Irrigation Training Toolbox
Irrigation Water Management Plan

USDA - SCS Fact Sheets

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Fact Sheet

What is Irrigation Water Management

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Soil Conservation Service

What

Simply, irrigation water management is knowing when to irrigate and how much water to apply.

Key Considerations

Key considerations in irrigation water management include soil, water quantity and quality, crops, climate, available labor, and economics. These factors are all interrelated.

Soil. The soil provides physical support for the plant and serves as a reservoir for nutrients and water. The chosen irrigation method must suit the soil intake rate. For example, soils with a very high intake rate are difficult to irrigate with surface methods, and soils with very low intake rates are more difficult to sprinkle. The soil must be capable of storing enough moisture between irrigations so that the plant will not suffer from lack of water, and deep enough so that the plant can develop an adequate root system. There are several methods for monitoring soil moisture. All require experience with soils and crops before accurate decisions can be made about when to irrigate and how much water to apply.

Water Supply. Adequate water to meet crop needs throughout the irrigation season and during periods of peak use by crops is another consideration. The water supply may limit the acreage irrigated.

Water Quality. Quality of water can have a serious affect on crop production and soil performance. For example, water containing chlorides sprinkled on some crops may cause leaf burn. Water quality also can influence the way plants use fertilizer. A water analysis and proper interpretation are important tools for water management.

Crops. Each crop needs different amounts of water; the amounts vary with the length of the growing season and what portion of the plant is harvested. Root systems need to be considered, too. Shallow-rooted crops will require more frequent but lighter irrigations than deep-rooted crops. By understanding the crops need for water at various stages, you can schedule irrigations to more accurately meet the crop's water demands. For example, in the first quarter of a crop's growing season, the plant's use of water is low. The need for air around the roots is high because root development is critical at this stage. Over-irrigation reduces both the volume and depth of the root growth. The flowering and pollinating stage is also a critical time. The roots are more fully developed and must supply adequate water to the plant. As a plant matures and fruit or grain is set, the demand for water may decrease.

Climate. Climate determines the need for water and the crops grown and influences the choice of irrigation methods. Climate includes the amount of precipitation in an area and how it is distributed throughout the year. Areas with good spring and early summer rains may require only supplemental water. In arid areas, irrigation may be necessary to meet all the plant's water needs. Temperature and wind directly affect plant requirements, although it may be possible to modify these factors through irrigation. For instance, sprinkler irrigation has been used for crop cooling to protect sensitive crops during frost.

Economics. Economics is an important consideration in deciding how to improve your irrigation management. The cost of water, labor, and energy will influence what you do. Your decision will require an analysis of your operation. Improving the management of your existing system is usually more economical that changing types of systems. A profitable operation—part of irrigation water management's basic goal—produces the best crop yields per acre with the available water.

For more information Contact your local office of the Soil Conservation Service.

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Soil Management

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What

Soil management is an integral part of water management because of the soil's role in storing water for plant growth. As a farmer, you have a direct impact on the soil through the tillage operations performed and the use of plant residue or other organic matter. The soil profile may be modified by mechanical operations.

Soil Inventory

The first step in planning a soil management program is to have an inventory of the soil resources. Your local Soil Conservation Service personnel can provide this inventory in some areas. It will include a summary of the physical properties of each soil, listing such things as available water capacity, intake rate, textures and the shrink-swell potential.

Management Techniques

Reduced tillage. Reducing the number of tillage operations saves fuel, labor, and wear on equipment. It reduces soil compaction, thus improving the water movement rates and plant root environment.

Fewer tractor trips will save moisture during seedbed preparation and cultivation. When the soil is plowed or disced, moisture is lost. If the soil is wet, compaction occurs. This may be prevented by using no-till planting or by performing more than one operation in a single trip. Herbicides to control weeds can replace cultivation operations.

Residue management. The benefits of leaving the crop residue on the surface are multiple. The residue serves as a mulch to reduce erosion from both wind and water and to increase water infiltration. Residue also reduces surface evaporation. Where crop residue must be plowed under, rough soil surface provides some of the same benefits. Some crops and some irrigation systems allow planting directly into such rough soil conditions. Residue adds organic matter to the soil; this has a direct influence on soil-water relationships. Growing high residue producing crops in a rotation or adding manure improves the soil condition. Mulches cool the soil when it is hot and warm it during cold weather. Residue moderates the temperature range.

Chiseling or ripping. Traffic over soil or working it too wet develops compact layers and plow pans. Soil compaction is often visible in decreased water intake rates or in poor crop growth. This problem may be identified by digging holes, especially in the traffic rows, to find the compacted layer or by digging up several plants to find restricted root growth. Surface livestock traffic pans or surface platey structure is often found in fields that are grazed when wet. Chiseling or subsoiling when the soil is dry is needed to break these pans and layers.

Farmers must plan tillage operations, crop rotations and livestock grazing to prevent the reoccurrence of soil compaction. Reduced tillage or no-till will help prevent the return of plow pan and compaction layers. Once the pan is broken, deep-rooted crops included in the rotation, minimum tillage, and variable depth plowing will help maintain the open condition. By scheduling tillage operations when the soil is dry, compaction will be minimized.

Summary

Many kinds of soil management are required in a farming operation. However, the primary purpose is to provide an ideal environment for the plant roots to grow and obtain adequate moisture and nutrients. The decisions necessary to achieve this vary from one location and soil to another. When properly applied, soil management saves money and time as well as increases crop yields.

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Water Application Methods

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Irrigation Methods

Irrigation methods can be divided into three categories: surface, sprinkler and trickle. How you irrigate will depend upon the soil, crop, climate, topography, water quantity and quality, labor supplies, and economics.

System Efficiencies

Irrigation water delivery systems run at different efficiencies. Properly designed and managed systems will have similar efficiencies. The potential efficiencies of sprinkler systems under good management range from 65 to 85 percent, surface systems 50 to 90 percent, and trickle 70 to 95 percent.

Borders. The border method of irrigation is commonly used on crops such as alfalfa, pasture and small grains. The water is confined between low dikes. The distance between the dikes depends on the cross slope of the land and the amount of water available. The border length depends on the natural field boundary, the soil and the amount of water available. If the soil intake rate is high, the length will be short, and visa versa. *Level borders* have no slope and water is retained within the borders until it has infiltrated into the soil. No tailwater runoff is produced. *Graded borders* have a gentle slope. Water is applied at the upper end and shut off when it covers about three-quarters of the border. The water then advances to the end of the border.

Furrows. Furrows, channels cut in the soil, are used on row crops such as corn or sugar beets. Furrow irrigation is similar to border irrigation but only a portion of the ground surface is covered with water. Small furrows are called corrugations. Furrows can be straight or follow the ground contour. Water is usually distributed into each furrow using siphon tubes or gated pipes. *Level furrows* are similar to level borders: the desired amount of water is applied and the flow shut off. With level furrows the water is stored in the furrow and infiltrates into the soil. In *graded furrows,* the water should advance to the far end of the furrow in a quarter of the time required to apply total irrigation water.

Contour ditches. This method is well suited to rough ground where water is reasonably abundant. The ditches installed on the contour are used to irrigate close-growing sod crops such as alfalfa and pasture. Water is forced over the top of the ditch banks using canvas or plastic check dams. The water spreads down the slope and irrigates the area contour ditches. Close-spaced contour ditches keep the water spread over a wide area.

Surface Systems

Tailwater recovery. Mismanagement of irrigation runoff water has given surface systems a bad name. A tailwater recovery system should be used with surface systems that produce runoff. These recovery systems can improve irrigation application efficiencies by 5 to 30 percent depending on management. They can also save labor and energy. Systems usually include a way to collect, store, and return the runoff to the irrigation distribution system. Recovery systems are basically two types. One type consists of a small sump with a fast cycling pump that has an automatic control. The other type is a larger sump with a larger pump that may be either automatically or manually controlled.

Sprinkler Systems

With the sprinkler systems, water is applied through nozzles as a spray resembling rain. Pressure for the system is usually obtained by pumping, although gravity may provide enough pressure in some cases. Sprinkler systems vary greatly in size, cost, and adaptability. Broad classifications include linear move, hand move, wheel lines, big gun, center pivot, and solid sets. Sprinkler systems should be designed to apply water at a rate less than the intake rate of soil. Mismanagement may not be obvious since overapplication is lost to deep percolation. Sprinkler systems must be properly designed, maintained and managed to operate efficiently. Runoff is a problem from the outer part of the circle of center pivots.

Trickle Systems

Trickle irrigation systems (trickle, drip, bubble) apply filtered water directly onto or into the soil at specific points. Emitters must be located close enough together to wet the plant root zone. High soil water content is maintained by frequent, low volume applications of water to the root zone of the plant. How often water is applied depends upon crop, weather, and management. Over-irrigation is usually not obvious because excess water is lost to deep percolation. Emitter clogging can be a problem that requires maintenance. Trickle systems can be easily automated. However, if the automation does not reflect changing plant water needs, it can lead to over-irrigation. Constant management and maintenance are necessary for high efficiency.

Summary

Careful consideration should be given to all advantages and disadvantages before selecting a system or changing from one irrigation system to another. Many times improving an existing system is less expensive than changing methods. Most inefficiencies are caused by selecting the wrong method of irrigation or mismanagement of the system. The systems themselves are usually not to blame for low efficiencies.

For More Information

Contact your local office of the Soil Conservation Service.

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Irrigation Scheduling

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What

Irrigation scheduling is simply deciding when or how long to apply irrigation water. The increased cost of irrigation water, coupled with decreasing water supplies, has made scheduling important in the management of every irrigated farm.

Kinds of Scheduling

What method of scheduling you use will depend on the availability of irrigation water. If adequate irrigation water is available throughout the growing season, more precise methods of scheduling are possible. If water is limited, your scheduling objective is to get the best crop yield per inch of water you apply. Your scheduling method may be one or a combination of the following:

Checkbook method. This method requires that the landowner know how much water is applied at each irrigation. Based on normal daily withdrawal rates by the crop, or current published rates, the landowner merely "checks off" the daily crop use until the moisture reaches a predetermined deficit level. When the soil moisture "bank account" reaches this level, the next irrigation is started. Rainfall or other climatic conditions that affect water use of the crop can be inserted into this method. Check the balance occasionally for accuracy. Soil moisture content is necessary for the "checkbook balance."

Actual use methods. These methods work best with the "checkbook method." Instead of having the landowner use a normal daily water withdrawal rate, actual use methods measure the water use of the crop by some type of field determination. These can measure either actual soil moisture or actual in-field evaporation. With simple bookkeeping procedures or complex computer programs, the data can give the landowner a "crop's eye" view of water use.

Crop growth stages. This method concentrates on irrigating crop growth; it is used most often by farmers who have a limited supply of water to meet the total water needs of the crop. Irrigating at certain stages of crop growth will maximize the yield per inch of water applied and make the most effective use of irrigation water available. These stages of growth vary from crop to crop, but generally, the stages at which irrigation water should be applied to achieve the optimum crop response are flowering stage, grain or fruit production stage and grain or fruit filling stage.

The Soil Conservation Service has guidelines tailored to the various crops grown in the state. These delineate the stages of growth at which irrigations should be applied to optimize yield per acre inch of water applied.

Summary

Regardless of the type of irrigation scheduling system used, a landowner should realize that scheduling is just one part of the farm's overall irrigation water management system. To make any scheduling effective, the landowner must be able to make decisions regarding the amount of irrigation water applied and the effectiveness and uniformity of the current water application method.

For More Information

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Water Measurement

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Purpose

Water measurement helps you manage the amount of water to apply for the best crop yield. Measurement often results in a decision to use less water. This information can help you make the best use of water supplies.

Irrigation water can be measured in three ways: in-ditch devices, flow meters, or on-field methods.

Measuring Methods

In-ditch devices. In-ditch devices provide a method of measuring delivery rates and quantities. The devices measure the rate of flow in an open channel. The rate of water flowing over or through these structures has an established relation between the beginning head (depth of flow) and the discharge. These calibrated devices can measure the discharge rate in cubic feet per second (cfs), gallons per minute (gpm), or miner's inches.

Knowing the rate of flow and the time over which this rate is maintained, the total water volume used can be calculated. Using metering devices that measure in cubic feet per second is convenient because 1 cfs equals 1 acre-inch per hour or 1 acre-foot in 12 hours.

The table on back compares the characteristics of each device and gives its advantages and disadvantages.

Flow meters. Flow meters are attached to a closed pipeline or discharge pipe and measure the flow of water. *Propeller meters,* the most commonly used, have a rubber, fiberglass, or metal propeller attached to an indicator head that records accumulated volume and flow, such as acre-feet or gallons per minute (gpm). *Sonic or doppler velocity meters* are portable, sensing devices clamped to the outside of the pipeline. Sensors determine the difference between the velocity of the approaching water and the departing water by reflected sound waves. Meters are adjusted to the diameter of pipe and give a readout in gpm flow in the pipe. *Magnetic field velocity meter,* another portable system, uses a coil of wire that is lowered into the flow stream. The coil is electrified to create a magnetic field. The sensor measures the reduction in the magnetic field strength caused by the flowing water. Meters can be adjusted for pipe size and give a readout in gpm flow. Accumulated volume recording devices are available. *Velocity tubes* measure water velocity in the pipe. These devices are often used to test pumps or monitor flow in pipelines where occasional checks are needed. When the velocity and inside pipe diameter are known, gpm flow can be determined.

On-field methods. When siphons are used, the delivery rate of individual siphons can be measured. Water flow in a furrow can be measured by an orifice device.

For More Information

Contact your local office of the Soil Conservation Service.

Comparison of in-ditch metering devices

Type of flow measuring device	Rate of flow 1/ (capacity)	Error given 2/ flow range	Installation 3/ requirements	Headloss required	Cost	Advantages	Disadvantages
V-Notch sharp created weir (triangular weir)	Virtually all flow rates	5/100	Upstream stilling basin usually required approach velocities less than 0.5 ft/sec	large	inexpensive	Accurate, simply constructed, low maintenance, portable weirs available, particularly suited to small flows	Silting in, large head difference needed, sensitive to measuring errors, at large flows, exacting installation
Trapezoidal, sharp created weir, or Cipolletti weir	Virtually all flow rates	2/15	Upstream stilling usually required for approach velocities less than 0.5 ft/sec	large	inexpensive	Accurate, low maintenance, does not clog with surface debris	Silting in, large head difference required, exacting installation, sensitive to measuring errors
Rectangular; created weir	Virtually all flow rates	5/30	Upstream stilling basin large usually required for approach velocities 0.5 ft/sec	large	inexpensive	Accurate, wide range of flow, low maintenance, portable weirs available, does not clog with small floating debris	Silting in, sensitive to measuring errors, large head differential, exacting installation
Modified broad created weir (Replogle flume)	Virtually all flow rates	2/35	Upstream flow parallel to flume i.e., concrete lined ditch, or irrigation furrow	small	inexpensive	Easily constructed, onsite, prefab, or portable; dimensions and installation not as critical as other measuring devices; low maintenance;	No disadvantages know
Cut throat flume long throat flume WSU flume	Virtually all flow rates	3/35	Upstream flow parallel to flume i.e., concrete lined ditch	small	moderate	Accurate, low maintenance, usually none clogging	Exacting dimensions and installation requirement difficult
Parchall flume	Virtually all flow rates	3/50	Upstream flow parallel to flume, installed level	small	expensive	Accurate, low maintenance, low head in place prefab, or portable	Difficult to construct
Submerged orifice	Virtually all flow rates	5/10	Straight length channel, minimum	small	moderate	Less head required than a sharp created cost than a Parchall flume, easily understood, easily constructed	Will clog with debris, needed to recognize nonstandard (inaccurate)
Metergates (slidegates)	Flow rates over 300 gpm (0.7 cfs)	10/30	Stilling wells to indicate upstream and downstream head are required	medium to large	expensive	May be used as a water control device (within limits)	Expensive, may clog with debris, must be calibrated for each installation unless installed according to standard

1/ Based on using the proper sized weir, flume, or orifice for the flow range under consideration.

2/ Flow range is expressed in maximum divided by minimum flow to be measured. Example: Flow rate through a properly installed V-Notch or sharp-crested weir would be measured within 5 percent of the actual flow if the weir were being operated between 1 and 100 gpm (100:1-100), a preperly sized and operate submerged orifice would measure flows within 5 percent if it were operating between 5 and 50 gpm (50:5-10), 10 and 100 gpm, 50 and 500 gpm, etc.