Water requirement of some vegetable crops

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Presentation

to the great Master of Humanity
our prophet

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INTRODUCTION

The major constituent for all the living cells, plant or animal, is water. Therefore the maintenance of the correct osmotic pressure by regulating the water balance is vital to all living cells. In the living plant, water occurs in many states; osmotic water, hydrostatic water, water of hydration, water of imbibition, and is involved in all physiological processes. Consequently the plant-water relationship must be studied to increase our knowledge with regard to the effect of water on plants and to increase the yield of economic crops.

The supply of water to plant is a problem in all parts of the world where there is an annual water deficit between the amount of water naturally available and the quantity that the plant need. In areas where water is artificially supplied, considerable effort is devoted to study the effect of the agricultural technique on the wastage of water as well as the effect of cultivation on the rate of water penetration into the soil.

Irrigation practice has led to a need for reasonably accurate estimates of the amount of water required. Broadly, these estimates may be divided into two groups; those of short-term and of long-term needs. Short-term needs are generally taken to be the water requirements during the crop life in any given region. Such estimates are an aid to day-to-day work [illegible]

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on the farm and enable the soil moisture deficit to be kept within acceptable limits. The aim of the studies and suggestions in this area is to keep an approximate balance between the water which is used by the crop and that which it receives. In addition, there is some readily available moisture in the soil, the amount of which depends on soil type and plant rooting depth. Long-term needs are useful mainly in connection with planning and should be capable of providing estimates of the quantities of water required to irrigate a given rotation of crops over a period of years.

The irrigation requirement is the amount of water, exclusive of precipitation, that is needed for the production of crops. It includes plant transpiration, evaporation, deep percolation and other economically unavoidable wastes.

A large part of the irrigation water is consumed by evaporation and transpiration, the two processes are usually considered as one process and called evapotranspiration or consumptive use. Consumptive use is the best index of irrigation requirements.

Various methods have been used to determine the amount of water consumed by agricultural crops and native vegetation.

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2. REVIEW OF LITERATURE

In the last few years, studies have been undertaken at the Ministry of Irrigation in Egypt to determine the irrigation requirements either by the statistical, approximate, or empirical applied methods. The irrigation requirements for cotton, wheat, corn, broadbean, onions, alfalfa and rice were determined in 1964 for Upper-, Middle-, and Lower-Egypt.

Various methods have been used to determine the amount of water consumed by agricultural crops and natural vegetation. The source of water used by plant during the growing season, whether from precipitation alone; irrigation plus rainfall, or ground-water plus precipitation is a factor in selecting the proper method. Hydrologists and engineers have developed and published formulas for estimating evaporation and evapotranspiration (Et). during the first half of the 20th century. The recent available literature on ET is so extensive, for example Robinson and Jenson (1961) of the U.S. Geological survey published a compilation of the literature for the years 1900-1958. A bibliography compiled by Christiansen and Lauritzen (1963) included some of the more recent publications and reports.

Evapotranspiration investigations could be divided into two categories. The first one is the "theoretical" in which

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evapotranspiration is estimated by the assistance of special formulas, while the second: one is the "Practical or emperical," method.

2.1. Relation of Evaporation to Evapotranspiration (Et)

Evaporation has a major merit on consumptive use. Pruitt and Angus (1961) used weighing lysimeter to determine Et. from mature rye-grass. At the same time, they determined evaporation by means of U.S.W.B. class "A" pan, located in large grassed field and a relationship between the two treatments were studied. They found that a relationship was almost a straight-line. The authors found the ratio of Et. to evaporation was about 0.5, but it must be 0.7 to 0.8 for days of high dry north winds. They explained that the cause of the difference in the ratio is the additional sensible heat transferred through the walls of the pan on the strong dry north wind days accompanied by some transpiration control by the plants. This could be supported by Lemon(1957) who indicated that when soil-moisture tension was 15 atmospheres permanent wilting point (P.W.P.) the Et of cotton was zero. Fahmi (1958); Denmead and Shaw (1959); Hajjo (1961) and Hansen (1963) concluded that the ratio of consumptive use to evaporation varies during the growing stages according to the crop growth stage. In the early growth stages, the ground is not completely covered, and some of the energy available is not utilized by the crop. In the later stages of the crop growth a noticeable reduction in Et. will occur because of

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the physiological effect of crop maturity. Penman (1948) found that the ratio of Et./Ev. (Evaporation) varied with the season as given below :

Season	Et./Ev.
May to August	0.80
March-April, September-October	0.70
November to February	0.60
Average for the Year	0.75

2.2. Factors Affecting Evapotranspiration

2.2.1 Soil and water-supply

Water can be stored in soil in limited amounts. The soil holding. Capacity limits the amount that could be stored for future plant use. The term "field-capacity" is used sometimes to express the amount of water that remains in the soil moisture reservoir after the application of water and the excess has leached away. The water of field capacity has two ways to be consumed; the first one is by the plant and the second by evaporation from the soil. The soil moisture within the root zone is the primary factor affecting the water supply available to the plant. This depends on stored moisture in the soil. Soil conditions affect and limit the plant water consumption. When these conditions are

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not favorable to plant growth, they inhibit its root development. Salinity of the soil solution decreases the availability of water to plant as it increases the soil moisture potential. Veihmyer (1927); Vehihmyer and Hendriksen(1943, 1955) and Veihmyer, Pruitt and McMillan (1960) indicated that soil moisture is not a limiting factor until it approaches the wilting percentage, Gardner and Ehlig (1963) indicated that soil moisture begins to be a limiting factor as plant began to wilt and that thereafter, the rate of transpiration is a linear function of the soil moisture. Some writers have assumed that transpiration rate is directly proportioned to the available moisture in the soil.

Thornthwaite and Mather (1955) indicated that actual evaporation decreases gradually as the soil dries out. They showed smooth curves based on the assumption that the rate of Et was proportional to the amount of available moisture in the soil. Eser (1884) as cited by Kramer (1954) indicated that the evaporation from soil in contact with free water is 2 to 4 times as fast as evaporation from well-drained soils. Baver (1948) agreed with the same conclusion.

2.2.2. Plant factors

The morphological features of the plant such as type of epidermis, kind, distribution, size and openings of stomata, may

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2.3. Determination of (Et.)

2.3.1. Direct methods

Various methods have been used to determine Et. for many agricultural crops. The main factor interacting the method for determining Et. is the source of consumed water by plant; whether from precipitation alone, irrigation plus rain fall or ground water plus precipitation. The principal methods are: tank and lysimeter experiments, field plot experiments, soil moisture depletion studies, the intigration method and inflow - outflow method for large areas.

Tank lysimeter experiments :

The early lysimeter experiments began in 1933 by Young (1933) and Young and Blaney (1942). They placed tanks in surroundings of natural growth of the same species, i.e., in their natural environment, so that Et. would presumably to the same as for similar growth outside the tank. Israelsen and Hansen (1962) stated that lysimeters equiped with Mariotte water supply tanks have proved successful in consumptive use measurements from water tables at various depths. Double-type soil tank with an annular space between the inner and outer shells are considered the best. The differences in daily or weekly readings of a glass gage attached to the supply tank determine the amount of Et.

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measured the water used by 14 crops during 10 - years period,(1902-1911). The obtained yields were plotted against the total water used. For nearly every crop, yields decreased rapidly up to a certain point, with an increase of water and then decreased. Widtose considered the amount of water used at the peak in the curve as the consumptive use by similar methods. Many other Agronomists all over the world determined et. by similar methods.

Soil water Depletion

This method is usually suitable for areas where soil is fairly uniformed and the depth to ground water is such that it will not influence soil moisture fluctuation within the root zone. Soil moisture is determined before and after each irrigation by means of several ways on desirable depths to obtain great accuracy. Apart from random sampling errors, and uncertainty attached to calibration curves of soil moisture resistance units when these are used to follow depletion, the main errors appear to arise from failure to sample the full depth of rooting and from the assumption that percolation is negligable.

Russel (1961) indicated that in spite of percolation being negligable when water content is below field capacity, this is not true for all soils. The lower horizones of deep soils may still loose water by drainage when the upper ones are below field capacity.

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