

**Determination of ET of crops by soil moisture depletion method and  
Determination of water requirements of crops (calculations)****Aim**

Construction of crop coefficient curves for important crops of the region and determination of crop evapotranspiration

**Crop Water Requirements:**

In designing an irrigation system, the primary objective is to know the water requirement of crops. Water requirement of crops are determined either by field cultivation or by estimation through commonly used empirical formulae such as Blaney Criddle, radiation, Penman or pan evaporation method.

**Definitions:****Crop water requirement or evapotranspiration ( $E_{T_{rep}}$ ):**

It may be defined as the rate of evapotranspiration of a disease-free crop growing in a field of not less than one hectare under adequate fertility and water supply so that full productive potential can be achieved in prevailing environment. Evapotranspiration requirement of a crop refers the ET and expressed in mm/day.

**Reference crop evapotranspiration (ET):**

It is the rate of evapotranspiration from an extended surface of 8-15 cm tall green grass of uniform height, actively growing, completely shading the ground and not short of water. ET, may be computed by using the empirical formulae and meteorological data for the specific period.

**Crop coefficient (K):**

It is the ratio of crop evapotranspiration,  $E_{Top}$ , and the reference crop evapotranspiration. ETs. when both apply to large field under optimum growth condition.

## **Ground Cover:**

Drip irrigation system is mainly used to irrigate orchard or row crops. At the young stage of crops the most of fields remain unshaded. It is more usual to wide spaced crops. During this period there is little loss of water in the form of evaporation and transpiration from the unshaded portion whereas it occurs considerably in surface or sprinkler irrigation. Thus, water requirement in crops in conventional method includes the non-beneficial evaporation or transpiration from the unshaded or uncovered areas in the field. This is taken into account in calculating the water requirement of crop in drip irrigation and is modified by introducing the reduction factor called ground coverage factor (K). The method of accurate estimation of K, is still to be developed. However, the following relationships may be used for approximate estimation in which the ground cover, GC, is the fraction of the total surface area actually covered by the foliage of the plants when viewed from directly above (FAO, 1980).

### **(i) Keller and Karmeli (1974):**

$K = \frac{GC}{0.85}(1) \text{ or } 1$ , whichever is the smallest

### **(ii) Freeman and Gazzoli:**

$K, GC (1-GC)$

### **(iii) Decroix :**

$K=(0.10+ GC) \text{ or } 1$ , whichever is the smallest (3)

**The value of 0.10 includes the oasis effect, which is very important when the coverage is small.**

With the consideration of above terms and relationships, the water requirement of crop in drip

irrigation is:

$$ET_{crop} = K_p \times K_c \times K_r \times E_{pan} \quad (4)$$

We know the pan evaporation ( $E_p$ ) is very close to  $E_{To}$ , therefore  $E_T$ , often estimated by a multiplication factor called pan factor ( $K_p$ ) to ( $E_{pan}$ ). Therefore, the equation (4) becomes,

$$ET_{crop} = K_p \times K_c \times K_r \times E_{pan} \quad (5)$$

**Problem 1:** The following are the pan evaporations ( $E_{pan}$ ) reference crop evapotranspirations ( $E_o$ ) and crop co-efficients ( $K_c$ ) of an arbitrary location and crop

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov	Dec
<b>Epan mm/day</b>	2.5	2.6	4.1	4.3	5.2	5.2	5.2	4.9	4.8	3.5	2.8	2.7
<b>Eo mm/day</b>	1.75	1.90	3.0	3.25	4.1	4.2	<b>3.9</b>	<b>3.7</b>	3.3	2.8	1.9	1.8
<b>kc</b>	0.6	0.6	0.7	0.75	0.8	0.8	0.9	0.9	0.8	0.7	0.6	0.6

### For the month of January

Determine the  $K_p$  values and water requirement of crop ( $E_{Top}$ ) at different months. Assume 45 % ground coverage from January to March and 60 % for the remaining months.

**Solution:** Using Decroix assumption,

$$K_p = 0.1 + GC$$

$$= 0.1 + 0.45$$

$$= 0.55, \text{ when GC is 45\%}$$

and

$$K_p = 0.1 + 0.6 = 0.7, \text{ when GC is 60\%}$$

$$E_{Tp} \text{ in any month} = K_p \times K_c \times K_r \times E_{Tpan}$$

For the month of January  $K_p = E_{To}/E_{pan} = 1.75/2.5 = 0.7$

$E_{Tcrop} = 0.7 \times 0.6 \times 0.55 \times 2.5 = 0.58 \text{ mm/day}$

**Problem 2.** The following information were obtained in a research of papaya cultivation under drip irrigation at Gayeshpur, West Bengal.

The daily requirement of a plant was determined by,

$V = E_{pan} \times K_p \times K_c \times A$

where, V = volume of water applied to each plant, l/day

$E_{pan}$  pan evaporation x 1.0, 0.8 and 0.6 at the irrigation level of 11, 12 and 13. respectively.

K Crop factor (assumed 0.8, 1.0 and 1.2 at 4-6, 7-9 and 10-12 months respectively of the crop age)

$K_c$ , pan factor 0.8

A area under a plant - 2 m x 2m

Yield 36225, 40200, 38550 and 31200 kg/ha for I, 12 and conventional method of irrigation respectively.

- A. Determine the volume of water applied at each plant at different irrigation levels for a pan evaporation of 5mm in a day at 5th month of crop age.
- B. If the cumulative pan evaporation (CPE) during the period except in the rainy days for which irrigation was required was 240 mm, find the total depth of water applied in each irrigation level.
- C. Determine the irrigation water use efficiency in different irrigation treatment and per cent increase in yield over conventional method.

**Solution:**

(a)  $V = E_{pan} \times K_p \times K_c \times A$

$I_1 = 5 \text{ mm} \times 1.0 \times 0.8 \times 0.8 \times 4 \text{ m}^2$

$5/1000 \times 4 = 0.002 \text{ m}^2 = 12.8 \text{ l/day}$

$I_2 = 5 \text{ mm} \times 0.8 \times 0.8 \times 0.8 \times 4 \text{ m}^2 = 10.24 \text{ l/day}$

$I_3 = 5 \text{ mm} \times 0.6 \times 0.8 \times 0.8 \times 4 \text{ m}^2 = 7.68 \text{ l/day}$

(b) Depth of water applied at any irrigated level,

$$I = Epan \times Kp \times K$$

The crop coefficient is taken 1.0 as the average of the crop coefficients of 0.8, 1.0 and 1.2 during the period. Therefore,

$$I_1 = 240 \text{ mm} \times 1.0 \times 0.8 \times 1.0$$

$$= 19.2 \text{ cm}$$

$$I_2 = 240 \text{ mm} \times 0.80 \times 0.8 \times 1.0$$

$$= 15.36 \text{ cm}$$

$$I_3 = 240 \text{ mm} \times 0.6 \times 0.8 \times 1.0$$

$$= 11.52 \text{ cm}$$

(c) Irrigation water use efficiency (WUE) at irrigation level,

$$I_1 = \frac{\text{Yield/ha}}{\text{depth of water applied}}$$
$$= \frac{36,225 \text{ kg/ha}}{19.2 \text{ CM}}$$
$$= 1886.72 \text{ kg/ha - cm}$$

$$I_2 = \frac{40,200}{15.36}$$

$$= 2617.19 \text{ kg/ha - cm}$$

$$I_3 = \frac{38,550}{11.52} = 3346.35 \text{ kg/ha - cm}$$

WUE in conventional method =  $31200/24 = 1300 \text{ kg/ha}$

$$I_1 = \frac{36225 - 31200}{31200} \times 100$$

$$= 16.11$$

$$I_2 = \frac{40200 - 31200}{31200} * 100 = 28.85$$

$$I_3 = \frac{38550 - 31200}{31200} * 100 = 23.56$$

Irrigation Interval: Time between the start of successive field irrigation application on the same field, in days.

**Available soil moisture (ASM):**

The difference in moisture content of the soil between field capacity (FC) and permanent wilting point (PWP) is termed the available moisture:

$$ASM=FC-PWP$$

Generally, fines the soil texture, greater the available moisture holding capacity. Approximate available moisture holding capacity of different soil textural classes

<b>Soil texture</b>	<b>Available moisture holding capacity (per cent)</b>
Coarse, fine and loamy sands	6-10
Coarse, fine and loamy sands	10-14
Very fine sandy and silt loam	12-19
Clay and silty clay loam	14-20
Sandy and silty clays and clays	13-20

**Practical significance**

**Conclusion**