application rates for sprinkler package types 2 through 7. Note that although low pressure spray nozzles deliver the highest average application rate, the instantaneous application rate is lowest due to their 360 degree water pattern. On the contrary, high pressure impact sprinklers provide water to a narrow slice of soil as it rotates in a circular motion. Thus, when water is being supplied to the soil it is at a greater rate than the low

pressure spray. The impact of this factor is felt in the negative effect the larger water droplets have on soil structure and the infiltration rate of most soils.

Wetted Radius

The wetted radius of a sprinkler is an assessment of the relative distance the water will travel away from the sprinkler prior to reaching the soil. Larger wetted radii require larger water droplets and greater sprinkler pressure. Consequently, the high pressure impact sprinklers typically provide the greatest wetted radius. The wetted radius also provides an indication of the average application rate since the time of water application is affected by the total water application pattern while the application amount is not. Thus, larger wetted radii result in lower water application rates.

Water Droplet Sizes

Water droplet size is controlled by the outlet pressure of the sprinkler, diameter of the opening, whether the opening is circular or other shape and what type of impact pad or arm the sprinkler is equipped with. Thus, large high pressure impact sprinklers typically produce a greater percentage of large droplets. However, some sprinkler types produce water droplet sizes similar to high pressure impact sprinklers. A change in one or more of the factors mentioned at the start of this paragraph will alter the sprinkler's output considerably. Large water droplets cause high instantaneous application rates and can produce crusts on unprotected soil surfaces. Surface crusting reduces the soils infiltration rate hence increasing the potential for runoff.

Water droplets also affect evaporation and wind drift losses. Smaller droplet sizes are more prone to be carried by wind to some off-target location. Thus, larger droplet sizes reduce wind drift problems. Small water droplets have greater total surface area than large water droplets. Evaporation loss, though a small percentage of the total water applied, is greatest for small water droplets.

These two factors have led sprinkler companies to develop a variety of means to get more water to the soil surface. Included are: 1) drop tubes; 2) serrated impact plates for low pressure spray nozzles; 3) controlled droplet size outlets for low pressure impact sprinklers; 4) low trajectory angles on low pressure impact sprinklers; and 5) LEPA systems. It is imperative that soil surface-water droplet impact interactions be considered when making a sprinkler package selection.

A couple of examples may get the thought process going.

1. A farmer decides to use a mixture of spray nozzles and rotators. He wants the first three spans with rotators and the rest with sprays. A second farmer decides to use a mixture of spray nozzles and rotators. He wants the first three spans with sprays and the rest with rotators. The mixture is reversed on these two systems. Which farmer is wrong? Neither!!

The first farmer has soils, crops, etc. which allow him to use sprays all the way. His pivot machine, however, has outlets too far apart for sprays on the first three spans. Due to their greater wetted radius rotators will provide the necessary overlap. His mixture works just fine. The second farmer has a soil and crop condition that is not favorable to the high average application rate of sprays on the outer part of his system. Rotators produce lower average application rates so he installed them on the last several spans. But he can save some money with less expensive sprays on the first three spans. His mixture works just fine.

2. A farmer in the desert southwest went to a number of meetings, read many articles and talked to many people about sprinkler packages. He was most impressed with the concern over evaporation. He determined to cut evaporation

and wind drift loss to a minimum. He selected sprays with a coarse pad and on drops close to the ground. Compared to a low angle impact system he probably cut his evaporation and wind drift loss from 25% down to 10% -- a saving of 15%. However, this selection combined with an overlooked slope factor and heavy soil conditions which resulted in 40% runoff. Don't zero in on one characteristic. It is the combination that counts.

ADAPTING TO SPECIFIC CONDITIONS

Significant advances and new style heads have been developed for installation on center pivot sprinkler systems. The first center pivot systems were designed with constant spacing of high pressure impact sprinkler heads. Large guns were typically installed on the end of the lateral to extend the area irrigated beyond the lateral pipe line. The sprinklers were the same as those used on traditional hand move and solid set sprinkler systems. As the center pivot systems became more popular, the sprinkler head manufacturers began to design heads for specific application on center pivot systems.

The main problem with center pivot systems was to prevent runoff caused by the high application rates and reduce the wind drift. Wind drift is a problem since many of the heads are mounted fairly high above the soil surface to allow clearance of the lateral pipe above the canopies of tall crops. Evaporation was also perceived as a problem which limited the efficiency of center pivot systems. The increase in energy costs was the major driving force for changing to sprinkler heads which operate at lower pressures.

There are many factors that need to be considered when selecting and installing a sprinkler package on a center pivot. Probably the biggest factors in selecting the package are the system discharge and pressure which directly effect irrigation depth and the pumping cost. Pumping costs were decreased by first transitioning from high pressure (60-90 psi) to medium pressure (35-60 psi) and then to low pressure (20-40 psi). To decrease the wind drift for medium pressure sprinklers, the nozzle angle was reduced with quite visible benefits. The conversion to low pressure sprinkler heads was accomplished by changing from impact heads to spray nozzles. Many of the first spray nozzle conversions mounted the head on the top of the sprinkler lateral and increased the wind drift and evaporation. We now see most of these systems with the spray heads mounted on drop tubes to reduce the time for the water to reach the soil surface and therefore reduce the evaporation and wind drift.

Let's examine how these changes have effected the irrigation efficiency of center pivots. The main points to consider are the runoff, evaporation, wind drift and energy cost. Runoff has always been a problem with many of the center pivots, even with the high pressure systems. The peak application rate of a typical quarter section center pivot with high pressure sprinkler heads is 1 to 2 inches/hour. The medium pressure sprinklers with smaller pattern radii results with an increase in application rate (3 to 5 inches/hour). The low pressure spray systems result with application rates of 8 to 10 inches/hour. Very few soils have a sufficient intake rate to directly infiltrate the water as it is applied but must rely on surface storage to provide additional time for the water to infiltrate. The intake rate however is also effected by the operating characteristics of the sprinkler head as previously mentioned.

The drop sizes of the high pressure systems are generally large and will compact the soil surface and decrease the intake rate of the soil. This is particularly true early in the irrigation season when the crop is small and the soil surface is exposed. The advantage of the large drops is that the wind drift and evaporation are less. Research has demonstrated that the evaporation is probably less than 5% and is offset by the reduced crop evapotranspiration. The Et is reduced the most when the crop reaches effective cover and the demand for water is a maximum.

Larger drops result from a larger pattern radii and reduce the application rate at the soil surface. This allows more of the water to infiltrate and reduce the runoff. The soil sealing from the large drops causes a reduction in the intake rate but is not a problem if irrigations can be delayed until after the canopy shades the soil surface. The timing of the first irrigation or the tillage and cultivation practices are important considerations in determining the detrimental effects of large drops on reducing the intake rates.

The high pressures sprinklers also could be installed at wider spacings on the lateral and still provide sufficient overlap to provide a uniform irrigation. The conversion to medium and low pressure sprinklers require that the spacing be closer to provide the necessary overlap for uniform irrigation. Many of the medium pressure systems are installed with a variable sprinkler spacing to obtain the desired flow rates through the smaller nozzles and apply sufficient water near the outer end of the center pivot lateral.

The cost savings of pumping costs is the primary driving force for conversion to systems with reduced operating pressure. Unfortunately some of these conversions were made without proper consideration of the pumping plant. In general it is necessary to alter the pump if the potential cost saving benefits are to be achieved. Just placing a valve in the pipe line to reduce the pressure does not reduce the pumping costs as is possible with a new pump. If the same discharge is maintained, no reduction in pumping costs will result.

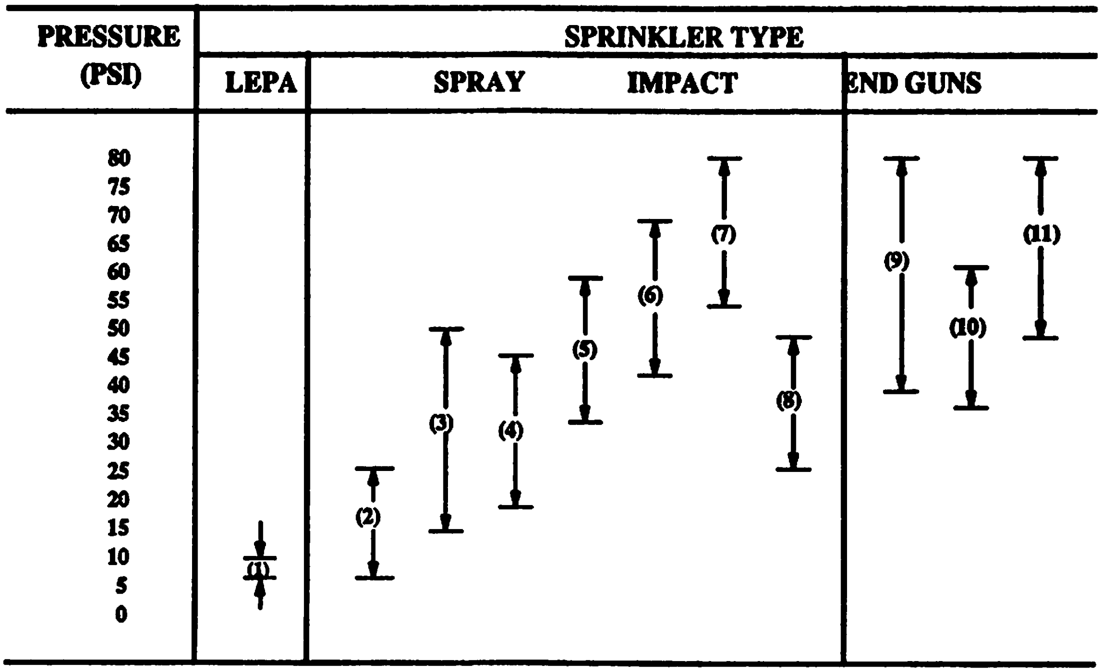
The spray nozzles are quite common and provide excellent results. The smaller drop sizes do not cause as much damage to the soil surface and may cause less surface sealing and intake reduction. However, unless the spray nozzles are put on drop tubes, the wind drift and evaporation are increased and the irrigation efficiency will be reduced. The application rates are increased with the smaller pattern radius. This can be overcome by using booms attached to the sprinkler lateral and move the nozzles away from each other to reduce the overlap and resulting application rate. Research has shown that the evaporation is much higher for small drops from spray nozzles than for the larger drops from the higher pressure impact sprinklers.

The increased application rates with the low pressure systems will generally exceed the intake rate. Many of the successful users of the low pressure systems provide for increased surface storage to reduce the surface runoff from the high application rates. Small dikes or pits are constructed in the furrows to increase the surface storage capacity. This is particularly true for the LEPA systems which operate at very low pressure and the heads mounted near the soil surface (approximately 12 inches). For best operation the row crops should be planted in a circle with the nozzle applying the water directly into the furrow.

Another factor that is generally ignored is the effect of start-stop of the tower motors which move the irrigation lateral. This factor will not influence the uniformity of the medium and high pressure systems that have large pattern radii (>30 feet). However, with the low pressure spray nozzles, with effective wetting patterns less than 25 feet diameter, the uniformity can be reduced with the non uniformity of start-stop travel times and distances. Alignment of the lateral on the towers becomes an important consideration to assure uniform irrigations.

The choice of sprinkler nozzle packages should not be made without the consideration of the various factors discussed. Remember that the cost of pumping is not just related to the pressure but also the discharge and the number of hours of operation. It is important to have a good management plan for scheduling irrigations to apply just the right amount of water to meet the crop water requirements. Excess irrigation can very quickly eliminate any savings from reduced pressure systems.

Table 1. Minimum end pressures on center pivots and linear move systems for various sprinkler devices.



(1) LEPA
(2) SPRAY NOZZLES
(3) ROTATORS
(4) SMALL IMPACTS- MODIFIED NOZZLES
(5) SMALL IMPACTS-ROUND HOLE NOZZLES
(6) LARGE IMPACTS-ROUND HOLE NOZZLES
(7) LARGER IMPACTS-(1-1/4")-ROUND HOLE NOZZLE
(8) IMPACT END GUN-MODIFIED NOZZLE
(9) IMPACT END GUN-ROUND HOLE NOZZLE
(10) GUN TYPE END GUN-MODIFIED NOZZLE
(11) GUN TYPE END GUN-ROUND HOLE NOZZLE

Table 2. Rating of output characteristics of sprinklers 2 through 7 from Table 1.

CHARACTERISTIC	SPRINKLER WITH THE HIGHEST	SPRINKLER WITH THE LOWEST
AVERAGE APPLICATION RATE	(2)	(7)
INSTANTANEOUS APPLICATION RATE	(7)	(2)
WETTED RADIUS	(7)	(2)
WATER DROPLET SIZE	(7)	(2)

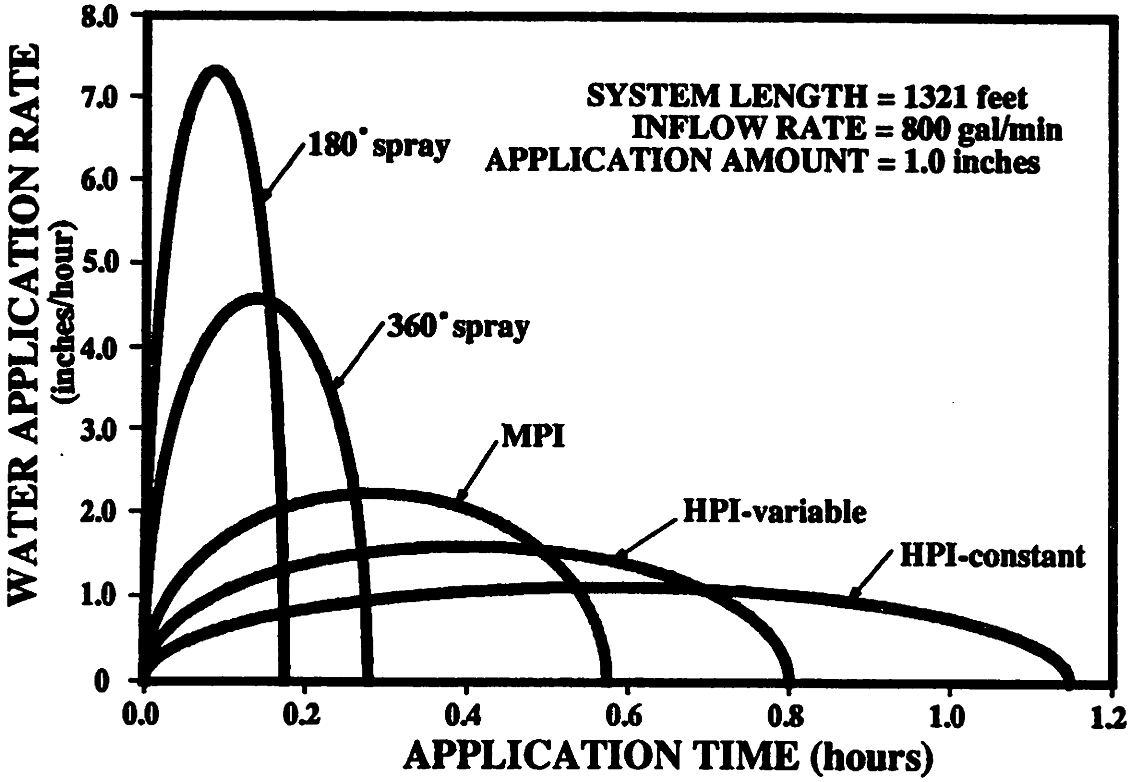


Figure 1. Water application rate curves for various sprinkler packages.