RAMA UNIVERSITY

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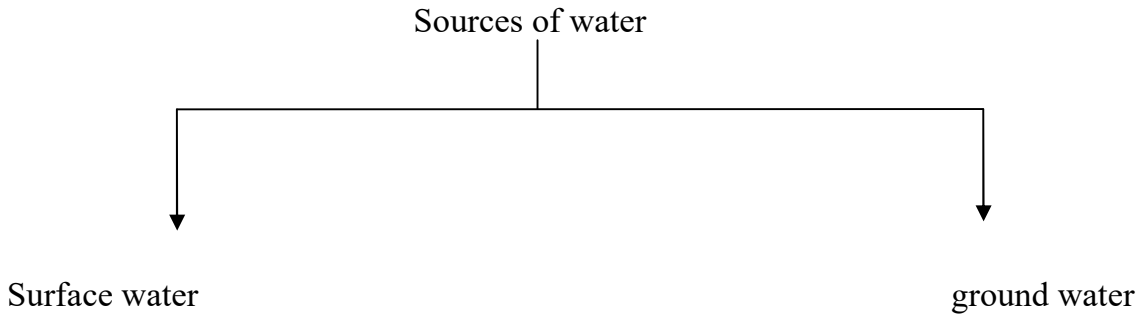
FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES

Water resources, soil-plant-water relationship, crop water requirement

Water resources

Water resources are the sources of water that are potentially useful.

- Uses of water include agricultural, industrial, household, recreational and environmental activities.
- 97 % of the water on the earth is salty water and only 3% is fresh water



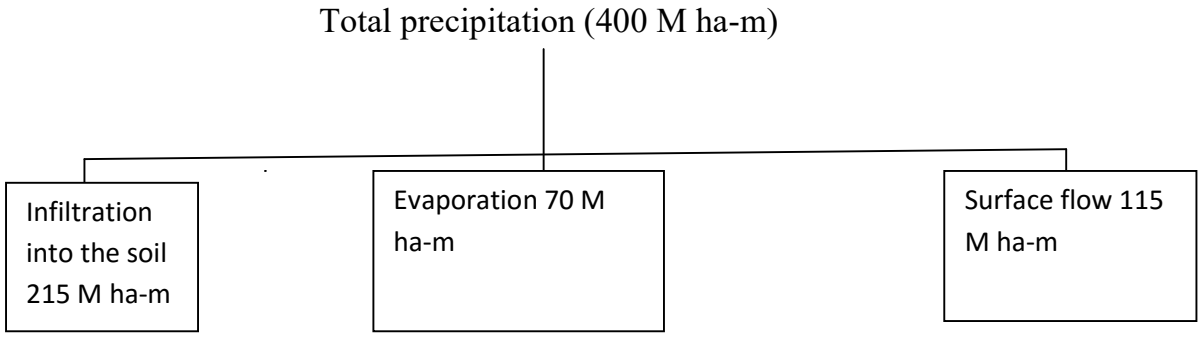
A. Surface water

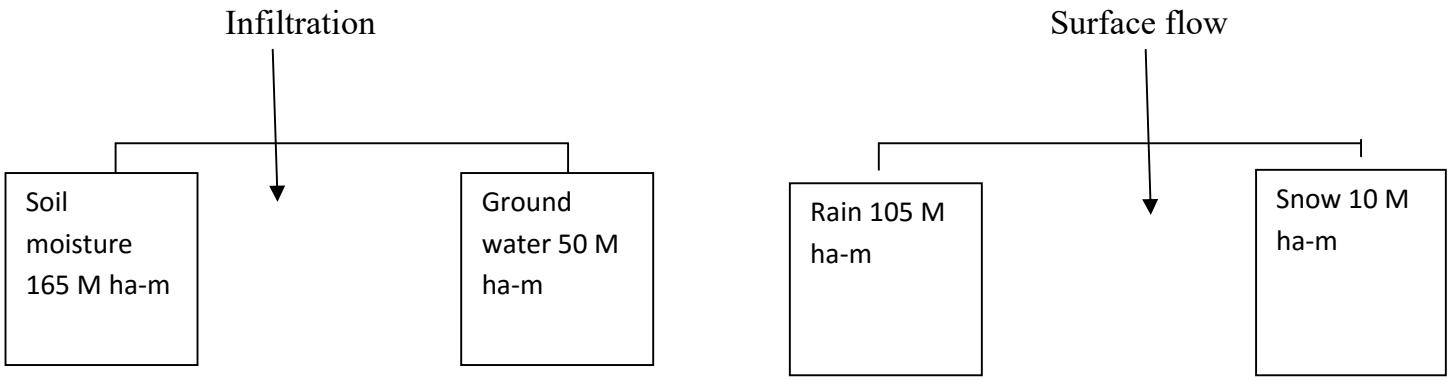
- Lakes
- Ponds
- Streams
- Rivers
- Storage reservoir
- Stored rain water

B. Ground water

- Springs
- Infiltration galleries
- Wells

Flow chart showing water resources of India





Soil-plant-water relationship

To design a successful irrigation system, it is essential to know the plant rooting characteristics, effective root zone depth, moisture extraction pattern and moisture sensitive period of crops.

Rooting characteristics of plants

The purpose of irrigation is to provide adequate soil moisture in the immediate vicinity of the plant roots. All plants do not have the similar rooting pattern i.e., root penetration and proliferation . Some plants have relatively shallow root system (annual crops), while others develop several meters under favorable conditions (tree crops).

Soil properties influencing root development

1. **Hard pan**
   Root penetration is seriously affected by the presence of a hard pan or compacted layer in the soil profile. Thus roots cannot penetrate a hard layer except through cracks.
2. **Soil moisture**
   Since roots cannot grow in soil that is depleted in moisture down to and below the permanent wilting point, a layer of dry soil below the surface in the profile can restrict root penetration.
3. **Water table**
   A high water table limits root growth and a rising water table may kill roots that have previously grown below the new water level.
4. **Toxic substances**
   Presence of toxic substances in the sub-soil also limits root growth and development . Saline layers or patches in the profile therefore inhibit or prevent root penetration and proliferation.

Types of water movement

Generally 3 types of water movement within the soil are recognized- saturated flow, unsaturated flow and water vapour flow.

1. **Saturated water movement**

The condition of the soil when all the macro and micro pores are filled with water, the soil is said to be at saturation, and any water flow under this soil condition is referred to as saturated flow.

2. **Unsaturated water movement**

The soil is said to be under unsaturated condition when the soil macro pores are mostly filled with air and micro pores (capillary pores) with water and some air, and any water movement or flow taking place under this soil condition is referred to as unsaturated flow.

Water absorption by plants

- Mechanism of absorption of water by plants In higher plants, water is absorbed through root hairs which are in contact with soil water and form a root hair zone a little behind the root tips.

  Mechanism of water absorption is of 2 types

1. **Active absorption of water**

   In this process the root cells play active role in the absorption of water and metabolic energy released through respiration is consumed.

2. **Passive absorption of water**

   It is mainly due to transpiration, the root cells do not play active role and remain passive.

Crop water requirement

Crop water requirement is the water required by the plants for its survival, growth, development and to produce economic parts. This requirement is applied either naturally by precipitation or artificially by irrigation. Hence the crop water requirement includes all losses like:

a) Transpiration loss through leaves (T)

b) Evaporation loss through soil surface in cropped area (E)

c) Amount of weather used by plants (WP) for its metabolic activities which is estimated as less than 1% of the total water absorption. These three components cannot be separated so easily. Hence the ET loss is taken as crop water use or crop water consumptive use.

d) Other application losses are conveyance loss, percolation loss, runoff loss, etc., (WL).

e) The water required for special purposes (WSP) like puddling operation, ploughing operation, land preparation, leaching, requirement, for the purpose of weeding, for dissolving fertilizer and chemical, etc.

Hence the water requirement is symbolically represented as:

$$WR = T + E + WP + WL + WSP$$

(The other application losses and special purposes are mostly indented for wet land cultivation. Hence for irrigated dry land crop the ET loss alone is accounted for crop water requirement).

The estimations of the water requirement of crop are one of the basic needs for crop planning on the farm and for the planning of any irrigation project.

Water requirement may be defined as the quantity of water required by a crop or diversified pattern of crop in a given period of time for its normal growth under field conditions at a place.

Water requirement includes the losses due to ET or CU and losses during the application of irrigation water and the quantity of water required for special purposes or operations such as land preparation, transplanting, leaching etc., Hence it may be formulated as follows

WR = ET or Cu + application loss + water for special needs.

It can also be stated based on “Demand” and “supply source” as follows

$$WR = IR + ER + S$$

Where,

IR - Irrigation requirement

ER - Effective rainfall

S - Contribution from ground water table.

Hence the idea about crop water requirement is essential for farm planning with respect to total quantity of water needed and its efficient use for various cropping schemes of the farm or project area. This crop water requirement is also needed to decide the stream size and design the canal capacity.

The combined loss of evaporation and transpiration from a cropped field is termed as evapotranspiration which is otherwise known as consumptive use and denoted as ET and this is a part of water requirement.

$$CU = E + T + WP$$

Therefore,

$$WR = CU + WL + WSP$$

The crop water requirement can also be defined as water required meeting the evapotranspiration demand of the crop and special needs in case of wet land crop and which also includes other application losses both in the case of wet land and garden land crops. This is also known as crop water demand.

The crop water requirement varies from place to place, from crop to crop and depends on agro-ecological variation and crop characters.

The following features which mainly influence the crop water requirement are:

1) **Crop factors**

a) Variety
b) Growth stages
c) Duration
d) Plant population
e) Crop growing season

2) Soil factors

a) Structure
b) Texture
c) Depth
d) Topography
e) Soil chemical composition

3) Climatic factors

a) Temperature
b) Sunshine hours
c) Relative humidity
d) Wind velocity
e) Rainfall

4) Agronomic management factors

a) Irrigation methods used
b) Frequency of irrigation and its efficiency
c) Tillage and other cultural operations like weeding, mulching etc/ intercropping etc

Based on all these factors, average crop water requirement for various crops have been worked out and given below for tropical conditions.

Irrigation requirement

The field irrigation requirement of crops refers to water requirement of crops exclusive of effective rainfall and contribution from soil profile and it may be given as follows

IR - WR – (ER + S)
IR - Irrigation requirement
WR - Water requirement
ER - Effective rainfall
S - Soil moisture contribution

Irrigation requirement depends upon the

a) Irrigation need of individual crop based on area of crop
b) Losses in the farm water distribution system etc.

All the quantities are usually expressed in terms of water depth per unit of land area (ha/cm) or unit of depth (cm).

Net irrigation requirement

It is the actual quantity of water required in terms of depth to bring the soil to field capacity level to meet the ET demand of the crop.

It is the water applied by irrigation alone in terms of depth to bring the field to field capacity level. To work out the net irrigation requirement, ground water contribution and other gains in soil moisture are to be excluded. It is the amount of irrigation water required to bring the soil moisture level in the effective root zone to field capacity, which in turn meet the ET effective root zone to field capacity, which in turn meet the ET demand of the crop. It is the difference between the F.C and the soil moisture content in the root zone before starting irrigation.

$$d = \sum_{i=i}^{n} \frac{Mfci - Mbi}{100} \times Ai \times Di$$

d = Net irrigation water to be applied (cm)
Mfci = FC in ith layer (%)
Mbi = Moisture content before irrigation in i^{th} layer (%)
Ai = Bulk density (g/cc)
Di = depth (cm) n = number of soil layer