

\* Irrigation

Artificial application of water to crop, to meet their water requirement for normal growth and yield.

(or) It is an artificial water supply to crop plant through different sources like dam, canal, channel, well, etc. for their normal growth and yield.

\* Irrigation management —

Application of water <sup>to crop</sup>, in correct amount and right time under better drainage to obtain maxi<sup>mum</sup> yield.

\* water management —

Distribution & application of water to the crop at prop. time and in correct amount & removal of excess amount of water. From field to promote the crop production economically in conjunction with crop prod<sup>y</sup> technology & management.

\* Objectives of Irrigation : —

- 1) To provide suitable moisture environment to crop, to obtain optimum yield by keeping good soil health.
- 2) Integrated management of surface water, ground water & rainfall.
- 3) Land precipitation prior to sowing.
- 4) For effective use of manures and fertilizers.
- 5) To adopt suitable cropping system & cropping pattern.
- 6) To grow more than one crop in a year.
- 7) For timely agri. operat<sup>y</sup> i.e. land preparation, sowing, fertilizers, etc.
- 8) To Adopt green manuring.
- 9) For control of weed. i.e. timely hoeing and weeding.
- 10) for High crop productivity.
- 11) To improve crop quality ( i.e. color, freshness, size, etc.)
- 12) Economic returns. (13) Employment opportunities.
- 13) Fertigation.
- 14) Nutrient management.

## ~~Topic~~ Classification of Soil Water \*

Soil water has been classified mainly into 3 heads.

(1) Gravitational water

(2) Capillary water

(3) Hygroscopic water

Besides two other types of water are known as water of crystallization and water vapour.

### [1] Gravitational water →

- "Water moving downward after saturation through soil under gravity known as gravitational water / excess / superflow water."

- ✓ After rainfall or irrigation all the macro & micropores are filled with water i.e. saturated of soil or maximum WHC.

- Due to thick film water molecules around soil particles held less tightly resulted in movement of water to the deeper soil layer in response to gravity.

- ✓ This water is not available to plant

- ✓ moisture held at 0 (zero) atm tension.

### [2] Capillary water : →

- "Water retained by soil after cessation of downward movement"

- is called as capillary water."

- ✓ 2-3 days of rainfall / irrigation water movement in soil is negligible i.e. known as field capacity.

- At F.C. macro pores are empty & micropores are filled with water, & is available to plant.

- ✓ Also known as water of cohesion

- C. water is available water for crop growth, also acts as medium for nutrient availability

- Usually available moisture held at  $1/10$  to  $15$  atm tension

- ✓ factors influencing C.W.

- ✓ texture, structure, organic & colloidal matter. } ↑ . C.W.

### [3] Hygroscopic water →

- "Amount of water which is absorbed by the soil from an atmosphere or saturated water vapour due to attractive forces on the soil particle surface."

- H.W. is held at  $10,000$  to  $31$  atm. tension.

- It is a non-liquid & in immobile stage.

- Also known as water of hydration or water of adhesion

- This water is not available to plant.

## \* Forces acting on soil water \*

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### 1) Forces acting on availability of water $\Rightarrow$ water movement in soil.

#### a) Gravitational force $\rightarrow$

- When soil is saturated condition, due to gravity force direction of flow is downward.
- The macro pores serve as the main channel for this gravitational flow.
- If the gravity is lesser in magnitude then there is no downward movement of water.
- It is stopped (ceases) when place of macro pores <sup>are</sup> taken by air.

#### b) Capillary force $\rightarrow$

- Once the flow due to gravitational force has ceased the water moves from wet region to dry region through micro pores in the form of thin  $\Rightarrow$  capillary film.
- For this water movement surface tension  $\Rightarrow$  capillary tension is responsible.
- Movement of water under unsaturated condition are due to surface tension.

#### c) Vapor tension $\rightarrow$

- Under unsaturated soil condition very little extend water moves from soil layers.
- As soil depth increases soil heat decrease results in wide temperature difference.
- This condition results in vapor movement towards upper soil layer or atmosphere.

### 2) Osmotic force $\rightarrow$

- Soil water contains certain amount of dissolved salts and other solutes and is termed as soil solution.
- Presence of solutes in soil water decreases the potential energy of water.
- The movement of water takes place due to difference in osmotic pressure of soil solution.
- Such a situation is observed in highly saline soils due to high salt concentration.

## II Plant water Relationship

### Role of water in plant

water is essential for growth and development of plant from germination to maturity.

#### 1] Important constituent of protoplasm :-

About 90-95% protoplasm is made up of water, hence in water absence and protoplasm there is no basis of life.

#### 2] Water is a universal solvent :-

many organic substances are dissolved in water. All the essential nutrients are dissolved in water only. Hence without water, nutrient absorption is not possible.

#### 3] Nutrient Absorption :-

The elements from soil are absorbed by roots from the soil through water only.

#### 4] Circulation and distribution of Nutrients →

water circulates nutrients to various parts of the plant and hence act as transportation medium.

#### 5] Water act as a reagent :-

water is directly participate in some of the metabolic reactions e.g. photosynthesis.

#### 6] Water maintains the plant temperature :-

During transpiration process water is circulated throughout the plant body & regulate the plant body temperature.

#### 7] closing and opening of stomata :-

water in plant body affects opening and closing of stomata. & thereby regulates the physiological process like absorption, transpiration; photosynthesis and respiration.

8) water maintain the turgidity of plant cell.

9) Cell elongation and growth of plant.

The hydrostatic pressure created in plant after water absorption plays important role in cell elongation and plant growth.

10) Sever as medium for chemical reaction :-

many chemical react<sup>n</sup> take place in plant body in which water is required. e.g. Hydrolysis of starch to sugar.

11) It regulate plant movement :-

like opening of flower, movement of leaves, roots etc.  
also essential for plant germination.

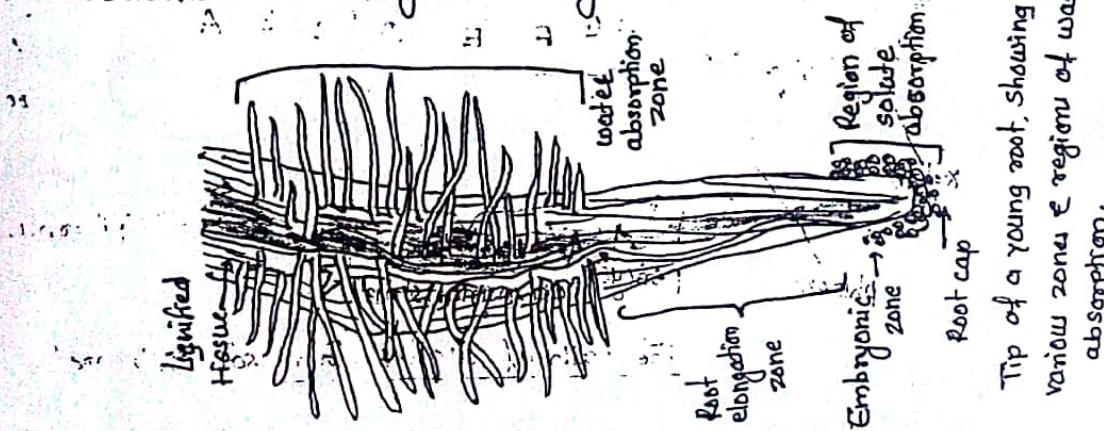
12) water is source of structural element which is required for carbohydrate synthesis during photosynthesis.

### Plant structure :-

- root system of plant provides the way to water enter into plant body, through root hairs.
- young root of plant are most important for water absorption.
- water moves towards cortical cell from root hairs and finally enters into xylem. (i.e. water conducting tissue)
- xylem conduct water (lift up & supplied) to various plant parts.

### \* Pathway summarized as -

soil water → Root hairs → Epidermis → cortex →  
→ Endodermis → Pericycle → Xylem → plant parts.



Tip of a young root, showing the various zones & regions of water absorption.

## \* Mechanism of Water Absorption

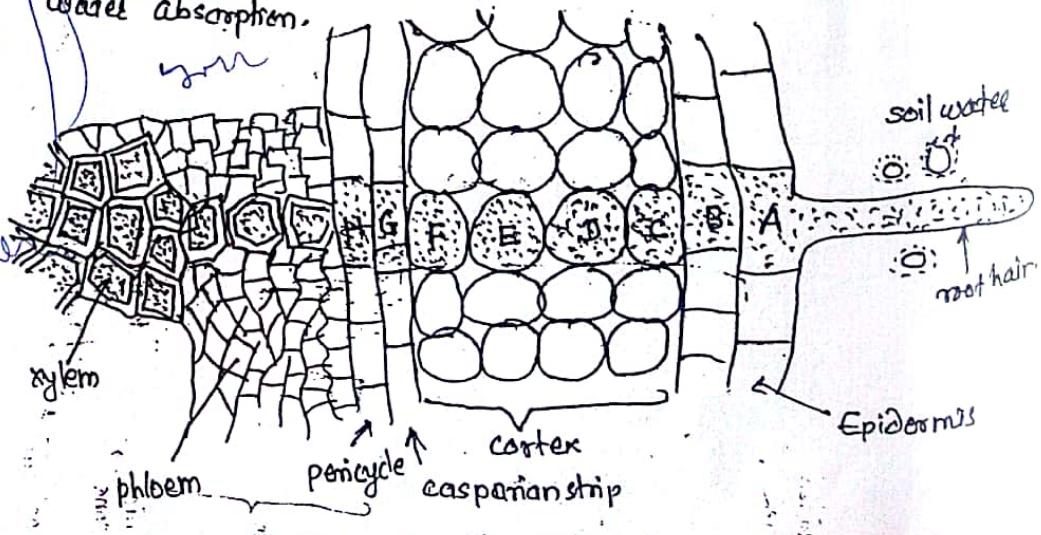
- Water is mainly absorbed by root hairs. Root hair region is the region of water absorption.
- The water from soil enter into the plant through root hairs towards cortical cells and finally into the xylem.
- Plant absorbs water mainly through two different types of mechanism. [Renner 1915]
  - 1] Active Absorption.
  - 2] Passive Absorption.

### 1] Active absorption :-

- ACTIVE →
- In this process root cells are actively involved hence this type of absorption of water is by root cells & not by root hairs.
  - Osmotic difference b/w soil water and cell sap in root cell plays important role in this process.
  - Osmotic pressure ( $\text{OP}$ ) of the cell sap in root is generally higher than osmotic pressure of soil water. Hence water from soil enter into root cell.

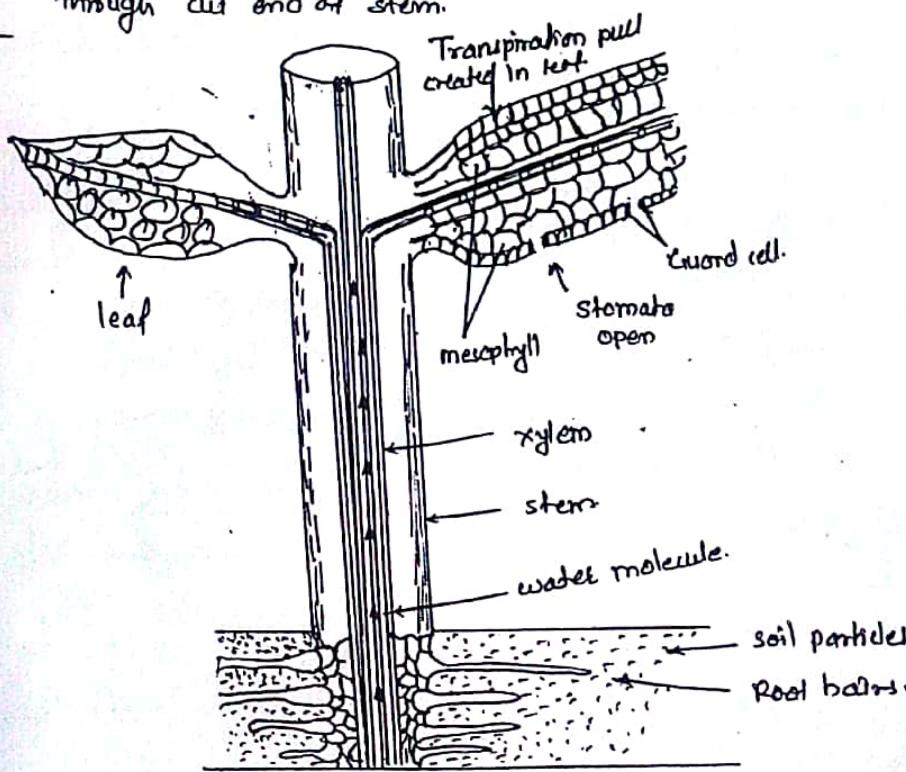
The value of root pressure developed is, 1 to 3 atm

The osmotic activities of cells are contribute to absorption of water and hence known as active absorption @ osmotic water absorption.

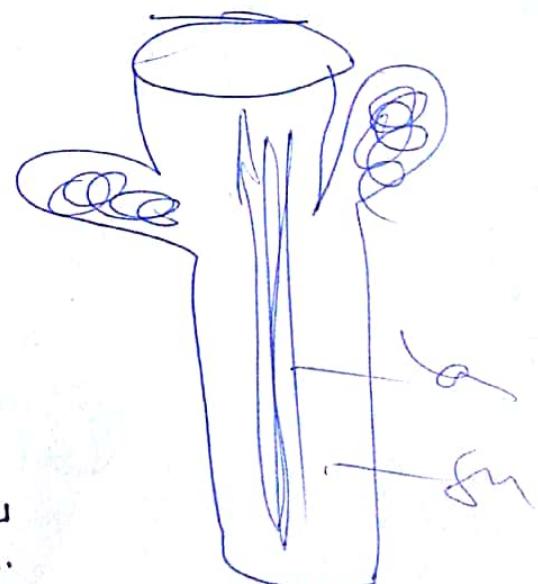


2] {Passive Absorption} :-

- In this mechanism root cells are not involved.
  - Root cells do not play any role in water absorption hence water passes through root cells but not absorbed by root cells.
  - Force generated at the top of plant and in leaves play a vital role in water absorption.
  - The root cells are acting only absorbing agent.
  - "The transpiration pull" or transpiration force generated due to stomatal transpiration in leaves which creates a tension in xylem cells of leaves.
  - This tension [water diffusion pressure deficit (DDP)] is transmitted root hairs.
  - In this process roots are passive hence known as passive absorption.
- \* Absorption and transpiration are closely related, rate of absorption is equal to rate of transpiration.
- \* When water potential in leaves, roots & soil become equal, water absorption becomes negligible.
- \* In this process absorption may take place without root also even through cut end of stem.



Passive absorption of water.



## \* Factors Affecting Water Absorption

Imp plant requires water for their growth and development.

About 98% of absorbed water is lost during transpiration.

The absorption of water is influenced by many factors as below.

### 1] Atmospheric factor :-

- Atmospheric factor such as temperature, relative humidity, wind velocity, solar radiation decides the evapo-transpiration rate.
- High temperature, wind velocity, solar radiation, low humidity increase the evapo-transpiration rate. thereby water requirement and vice versa. [directly proportional]

### 2] Soil factor :-

soil factors like, available water, concentration of soil solution, hydraulic conductivity of soil, soil temperature, soil aeration etc. affect the water absorption rate.

#### 1] Effect of available water :-

- The amount of available soil water in both the F.C and P.W.P changes with change in soil.
- If the hydraulic conductivity of soil is more/high the water movement towards the root occurs at faster rate. also if the soil water potential is more than plant water potential then movement of water toward the plant is more.

#### 2] Concentration of soil solution [soluble salts] :-

- Due to high concentration of soluble salts osmotic pressure increases resulted in reduced absorption rate.

#### 3] Soil Temperature :-

- soil temp. affect water absorption.
- Under low  $(10^{\circ}\text{C})$  soil temp. root growth is restricted also temp above  $40^{\circ}\text{C}$  affect the water absorption.
- The suitable temp. range for optimum water absorption is  $10^{\circ}\text{C}$  to  $25^{\circ}\text{C}$ .

### 4) soil aeration : →

- A continuous poor aeration of soil due to water logging cond<sup>t</sup> restricts the root growth and water absorbing root surface.

- It is major problem in high rainfall case in case of heavy soil.

### 5) Plant factors : →

#### 1) Root structure and root system : -

The depth, nature of root system and number of root hairs present on roots are important in water absorption.

#### 2) leaf size and anatomy : -

optimum plant growth increases the leaf area, which increase number of stomata & results in to more transpiration and absorption.

#### 3) cellular metabolism : -

e.m. increase the respiration which increase water absorption and vice versa.

#### 4) Root concentration : -

conc. of root is more in upper 30 cm soil layer & near plant base. more no. of roots absorb more water.

#### 5) Root distribution : -

Root efficiency is more when their spreading (arrangement) is in triangular form. Root arrangement is directly related to water absorption.

#### ⑥ rooting characteristics : -

- Root development is important for better plant growth
- It determine the amount of water that can be absorb by plant.
- Extensive and deeper root system allow the continuous plant growth for longer period.

Topic - 05Evaporation, Transpiration, Evapo-transpiration.Factors affecting EvapotranspirationEvaporation

Evaporation is the physical process by which a liquid is transferred to gaseous stage. Evaporation from soil surface, free water or vegetative cover is diffusive process by which liquid water in the form of vapor is lost to atmosphere.

Two essential criteria for evaporation process are:-

1. Source of heat : to transform liquid water in to water vapor.
2. Presence of concentration gradient between evaporating surface and surrounding air for water vapor diffusion.

\* Factors affecting evaporation rate:-

- ✓ Water surface area exposed to atmosphere
- ✓ Vapor pressure difference between saturation vapor pressure and dew point of the air
- ✓ Soil moisture content.
- ✓ Atmospheric humidity
- ✓ Vegetative cover density
- ✓ Quality of water
- ✓ Soil and air temperature
- ✓ Wind velocity
- ✓ Mulch
- ✗ atmospheric pressure

Transpiration

It is the process by which loss of water from aerial parts of plant in the form of water vapors. Transpiration causes movement of water from the soil in to the roots, stem leaves and to the atmosphere. It controls the rate of absorption and the ascent of sap. If transpiration exceeds, result in stress. The process of transpiration includes-10 to 20 % loss through cuticle (cuticular transpiration), 80 to 90 % transpiration loss through stoma, 0.1 % loss through lenticular transpiration. Plant absorb large amount of water from soil by roots. This absorbed water is carried to the aerial parts of the plants and only 1 to 2 % is utilized by the plant for building of process to perform various biological activities while most of water (98-99 %) is lost in the form of water vapors.

From this it is clear that the total amount of water absorbed by plant exceeds their actual needs. This surplus water is lost from the aerial surface of plants in the form of vapors. This is called transpiration. Factor influencing Transpiration are External factor (Climatic factors) i.e. Temperature, light intensity, Atmospheric humidity, wind velocity and Internal factors of plants are Leaf size, leaf arrangements, stomata number and size, coating of wax, efficiency of root system.

**Evapotranspiration:** Loss of water from open bodies & plants parts

It is the total water lost due to evaporation from the soil and transpiration from crop for particular area during specified time. It is difficult to separate out the two losses; they are combined into one term ET. However the term consumptive use (Cu) expresses the quality of water lost in crop transpiration and that used by the plant for its metabolic activities.

$$Cu = ET + \text{water used for metabolic processes}$$

Since the water required for metabolic activities is negligible, less than 1 % evapotranspiration. Therefore the term Cu is generally taken as equivalent to ET. Evapo-transpiration constitutes nearly 99 % of total water uptake.

**Factors affecting Evapotranspiration:-**

Climatic Factors	Soil Factors	Crop Factors	Cultural Factors
• Radiation	• Depth of water table	• Plant morphology	• Frequency of irrigation
• Precipitation	• WHC	• Crop geometry	• Quality of water
• Sunshine	• Amount of vegetative cover	• Plant cover	• Tillage
• Wind velocity	• Hydraulic conductivity	• Stomatal density	
• Temperature	• Color of soil	• Root depth	
• Relative humidity			

→ Loss of water from open bodies and plant parts

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## Factors affecting Effective Rainfall.

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### [1] Rainfall characteristics :-

- Rainfall intensity and distribution influence surface runoff & infiltration.
- Greater rainfall intensity reduce effective rainfall efficiency.
- Well distribution and light frequency of rainfall increase E.R. efficiency.

### [2] Land characteristics:

- Land slope influence the infiltration rate and thereby surface runoff rate.
- greater slope land results in less E.R. efficiency while leveled land results in high infiltration ultimately less runoff & is effective.

### [3] Soil characteristics :-

- High infiltration rate and permeability  $\uparrow$  rainfall effectiveness.
- It depends on soil texture, structure, & bulk density, org. matter content. W.H.C of soil  $\uparrow$  fraction of E.R.
- Proportion of E.R. is lesser in irrigated area than un-irrigated area.

### [4] Ground water characteristics :-

- Deeper the water table greater the E.R. & vice versa.

### [5] Management practices :-

- management / tillage practices like ploughing, mulching, bunding, contour tillage reduce runoff and  $\uparrow$  E.R.

### [6] Crop characteristics :-

- Deep rooted crop  $\uparrow$  the proportion of E.R.
- E.R. is directly proportional to water uptake by the crop.

### [7] Climate :- The adm. temp., R.H., wind velocity, radiation intensity determine the crop water requirement & hence affect E.R.

### [8] Deep percolation :- D.P. after heavy rains or irrigation reduce E.R.

### [9] Ground water contribution :- If G.W.C. is high E.R. is less.

### [10] Carry over soil moisture :- moisture present before crop

### planting or betw. cropping seasons. influence E.R.

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various types of crops particularly shallow rooted crops are well adapted to subirrigation. crops like wheat, jowar, bajra, potato, beet, beet, fodder etc. can be irrigated by subirrigation.

Advantages : →

- ① soil water can be maintained at a suitable tension favourable for good plant growth
- ② evaporation losses are much less,
- ③ labour cost for irrigation is much less.
- ④ used for soil having less water holding capacity.

Disadvantages / Limitations : →

- ① initial cost is more
- ② presence of high water table restrict this method.
- ③ there are chances of saline & alkali soil condition.

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### [C] Overhead or sprinkler irrigation methods

The application of water over the field in the form of spray or rain like droplets is called sprinkler irrigation. This system may be used for many crops and on all types of soils. of widely different topography and slopes. This system is designed to apply sufficient water to meet the crop demand at peak periods of consumptive use.

Advantages : →

- ① avoid percolation losses
- ② water application efficiency (80-85%)
- i.e. very high
- ③ uniform application of water
- ④ save irrig.
- water quantity up to 25-60%
- ⑤ no need of bunds & irrigation channels
- ⑥ less cost than drip irrigation.
- ⑦ land leveling is not necessary.
- ⑧ no problem for intercultivation.
- ⑨ suitable for close growing and high value crop.

Disadvantages / Limitations : →

- ① installation cost is more
- ② evaporation losses are high under high temperature
- ③ high energy is required for operating
- ④ high wind speed causes uneven distribution of water ( $> 12 \text{ Km/ha.}$ )
- ⑤ not recommended with water having high salts particularly during summer season.

~~IMP~~ (10) Micro irrigation and its type, Drip irrigation, Components and its merits and demerits, Fertigation - Definition and Advantages. (47)

~~IMP~~ (11) Micro-Irrigation :-

"Method of irrigating in which low volume of water applied at low rate with high frequency."

- In this method frequent water application is required in the form of discrete drops, continuous drop, tiny stream or miniature spray through emitter or applicator.

(12) Methods of micro-irrigation:

- 1) Drip irrigation
- 2) surface irrig.
- 3) Line source tubing
- 4) Inline Drip lines
- 5) bubbler irrig.
- 6) pitcher irrig.
- 7) micro jet sprinkler
- 8) micro sprinkler
- 9) mini sprinkler
- 10) mister irrig.
- 11) spray irrigation.
- 12) Pop-up irrig.

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~~IMP~~ (13) Drip Irrigation (Trickle Irrigation) :-

"It is defined as the precise, slow water application through dripper directly crop root zone."

- This method is profitable in areas where water is scarce or of poor quality. It is well adopted for widely spaced crop.
- By this method soil moisture can be maintained at field capacity during crop growing period.
- Water is applied at a small point called dripper or emitter.
- It is mainly divided into (types)

(1) surface drip irrig. (2) sub-surface drip irrig.

1) surface drip irrigation :-

In this method water is slowly applied through dripper (emitter) at the root zone of crop.

In all surface drip irrig. systems except emitter other components are same.

## 2) sub-surface drip system: →

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"In this system pipes (main, submain, laterals) are buried below the soil surface to a depth of 4"-6" depending upon soil types."

- components are same as that of in surface irrig. system.  
except lateral pipes and emitters, operated at  $0.3 - 0.5 \text{ kg/cm}^2$  pressure.

## 3) Components of Drip irrigation system

- 1) water source.
- 2) Pumping unit
- 3) Filter or filtration unit
  - i) sand filter (Gravel filter)
  - ii) screen filter.
  - iii) Disc filter
- 4) fertilizer application unit
- 5) Main line
- 6) sub-main line
- 7) Lateral.
- 8) emitters (drippers)
- 9) control valves. (Ball valve)
- 10) Flush valves
- 11) Non-return valve
- 12) Pressure gauge
- 13) Grommet & Take-off
- 14) end caps (end sets)

For detail information  
Refer practical manual  
Ex. No. (09) Page 33-38

## 4) Advantages / Benefits / merits of Drip irrigation.

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- 1) It save irrig. water up to 40 - 70 %.
- 2) High water application efficiency.
- 3) Increase in yield 25 to 100 % compare to surface irrig.
- 4) Provide sufficient amount of water through out the growing season of crop.
- 5) weed infestation is controlled up to 20 - 30 %
- 6) localized application of fertilizer is made.
- 7) well adapted to widely spaced crop.
- 8) Improves the yield and quality of produce.
- 9) suitable for undulating, slopeing land without erosion
- 10) Reduce losses of water through evaporation & seepage.
- 11) saving in labour up to 30 - 95 %.
- 12) maintain physical soil condition.

## ④ Disadvantages / Limitations / Demerits.

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- 1) Initial installation cost is high.
- 2) Not useful in crop rotation due to change in plant geometry.
- 3) Required planting technique.
- 4) most suitable only in water scarcity area and for widely spacing crops.
- 5) clogging / chocking problem.
- 6) Restricted root development of crop
- 7) salt accumulation at the root zone ~~peri~~ periphery

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## ⑤ Fertigation :-

- Defn - "Application of fertilizer through irrigation water is called as fertigation."
- Due to drip irrigation application of water soluble fertilizers at appropriate times and in desired concentration is possible.

## ⑥ Advantages :-

- 1) fertigation helps in uniform application of fertilizer.
- 2) fertilizers are placed in root zone.
- 3) It is a quick and convenient method
- 4) fertigation saves fertilizer
- 5) Due to fertigation frequent application is possible.
- 6) prevent ground water pollution.
- 7) It allows applicati<sup>n</sup> of fertilizer in different grades
- 8) suitable for crop growth stage.
- 9) required very less labour cost
- 10) Fertigation provides micronutrients application along with major nutrients i.e. NPK.

## ⑦ Limitations :-

- 1) suitable only for water soluble fertilizer.
- 2) corrosion problem of material.
- 3) Required water soluble fertilizers of suitable grade are not freely available in India.

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## Factors affecting water use efficiency (WUE)

→ A] Plant characteristics :-

1] Crop duration

If crop durat<sup>n</sup> is more it required more water which alternately decrease WUE.

2] Root depth :-

shallow rooted crop required more water as compare to deep rooted crop hence in shallow rooted crop WUE is less.

3] No. of leaves :-

If no. of leaves one more it means loss of water through transpiration is more which decrease WUE.

4] Leaf angle :-

If leaf stem angle is more than  $90^\circ$  it results in facing of more solar radiation which decrease WUE.

5] Photosynthesis Rate :-

$C_4$  plant are higher photosynthetic as compare to  $C_3$  plant. Higher photosynthetic efficiency contribute to higher WUE.

→ B] Planting method :-

Plant population, spacing and planting pattern influence the WUE. If plant density (plant popul<sup>n</sup>) increases WUE decreased. Closer distance (less spacing) both plants and leaves ~~decrease~~ increase WUE while Dwarf variety also increase WUE.

→ C] Agronomic practices (managemental practices)

proper tillage operations, sowing time, optimum plant population, right time and quantity of fertilizer application and inter cultivation (intercultural operations) as well as proper quality, quantity, method of irrigation... contributes higher yield which results in higher water use efficiency.

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## measures to improve WUE :-

→ A] Plant management practices :-

1] Plant species Adoption:

plant characters like duration, root system, leaf area, no. of leaves, height affects water requirement. For higher crop yield and more WUE it is essential to select suitable plant spp. for particular climate.



2] planting pattern :-

Planting pattern have direct effect on yield, solar energy capture, and evaporation and thus direct effect on WUE.

3] planting date :-

Optimum planting date insure good germination & its further growth. The planting date also indicates the right type of climate for plant optimum growth, which increase WUE.

4] Weed control :-

Weed competes with crops for light, nutrient and water hence more weed intensity depress the normal plant growth. To increase WUE elimination (control) of weed is essential.

5] Plant protection :-

It is essential for healthy plant growth to protect the crop from drought, insect and pest. & their by to increase WUE.

→ B] Soil management practices:

1] Tillage :- Tillage operations plays an important role in the preparation of seed bed, conservation of soil moisture, infiltration characteristics proper seed placement, & weed control. Hence tillage influence crop yield and WUE.

2] Fertilizer application :-

Fertilizer application increase WUE. There is relationship between soil moisture and nutrient availability. Hence Type, quantity and method of fertilizer application is important.

④ Conjunctive (alternative) use of water.

multiple water resources like canal water, & well water as well as poor and fresh water from surface and ground helps to maintain crop and soil health.

⑤ Consumptive use of water (CU) :-

The quantity of water lost in evapotranspiration and water used by plant for metabolic activity commonly known consumptive use.

$CU = ET + \text{water used for metabolic activities of plant}$   
water used for metabolic activities is less than 1% of ET. Hence  $CU = ET$  (99%). Average daily water used in few days (short period) is called peak period of CU.

⑥ Seasonal CU :- Amount of water losses by ET during crop growing season. Known as seasonal C.U.

⑦ Factors affecting CU :- Are similar as ET. In chapter no. ⑤