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IES/GATE

CIVIL ENGINEERING

VOLUME – IV

Irrigation & Hydrology

SIERRA INNOVATIONS

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Irrigation & Hydrology

Hydrology

Chapter 1 - Irrigation

Introduction :-

(1) Every crop requirs a certain quantity of water after a certain fixed interval, throughout its period of growth.

If the natural rain is sufficient and timely so as to satisfy both of the above requirement, no irrigation water will be required for producing that crop.

(2) In a tropical country like India, the natural rainfall is neither sufficient nor does the water fall regularly as required by the crops. Therefore, Irrigation is significantly needed.

Note :- Different crops will have different water requirement and the same crop may have different water requirements at different places of the same country, Depending upon the variations in climate, types of soil, Methods of cultivation & useful Rainfall etc.

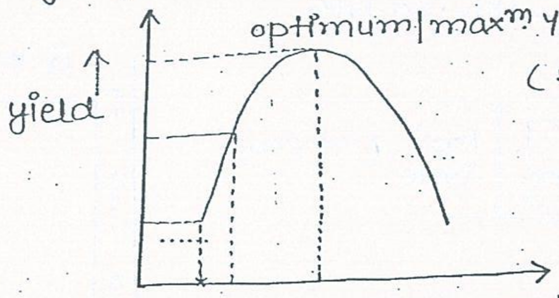
Definition of Irrigation :

Irrigation may be defined as science of artificial application of water to the land/ fields, in accordance with the crop requirements throughout the crop period for full development of the crops.

Advantages of Irrigation :-

(1) Increase in food Production. (irr. helps in resing crop yield, & hence to attain self sufficiency in food).

(2) Ensuring optimum growth (or) yield.



(yield will be smaller for any quantity lesser than or excess of the opt^m qunty.)

(3) Elimation of mixedcroping. (when irr. is not assured) { wht if weather cond^n is not good for one of crop it they may be good too other
(sowing together of 2 or more crops in the same field.)

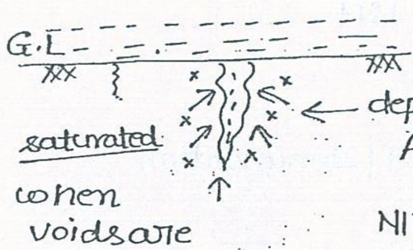
(4) Generation of Hydro electric power. (cheaper power generation).

(5) Improving Domestic water supply.

(6) In land navigation.
(very useful) – for w.s.

Disadvantages of Irrigation :

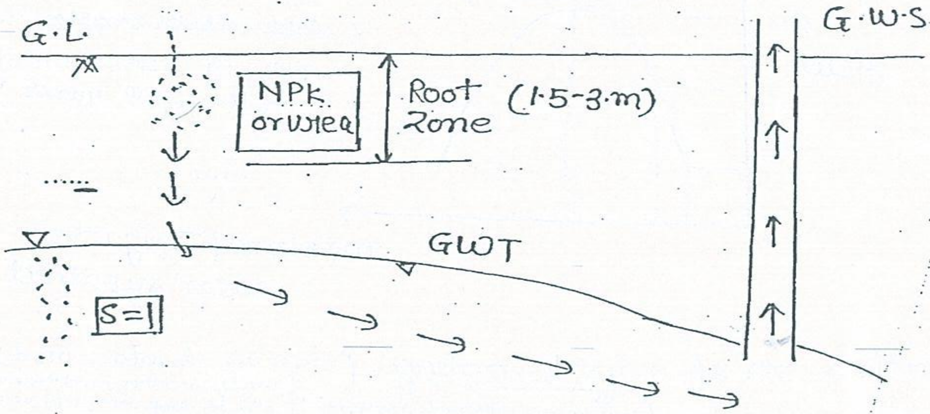
(1) Over Irrigation may cause water logging which reduces crop yield.



(2) Irrigation may lead to creation of climatic condition, which is favourable for the spread of diseas like Dengue & maleria.

(3) Irrigation may lead to seepage of Nitrates into the ground water table.

Urea – $NH_2 \cdot CO \cdot NH_2$



Types of Irrigation :-

- Irrigation
  - Surface
    - Flow
      - Perennial
      - Flood | Inundation
    - Lift
  - Sub-surface
    - Natural
    - Artificial

1. Surface Irrigation

Definition –

"In this method of Irrigation, the water directly wets the soil surface." It can be further classified as –

(i) Flow Irrigation →

when water is available at such a height that it can be directly applied to the agricultural field by only the action of gravity, this method of Irrigation is called Flow Irrigation.

(ii) Lift Irrigation :-

If the water is lifted up by some mechanical or mannual action ex- pump etc. and then supplied for Irrigation then it is called lift Irrigation. Ex. Tubewell.

Flow Irrigation can be further classified into –

(a) Perennial Irrigation :- In this system of Irrigation, constant & contineous water supply is supplied to the crops in accordance with the requirements, throughout the crop period.

(b) Flood Irrigation :- In this method of Irrigation, soil is kept submmerged & flooded with water, so as to cause thorough saturation of the field.

This system of Irrigation is also called un-contralled Irrigation.

2. Sub-Surface Irrigation

In this method, water does not wet the surfaced and is directly applied to the root zone by action of capillarity.

It can be divided into fallowing 2 types —

(i) Natural Sub-Surface Irrigation :-

Leakage water from channels etc. goes underground and during passing through root zone, it may Irrigate

when under ground irrigation is achieved simply by natural process, without any additional extra efforts, it is called natural sub-surface Irrigation.

(ii) Artificial Sub-Surface Irrigation :-

When a system of open jointed Drains is artificialy laid below the soil, so as to supply water to the crops by capillarity, then it is known as Artificial sub-surface Irrigation.

TECHNIQUES OF WATER DISTRIBUTION

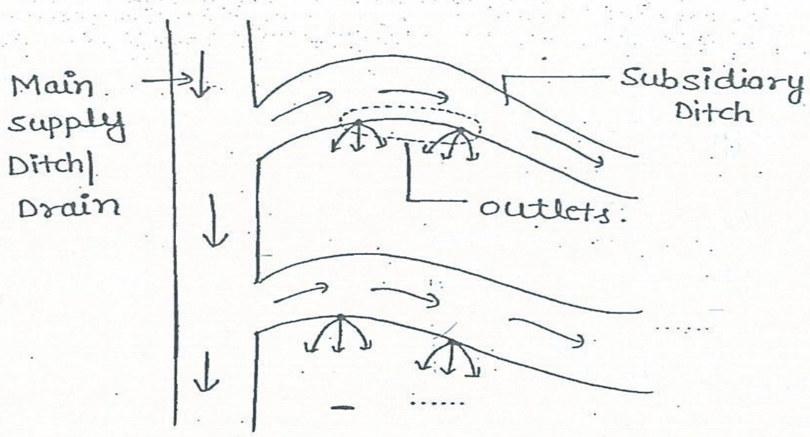
(1) Free Flooding (or) Ordinary Flooding :- (wild flooding)

⇒ In this method, the flow of water is not controlled.

⇒ This method is suitable for close growing crops.

⇓

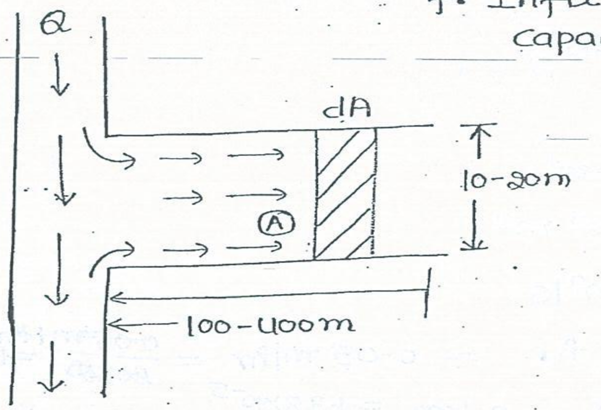
Rice (Used on Rolling land) (topography irregular).



(2) **Border Flooding** :⇒ In this method, the land is divided into a no. of strips seperated by low leeves, which are called Border.

⇒ The land/field area is confined b/w 10 to 20m width and 100 – 400 m of length.

f: Infiltration (cm/hr) capacity



Derivation :– Time 't' required for irrigation(ing) an area 'A', for given discharge (Q).

(*) Let in time 'dt', Area irrigated further is = dA { for depth of water = y }.

$\Rightarrow Q \cdot dt = A \cdot f \cdot dt + y \cdot dA$

$$t = \frac{2.303\, y}{f} \cdot \log_{10} \frac{Q}{Q - fA}$$

At, $t \to \infty$ $\Rightarrow Q - fA_{max} = 0$

$$* \quad A_{max} = Q/f \quad *$$

Que 8(1) Find the time required to irrigate a strip of land whose area is 0.04 hect. from a tubewell, having a discharge of 0.02 m³/s. Infilteration capacity of soil is f = 5cm/hr, & Avg. Depth of flow in the field is 10 cm.

$$\Rightarrow \quad t = \frac{2.303\, y}{f} \cdot \log_{10} \frac{Q}{Q - fA}$$

$A = 0.04$ hect.

$= 0.04 \times 10^4\ m^2$

$Q = 0.02\ m^3/s$

$f = 5\ cm/hr. = 0.05\ m/hr = \frac{0.05\ m/hr}{60 \times 60} = 1.38 \times 10^{-5}$ ~~= 1.38~~ ~~= 180 m/sec.~~

$y = 10\ cm. = 0.1\ m$

$$t = \frac{2.303 \times 0.1}{1.38 \times 10^{-5}} \log_{10} \frac{0.02}{0.02 - (1.38 \times 10^{-5} \times 0.04 \times 10^4)}$$

$t = 2340.73$ Sec

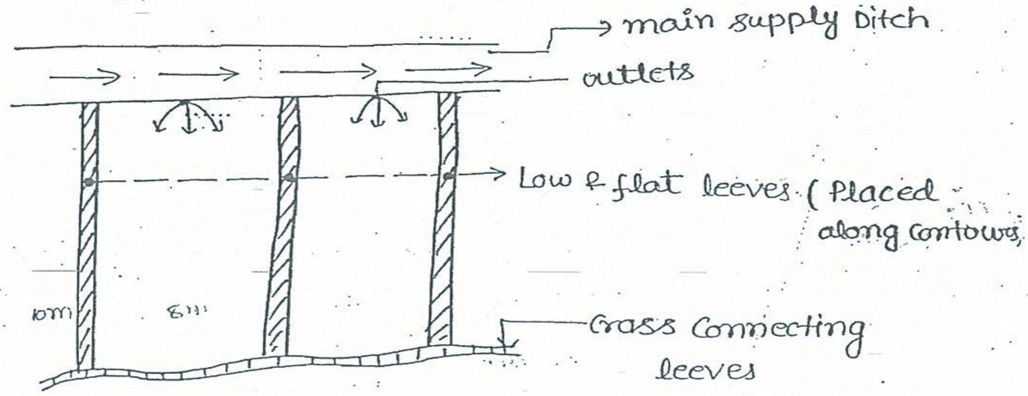
$\boxed{t = 39.05\ min}$

$A_{max} = \frac{Q}{f} = \frac{0.02}{1.38 \times 10^{-5}}$

$= 1449.275\ m^2 = 0.144$ ha

(3) Check Flooding :

This is a modified form of ordinary flooding in which the water is contralled by surrounding the check area with cross connecting leeves. These leeves are generally constructed along the contours

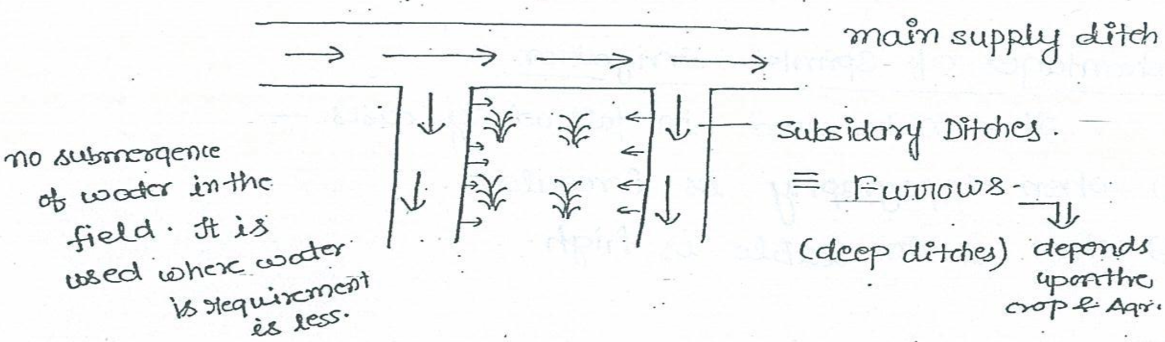


use in Hilly areas.

(4) Furrow Irrigation :-

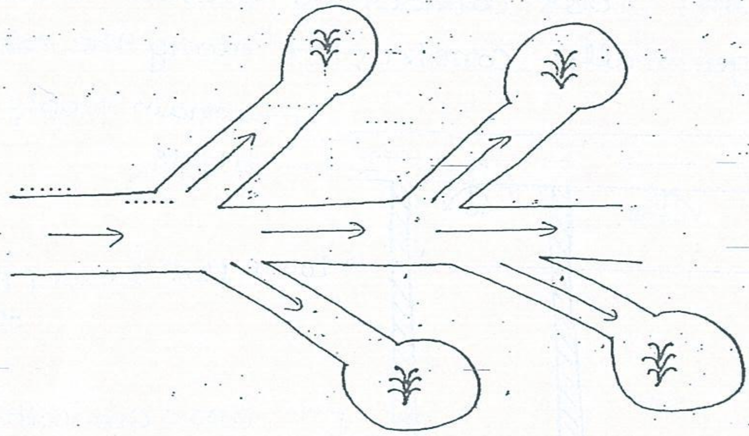
Furrows are narrow ditches which are excavated b/w rows of plants & carry irrigation water through it.

In this method of Irrigation only 20 to 50% of the field area is wetted & therefore, evaporation losses are considerably reduced.



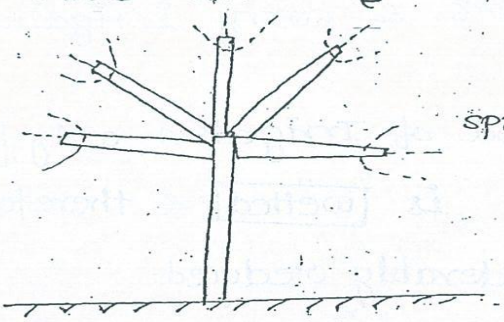
(5) Basin Flooding :-

This is a special type of flooding (check flooding) and is specifically adopted for orchid trees.



(6) Sprinkler Irrigation :-

In this method of Irrigation, water is applied through a network of pipes & pumps and water is made available in the form of spray.



Advantages of Sprinkler Irrigation :

It can be used in following cases —

(1) when topography is irregular.
(2) when water table is high.

(3) when soil is permeable or less permeable.

(4) when water is not easily available.

(5) when seepage loss is more.

(6) when no. of labour have to be reduced.

(7) when fertilizers & Insecticides are to be mixed with Irrigational water.

Disadvantages of Sprinkler Irrigation :-

(1) Evaporation loss is more.

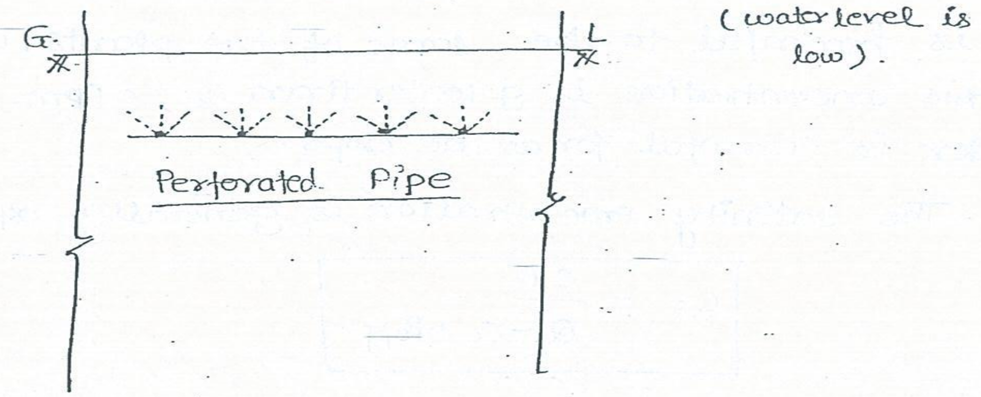
(2) Initial Installation cost is high.

(3) Technical man power is required.

Note : This method of Irrigation is not suitable for heavy Irrigation. Ex. Rice.

(7) Drip Irrigation :-

This is also called as trickle Irrigation. In this method, water is directly applied in the root zone of the plants using drip nozzels.



Note : → Evaporation & seepage losses are considerably reduced in this method of Irrigation.

→ This method can not be used when heavy irrigation is required.

→ Like the sprinkler system, this method also involves technical knowledge and therefore not adopted by ordinary farmers.

Quality of Irrigation Water :-

(1) Sediment Concentration :- (Young mountain - Himalays.)

when fine sediments from water is deposited on sandy soil, the firtility of the land is improved. whereas, if sediments are obtained from the eroded areas then fertility gets reduced.

(2) Concentration of saluble salts :-

If the salt concentration is greater than 700 ppm it is harmful to the some of the plants, whereas, if this concentration is greater than 2000 ppm. then this water is harmful for all the crops.

The salinity concentration is generally expressed as

$$C_S = \frac{C \cdot Q}{Q - C_u + P_{eff}}$$

where,

Q is quantity of water applied.

C → Concentration of salts in Irrigation water

Cu → Consumptive use of water

Peff → Usefull rainfall.

Note :- Salt concentration is usually measured by finding the electrical conductivity of water. (μmho/cm).

Classification of Irrigation water Based upon electrical conductivity :-

E.C (μmho/cm)	Classification
100 − 250	C_1 → low — Irrigation
250 − 750	C_2 → medium — Note →
750 − 2250	C_3 → High
>2250	Cu → Very high — × can not be used as irrigation H_2O.

Note : C_2 & C_3 can be applied as irrigation water if required treatment is done according to crop requirement.

(3) Proportion of Na^+ ions :- It is often expressed in terms of SAR (Sodium Absorption Ratio) where SAR =

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}}$$

, in 'emp' (equivalents per million).

Classification of Irrigation water Based upon SAR values :-

SAR Values (epm)	classification
0 – 10	S_1 → low
10 – 18	S_2 → Medium
18 – 26	S_3 → High
> 26	S_4 → Very high

Note :

The SAR values can be reduced by adding Gypsum ($CaSO_4$) in the soil or in the Irrigation water.

(4) Boron Concentration :

Traces of boron (B) are found to be useful for plants growth, However, if its concentration becomes more than 0.3 ppm, it may prove to be toxic to some of the plants.

Note (*)

Sodic Soils :-

(1) Sodic soils are charcterised by high concentⁿ of Na^+ ions.

(2) They are defined as consisting and exchangable Na^+ %age greater than 15%.

(3) These occure within arid areas & are unstable show poor physical & chemical property. delay water infilteration

(#) & availability, therefore finally effecting plants growth.

Chapter 2 - Water Requirements of Crops

*) Imp for GATE & ES.

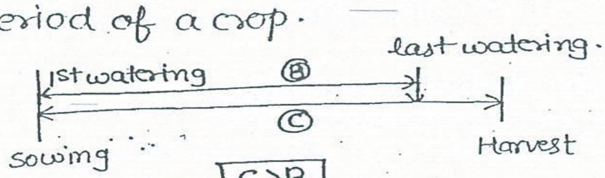
Introduction:-

The term 'water requirements of crops' means, the total quantity & the way in which a crop requires water from the time it is sown to the time it is harvested.

(1) **CROP PERIOD:-** The time period from the instant of sowing of a crop to the instant of its harvesting is called crop period.

(2) **Base Period:-**

It is the time period from the I^{st} watering of a crop to its last watering before Harvesting is called the base period of a crop.



C>B

C≈B

Note: (*) Although crop period is slightly more than the base period But for all practical purposes they are taken as equal time period, & generally expressed in 'days'.

(*) Therefore, the term like growth period, crop period, Base Period etc are one and the same thing representing base period.

(III). Delta of a Crop :-

Introduction :- The summation of total water depth supplied during the base period of a crop for its full growth, represents the total quantity of water required by the crops for its perfect maturity.

Delta :- This total depth of water (in cms) required by a crop to come to maturity is called its delta.

Que :-(1) If wheat required about 7.5 cms. of water after every 28 days, & the base period for wheat is 140 days & then the delta of wheat is —

$$\Rightarrow \quad \text{Delta} = \frac{7.5}{28} \times 140$$

$$= 37.5 \text{ cms.}$$

Delta for certain Important Crops :-

Crops	Delta (cms.)
Sugar cane	120
Rice	120
cotton	50
Maiza	25
Fodder	22.5
wheat	40 cms.

Duty of water :-

It may be defined as the no. of hectares of feild irrigated for full growth of a given crop by a supply of $1\ m^3/s$ of water continuously during the entire base period of that crop.

Duty is generally represented by **D**.

UNIT – hectares

Relationship b/w B, Δ, D :-

Let there be a crop of base period 'B', and let one cumec of water be applied to this crop continuously on the feild for B days.

(i) $\text{Vol. A} = 1\ \frac{m^3}{s} \cdot B \times 24 \times 60 \times 60 = 86400 \cdot B\ m^3$ — ①

∴ Area irrigated for above given condition = D(ha.)

(ii) Vol. A = Area × total depth

$= D_{ha} \times \Delta$ — ②

equating ① & ②

$\Rightarrow 86400 \cdot B\ m^3 = D \times 10^4\ m^2 \cdot \Delta$

$\Rightarrow \boxed{\Delta = \frac{8.64\,B}{D}}$, m

$\Rightarrow \boxed{\Delta = \frac{864\,B}{D}}$, cm

B – days

D – $\frac{ha}{cumec}$