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Solid Set Sprinkler Systems

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Solid set sprinkler systems have the lowest irrigation labor requirement and the highest per-acre equipment cost of any type of sprinkler system. Solid set systems enable the farmer to improve management practices so yields and quality of most crops are increased. When properly designed and operated, the solid set system can be used to apply fertilizer, water for frost protection or crop cooling, herbicides, insecticides and fungicides, in addition to normal irrigation.

PURCHASING CONSIDERATIONS

If you are considering a solid set sprinkler system for your farm, investigate the advantages and disadvantages of each type of solid set, including the system design and operation, the equipment and operating costs and maintenance requirements. Systems can be rented, rented with option to purchase or purchased outright. Renting may be advantageous when the acreage of high value crops irrigated by solid set systems varies from year to year. Renting with option to purchase reduces the initial capital outlay.

Although solid set systems normally require very little repair and few replacement parts, the availability of a future source for these items should be considered.

SYSTEM DESCRIPTION

A farm irrigated with a solid set sprinkler system has enough pipe, sprinklers and valves so that the sprinkler laterals are not moved during or between irrigations. The type of system is determined by the lateral, which may be portable or permanent.

Portable Laterals

Portable lateral systems have hand move laterals connected to every outlet along the main pipeline. This main pipeline can be either portable or permanent. Laterals are placed in the field at the beginning of the irrigation season and are not moved until the end of the irrigation season or harvest. They are then removed and stacked in a farm storage area. These systems are used on high value crops, such as potatoes. Other farm crops may be irrigated with either a hand move or a sideroll system. The solid set system may be moved about the farm as the high value crop fields are changed.

A typical portable lateral system used in Idaho has a quarter-mile 3-inch-diameter aluminum pipeline. Some systems use both 4-inch and 3-inch-diameter laterals and some only 4-inch laterals. The size of the lateral is determined by the discharge capacity of the sprinklers and the lateral length. Single-nozzle sprinklers usually are equipped with nozzles 7/64, 1/8, 9/64, or 5/32 inch in diameter and are usually spaced 40 feet apart on the lateral. Main pipeline outlets are spaced from 50 to 60 feet. Required operating pressures for these sprinklers range from 50 to 60 p.s.i. at the nozzle.

Permanent Laterals

The permanent lateral systems have pipes and sprinklers that remain unmoved in the field for the life of the system. The system may be on the ground surface or buried. Buried pipelines are placed deep enough to permit land preparation and crop harvesting without disturbing them. A post is usually installed at each riser to protect it from machinery or animal damage. Sprinkler spacing on the lateral may range from 40 to 300 feet. Spacing of the outlets on the mainline may range from 50 to 330 feet, depending on the type, size and discharge of the sprinklers. The required nozzle pressures depend on sprinkler and nozzle sizes used, but range from 50 p.s.i. for standard sprinklers to 120 p.s.i. for big-gun-type sprinklers.

Valves

All systems have valves that control water flow to individual laterals, blocks of laterals or individual sprinklers on each lateral. These valves may be operated manually, with time clocks or with remote controllers. Automatic controllers are used with electric or air-controlled valves to automate the solid set system. Sprinklers are turned on at pre-determined times and shut off as scheduled. Soil moisture measuring instruments (tensiometers and soil moisture blocks) may be used to start an irrigation cycle in some automatic systems.

Some solid set systems have valves that control each sprinkler, operating only one sprinkler on each lateral at a time. This permits use of lateral pipe smaller than needed to operate multiple sprinklers on each lateral. An example is a solid set system having big-gun-type sprinklers on a grid spacing of 165 x 300 feet with an electrical control valve for each sprinkler.

There are also sequencing valves on each sprinkler on which operation is controlled by varying the water pressure in the system. Reducing the water pressure to 0 p.s.i. for 0.5 to 1 minute will shut off the operating sprinkler. When operating pressure is resumed, the next sprinkler along the lateral is turned on. This procedure is repeated for the number of sprinklers on a lateral until the entire area is irrigated. The pressure may be changed either by shutting off the pump or by an electric or air-controlled valve in the main pipeline.

One problem encountered with these pressure-operated sequencing valves is that when the pressure is turned off for 5 minutes or longer, the sprinkler on the lateral nearest the main line will be turned back on. If there is an extended electrical power interruption that stops the pump, all sprinklers nearest the main line could be turned on even if the area had just recently been irrigated. It may be necessary to sequence the sprinkler system pressure several times to reset the operating sprinklers to the correct location after a power outage.

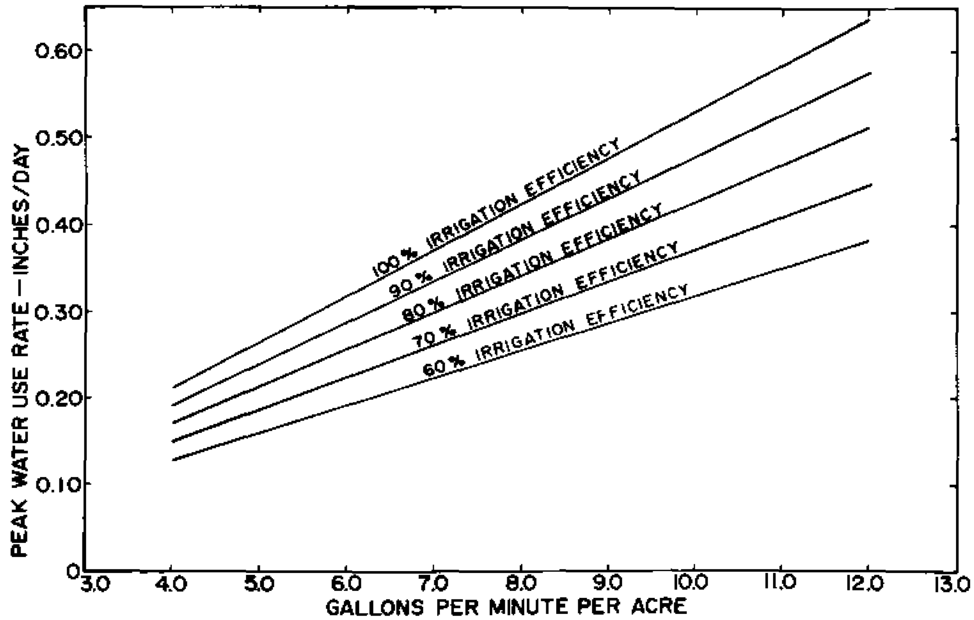

Fig. 1. Water needed for one acre for various daily peak water use rates and irrigation

SYSTEM DESIGN

The design of a solid set sprinkler system follows the same principles as used to design other "set" sprinkler systems. Information on soils, water use by crops and water supply is needed for proper design. Water-holding capacity for the root zone depth and water intake rate information can usually be obtained at the local Soil Conservation Service, County Extension or U.S. Bureau of Reclamation offices.

The system should be designed to meet the peak water use rates of the crops. Table 1 gives the peak rate for 6 major crops grown at 11 locations in Idaho.

The capacity of the system needed depends on the acreage irrigated, the peak water use rate and the irrigation efficiency of the solid set system. Fig. 1 combines all these factors, so that the design capacity to supply 1 acre can be determined. The system capacity is then the acres planted to each crop multiplied by the peak use rate in gallons per minute (g.p.m.) per acre.

For example, consider a solid set system for irrigating 80 acres of potatoes, 40 acres of corn and 40 acres of sugarbeets in the Twin Falls area. Assume the average irrigation efficiency is 70%. From Table 1, the peak water use rate is 0.31 inch per day for potatoes, 0.28 inch per day for corn and 0.30 inch per day for sugarbeets. From Fig. 1, 8.25 g.p.m. per acre are needed for potatoes, 7.5 g.p.m. per acre for corn and 8.0 g.p.m. per acre for sugarbeets. The system capacity is 1,280 g.p.m. (80 x 8.25) + (40 x 7.5) + (40 x 8.0) .

Table 1. Peak crop water use rates in Idaho.

Area	Alfalfa	Corn	Grain	Pasture	Potatoes	Sugarbeets
	inches/day					
Bonners Ferry	0.25	0.22	0.22	0.22	0.24	----
Caldwell	0.33	0.28	0.30	0.29	0.31	0.30
Council	0.29	0.25	0.26	0.25	0.28	0.26
Dubois	0.28	0.24	0.25	0.24	0.27	0.25
Grand View	0.34	0.30	0.31	0.30	0.32	0.31
Grangeville	0.29	0.25	0.26	0.25	0.28	0.26
Idaho Falls	0.29	0.25	0.26	0.25	0.28	0.26
Lewiston	0.34	0.29	0.30	0.30	0.32	----
Moscow	0.29	0.25	0.26	0.25	0.28	----
Pocatello	0.30	0.26	0.27	0.26	0.29	0.27
Twin Falls	0.33	0.28	0.29	0.28	0.31	0.30

The water supply, pumping equipment, mainlines and lateral pipelines must be designed to distribute this volume of water. The mainlines should be sized to provide the most economical balance between pipe cost and power consumption cost. When solid set systems are operated in blocks of laterals and larger quantities of water are carried by some main or submain pipelines, they must be larger than when the laterals are scattered throughout the field.

The design of the laterals for a field depends upon the type of sprinkler used, the nozzle size and the nozzle pressure. In selecting the size of the laterals, the general design rule is to limit pressure loss to a maximum of 20% of the pressure at the entrance to the lateral. This includes friction loss and elevation changes. Sprinkler spacing on laterals should not exceed 40% of the wetted diameter shown in the sprinkler head performance catalogs for the sprinklers used. Spacing of the lateral outlets on the mainlines should not exceed 65% of the wetted diameter.

Sprinkler spacing should be reduced under windy conditions. One sprinkler manufacturer recommends these spacings for winds up to 7 miles per hour. For winds 7 to 10 miles per hour, the lateral spacing should be reduced to 60%. For winds above 10 miles per hour, the recommended sprinkler spacing is 30% of wetted sprinkler diameter on the lateral and lateral spacing on the main pipeline is 50% of wetted sprinkler diameter.

The average application rate of a sprinkler system depends on sprinkler spacing and the discharge from each sprinkler. Table 2 gives the average application rates per hour for various sprinkler discharges and spacings in the field. The application rate should be less than the water intake rate of the soil or water will run off, causing poor irrigation and reduced crop yields.

The depth of water applied is the product of the application rate and the hours the laterals are operated at each set. For example, a 5 g.p.m. discharge from each sprinkler with sprinkler spacing at 40 x 50 feet gives a gross application rate of 0.24 inch per hour. If the system is operated 12 hours with an irrigation efficiency of 70%, a net application of 2.02 inches will be made to the soil profile if there is no run-off.

OPERATION

The success of any solid set sprinkler system depends on the design, installation and operation of the system. Correct design and installation should be the responsibility of the manufacturer, distributor and dealer. Correct operation is the responsibility of the farmer or his irrigator.

Table 2. Average application rates for various sprinkler discharge and spacings.

Spacing	Gallons per minute from each sprinkler																			
feet	1	2	3	4	5	6	8	10	12	15	18	20	25	30	40	50	100	200	500	1000
	inches per hour																			
20 x 20	.24	.48	.72	.95	1.20	1.44	1.92													
20 x 30	.16	.32	.43	.64	.80	.95	1.28	1.60	1.93											
20 x 40	.12	.24	.36	.48	.60	.72	.95	1.20	1.46	1.81	2.17									
25 x 25	.15	.30	.45	.61	.77	.92	1.23	1.54	1.85	2.31										
30 x 30	.11	.21	.32	.43	.54	.64	.85	1.07	1.28	1.61	1.93	2.14								
30 x 40		.16	.24	.32	.40	.48	.64	.80	.95	1.20	1.45	1.61	2.01	2.40						
30 x 50		.13	.19	.25	.32	.38	.41	.64	.76	.96	1.15	1.28	1.60	1.92						
30 x 60		.11	.15	.21	.27	.32	.43	.53	.64	.80	.95	1.07	1.54	1.61	2.14					
40 x 40		.12	.18	.24	.30	.36	.48	.60	.72	.90	1.08	1.20	1.50	1.80	2.40					
40 x 50		.10	.14	.19	.24	.29	.38	.48	.58	.72	.65	.95	1.20	1.44	1.92					
40 x 60			.12	.16	.20	.24	.32	.40	.48	.60	.72	.80	1.00	1.20	1.60	2.00				
50 x 50			.12	.15	.19	.23	.31	.39	.46	.58	.69	.77	.95	1.15	1.54	1.92				
50 x 60			.10	.13	.16	.19	.26	.32	.39	.48	.58	.64	.80	.96	1.28	1.60				
50 x 70				.11	.14	.17	.22	.28	.33	.41	.49	.55	.69	.82	1.10	1.37				
60 x 60					.13	.16	.21	.27	.32	.40	.43	.53	.67	.80	1.07	1.34				
60 x 70					.11	.14	.18	.23	.27	.34	.41	.45	.57	.69	.92	1.15				
60 x 80					.10	.12	.16	.20	.24	.30	.36	.40	.50	.60	.80	1.00				
70 x 70					.10	.12	.16	.20	.24	.29	.35	.39	.49	.59	.79	.98	1.95			
70 x 80						.10	.14	.17	.21	.26	.31	.34	.43	.52	.69	.85	1.72			
70 x 90							.12	.15	.13	.23	.28	.30	.37	.45	.61	.76	1.52			
80 x 80							.12	.15	.18	.23	.27	.30	.38	.45	.60	.75	1.50			
80 x 100							.10	.12	.14	.18	.22	.24	.30	.35	.48	.60	1.20			
100 x 100								.10	.12	.14	.17	.19	.24	.29	.39	.48	.95	1.93		
100 x 120									.10	.12	.14	.16	.20	.24	.32	.40	.80	1.60		
150 x 150													.11	.13	.17	.21	.43	.85	2.14	
150 x 180														.11	.14	.18	.36	.71	1.73	
200 x 200															.10	.12	.24	.48	1.20	
300 x 300																	.11	.21	.53	1.07
360 x 360																		.15	.47	.74

System management includes timing applications to meet crop water requirements and refill soil-water storage capacity. A solid set may be operated the same as a hand move, at the normal irrigation interval. When irrigation is needed, fill the soil profile. Then let it dry down to the desired soil moisture level before the next irrigation.

Under windy conditions, water distribution will be more uniform with multiple applications. Idaho's average windspeed varies from 6.5 to 9 miles per hour with a high percentage of gusty winds in May and June. Irrigators in windy areas may want to apply frequent 1-inch applications. In many areas during peak use a 1-inch irrigation will be applied every 3 days.

Light, frequent applications will not wet the soil deep enough to keep the submoisture at adequate levels. For example, during the season potatoes will require 1 or 2 heavy applications to wet the root zone. Dig a hole and moniter the subsoil moisture. When it gets too dry, apply enough water to fill up the root zone. Then resume the light, frequent irrigations until another heavy application is needed.

Early and late in the season, crop water use is less than in the middle of the season. The sprinkler system is designed to apply water at the peak use rate when operating continuously. For early and late season irrigations, apply smaller amounts of water by operating each lateral for a shorter time or increasing the time interval between applications.

In Idaho, portable lateral systems are used mostly on potatoes and sugarbeets. The portable laterals are placed in the field after early spring cultivation. Since moving the laterals into and out of a field requires much labor, many irrigators report they do not reduce their labor costs as much as expected. Some farmers further reduce labor needs by using special pipe trailers on which the lateral pipe from the fields is stacked by hand. After the trailer has been properly loaded in the field, the pipe load is banded in several places to form a bundle. This is lifted from the trailer with a mechanical lifter and placed on a pipe stand at the storage yard, ready to be returned to the field for the next season. This procedure reduces pipe-moving labor about 35% compared with hand loading and unloading the laterals.

Solid set sprinkler systems are usually operated in blocks of adjacent laterals. This reduces irrigation labor required during high water use periods, but may require larger main pipelines to maintain proper sprinkler pressure. The number of laterals in operation at one time will be determined by the rate at which water is available.

When electronic controllers are used to automate the solid set system, they are programmed by the irrigation operator according to the crop, water use and the root zone water storage capacity.

Fertilizer can be applied with the solid set sprinkler system. For accurate metering, liquid fertilizers are usually injected into the sprinkler system with a gear-driven pump. Fertilizer distribution through the sprinkler system is equivalent to the water distribution pattern. Since cumulative water distribution improves with the number of irrigations over the season, distribution of fertilizer will be more uniform with multiple applications. However, tests have not yet indicated a yield benefit from multiple fertilizer applications compared to one adequate application in the spring, even on very sandy soils unless they are over-irrigated.

Solid set sprinkler systems can also be used for frost protection. A system used for frost protection must be designed to apply the depth of water needed to give the frost protection desired. This varies from location to location. Obtain professional assistance to design a solid set system for frost protection.

Solid set systems have been used for crop cooling in some areas. Research in Idaho is insufficient to prove the advantages or disadvantages of this use, except for coloring apples. Overhead sprinkling of Delicious apples has increased their color and grade at picking time.

Other possible uses of solid set sprinkler systems include application of weed control chemicals and control of soil moisture to activate the chemical. Applications of insecticides, fungicides and sprout inhibitors to potatoes are possible future uses that need research to determine their effectiveness and the sprinkler system performance required.

COSTS

Costs of solid set sprinkler systems will vary with the equipment used, spacing of laterals and the extent of automation required. As a comparison of costs of different types of solid set systems only, these values are based on early 1974 prices:

Manually operated systems with portable laterals for potatoes and sugarbeets cost $450 to $550 per acre with 3-inch laterals, $500 to $600 with 4-inch laterals. Automation devices cost $65 to $100 per acre more.

Systems with buried laterals and mainlines usually have wider spacings of sprinklers, so they cost about the same as systems with portable laterals.

Systems with sequencing valves varied from $350 to $500 per acre, depending on sprinkler spacing, type of pipe used and type of automation.

About This Publication ...

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