



EM4832

Set-Move and Permanent Sprinkle Irrigation Systems

Set-move sprinkle irrigation systems include wheel-lines, hand-lines, and permanent solid set systems. Evaluate the operation, management and maintenance of these systems periodically to ensure that water is being applied with high efficiency and uniformity. Older set-move systems may have inherent design problems, including excessive pressure variation, and too-wide sprinkler spacings. These limit efficiency and uniformity of application.

Typical problems found in set-move systems are explained. Use the simple measurements outlined to determine if problems exist. Suggestions for making system improvements are given. Water savings and increases in water application efficiency and uniformity often result.

Application Efficiency and Uniformity

Irrigation application efficiency is defined as the average ratio of the amount of water applied and stored in the root zone to the gross amount of water applied. It gives an idea of the magnitude of losses which occur during application. These losses include runoff, deep percolation of water below the root zone of the crop, evaporation, and wind drift. Application efficiency depends on the uniformity of irrigation and system management. It will vary during the season depending on environmental factors at each irrigation—such as wind speed, temperature, and humidity. Typical average application efficiencies for set-move sprinkle systems range from 65% for hand-lines to 80% for undertree solid set sprinklers.

Irrigation uniformity is a measure of the evenness of water distribution on a field. A uniformity of 100% indicates that all parts of the field receive

the same amount of water. Irrigation uniformity depends largely on the hydraulic design of the system and on system maintenance. Design set-move sprinkle systems to have a minimum coefficient of uniformity of 80%. Environmental factors, such as wind, operation of the system at pressures lower than the design pressure, and system wear, all cause irrigation uniformities less than 80%. There is a consequent reduction in application efficiency and an increase of lost or wasted water.

System Evaluation

A number of simple measurements can be made on set-move sprinkle systems to determine how the system is operating. WSU EB1305, *Sprinkler Irrigation—Application Rates and Depths*, provides a procedure for making these measurements. Basic tools needed are a container of known volume, such as a 5-gallon bucket or 1-gallon milk jug, a short section of hose having a diameter large enough to fit loosely over the sprinkler nozzle, a set of new drill bits, a pair of vise grips, a tape measure, a stop watch or wrist watch with second hand, and a Pitot tube pressure gauge. This last item, available at local sprinkler irrigation dealers, allows you to measure the pressure at each sprinkler nozzle. Make the following measurements on several sprinkler heads while the system is operating under normal conditions.

Sprinkler Flow Rate. Use the hose over the operating sprinkler nozzle to direct water from the sprinkler into the 5-gallon bucket or other container. Measure the time it takes to gather this known volume of water. Convert the volume and time into the sprinkler flow rate in gallons per minute. For instance, 5 gallons collected in 45 seconds equals (5 gal x 60 sec/min divided by 45 sec) 6.7 gpm.

For best uniformity, there should be no more than 10% difference in flow rates from one head to another operating at the same time on the system.

Use sprinkler flow rate to determine the sprinkler application rate and eventually the depth applied. To accomplish this, measure the sprinkler spacings on the lateral and the lateral spacings on the mainline (both in feet). This applies equally to all types of spacings—square, rectangular and diamond. The average gross application rate under the sprinkler (inches per hour) equals:

$$\text{gross application rate (in/hr)} = \frac{\text{sprinkler gpm} \times 96.3}{\text{sprinkler spacing (ft)} \times \text{lateral spacing (ft)}}$$

Multiply this by the set time in hours to find gross depth applied. Gross depth is multiplied by the application efficiency to find the average net depth applied. This is the amount of water available to the crop in the root zone as a result of irrigation.

Sprinkler Pressure. Measure sprinkler pressure using the Pitot tube pressure gauge. Hold the end of the Pitot tube in the center of the sprinkler jet about 1/16 inch from the nozzle. A fan shaped plume of water around the tube is created. As energy in the jet is directed up into the base of the pressure gauge, the needle registers a reading.

There should be no more than a 20% difference in pressures between any two sprinklers operating at the same time. Excessive pressure variation on set-move systems is a large problem. It is caused by poor hydraulic design, system wear, poor system management and elevation differences on the system.

Many systems have been designed with pipes that are too small. This causes excessive pipe friction losses and consequent pressure losses from point to point. Systems have also been designed taking little or no account of the effect of elevation on pressure within the system. Each foot of elevation gain or loss is equal to 0.43 psi. Using pressure regulators on the system, or pressure-compensating nozzles can even out excessive pressure variation.

Many systems are operating under conditions for which they were not designed. Often systems are

managed with more sprinklers than the pumping system was designed to operate. This lowers sprinkler operating pressures below the desired level. The system must operate at the pump design capacity and head for efficient, uniform irrigations. Use a pump test to determine whether the pump is operating efficiently or if it needs repair or replacement.

Sprinklers operating with pressure too low form large droplets because of inadequate jet breakup. Doughnut patterns form, and uniformity is poor. Large droplets cause breakdown of surface soil aggregates, reduced infiltration and increased runoff losses. Sprinklers operating with pressure too high form many small droplets and mist. Evaporation and wind drift losses are high. The throw pattern is also reduced, reducing the irrigation uniformity.

Sprinkler operating pressure is important for uniform, efficient irrigations. Systems with traditional round orifice nozzles and 3/4-inch sprinklers should generally have at least 50–55 psi at the sprinkler, while those with 1/2-inch sprinklers should have at least 40 psi.

Nozzle Inventory and Nozzle Wear. Generally, set-move systems are designed with one nozzle size. Systems acquire a variety of nozzle sizes as they age. This occurs naturally through nozzle wear. Replacement of sprinkler heads and nozzles, and attempts to control pressure variation with different nozzle sizes lead to use of mixed nozzle sizes on set-move systems. Inventory the nozzles used on a system. If more than one size nozzle is found, uniformity and efficiency problems will occur. Do not mix nozzle sizes. Use nozzles all the same size. Control pressure variation by using pressure regulators or pressure-compensating nozzles.

Some older systems use double nozzle sprinklers. One nozzle may be capped, or a head may be replaced with a single nozzle head. Use only single nozzle sprinklers or double nozzle sprinklers on the system. Make sure the two nozzle sizes on double nozzle sprinklers are uniform throughout the system.

Measure nozzle wear while the system is operating. Insert the shank end of a drill bit the same

size as the nozzle into the nozzle. Hold the drill bit with vise grips. If the flow shuts off completely, then the nozzle is in good shape. If the drill bit fits loosely and spray leaks around the drill bit, replace the nozzle. Sediment in the irrigation water causes nozzle wear. Replacing worn nozzles saves water and pumping costs and improves irrigation uniformity.

Sprinkler Spacings and Throw Patterns. Sprinkler spacing, discussed above, is used to determine the sprinkler application rate. It is important to assess the sprinkler spacings relative to the size of the throw pattern. For good uniformity of application, the sprinkler spacing on the lateral should be 50% of the sprinkler throw pattern diameter. Spacing of laterals on the mainline should be 65% of the throw pattern diameter. This applies for wind conditions up to 7 to 10 mph. For windier areas, reduce the spacings. Keep the shortest leg of a rectangular sprinkler spacing perpendicular to the prevailing wind direction.

For hand-lines and wheel-lines where wind is a problem or spacings are wider than recommended, improve irrigation uniformity by using a lateral offset program. This entails setup of the lateral midway between the lateral settings of the previous irrigation at every other irrigation. Install a swing pipe from mainline connection to the lateral.

Soils Problems. Soils within a field or block will vary, having different intake rates as well as different slopes and different available water holding capacities due to texture or depth. Set-move sprinkle systems are designed with application rates less than or equal to soil intake rates. If this is not the case, excessive runoff and soil erosion losses occur. Systems are designed for one application rate and one depth applied for a given set time. If soils vary too much, inefficiencies occur—some areas may have runoff, other areas may be overirrigated.

Where economically practical, valving and blocking within a solid set sprinkle system can overcome these problems. When using all set-move

systems, installing valves on each sprinkler riser can offer significant management flexibility, although labor input increases as well. In years when water supplies are tight, turning individual sprinklers on and off according to soil or other conditions can stretch available water much further. Areas having different requirements compared with a field or block on the average can be much more efficiently irrigated.

Environmental, Other Factors. When possible, operate all sprinkle systems during less windy and cooler times of day. Avoid irrigating in the heat of the day. If system capacity allows, turn the system off during high winds. Fifty to 75% of the water may be lost to evaporation and wind drift under warm, dry, windy conditions. Uniformity of application will also be poor.

When supplies are tight and canal deliveries are at much reduced rates, there may be a tendency to irrigate with frequent, light applications to try to keep up. This strategy will not be as efficient as irrigating with larger, less frequent applications. The percentage of applied water lost to light, frequent irrigations is higher than for less frequent, larger irrigations, as long as there is no overirrigation. See the WSU Drought Advisory, EM4825 *Scientific Irrigation Scheduling*, for more information.

Information on soil moisture monitoring and crop evapotranspiration from Washington's Public Agricultural Weather Stations (PAWS) and Washington Irrigation Scheduling Expert (WISE) are available on the Scientific Irrigation Scheduling (SIS): web page <http://sis.prosser.wsu.edu>

Drought advisories and other Washington State University Cooperative Extension Bulletins are available online at <http://pubs.wsu.edu>
Type "drought" in the search box for downloadable files.

By Thomas W. Ley, former WSU Cooperative Extension irrigation engineer, WSU Irrigated Agriculture Research and Extension Center, Prosser.

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