



EM4825

Scientific Irrigation Scheduling

Washington's Scientific Irrigation Scheduling website at <http://sis.prosser.wsu.edu/> has a number of tools to help implement SIS, including:

PAWS Washington's Public Agricultural Weather System provides real-time access to weather data, pest/disease models, and crop water use estimates from 58 stations. http://sis.prosser.wsu.edu/weather_data.htm

WISE Washington Irrigation Scheduling Expert software and tables integrate PAWS and soil moisture monitoring with your crop and irrigation system to predict when and how much to irrigate. <http://sis.prosser.wsu.edu/wise.htm>

SIIP Surface Irrigation Improvement Project describes several methods to limit the amount of erosion from a surface irrigated field. <http://siip.prosser.wsu.edu/>

Scientific irrigation scheduling is a tool growers can use to improve irrigation water management. When used properly, it indicates when to irrigate, how much water to apply, and how to apply water to satisfy crop water requirements and avoid plant moisture stress.

A true scientific irrigation scheduling program also provides forecasts of future irrigation dates and amounts so that other farm operations can be planned around irrigation events. When carefully used, irrigation scheduling saves water, energy, labor, and fertilizer, and in many cases improves crop yields and crop quality. When water supplies are tight and deliveries are made at much reduced rates, irrigation scheduling can help growers stretch available water for greatest benefit on irrigated crops.

Approaches

Many approaches try to answer the questions of when to irrigate and how much water to apply. Some approaches use plant observations and measurements, and some use soil measurements or monitoring. Measurements such as plant temperature and leaf water potential provide good information about plant water status and, thus, tell reliably when irrigation is needed. However, the amount of water to apply is not readily apparent.

Growers can use soil water measurements and monitoring to find out when soil water levels are depleted and how much water is needed to irrigate the soil up to field capacity. Some would argue how well this approach correlates with plant moisture status.

To adequately answer when, how much, and how to apply water, use an approach that takes into account the plant, the soil, and the irrigation system. Scientific and engineering information about crops, soils, and irrigation systems is available and can be used to schedule irrigations through a process similar to balancing a checkbook.

Checkbook Method

This method requires knowing the net amount of water applied at each irrigation, the total water available, usable soil water in the crop root zone, and the rate at which the crop extracts water from the soil. These three factors are balanced against each other to ensure the root zone soil water is not depleted too much. They also can project when root zone soil water will reach a level that requires replenishment.

The total available soil water in the crop root zone represents the bank account. The amount of usable soil water in the crop root zone is the checkbook balance. If soil water becomes too low, or the root

zone becomes dry, the crop may experience moisture stress, reducing yields or crop quality.

There is also a maximum soil water level, which is equivalent to the field capacity of the soil. If you irrigate so that the soil water exceeds field capacity, then deep percolation occurs. This causes nutrient leaching from the root zone, and possibly salinity or high water table problems, as well as a loss or waste of limited water.

Crop water use represents writing a check or making a withdrawal from the bank account. When you irrigate, or when it rains, a deposit is made. Use available information to determine the size of the bank account for your fields and then keep track of withdrawals and deposits so that you maintain the checkbook balance within desirable limits with the fewest service charges.

Soils Information

Soil data needed to keep track of the soil water bank account are the soil depth and soil total available water (defined as the difference between the soil field capacity and the soil permanent wilting point). Soil depth is important because it may represent a barrier to root growth. If soil depth does not limit the root growth, then the depth of plant rooting defines the size of the soil water bank account.

You can obtain general information on soil total available water from a number of sources. The best place to start is with soil survey information prepared by the Natural Resources Conservation Service (NRCS). You need to determine the soil series or type for each irrigated field and the variability of the soils within the field.

For many irrigated locations this information is mapped out in NRCS Soil Surveys. The total available water in the soil profile has been measured or estimated for soils included in the surveys. This information is also given in the State of Washington Irrigation Guide, available as a reference book at each NRCS or Washington State University Cooperative Extension office.

The total available water figure for a given soil will most often be given as so many inches per

foot of soil; that is, for a Warden silt loam, the number might be 2.3 inches per foot. The soil depth or the crop rooting depth, whichever is less, is multiplied by the total available water per foot to find the total available for the root zone. For instance, for the Warden silt loam above, if a crop has a 2-foot root zone, then the total available in the root zone is (2×2.3) 4.6 inches.

Do not plan to use the total available water in the soil profile between irrigations, as the crop may be seriously moisture stressed when the soil approaches the permanent wilting point. Use a maximum allowable depletion (MAD) of the total available soil water to avoid this stress situation. For most crops a safe level of allowable depletion is around 50%–65%. Manage moisture sensitive crops, such as vegetables, with a MAD of 25% to 40%. Some drought tolerant crops, such as wine grapes, can get by with MAD levels as high as 80% to 90%. The total available water times the MAD determines the usable water in the root zone. For the above example, if MAD is 50%, then the usable water is (0.50×4.6) 2.3 inches. This is the amount of water allowed for use from the root zone in between irrigation periods. Consult your local Extension office for more information.

Irrigation System Information

A key piece of irrigation system information is the net amount of water applied by your system. Determining this requires measurements of system gross application rate and irrigation application efficiency. The net amount of water applied equals the gross application rate of your irrigation system multiplied by the irrigation set time and the irrigation application efficiency. This net amount of water represents the amount which actually enters the root zone and is available for the plant to use. Consult the WSU Drought Advisory EM4822 *Irrigation System Evaluation*, available from your Extension agent, for more information.

Rainfall also adds to the bank account. Measure rainfall in the field, using a simple rain gauge. Rainfall amounts of 0.25 inches and less falling on bare soil are generally considered ineffective, because they evaporate rapidly. When the crop has developed a vegetative canopy that shades at least 70% of the ground surface then most of the

rainfall can be considered effective, since it temporarily reduces crop transpiration.

Crop Information

Many factors determine crop water use, including crop type, crop density, amount of vegetative cover or leaf area, crop health, soil moisture levels, stage of growth, climate, and environment. Crop water use for all crops typically begins at very low rates in the spring because there is little or no demand—perennials have not leafed out yet, annuals are very young or just planted, and climatic conditions are cool with little atmospheric demand for water.

As crops develop and climatic conditions progress toward summer, demand for water increases rapidly, reaching a peak along with summer weather conditions. Water use typically falls off as the weather cools in late summer, or as the crops reach maturity and are harvested. The amount of usable soil water and how it is replenished must be balanced against this demand pattern. A fixed irrigation schedule, such as irrigating by the calendar, will always lead to applying and wasting too much water in the spring and fall, and perhaps not keeping up in the heat of the summer.

Estimates of crop water use are available from a variety of sources. Seasonal and monthly net crop water requirements based on long-term weather records and well-irrigated conditions are published in the NRCS *State of Washington Irrigation Guide*. Figures are available for 40 different crops at over 70 locations around the state. They represent the average net maximum demand for water.

Washington Public Agricultural Weather System (PAWS) provides historic and "real-time" estimate of crop water use for 59 locations and 25 crops. The CROP WATER USE models can be accessed from the internet at <http://index.prosser.wsu.edu/paws/WATERUSE>. The main PAWS website also accesses weather data, frost information, and

crop models for plant diseases and insect pests at <http://index.prosser.wsu.edu>. A PAWS subscription (user id and password) can be obtained by contacting Todd Elliot or Lynn Hartz at 509-786-9367 or wsupaws@perfection.prosser.wsu.edu.

Current or actual crop water demand has been estimated in Washington using pan evaporation rates. Data collected daily during the irrigation season are published in the weather section of local newspapers. Consult your local WSU Extension office for more details.

You will also need information about crop rooting characteristics. This includes the depth of rooting and the distribution of roots with depth. Many perennial crops can be very deep-rooted, if planted on deep soils. However, it is important to realize that most of the water uptake probably comes from the top 50% to 75% of the root zone. Tailor your irrigation management to reflect this.

Summary

Once you define the soil water bank account and determine the current balance, schedule irrigations so that when the usable soil water (checkbook balance) drops to a predetermined limit, you apply an irrigation to refill the soil to field capacity, knowing the application rate and efficiency. Evaporation reports are available to help you determine the rate of crop water withdrawal from the root zone. It is always a good idea to physically check the soil water status using a soil probe or auger, checking to the full expected rooting depth. Use weather forecasts to project roughly when the next irrigation will be needed.

The process described here will help you save and stretch water, especially where no attempt has been made to use scientific information in a systematic record-keeping procedure. For further assistance and information contact your local WSU Extension office.

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