Evaporation: Evaporation of water from soil surface

Transpiration: Evaporation of water from plant surface

Evapo-transpiration (ET) (Consumptive use of water)

Quantity of water transpired form soil and plant during growth period

Reference Crop Evapo-transpiration (ET_0)

Rate of evaporation, from an extended surface of 8 to 15 cm tall green grass cover of uniform height, actively growing, completely shading the ground and not short of water.

Crop Factor or Crop Coefficient (Kc)

Selected for given crop and stages of crop development under prevailing climatic condition (ETc/ETo). Kc is different for all the four growth stages of the crop.

Canopy Factor (Ground Cover)

Ratio of the area covered by the plant foliage to the total area (ratio of plant shaded area at 12 noon to the area (it a product of P x P and R x R Spacing)

Evapo-transpiration based Crop Water Budgeting

(daily water requirement)

EVAPO-TRANSPIRATION

In a cropped field water can be lost through two processes

- Water can be lost from the soil surface and wet vegetation through a process called *evaporation (E)*,
- The second process of water loss is called *transpiration* (T), whereby liquid water contained in plant tissues vaporizes into the atmosphere through small openings in the plant leaf, called stomata.
- The combination of these two separate processes, whereby water is lost on one hand by evaporation from the soil surface and on the other hand by transpiration from a plant, is called *evapotranspiration (ET).*
- Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes.

Factors affecting ET

- Evaporation is affected by climatological factors such as solar radiation, air temperature, air humidity and wind speed. Where the evaporating surface is the soil surface, the degree of shading of the crop canopy and the amount of water available at the evaporating surface are the other factors that affect the evaporation process.

  Transpiration also depends on the energy supply, vapour pressure gradient, solar radiation, air temperature, air humidity and wind. The soil water content and the ability of the soil to conduct water to the roots also

determine the transpiration rate, as do waterlogging and soil salinity. Crop characteristics, environmental aspects and cultivation practices also have an influence on the transpiration.

PLANT WATER DEMAND/REQUIREMENT

- **Evaporation**
  - Evaporation is the process whereby liquid water is converted to water vapour (vaporization) and removed from the surface (vapour removal). Water evaporates from a variety of surfaces, such as lakes, rivers, pavements, soils and wet vegetation.
- **Transpiration**
  - Transpiration consists of the vaporization of liquid water contained in plant tissues to the atmosphere.
- **Evapotranspiration**
  - The combination of two separate processes whereby water is lost on the one hand from the soil surface by evaporation and on the other hand from the crop by transpiration is referred to as evapotranspiration (ET).

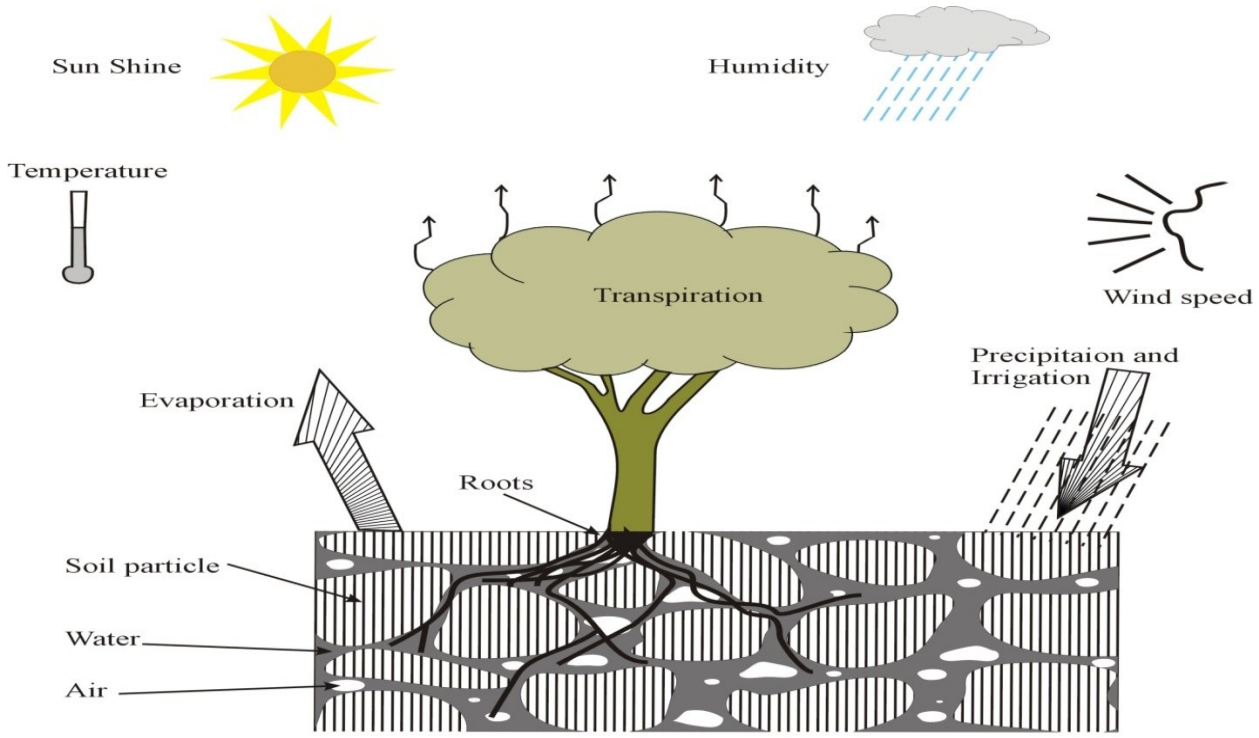
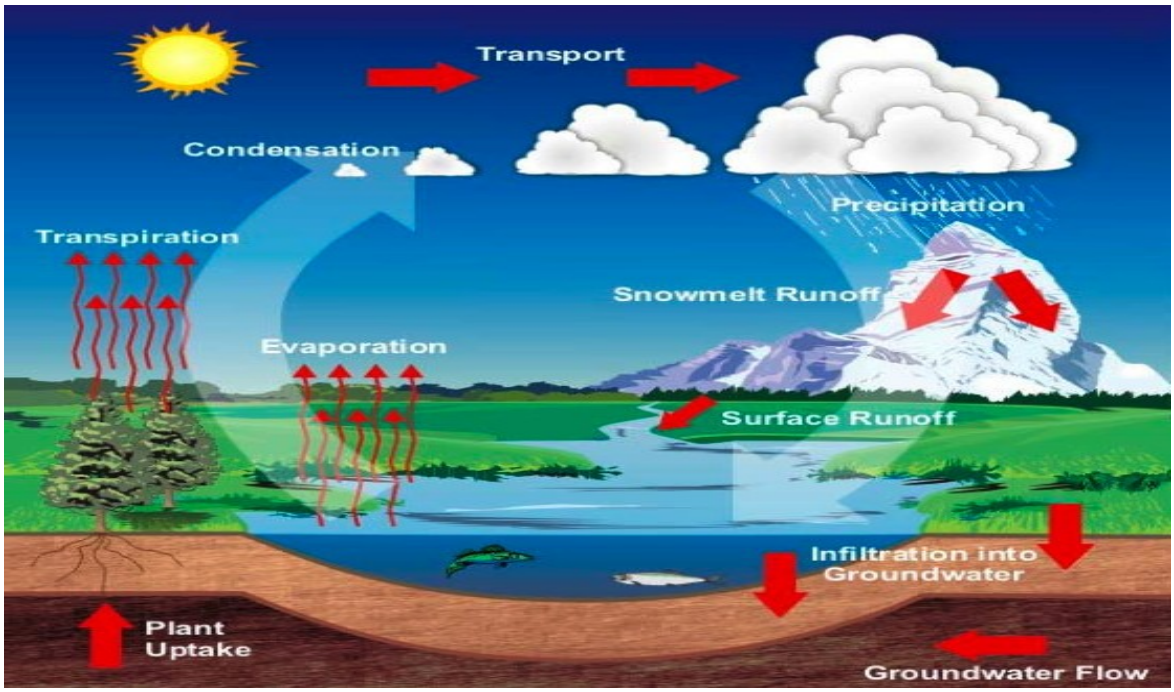
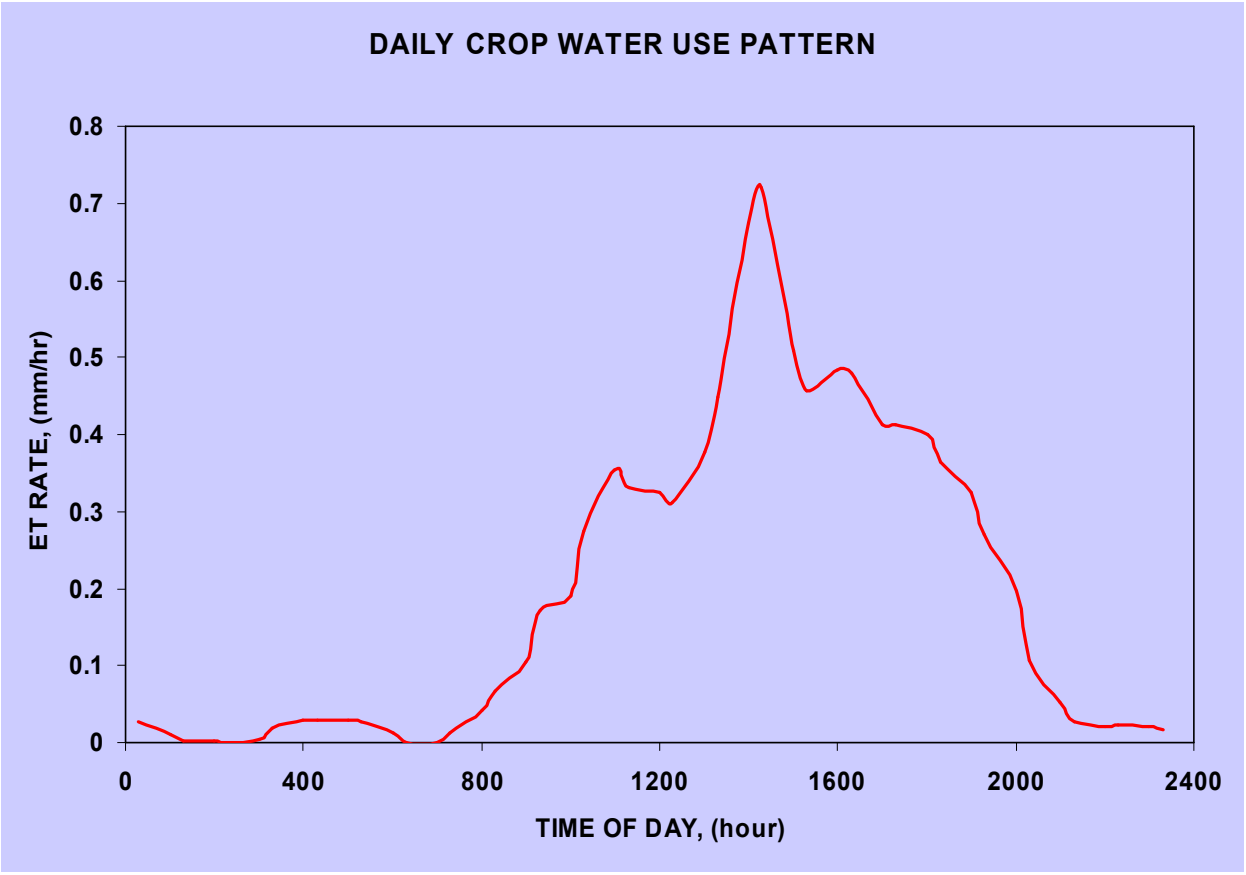


Fig.2.6 Evapotranspiration Process



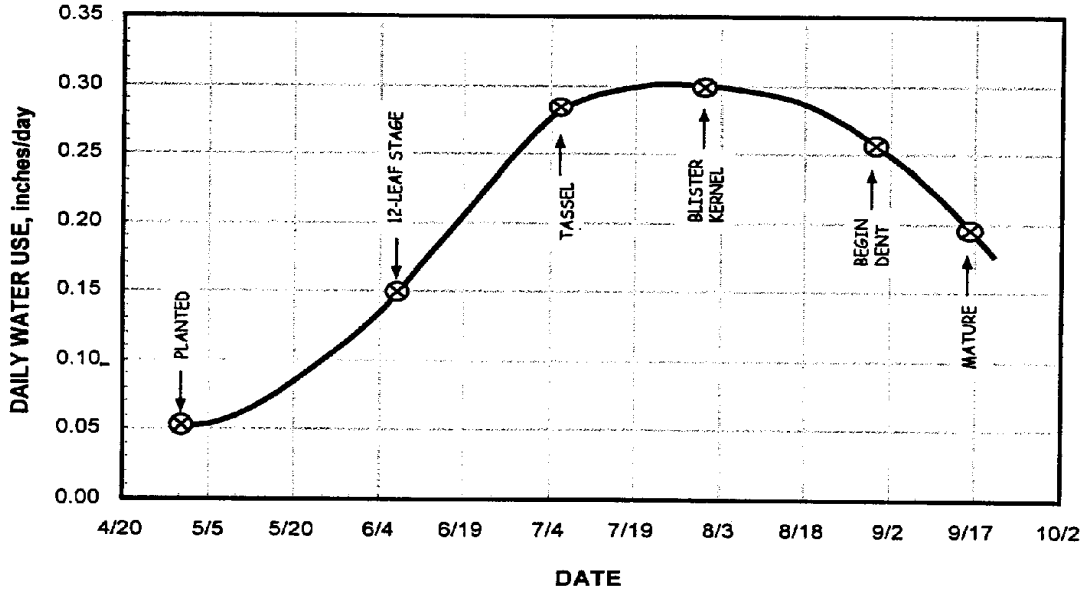
Plant Water Use Patterns

Daily Water Use: peaks late in afternoon; very little water use at night



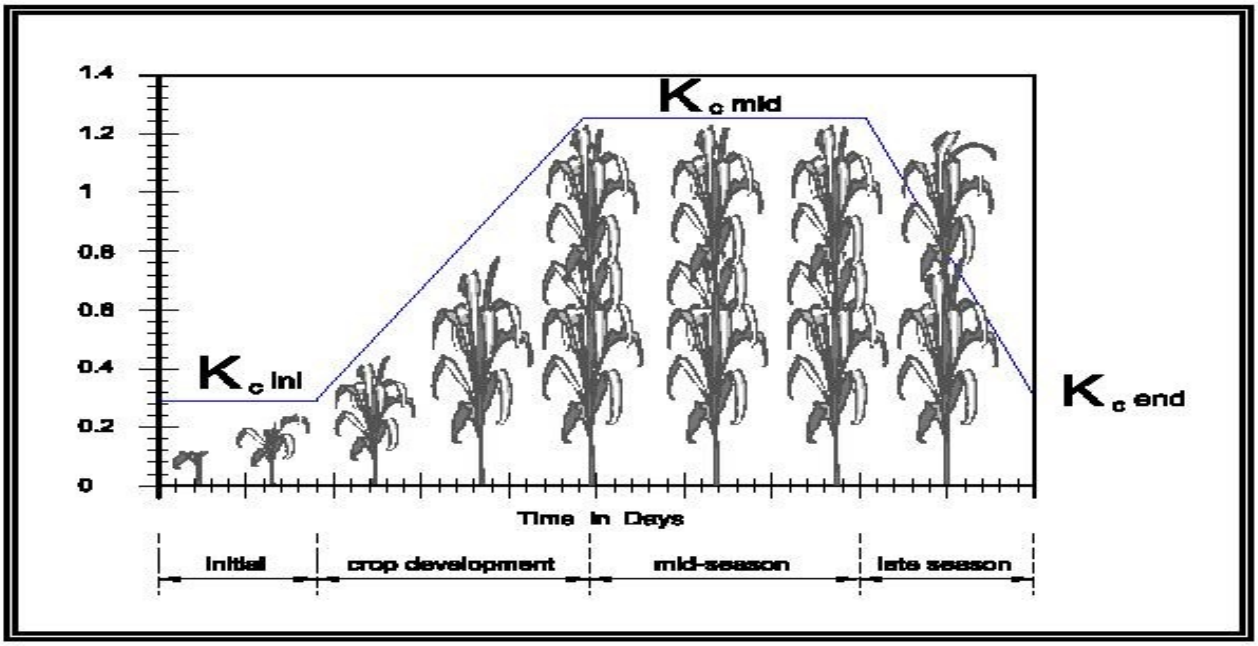
Plant Water Use Patterns

- Seasonal Use Pattern: Peak period affects design



Growth Stage

- When the crop is small evaporation is the main process, but once the crop is fully grown and completely covers the ground transpiration becomes the dominant process.
- It has been estimated that at crop sowing 100% of the total ET comes from evaporation, while at full crop cover evaporation accounts for about 10% of ET and transpiration for the remaining 90%.



Evapotranspiration Modeling

- Estimation based on:
  - climate
  - crop
  - soil factors

  ETc = Kc x ETo
    - ETc = actual crop evapotranspiration rate
    - ETo = the evapotranspiration rate for a reference crop

      Kc = the crop coefficient
- Reference Crop ET (ETo)
  - ET rate of actively growing, well-watered, "reference" crop
  - Grass or alfalfa used as the reference crop (alfalfa is higher)
  - A measure of the amount of energy available for ET
  - Many weather-based methods available for estimating ETo
    - (FAO Blaney-Criddle; Jensen-Haise; Modified Penman; Penman-Montieth)
- Crop Coefficient (Kc)
  - Empirical coefficient which incorporates type of crop & stage of growth (Kcb); and soil water status-- a dry soil (Ka) can limit ET; a wet soil surface (Ks) can increase soil evaporation
  - Kc = (Kcb x Ka) + Ks
  - Kc values generally less than 1.0, but not always

Reference ET$_o$

- The evapotranspiration from a reference surface not short of water is called the reference crop evapotranspiration and is denoted by ETo.

  The reference surface is a hypothetical grass reference crop with specific characteristics

A: Method of Measuring ETo By Pan Method

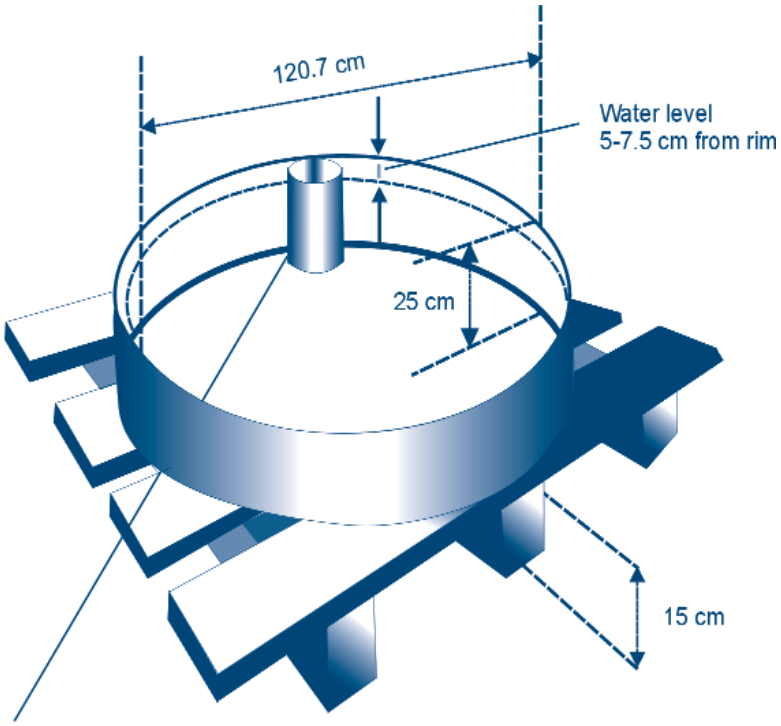
ETo is estimated from pan evaporation

- The pan has proved its practical value and has been used successfully to estimate reference evapotranspiration by observing the evaporation loss from a water surface and applying empirical coefficients to relate pan evaporation to ETo.

ETo= ETpan x pan coefficient

Pan Coefficient = 0.75

- Unit of Measurement:
  - The evapotranspiration rate is normally expressed in millimetres (mm) per day.



B: Measuring ETo, Penman-Monteith Equation

ETo = (0.408 Δ (Rn - G) + γ (900/T + 273)u2 (es - ea))/Δ + γ (1 + 0.34 u2)

Where:

- ETo = Reference evapotranspiration (mm/day)
- Rn = Net radiation at the crop surface (MJ/m2 per day)
- G = Soil heat flux density (MJ/m2 per day)
- T = Mean daily air temperature at 2 m height (°C)
- u2 = Wind speed at 2 m height (m/sec)
- es = Saturation vapour pressure (kPa)
- ea = Actual vapour pressure (kPa)
- es - ea = Saturation vapour pressure deficit (kPa)
- Δ = Slope of saturation vapour pressure curve at temperature T (kPa/°C)
- γ = Psychrometric constant (kPa/°C)