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). Also, this article will provide insight into the differences between the two terms. A common understanding of these widely used concepts will help to make communication easier between farmers/growers, extension agents, and researchers in the academic environment.

Evapotranspiration is a combined process of evaporation (E) from soil and plant surfaces and transpiration (T) through plant canopies. Evapotranspiration (ET) is important for many disciplines, including irrigation system design, irrigation scheduling, hydrologic and drainage studies, and water resources management. During the evapotranspiration process, water transfers from the soil and plant surface into the atmosphere as vapor. In practice, estimating the evapotranspiration rate for a specific crop requires first calculating potential (ET_p) or reference (ET_o) evapotranspiration. Then applying the proper crop coefficients (K_c) will allow estimation of actual crop evapotranspiration (ET_a) (FAO, 1998).

Clearly defining "potential" or "reference" evapotranspiration is important to eliminate the crop-specific changes in the evapotranspiration process. The "potential" evapotranspiration definition attempts this by assuming the constant crop conditions. However, in this definition, the reference crop is not very well specified, potentially creating a problem in the total elimination of crop components. Since hypothetical crops are the basis for "reference" evapotranspiration, the process of eliminating crop-specific changes is much easier (McMahon, 2013).

Potential evapotranspiration (ET_p): This concept was first introduced in the late 1940s and 50s by Penman 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" (Penman, 1948). In the potential evapotranspiration definition, the evapotranspiration rate does not relate to a specific crop. The main confusion with this definition is that many horticultural and agronomic crops fit into the description of the 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 crops may be as much as 10 to 30% greater than that occurring from a short green grass (Xiang, 2020).

Reference evapotranspiration (ET_o): Reference evapotranspiration is 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 (FAO, 1998). In the reference evapotranspiration definition, the grass is specifically the reference crop. This crop is assumed to be free of water stress and diseases. In the literature, the terms "reference

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evapotranspiration" and "reference crop evapotranspiration" have been used interchangeably and they both represent the same evapotranspiration rate from a short, green grass surface.

Reference evapotranspiration intends to avoid ambiguities that existed in the definition of potential evapotranspiration. By adopting a reference crop (grass), consistent crop coefficient selection has become easier and more practical (Djaman, 2013). As a result, actual crop evapotranspiration (ET_a) estimates in new areas are more reliable. The introduction of the reference evapotranspiration concept also helped transfer crop coefficients from one location to another. Reference evapotranspiration allows more consistent crop coefficient selection and evapotranspiration equation calibration for a given local climate.

Historically, two main crops have been used as reference crops: grass and alfalfa. In Florida, the reference crop is grass since alfalfa is not commonly grown (SFWMM, 2005). 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 three reasons: (FAO, 1998) the characteristics of the grass are better known and defined (McMahon, 2013), 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.

Another difference between the potential and reference evapotranspiration is that the weather data collection site is well-defined in the reference evapotranspiration definition. Also, in the reference evapotranspiration definition, the climate data used to estimate reference evapotranspiration must be collected in a well-defined (reference) environment. Therefore, 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°C to 6°C (9°F to 10.8°F) higher in a dryland (non-irrigated) than in a well-irrigated land. The differences in the air temperature will also affect the relative humidity and vapor pressure deficit values. These differences will ultimately cause differences in the reference evapotranspiration calculated using the weather data collected from the two sites (dry versus well-irrigated) (FAO 1998, Djaman, 2018).

Since its introduction, the reference evapotranspiration concept is gaining significant acceptance by engineers and scientists worldwide. Specific equations and standardized procedures are 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 ETo. This equation has been increasingly gaining acceptance and is used throughout the world for reference evapotranspiration estimations. It is recommended to use the grass-reference evapotranspiration concept for irrigation scheduling and water management, hydrologic studies, and drainage research in Florida. This will establish a common and standard ground between the growers/farmers and their advisors and between the researchers in Florida and other states.

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