WATER BALANCE IN AGRICULTURAL AREAS

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Contents

1. Introduction

Water is essential for agricultural production. Physiologically, water is needed for all plant functions and processes. In plain words, "without water there would not be any agricultural productivity". Agricultural water needs depend on the climatic characteristics of a given region mainly precipitation, solar radiation, temperature, wind speed and relative humidity. In Defining a water balance for agriculture the first step would be to determine the plant water requirements and then in irrigated areas to quantify the water losses due to transport, distribution and application of water.

In tropical humid climates rainfall amounts are enough to satisfy dry-land agricultural production. However, in humid climates during the dry season supplemental irrigation water is needed in order to produce crops. Under sub-humid and arid climates, given the continuous water deficit, the irrigation water requirements could be as much as 95 percent of the total plant water needs. For irrigated areas, after determining net crop water requirements the total amount of water required is calculated by adding the water losses due to conveyance, distribution and application of water. Irrigation losses include surface runoff, water spillage and leakage from the water distribution system, water seepage from unlined canals and furrows. The net water balance for agriculture will be a function of climate characteristics, soil water holding capacity and crop factors.

2. Net Water Requirements

Consumptive water used by crops vary according to local climatic demands mainly radiation, temperature, wind and relative humidity. Crop factors as rooting depth, plant type and varieties are also important in establishing water requirements for a specific crop. The standard method to estimate consumptive water use by crops is based on plant evapotranspiration (Phene, C. et al., 1985). Evapotranspiration is defined as "the combined process by which water is transferred from the earth surface to the atmosphere". It includes evaporation from liquid water from the soil and plant surfaces, plus transpiration of liquid water through plant tissue expressed as equivalent depth of water per unit area.”

Weighing lysimeters are the most accurate means of direct measurement of evapotranspiration. A lysimeter system use~~s~~ a water balance approach involving periodic determination of root zone soil moisture, rainfall, irrigation or drainage. A standard lysimeter should be large enough to represent field conditions: 1.5-m. length by 2.0-m. width and 2.5 m. depth. The soil within the lysimeter structure should be undisturbed and a sensitive weighing system should be ~~in~~ place at the bottom of the soil to accurately measure changes in soil water content. In addition lysimeter measurements should be replicated creating the need for a lysimeter network. The construction, installation, accuracy and maintenance of a lysimeter network require considerable financial and operational resources that exist on large agricultural research centers. Within agricultural research centers lysimeters are used to calibrate empirical evapotranspiration equations that estimate evapotranspiration based on climatic data.

Solar radiation methods are considered the most accurate of the empirical methods used to estimate evapotranspiration. The main limitation for solar radiation methods is the lack of solar radiation data that is limited to complete type “A” meteorological stations. According to Burman et al. 1983, the Jensen - Haise Modified method has shown a good calibration as referred to lysimeter measurements. The method is described as follows:

$$E_{tr} = C_T (T-T_x) R_s \quad (1)$$

where,

E_{tr} = Crop evapotranspiration, has the same units as R_s, and is compatible with alfalfa based crop coefficients,

$C_T = 1 [C_1 + 7.3 C_H]^{-1}$ and $C_H = 50 \text{ mb} [e_2 - e_1]^{-1}$ where:

e_2 is the saturation vapor pressure of water in milibars at the mean monthly maximum air temperature of the warmest month of the year,

e_1 is the saturation vapor pressure of water at the mean monthly minimum air temperature of the warmest month of the year.

$C_1 = 38 – 0.0066 E$; where E is the site elevation in meters.

$T_x = -2.5 – 0.41 (e_2 - e_1) - 0.0018 E$

To convert from reference crop evapotranspiration E_{tr} to daily crop evapotranspiration E_t, adequate crop coefficients are needed; equation (2) is used:

$$K_c = E_t (E_{tr})^{-1} \quad (2)$$

where:

K_c is the dimensionles crop coefficient for the particular crop at the existing growth stage and surface soil moisture condition.

In tropical humid climates rainfall amounts are enough to satisfy dry-land agricultural production; However, this dry land agricultural schemes are very sensitive to climatic change and the productivity is linked to precipitation patterns. For the humid tropics, the estimated monthly crop water requirement range from 65 millimeters in the wet cloudy season, to about 230 millimeters during the dry season. The average crop water use is about 160 centimeters a year. Of an average yearly rainfall of 200 centimeters about fifty percent or 100 centimeters, are used for agricultural production. The remaining fifty percent goes to surface runoff and subsurface water flow. During the dry season agricultural production uses supplemental irrigation water. During this period the water demands are higher due to intense solar radiation.

In the middle latitudes during summer the net crop water requirements could get as high as in the tropical climates due to the increase in daylight. In arid regions water requirements stay high the whole year and have been estimated to be about 176 centimeters.

Table 1 shows average seasonal evapotranspiration amounts for different crops. The lowest values correspond to plants with relative shallow root development like ~~as~~ beans and the higher values to sugar cane, bananas and nuts with deep root development. For a given crop, the seasonal evapotranspiration values shown on Table 1, fluctuate depending on climate, time of planting, crop stage and soil water level. Under similar climatic conditions, the minimum value corresponds to initial crop development stages and the higher value to full development of the rooting system stage.

Crop	Seasonal ET (cm.)	Crop	Seasonal ET (cm.)
Beans	25 – 50	Coffee	80 - 120
Corn	40 – 75	Cotton	55 - 95
Sorghum	30 - 65	Vineyards	45 - 90
Soybeans	45 - 82	Sugar Cane	100 - 150
Rice	50 - 95	Citrus	65 - 100
Onions	35 - 60	Nuts	90 - 130
Potatoes	35 - 63	Alfalfa	60 - 150
Tomatoes	30 - 60	Bananas	70 - 170

ET: Evapotranspiration

Table 1: Ranges of seasonal Crop Evapotranspiration “ET”
(from Burman. et al, 1983 .)

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