DROUGHT ADVISORY

EM4828

Surface Irrigation Systems

Surface irrigation is the introduction and distribution of water in a field by the gravity flow of water over the soil surface. The soil acts as the growing medium in which water is stored and the conveyance medium over which water flows as it spreads and infiltrates. Common surface irrigation systems used in Washington are rill or furrow irrigation, and to a lesser extent, border irrigation. Some lands, particularly pastures, are irrigated by wild flooding, in which there is little control over the amount of water applied or where it soaks into the ground.

Factors Affecting Efficiency and Uniformity

To achieve high efficiency and uniformity of irrigation using unpressurized gravity water application methods, all parts of an irrigated field should receive water for near equal lengths of time, with a minimum of water lost to runoff or to deep percolation below the root zone. Since the soil is quite porous, the flow rate of water is continually reduced as it spreads. Thus, getting water uniformly spread over a field requires careful management. There must be a balance between the size and shape of a field, slope, water flow rate, sod infiltration characteristics, and surface roughness, such as soil clods or vegetation that retard water flow.

Soils with high infiltration rates (usually the sandy and coarse-textured soils) are not well-suited for surface irrigation. Either field sizes must be kept small, or large flow rates are needed to achieve even applications. Soils with moderate to low infiltration rates (loams and other fine-textured soils) are better for surface irrigation.

Fields should have a uniform grade in the direction of water flow to obtain best results. A uniform grade or level surface prepared through precision land leveling helps to provide equal infiltration opportunity times. Field slopes in excess of 3% are not recommended, unless the field is planted to a permanent sod-forming crop or unless other means of erosion control are used. Very low flow rates are used in this situation.

The water flow rate into a field or furrow is an important design factor. It must be carefully balanced against the soil type and slope so that erosion is minimized, and against the field slope and length so that the water reaches the end in a reasonable amount of time. Operating the system at flow rates below or above the design flow rates can lead to inefficient and nonuniform applications. Once the water reaches the end of the field, growers must manage the inflow to reduce tailwater runoff losses.

There should be some means of controlling the direction of water flow. In furrow or rill irrigation the furrows act as conveyance channels. The size, shape and spacing of the irrigated furrows affect the soil volume wetted. When border irrigation or other flooding methods are used, dikes or borders are constructed to contain the flow within the desired field area. The State of Washington Irrigation Guide provides recommendations on surface irrigation system design and operation by soil type.

Management for High Efficiency and Uniformity

Surface irrigation systems can be as efficient as most other methods. This requires improving the management and control of water, knowing how much water is applied and scheduling applications according to soil water levels and crop

needs. 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

Typical water application efficiencies for unimproved surface irrigation systems range from 45% to 60%. Using careful management, improved water control, and re-use of tailwater runoff, growers can boost efficiencies to 70% to 85%. Differences in the amount of water which infiltrates between the top and bottom ends of the field are inevitable. Tailwater runoff is also inevitable if the bottom ends of fields are to be adequately irrigated. Using rill systems and improved management, which is enhanced by improved on-farm water delivery facilities, growers can reduce overwatering losses at the top ends of fields and the runoff losses at the bottom.

Growers will obtain the best water application from the top end of a field to the bottom if the water reaches the end of the field within one-quarter of the planned irrigation duration. Where possible, adjust inflow stream size to meet that schedule for the field length. For instance, if you plan to irrigate with 48-hour sets, water should reach the end of the field, or advance, within 12 hours for best results.

Use the largest, nonerosive stream size possible to achieve the desired advance time. For most conditions, the maximum safe stream size in gallons per minute per rill is found by dividing the field slope in percent into 10 (10/S,%). As an example, a field with a 2% slope should have a maximum stream size per rill of 5 gallons per minute. If water cannot be made to advance to the end of the field within the desired time using the maximum stream, then the field is probably too long for that given combination of slope and soil type.

Cut the field in half by adding water distribution facilities at mid-length (that is, gated pipe, buried distribution pipeline with risers and valves). Tailwater from the upper half can be used to supplement the irrigation of the lower half or caught in a ditch for re-use elsewhere on the farm.

Furrow lengths up to 1/2 mile on relatively flat slopes (less than 0.5%) can be efficiently irrigated using large streams. As a practical limit, however, field lengths of 1/4 mile or less are recommended for most Washington conditions.

Surge flow surface irrigation, which has received recent research attention, has provided significant increases in the uniformity of water application from the top to the bottom end of a field. Using surge flow, researchers have been able to advance water to the end of the field at the same rate as with conventional furrow irrigation while using only 50% to 60% of the water. Longer fields can be more efficiently irrigated with surge flow. Application efficiency of surge flow with tailwater reuse can be as high as 75% to 90%. Please see the WSU Drought Advisory EM4826, *Surge Flow Surface Irrigation* for more information.

Once water reaches the end of the field, cut back the stream size by 1/3 to 1/2 so only a small, but continuous stream of runoff water exits out the end of the rill. This will minimize runoff losses during the remainder of the irrigation. The cutback in flow can be achieved by:

1) adjusting the siphon tube setting or using two siphon tubes during the advance phase and removing one after the water reaches the end of the furrow;
2) closing the gates part way with gated pipe; and
3) closing the valves part way with buried pipelines having risers and adjustable valves.

Vegetation in furrows slows water movement along furrows and rills. Weed control in the bottoms of the furrows is very important for achieving uniform water application and reducing deep percolation losses. Cultivation and the formation of a loose soil surface with soil clods impede water flow and increase water intake. In a water-short year, control weeds chemically and avoid cultivating if at all possible. Otherwise, use a furrow packer or smoother after the cultivator to reduce deep percolation losses. Also applying Polyacrylamide (PAM) after soil cultivation will increase lateral water penetration and decrease soil erosion. PAM should also allow increased furrow flow rates that will improve uniformity of irrigation.

While water is available early in the irrigation season, irrigate in all your furrows or rills to completely fill the soil profile to field capacity and maximize soil water storage. Be careful not to overirrigate, as crop root damage may result. When water becomes short, it will help to irrigate in only one furrow per row on wide spaced plantings, such as orchards, vineyards, and hopyards. This will minimize evaporation losses and reduce water use by the cover crop or weeds. Use the same furrow all season.

For closer spaced plantings, such as asparagus and mint, irrigate in every other furrow and do not switch back and forth. Irrigating in the same furrows all season will help save water by minimizing the wetted soil evaporation, reducing the germination of weed seeds and reducing the losses from increased soil intake rates.

Tailwater Runoff

The water which leaves any surface irrigated field as runoff is a loss to that field and to the farm unless there are facilities for catching the water and re-using it on the farm. The amount of runoff is typically between 30% and 50% of the water introduced at the top of the field. If this water is re-used it can represent a significant supplemental supply compared with allowing the runoff to leave the farm. Generally, you can use a common collector ditch across the bottom of the field to channel the water into the headland facilities of a downslope field, or into a small pond for storage and later use. Tailwater ponds are often fitted with low lift pumps to move the water to other areas of the farm or back to the top end of the same field. These ponds can also catch sediment in the runoff water. See WSU EB1109, *Sediment Basin Design*, for more information.

Headland Facilities

Keep earthen ditches weed-free. Seal cracks and gopher holes. Silt which accumulates offers natural scaling. Leave this silt in place until the ditch capacity is too greatly reduced.

Eliminate seepage losses from earth ditches by using plastic linings or replacement with a concrete-lined ditch or pipeline. Gated pipe and buried low pressure pipelines with risers and valves minimize evaporation losses and weed/grass problems. Increased water control offered by these systems, particularly the flow rate into each furrow, is an important advantage in improving water management.

Water Measurement

Knowing how much water is applied with any method of irrigation is a key to good management. It is more difficult to determine amounts of water applied when using surface irrigation than when using any other method. However, tools and techniques are available, ranging from farm delivery gate measurements to siphon tube measurements, to individual furrow flow measurements. A WSU Extension publication, C0912, *Determining the Gross Amount of Water Applied—Surface Irrigation,* gives information on converting farm delivery weir flow measurements to gross depth of water applied.

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