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FLORIDA

IFAS EXTENSION

Basic Irrigation Terminology ¹

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The purpose herein is to define terminology commonly used by irrigation researchers, system designers, and other persons working in irrigated agriculture. A common understanding of these terms will make communication easier between researchers, extension specialists, and growers. The ability to communicate effectively and efficiently about agricultural water is extremely important and will become increasingly so, as fresh water supplies for irrigation become more scarce.

GENERAL WATER TERMS

Capillary Water: Water which remains in the soil pore spaces after gravity drainage has occurred. This water resides in the soil pores where capillary forces balance gravity forces such that a negligible amount of further drainage takes place. This water is available for plant use and exists in the soil under suctions in the range of 0.1 to 31 bars. The water in the range from 15 to 31 bars is not readily available and attempts to use it could result in permanent crop wilting. The suction ranges are approximate.

Effective Rainfall: The portion of a rainfall that infiltrates into the soil and is stored for plant use in the crop root zone. During a rainfall event, part of the

rain will run off the surface of the soil, get trapped in the foliage, or percolate through the bottom of the root zone. This water is not available for plant growth and, therefore, is not considered to be effective rainfall. Effective rainfall is generally expressed as a depth of water over a unit area (e.g. in/acre).

Evapotranspiration, ET_p or ET: The depletion of water from the soil as a result of crop transpiration and evaporation from the soil surface upon which the crop is grown. Evapotranspiration is commonly referred to as consumptive use. Potential evapotranspiration (ET_p) is that water which would be consumed by a short, well watered, vigorously growing crop that completely shades the ground surface. Actual evapotranspiration (ET) is the actual consumption of water by a specific crop considering that each crop has different growth characteristics with respect to root and foliage growth, planting dates, and water needs. ET and ET_p are generally expressed as volumes of water used in an irrigated area over a unit time increment (volume/area/time, e.g. in/hr, cm/day, etc.).

Gravitational Water: Water that moves into, through, or out of a soil under the influence of gravity forces. Gravitational water drains rapidly from the

1. This document is AE66, one of a series of the Agricultural and Biological Engineering Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date May, 1995. Reviewed July, 2002. Visit the EDIS Web Site at <http://edis.ifas.ufl.edu>.

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soil and is not considered to be available for plant use. Generally, this water exists in a soil profile at suctions less than field capacity (i.e. less than approximately 0.1 to 0.33 bars).

Hygroscopic Water: Water that is strongly bound to the soil particles at suctions greater than 31 bars. This water cannot be used by plants. The suction limit is, again, approximate.

Irrigation: Application of water by artificial means. Purposes for irrigating may include, but are not limited to, supplying evapotranspiration needs, leaching of salts, and environment control.

Irrigation Interval: The time period between the start of successive irrigations.

Precipitation: For agricultural water purposes, the verb form of the term precipitation is the natural deposition on the earth's surface of water in the forms of rain, sleet, hail, snow, or mist (fog). In humid areas where freezing temperatures do not generally occur, precipitation is used synonymously with rainfall. The noun form of the term precipitation is generally associated with the depth or volume of water that fell over a unit area.

Water: The liquid form of the compound H_2O that exists between ice (at temperatures below 0 degrees Centigrade or 32 degrees Fahrenheit) and vapor (at temperatures above 100 degrees Centigrade or 212 degrees Fahrenheit). The water molecule consists of a central oxygen atom with two hydrogen atoms attached at a separation angle of about 105 degrees. Water is an excellent solvent because of its chemical properties. Nutrients required for plant growth are dissolved in the soil water which is then taken up by the plant root system. Water is also used for plant cooling.

SOIL WATER TERMS

Field Capacity, FC: The water content of the soil in the crop root zone after most gravity drainage has occurred, generally 1 to 4 days after an irrigation or flooding event, or in the range of 0.10 to 0.33 bars suction. The water content is expressed as the ratio of the volume of water, at field capacity, to the volume of soil sampled.

Permanent Wilting Point, PWP: Also called the wilting point, PWP is the water content of the soil in the crop root zone when the crop can no longer extract water from the soil. When soil water contents fall below this level, irreversible wilting and crop damage occurs. Soil suctions at PWP are generally greater than 15 bars. PWP is expressed as the ratio of the volume of water, at the permanent wilting point, to the volume of the soil sampled.

Readily Available Water, RAW: The amount of water in a crop root zone that can be easily extracted by the crop. RAW is the fraction of the difference between FC and PWP that crops can use such that no stress caused by a lack of water occurs. Although crops can theoretically use all the water between FC and PWP, as PWP is approached the water becomes harder to extract and water stress and yield reductions will occur. Therefore, irrigations are scheduled when a fraction of the difference is used. The volume that the crop is "allowed" to use prior to another irrigation is RAW. RAW is expressed as a volume of water per unit of irrigated area, or as a depth of water per unit area in the same units as rainfall.

Root Zone: The depth of soil profile occupied by the root system of the crop. The root zone is the portion of the soil profile that is generally considered to store water available for crop use. The depth of root zone varies for soil types, crops, and water availability. The presence of a high water table, hard pan, or other impermeable layer will result in a rooting depth that is shallower than the maximum potential root zone for the same crop grown on a deep, well drained soil.

Soil Water Content, SWC or γ_w : The volume of water present in a unit volume of soil. SWC can be expressed as the ratio of the volume of water in a soil to the volume of the soil sampled shown in Equation 1:

The multiplier, γ_w (gamma beta), is the bulk-specific gravity of the soil which is defined as the density of the soil divided by the density of water. SWC is also referred to as soil moisture content.

Soil Water Deficit, SWD: The amount of water that is depleted by a crop between irrigations that

needs to be replenished during the forthcoming irrigation. SWD corresponds to the difference between field capacity (FC) and the soil water content (SWC) at the time of interest, or the amount of water that must be added to the root zone to return it to field capacity. SWD is generally expressed as a volume of water over an irrigated area (e.g. acre--inches/acre or inches).

Total Available Water, TAW: The total water in the crop root zone that is available for crop use. TAW is the difference between field capacity (FC) and the permanent wilting point (PNW) multiplied by the depth of the root zone. Units of expression are generally a volume per unit irrigated area (e.g. acre--inches/acre or inches).

IRRIGATION WATER TERMS

Volumes of water are expressed in two major ways when dealing with irrigation. The first includes the traditional volume units including acre-feet, acre-inches, cubic feet, gallons, cubic centimeters, cubic meters, etc. The second set of terminology used to describe water volumes are depth or length units such as inches, feet, centimeters, etc. An inch of water applied during an irrigation can be envisioned as a uniform application of one inch of water over a flat surface, equivalent in area to the land surface area that was irrigated. The terminology can be mathematically derived by understanding that a volume with units of in^3 divided by an area with units of in^2 yields a length or depth in inches (e.g. acre-inches/acre = inches).

Deep Percolation, DP: Water, or the volume of water, that drains vertically through the bottom of the crop root zone such that it is lost with respect to potential crop use.

Infiltration, z: The passage of water through the surface of the soil or the volume of water that passes into the soil profile over a unit irrigated area.

Leaching Requirement, LR: The amount of water that is required to be added to the soil profile during an irrigation to ensure that excess salts are removed from the root zone in runoff, deep percolation, or lateral seepage.

Tailwater, TW: Water that exits the field area as surface runoff during or after an irrigation or rainfall event. TW is expressed as either a volume or a depth. When expressed as a depth, the volume of tailwater is visualized as the depth of water that would result if all the tailwater were evenly distributed over a flat, uniform surface with an area equivalent to the field size.

Water Applied, W_a or D_a : The amount of water actually applied during an irrigation, expressed as a volume (W_a) or a depth (D_a). The water applied can be either more or less than the water requirement.

Water Requirement, W_r or D_r : Also called the irrigation requirement, the water requirement is the amount of water that must be applied to satisfy the demands of the crop system. It is expressed as a volume (W_r) or a depth (D_r). The water requirement includes the soil water deficit, the leaching requirement, and water used by the plants during the irrigation and gravity drainage phases. If other reasons for irrigating are involved, such as frost protection, bed forming, subsidence control, etc., these volumes or depths must be included. Likewise, if the irrigation is not meant to accomplish a task during an irrigation, the component need not be included in the requirement for that particular irrigation. For example, irrigation for frost protection is seasonal and therefore whatever portion of the water above evapotranspiration needs, being applied strictly to achieve frost protection, need not be included in the water requirement of a summer irrigation.

Water Stored, W_s or D_s : The amount of water that is stored in a crop root zone, for use by the crop, as a result of an irrigation. Water stored can be expressed as a volume (W_s) or a depth (D_s).

IRRIGATION EVALUATION TERMS

There are a wide variety of evaluation terms in use today. Additionally, terms or parameters are created to account for specific conditions unique to certain areas and crops. It is important to determine what irrigation factors are applicable and important in your operation, and then select the performance indicators that are meaningful to your particular

situation. Some of the more commonly used parameters are defined below.

Application Efficiency, E_a : The percentage of the water applied that is stored in the crop root zone for use by the crop. Alternatively, if water is required for reasons other than replenishing the SWD, then E_a can be defined as the percentage of water applied that can be beneficially used by the crop. (Equation 2)

$$E_a = \frac{100D_z}{D_a}$$

Equation 2 .

Conveyance Efficiency, E_c : The percentage of the water introduced to the farm at the inlet structure that actually reached the field to be irrigated. Losses may occur due to seepage, evaporation, leaks, etc. (Equation 3)

$$E_c = \frac{100W_{in}}{W_a}$$

Equation 3 .

Where W_{in} is the volume of water introduced at the inlet structure.

Deep Percolation Percentage, DPP: The percentage of the water applied that is lost to the crop through vertical drainage below the crop root zone. (Equation 4)

$$DPP = \frac{100DP}{D_a}$$

Equation 4 .

Irrigation Uniformity, U: A measure of the spatial variability of applied or infiltrated waters over the field. Several indicators can be used to place a numerical value on the irrigation uniformity by statistically representing the deviations in water applied, or stored in the crop root zone, from the field average. The irrigation uniformity is generally expressed as a percent with 100% representing perfect uniformity.

Requirement Efficiency, E_r : The percentage of the water requirement or soil water deficit that was stored in the root zone. If the purpose for irrigating included reasons in addition to replenishing the crop root zone, then these terms must also be included. (Equation 5)

$$E_r = \frac{100D_z}{D_r}$$

Equation 5 .

Tailwater Percentage, TWP: The percentage of the water applied that is lost to the crop through surface runoff. (Equation 6)

$$TWP = \frac{100TW}{D_a}$$

Equation 6 .

TYPES OF IRRIGATION SYSTEMS

Basins: Water is ponded on a flat or slightly graded field with bermed boundaries. Water is introduced onto the field surface in amounts equal to the water requirement and allowed to infiltrate into the root zone.

Borders: Water is spread in sheet flow over a field from a head ditch or field ditches in a controlled flooding situation. Fields are either level or graded with either ditches or berms separating field units.

Bubbler: An irrigation system that falls into the trickle category in which water is applied to the soil surface as a small stream or fountain. Discharge rates are generally greater than those for drip, but less than 60 gal/hr.

Crown Flooding: A field with raised beds is flooded up to near the bed crowns. The water is held for a period of time to allow for infiltration before it is allowed to drain.

Drip: A category of trickle irrigation in which water is applied to the soil surface in discrete or continuous drops, or tiny streams through emitters. The terms drip and trickle irrigation are often used interchangeably. However, the American Society of Agricultural Engineers Practice ASAE EP405 makes the distinction that trickle irrigation includes systems with higher discharge rates than most drip systems. To be classified as drip irrigation, point source emitters should have discharge rates less than 3 gal/hr and line source emitters less than 1 gal/hr/ft of lateral.

Trickle: A low pressure system where water is distributed through closed pipelines. Water is applied directly, or very near to the soil surface, either above or below the ground surface, in discrete drops,

continuous drops, small streams, or spray. Flows and pressures are typically low. A wide variety of emitters are available to dissipate pressures at points, allowing water applications to the soil in small amounts with little force. The trickle irrigation category includes methods such as drip, subsurface, bubbler, and spray irrigation.

Furrows: Gravity is used as the driving force which pushes water down shallow, closely spaced ditches to spread water over a field surface. Fields are generally sloped and open at the bottom end, allowing runoff to occur. This type of system is generally used in heavy soils with deep soil profiles above water tables such that water table control is not a factor in supplying water to the crop root zone.

Seepage: A local term for subirrigation that depends on water table control to supply crop water needs from below the root zone.

Spray: An irrigation method that falls into the trickle category, characterized by the application of water to the soil surface as a small spray or mist. Discharge rates are generally less than 30 gal/hr.

Sprinkler: A pressurized system where water is distributed through pipes to the field and applied through a variety of outlet sprinkler heads or nozzles. Pressure is used to spread water droplets above the crop canopy to simulate a rainfall with potentially ideal intensities and durations for crop needs.

Subirrigation: A water table control system that uses the raising of the water table to add water to the root zone. Water is introduced into parallel open ditches and flows under the root zone through the soil profile to raise the water table to a level that allows for sufficient wetting of the root zone from the water table aquifer below. Closely spaced tile, perforated pipe, or mole drains that run perpendicular to the field ditches are often used to aid in the lateral spreading of water beneath the root zone.

Subsurface: A low pressure system that falls into the trickle category with the defining characteristic being that the laterals, emitters and line source tubes are buried beneath the soil surface, thereby applying water directly to the root zone. Discharge rates are of the same magnitude as drip rates.

REFERENCES

American Society of Agricultural Engineers. 1985. *ASAE Standards* . ASAE EP405. ASAE, St. Joseph, Michigan.

Brady, N.C. 1974. *The nature and properties of soils* . Macmillan Publishing Co., Inc., New York, New York.

Harrison, D.S. 1981. *Irrigation efficiencies* . University of Florida/IFAS Agricultural Engineering Fact Sheet AE-21.

Izuno, F.T. 1985. *Principles of on-farm water management* . University of Florida/IFAS Agricultural Engineering Extension Report 85-20.

Jensen, M.E., ed. 1983. *Design and operation of farm irrigation systems* . ASAE Monograph No. 3. American Society of Agricultural Engineers, St. Joseph, Michigan.

Soil Conservation Service. 1982. *Florida irrigation guide* . USDA-SCS, Gainesville, Florida.

Zazueta, F.S. 1984. *Understanding the concepts of uniformity and efficiency in irrigation* . University of Florida/IFAS Agricultural Engineering Fact Sheet AE-43.

Zazueta, F.S., A.G. Smajstrla, and D.S. Harrison. 1984. *Glossary of trickle irrigation terms*. University of Florida/IFAS Agricultural Engineering Fact Sheet AE-45.