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Evapotranspiration: Potential or Reference?[1]

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The objective of this article is to define two commonly used evapotranspiration (ET) concepts: potential evapotranspiration (ET_p) and reference evapotranspiration (ET_o); and to provide insight on the differences between the two terms. A common understanding of these widely used concepts in agricultural communities will help to make communication easier between farmers/growers, extension agents, and researchers in the academic environment.

The process known as evapotranspiration (ET) is of great importance in many disciplines, including irrigation system design, irrigation scheduling, and hydrologic and drainage studies. In a broad definition, the evapotranspiration is a combined process of both evaporation from soil and plant surfaces and transpiration through plant canopies. In the evapotranspiration process, the water is transferred from the soil and plant surfaces into the atmosphere in the form of water vapor. In practice, the estimation of the evapotranspiration rate for a specific crop requires first calculating potential or reference evapotranspiration and then applying the proper crop coefficients (K_c) to estimate actual crop evapotranspiration (ET_a).

The objective of defining “potential” or “reference” evapotranspiration is to eliminate the crop specific changes in the evapotranspiration process. In the "potential" evapotranspiration definition this is attemped by assuming the constant crop conditions. However, in this definition, the reference crop is not very well specified and this may create a problem in total elimination of crop component. Since "reference" evapotranspiration is based on hypothetical crop, the process of elimination of crop specific changes is much easier.

Potential evapotranspiration (ET_p): The potential evapotranspiration concept was first introduced in the late 1940s and 50s by Penman and it is defined as “the amount of water transpired in a given time by a short green crop, completely shading the ground, of uniform height and with adequate water status in the soil profile”. Note that in the definition of potential evapotranspiration, the evapotranspiration rate is not related to a specific crop. The main confusion with the potential evapotranspiration definition is that there are many types of horticultural and agronomic crops that fit into the description of short green crop. So, scientists may be confused as to which crop should be selected to be used as a short green crop because the evapotranspiration rates from well-watered

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agricultural crops may be as much as 10 to 30% greater than that occurring from short green grass.

Reference evapotranspiration (ET_o): Reference evapotranspiration is defined as "the rate of evapotranspiration from a hypothetical reference crop with an assumed crop height of 0.12 m (4.72 in), a fixed surface resistance of 70 sec m^{-1} (70 sec $3.2ft^{-1}$) and an albedo of 0.23, closely resembling the evapotranspiration from an extensive surface of green grass of uniform height, actively growing, well-watered, and completely shading the ground". In the reference evapotranspiration definition, the grass is specifically defined as the reference crop and this crop is assumed to be free of water stress and diseases. In the literature, the terms “reference evapotranspiration” and “reference crop evapotranspiration” have been used interchangeably and they both represent the same evapotranspiration rate from a short, green grass surface.

The reference evapotranspiration concept was introduced by irrigation engineers and researchers in the late 1970s and early 80s to avoid ambiguities that existed in the definition of potential evapotranspiration. By adopting a reference crop (grass), it has become easier and more practical to select consistent crop coefficients and to make reliable actual crop evapotranspiration (ET_a) estimates in new areas. Introduction of the reference evapotranspiration concept also helped to enhance the transferability of the crop coefficients from one location to another. In addition, with using reference evapotranspiration, it is easier to select consistent crop coefficients and to calibrate evapotranspiration equations for a given local climate.

Historically two main crops have been used as the reference crop, grass and alfalfa. In Florida, the reference crop is grass since alfalfa is not commonly grown. It is generally accepted that the grass reference crop is the type of grass with physiological and structural characteristics similar to perennial ryegrass (*Lolium perenne* L.) or alta fescue (*Festuca arundinacea Schreb*. Alta). Although alfalfa has the physical characteristics (leaf area index, roughness, etc.) closer to many agronomic crops than the grass, researchers generally agree that a clipped grass provides a better representation of reference evapotranspiration than does alfalfa. This is mainly because of the two reasons: (1) the characteristics of the grass are better known and defined, (2) the grass crop has more planting areas than alfalfa throughout the world and the measured evapotranspiration rates of the grass are more readily available and accessible as compared to the measured alfalfa evapotranspiration rates.

One of the other important differences between the potential and reference evapotranspiration is that the weather data collection site is well defined in the reference evapotranspiration definition. It is important to note in the reference evapotranspiration definition that the climate data that are used to estimate reference evapotranspiration need to be collected in a well-defined (reference) environment. Therefore, based on the definition, the weather data for the reference evapotranspiration estimations should be collected in a well-irrigated and well-maintained grass area. The irrigated grass area of the weather data collection site should be fairly large [(approximately two hectares) (4.94 acres)] because the quality of the weather data will ultimately affect the final estimated reference evapotranspiration value. For example, in a hot, dry month the average air temperature may be as much as 5 to 6 ^oC (9 to 10.8 ^oF) higher in a dryland (non-irrigated) than for a well-irrigated land. The differences in the air temperature will also affect the relative humidity and vapor pressure deficit values and these differences will ultimately cause differences in the reference evapotranspiration calculated using the weather data collected from the two sites (dry versus well-irrigated).

The reference evapotranspiration concept has been gaining significant acceptance by the engineers and scientists throughout the world since its introduction. Specific equations and standardized procedures are being recommended for reference evapotranspiration estimates. The International Commission for Irrigation and Drainage (ICID) and the Food and Agriculture Organization of the United Nations (FAO) Expert Consultation on Revision of FAO Methodologies for Crop Water Requirements recommended that the Food and Agriculture Organization of the United Nations Paper No. 56 Penman-Monteith equation (FAO56-PM) be used as the standard method to estimate ET_o. This equation has been increasingly gaining acceptance and used throughout the world for reference evapotranspiration estimations. It is recommended that the grass-reference evapotranspiration concept be used for irrigation scheduling and water management, hydrologic studies, and drainage researches in Florida in order to establish a common and standard ground between the growers/farmers and their advisors and between the researchers in Florida and other states.

References

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