## Introduction

1) Irrigation can be defined as the science of artificial application of water to the land (crop) as per crop requirement for total base period for full pledged nourishment of crops.

2) India is a tropical country having vast variation of climate, rainfall, topography and vegetation.

*3) Total geographical area of our country is about 328 Mha (1ha = $10^4$ sq.m) $328 \times 10^6 \times 10^4$ m2

4) Total cultivable area of our country is about 190 Mha

5) In India the minimum rainfall is in Rajasthan having depth about 25cm in a year. But maximum depth of rainfall in India is about 250 cm in cherrapunji (Meghalaya) - North eastern part.

6) To grow rice the minimum depth of water required is about 90cm which is not available in Rajasthan and some parts of country therefore it is very essential to supply water through cannals from a reservoir to meet the demand.

**7). In India the maximum intensity of irrigation is in Punjab & Harayana (More than 90

8) Important irrigation projects of India

i) Bakharanangal project

It is a concrete gravity dam. It has been constructed across river sutlej in Himachal pradesh. The height of the dam 226m

Number 1 of the world during 1962 before that Hoover dam in America in 1961 across (220m) Colorada. In India most dangerous river is

New no 1 is Grandian, Switz

It is a multipurpase project. Capacity of water stored (gross capacity of reservoir Govind sagar is about 9870 MCM (Million Cubic metre) $9870 \times 10^6 m^3$.

ii) Nagarjun sagar project (Andhra)

In area nalgonda one Buddist monk Nagarjun (to honour him).

It is made up of rockfill dam having height about ~~62m~~ 124m Its capacity very large about ~~4 MCM~~. 11000 MCM. It has been built across the river krishna. It is Andhra pradesh). Multipurpase project

iii) Hirakud :-

Hira - diamond, kud - storage.

It is made up of earthern dam (longest of India) It is in orissa. It has built across the river Mahanadi. Its height about 62m. Its storage capacity is about ~~80~~ 8100 MCM. Multi purpase project

iv) Mettur dam :-

It is made up of concrete gravity dam and it is multipurpase. Its height is about 65m. It has built across the river Cauvery. Its capacity is about 2400 MCM It is a Multipurpase. It is in Tamil Nadu

v) Iddukki project :-

It is made up of concrete Arch dam It is across the river periyar river It is in kerala Its height is about 174m. It is a multipurpase project. Capacity 2100 MCM

VI) Rihand Project:-

In uttarpradesh across the river rihand

It is madeup of concrete and rockfil dam across the river Rihand. Its capacity is about 9000 MCM. Its height is about 70m.

~~VII)~~

9) Neccesity of irrigation:

i) To take care of inadequate rainfall
ii) To take care of Uneven distribution of rainfall
iii) To ~~illumin~~ Eliminate mixed croping
iv) To get optimum growth of crops.

10. Advantages of irrigation

i) Increased production of Food grain
ii) To develop hydropower project
iii) To control drought or famine
iv) To grow forest/tree along the bank of canal.
v) To develop navigation.
vi) To control/minimize foreign exchange for foods. import

11) Disadvantages of irrigations:

i) Water logging takes place due to over irrigation
ii) Breeding of mosquitos takes place on Damp area.
iii) Unhealth climate takes place
iv) pollution of ground water takes place

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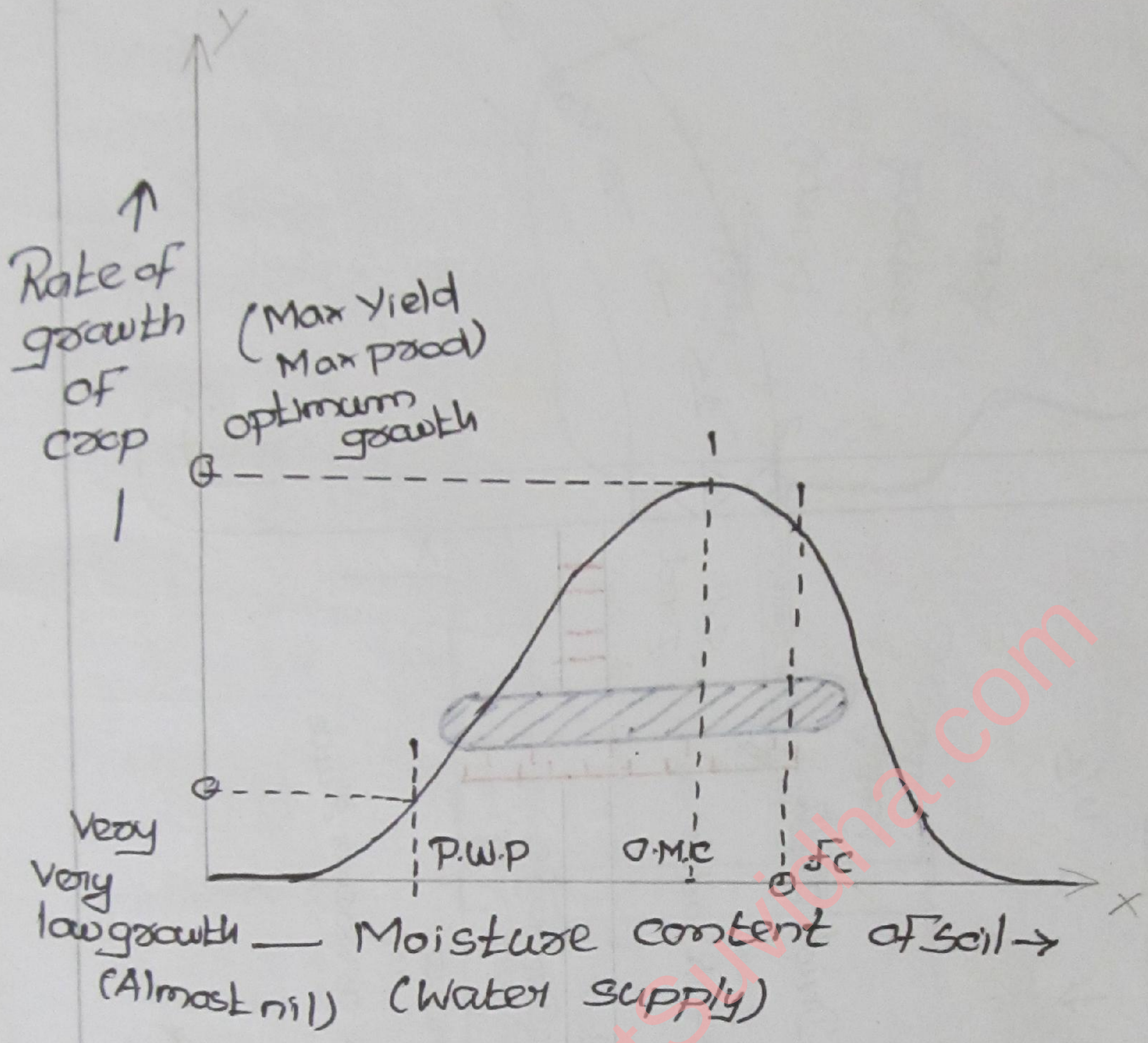
# Water Requirement of Crops & Soil-Water-Plant relations



P.W.P - Permanent wilting point (No growth of crop)

O.M.C - Optimum moisture content (Max growth of crop)

F.C - Field capacity (Little less growth)

Atmospheric pressure acting on human body 1.03 kgf/cm2

Max pressure human chest can withstand - 3.5 kgf/cm2

Water distribution System (layout)

① Diversion system (No storage)

07/09/19 ④

# Irrigation System & Methods

① There are two systems of irrigations

a) flow irrigation (canal)

b) lift irrigation (Tube well)

*

2. Duty of water of flow system is very low but duty of lift irrigation is very high

3) Flow irrigation carries manure which is good for crop but lift irrigation water is almost pure without manure which is not so suitable for crops

*

4) If water is supplied in ditches about 3cm apart and allowed to seep into the ground to provide capillary fringe such method of irrigation is called sub-surface irrigation

*

5 In Border Method of irrigation the flow of water is like open channel, unsteady, spatially varied with decreasing discharge.

6 If the land is divided into a number of small size units with bunds and water is filled on the land surface, then such method of irrigation is known as * Check basin which is most appilicable for * growing paddy.

7) In the Check basin method land is wasted by ridges and bunds, It is not suitable for growing crops which are sensitive to wet soil (gram, mustard, maize)

** 8 In the Drip irrigation Method (Trickle)

a) Deep perculation and runoff losses are eliminated

b) Water appilication efficiency is very high

c) Evapotranspiration is not completely eliminated.

d) Fertilizer can be applied along with the water

** 9 In Sprinkler irrigation.

a) No excess cost of land preparation
ie) Appilicable for slopy land

b) Excessive top soil erosion is not involved

c) Fertilizer can be applied with water

d) Evapotranspiration losses are maximum

e) The maximum application rate is governed by the infilteration capacity

f) It is particularly suitable in hilly terrain

** 10) Furrow Method

a) Most suitable for potato crop

b) Is essentially suited for soils with * low infilteration rate. like (clay)

c) Can be used in land having wide range of natural slope

d) Has considerabily less wastage of land compared to check basin

e) Has less evaporation loss compared to check basin.

11) 40 Sprinklers are arranged along 2 lines 20m apart and they are spaced 12m on each line. If the water supply rate is 1.5 cm/hr determine discharge required by the system in lps.

$$Q = n \times Q_1$$

$$= n \times \frac{\text{Volume}}{\text{time}}$$

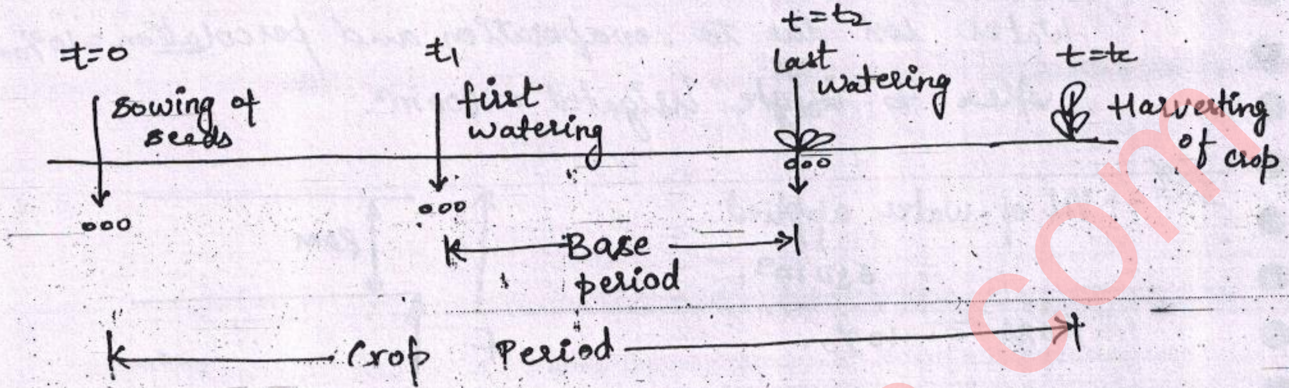
$$= n \times \frac{\text{Area} \times \text{depth}}{\text{time}}$$

$$= \frac{40 \times (20 \times 12) \times \frac{1.5}{100}}{60 \times 60} \times 1000$$

$$= 40 \text{ litres/seconds}$$

## → DUTY OF CROP :-

→ Duty of the crop is the area in hectare which can be irrigated by $\boxed{1m^3/s}$ of discharge throughout the base period of the crop.



④ Base period < crop period.

④ But for all ~~po~~ practical calculation (BP = CP)

## Base Period :-

→ It is the total period of irrigation during which water is applied to fields.

→ it starts from 1st watering after sowing of seeds upto last watering before harvesting of crop.

## CROP PERIOD

→ Time period from the time of sowing to harvesting of crops.

(NOTE):- ④ SUGARCANE — Largest Base period – 360 days

⇒ Perinial crop.

## ⇒ DELTA OF CROPS :- (Δ)

- It is the total water required by the crops for its complete growth during its entire Base period.

→ UNITS

Duty = hact./cumec

Delta (Δ) = cm.

## ⇒ DUTY & DELTA OF DIFFERENT CROPS :-

| Type of Crop | D (hac/cumec) | Δ (cm). |
|---|---|---|
| ✓RICE | 775 | 120. |
| ✓WHEAT | 1800 | 30. |
| ✓SUGARCANE | 730 | 120. |
| VEGETABLE | 1000. | 45 |
| FODDER | 2000 | 22.5 |

(*), In General, more is the duty, lesser is the Δ.

## ⇒ Relationship B/w Duty & Delta :-

Duty = Q = $m^3/sec$  Δ = cm.

Base period = B days.

Vol. of water supplied during the entire base period @ $1 m^3/s$ $= 1 \times B \times 24 \times 60 \times 60$

$= 86400 \; B \; m^3.$

Total area irrigated by above vol. (D) $= \frac{86400 B \times 10^{-4}}{\Delta \times 10^{-2}}$

$$\text{(hact/cumecs)} \rightarrow \boxed{D = \frac{864 \times B}{\Delta}} \quad \begin{matrix} \leftarrow \text{days} \\ \leftarrow \text{cm} \end{matrix}$$

$$\boxed{D = 864 \times \frac{B}{\Delta}}$$

B = days

Δ = cm

D = hact/cumec

$$\boxed{D = 8.64 \times \frac{B}{\Delta}}$$

B = days

Δ = m

D = hact/cumec

In FPS system

$$\boxed{D = 2 \cdot \frac{B}{\Delta}}$$

B = days

Area = $(\text{feet})^3$

D = Acre/cusec

Δ = ~~feet inch~~ feet

① 1 cusec = $(\text{feet})^3/\text{sec}$

1 cumec = $m^3/\text{sec}$

1 feet = 12 inch

1 inch = 2.54 cm.

1 feet = $12 \times 2.54 \times 10^{-2}$

1 feet = $\frac{1}{3.28}$ m.

$$\boxed{1m = 3.28 \text{ feet}}$$

$$1 \text{ cusec} = \frac{(\text{feet})^3}{\text{sec}} = \frac{(1/3.28)^3 \, m^3}{\text{sec}}$$

$$\boxed{1 \text{ cusec} = 0.0283 \text{ cumec}}$$

$$\boxed{1 \text{ Hac} = 2.47 \text{ Acre}}$$

$$\boxed{1 \text{ Acre/cusec} = 14.30 \text{ Hact/cumec}}$$

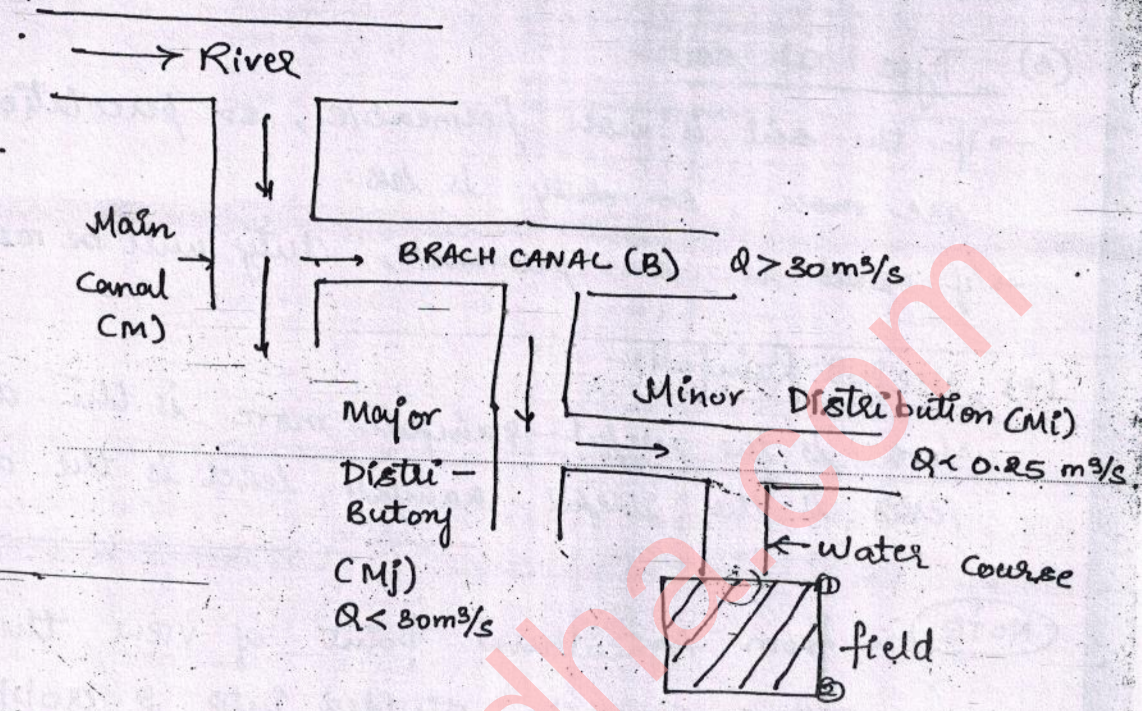
→ 1 Ha = $10^4$ $m^2$

→ 1 Acre = 4046.85 $m^2$.

→ 1 Hac = 2.47 Acre

1 Acre = 0.4046 Ha.

→ The duty at the various points in the canal system is not constant.



→ The value of duty increase from River → water course

→ The value of duty decreases in the field from pt ① to pt ②. (As the total losses i.e evaporation & percolation loss increases) Hence the duty decreases as we move forward in field.

**NOTE**

→ Duty at the head of water Course is known as "OUTLET DISCHARGE FACTOR"

⇒ **FACTORS AFFECTING THE DUTY OF CROP** :-

(1) Type of crop :- Crops which require more water have less duty & crops which require ~~more~~ less water have more duty. as more area can be irrigated for the same discharge if water requirement is less.

(2) Climatic condition:-

→ If the climate is warm, duty will be less as evaporation losses are more.

(3) Type of soil:-

→ if the soil is more permeable, so percolation losses are ~~more~~, so ~~duty~~ is less.

→ if soil is less permeable, duty will be more.

(4) Usefull Rainfall:-

More is the useful rainfall, more is the duty.
lesser is the useful rainfall, lesser is the duty.

NOTE :- from Agricultural point of view the entire year can be divided into 2 cropping seasons.

1) Kharif season → 1st Apr - 30th sept. (summer).

2) Rabi season → 1st oct - 31st March. (winter).

| Kharif CROPS | Rabi Crops |
|---|---|
| RICE | WHEAT |
| Maize | BARLey |
| JOWAR | GRAM |
| Bajara | LINSEED |

NOTE :- KHARIF TO RABI Ratio:-

it is the ratio of Area irrigated under Kharif season to that in Rabi season.

$\boxed{\frac{K}{R} = 0.5}$ i.e Area irrigated under Kharif = $\frac{1}{2}$ × Area irrigated in Rabi

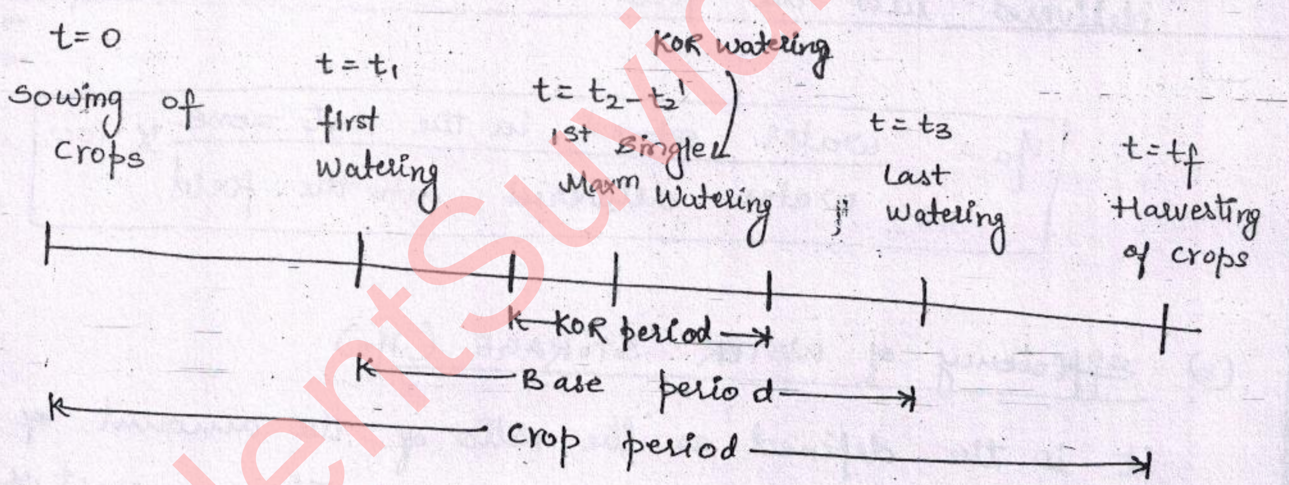
$\frac{K}{R} < 1$ always → as the duty in winter < duty in summer

→ PALEO IRRIGATION :-

- Sometimes in the intial stages before sowing of the crops water is applied to the field to bring back the moisture content upto its field capacity (as the moisture deficiency is very high) This is known as paleo irrigation.
- In summer the water content falls and hence in winter before sowing the water deficiency should be removed.

Hence, this is done before sowing of Rabi crops.

→ KOR WATERING & KOR PERIOD



→ KOR Watering is the 1st Watering given to crops when it is few centimeters high.

→ This is the maxm watering which is followed by the other watering of smaller magnitude.

→ The period for which the ~~core~~ Kor watering is done is known as Kor period.

| | RICE | WHEAT | SUGARCANE |
|---|---|---|---|
| KOR DEPTH | 19 cm | 13-5 cm | 16-5 cm |
| KOR WATERING | 2-4 weeks | 4-8 weeks | 3-6 weeks |

IMP →

# IRRIGATION EFFECIENCY :-

## 1) Efficiency of WATER CONVAYANCE ($\eta_c$):-

it is defined as the ratio of amount of water delivered into the field to the amount of water diverted into the canal.

Losses → Evap.
→ Infiltration

$$\boxed{\eta_c = \frac{\text{water delivered into the field}}{\text{water diverted into the canal.}} \times 100}$$

## 2) Efficiency of WATER Application ($\eta_a$)

it is defined as the ratio of amount of water stored in the root zone to the amount of water delivered into the field.

Losses → Evap.
→ Infiltration
→ Runoff.

$$\boxed{\eta_a = \frac{\text{water stored in the root zone}}{\text{water delivered into the field}} \times 100}$$

## (3) Efficiency of WATER STORAGE ($\eta_s$)

it is the defined as the ratio of the amount of water stored in the root zone to the amount of water required before irrigation.

$$\boxed{\eta_s = \frac{\text{water stored in the root zone}}{\text{water required before irrigation}} \times 100}$$

## (4) Efficiency of Water Distribution ($\eta_d$)

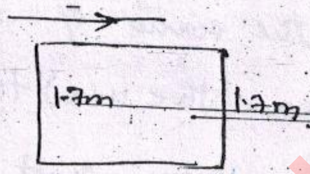
it indicates the degree of non uniformity of the water distribution throughout the field.

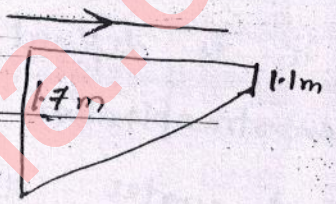
$$\boxed{\text{Efficieny of water distribution} = \left(1-\frac{d}{D}\right)\times 100}$$

D = avg depth of water stored during irrigation

d = avg value of the absolute deviation from mean depth.

⑤ it tells about the uniformity of application of water.





$D = 1.7$

$d = \dfrac{|1.7-1.7| + |1.7-1.7|}{2}$

$d = 0.$

$\underline{\eta_d = 100\%}$

$D = \dfrac{1.7+1.1}{2} = 1.4m$

$d = \dfrac{|1.7-1.4| + |1.1-1.4|}{2}$

$d = 0.3$

$\eta_d = \left(1-\dfrac{0.3}{1.4}\right)\times 100 = \underline{78\%}.$

## (5) Efficiency of Water-Use ($\eta_u$) :-

→ Defined as the ratio of amount of water benificially used by the crops to the amount of water delivered into the field.

$$\boxed{\eta_u = \frac{\text{water used beneficially by crop}}{\text{water delivered into the field}}\times 100}$$

NOTE

Water ~~is~~ which is beneficially used also includes leaching requirements.

NOTE

→ Water delivered into the field = surface runoff
+
Infiltration
+
evaporation
+
Water stored in root zone
+
Leaching

including in $\underline{\eta_a}$

water used Beneficially by crops → Water stored in root zone + Leaching

## ⑥ Efficiency of consumptive use

it is defined as the ratio of water required for evapotraspiration (consumptive use) to the net amount of water depleted from root zone

$$\boxed{\text{Effciency of consumptive use} = \frac{\text{Consumptive use (P-E-T)}}{\text{Amount of water depleted from root zone}} \times 100}$$

Q A stream of 180 l/s was diverted from a canal ~~ct~~ & 100 l/s was delivered to the field and the area of 1.6 Hactres was irrigated in 8 hrs. The effective depth of the root zone was 1.7ms. The runoff loss in the field was 420 m3 The depth of water penetration varied from 1.6m at the head of the field to 1m at the tail linearly. Available moisture holding capacity of the soil is 20 cm/m depth of the soil. It is required to determine water convenyance efficiency, $\eta_a$, $\eta_s$ & $\eta_d$. Irrigation was started at the moisture extraction level of 50% of available

Sol^n

$$\eta_c = \frac{100}{130} \times 100 = 76.9\%.$$

→ vol of water delivered into the field in 8 hr @ 100 l/sec.

$$= 8 \times 60 \times 60 \times 100 \times 10^{-3} = 2880\ m^3.$$

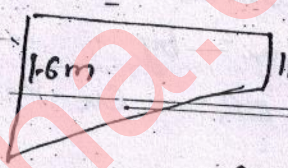
→ Runoff vol = 420 m³.

→ vol. of water stored in root zone = 2880 − 420 = 2460 m3.

$$\eta_a = \frac{2460}{2880} \times 100 = 85.4\%.$$

for ηd

$$\eta_d = \left(1 - \frac{0.3}{1.3}\right) \times 100$$



$$D = \frac{1.6+1}{2} = 1.3m.$$

$$d = \frac{|1.6 - 1.3| + |1 - 1.}{2}$$

$$d = 0.3.$$

$$\eta_d = ~~[illegible]~~.\ 76.9\%$$

for ηs

→ moisture holding capacity = 20 × 1.7 = 34 cm

water reqd. before irrigation = $\frac{34}{2} \times 10^{-2} \times 1.6 \times 10^4$

$$= 2720 m3$$

$$\eta_s = \frac{2460}{2720} \times 100$$

$$\eta_s = 90.4\%.$$

7-12-2012

⇒ CONSUMPTIVE IRRIGATION REQUIREMENT (CIR).

- It is the amount of water (irrigation water) reqd. in order to meet the consumptive use of the crops for the given crop period.

$$CIR = Cu - Pe.$$

Cu = amount of water reqd for the growth of groups

Pe = eff. Rainfall

- If water ~~con~~ corresponding to available moisture is given by

$$CIR = Cu - Pe - Ma$$

⇒ NET IRRIGATION REQUIREMENT (NIR)

→ NIR is the amount of irrigation water required in order to meet the evapo-transpiration needs and also other needs such as leaching.

$$NIR = CIR + LR$$

$$= Cu - Pe + LR \text{ or } Cu - Pe - M_A + LR.$$

⇒ FIELD IRRIGATION REQUIREMENT (FIR)

$$FIR = \frac{NIR}{\eta_u} = \frac{CIR}{\eta_a}$$

$$FIR = NIR + SR + Ev + If$$

## ⇒ GROSS IRRIGATION REQUIRED:-

$$GIR = \frac{FIR}{\eta_c}$$

$$GIR = FIR + \text{Losses in canal.}$$

16/8/11 A sandy loam soil holds the water at 140 mm/m depth between the field capacity and PWP. The root depth = 30cm. Allowable depletion of water is 35%. The daily water used by the crop is 5mm. and area to be irrigated is 60 ha and the water can be diverted at 28 l/s. The surface irrigation application efficiency is 40%. There is no rainfall and ~~grown~~ ground water contribution. Calculate ① the allowable depletion depth between the irrigation.

(ii) frequency of irrigation.

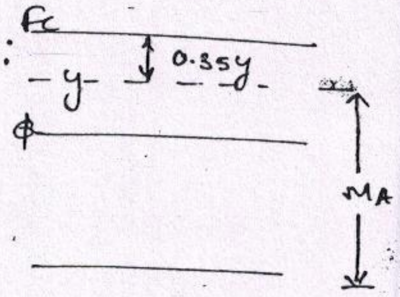
(iii) Net application depth of water.

(IV) Vol. of water req.

(V) Time to irrigate 4ha of the plot. If the water lost in the field channel is 15% of outlet discharge Calculate the quantity of water req. at the head of the canal.

Sol Moisture holding capacity $= \frac{14\cancel{0} \times 3\cancel{0}}{10\cancel{0}\cancel{0} \; 1\cancel{0}}$

$= \underline{\underline{4.2}}$ cm



(1) allowable depletion depth

$= 0.35 \times 4.2 = 1.47$ cm.

(11) frequency $= \frac{1.47 \times 10}{5} = 2.94 \simeq 3$ days

(iii) $NIR = C_u - \underset{\downarrow 0}{P_e} - \underset{\downarrow 0}{M_A} + \underset{\downarrow 0}{G_R} = 3 \times 5 = \frac{\underline{\underline{15 mm}}}{\eta} = \frac{15}{0.4} = 37.4$ m.

(iv) Vol. of water $= \frac{37.5}{10^3} \times 60 \times 10^4 =$ 22500m3

~~$\eta_a = (1 - \text{loss}\%)$~~

~~$= 1 - 0.15 = 0.85$~~

~~$FIR = \frac{15}{0.85} = 17.64 \text{ mm}$~~

~~time reqd $= \frac{V}{Q} = \frac{\frac{17.64}{10^3} \times 4 \times 10^4}{28 \times 10^{-3} \times 60 \times 60}$~~

~~time reqd =~~

time $= \frac{\text{Vol. corresponding to 4ha}}{Q}$

$= \frac{\frac{37.5}{10^3} \times 4 \times 10^4}{28 \times 10^{-3} \times 60 \times 60}$

(v) time to irrigate 4ha = 14.88 hrs.

(vi) $FIR = \frac{NIR}{1 - 0.15} = \frac{37.5}{0.85} = 44.11\text{mm}$

## ⇒ MEASUREMENT OF CONSUMPTIVE USE :-

$C_u$ (P.E.T.).

**Direct Methods**
- → field test
- → inflow - outflow
- → lysimeter

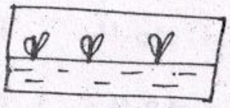
**INDIRECT Method**
- → BLAINEY CRIDDLE METHOD
- → Heagreaves — class-A — PAN - METHO

## ⇒ DIRECT METHOD :-

### 1) LYSIMETER METHOD :-

- Lysimeter is a closed water tight tank which is used for the measurement of evapo-transpiration by creating the conditions similar to the field conditions.
- Lysimeter measures the actual evapotranspiration

$$\boxed{\text{Lysimeter} - \text{AET}}$$



### 2) INFLOW - OUT FLOW STUDIES :-

- Based on the water-Budget equation.

$$(Q + P_e)\Delta t - (C_u + I_F + R + E_V)\Delta t = GR_2 - GR_1$$

Prb

## ⇒ INDIRECT METHOD :-

### 1) BLAINEY CRIDDLE METHOD :-

- According to this method consumptive use for 1 month is given by:-

$$\boxed{C_u = \frac{K.P.}{40}(1.8t + 32)} \rightarrow (\text{cm/month})$$

K = crop factor or consumptive use factor depends upon the type of crop.

t = Mean monthly temperature in °C.

if temp is given in °F

$$\{ °F = 1.8\,°C + 32 \}$$

$$\boxed{C_u = \frac{K \cdot P \cdot t}{40}}$$

P = monthly %age of annual day light hours for the given time ( generally in days).

Q. Determine the value of water ~~reo~~ reqd to be diverted from the head works to irrigate 5000 ha using the data given below. Assume 80% of the effective precipitation to take of the consumptive use of the crop. Also assume 50% ~~apple~~ efficiency of water application in the field and 75% efficiency of water conveyance.

| MONTH | TEMP (°F) | % hr of Sunshine | Rainfall (mm) | Cropfactor (K) | Cu = KPt/40 (cm) |
|---|---|---|---|---|---|
| JUNE | 70.8 | 9.9 | 75 | 0.8 | 14.01 |
| JULY | 70.4 | 10.2 | 108 | 0.85 | 16.12 |
| AUG | 72.8 | 9.6 | 180 | 0.85 | 14.85 |
| Sep | 71.3 | 8.4 | 115 | 0.6 | 8.98 |
| Oct. | 69.2 | 7.2 | 105 | 0.65 | 8.09 |
| Nov. | 55.8 | 7.6 | 25 | 0.7 | 7.42 |
| DEC | 47.4 | 6.5 | 0 | 0.68 | 5.23 |
| JAN | 48.6 | 8.2 | 0 | 0.7 | 6.99 |
| FEB. | 53.2 | 9.4 | 0 | 0.75 | 9.37 |
| MAR | 60.1 | 8.2 | 0 | 0.8 | 9.85 |
| APR | 62.5 | 8.3 | 0 | 0.7 | 9.07 |
| MAY | 67.5 | 9.3 | 0 | 0.82 | 12.84 |

$C_u = 125$ cm

$\Sigma R = 558\text{ mm} = 55.8\text{ cm}.$

$R_e = \frac{80}{100} \times R = 0.8 \times 55.8 = 44.6\text{ cm}$

$CIR = Cu - Pe$

$= 122.8 - 44.6$

$= 78.16\ cm$

Since leaching requirement not given NIR = CIR

$\therefore FIR = \frac{NIR}{\eta_a} = \frac{78.16}{0.5} = 156.32 cm.$

$GIR = \frac{FIR}{\eta_c} = \frac{156.32}{0.75} = 20842 cm.$

vol. of the water to be delivered in the canal = $208.42 \times 10^{-2} \times 5000 \times 10^4$

$=$ ~~100~~ $104.2 \times 10^6\ m^3.$

(2) **HEAGREAVES – CLASS A PAN METHOD :-**

$\boxed{Cu = K_p \times \text{Pan evaporation}}$

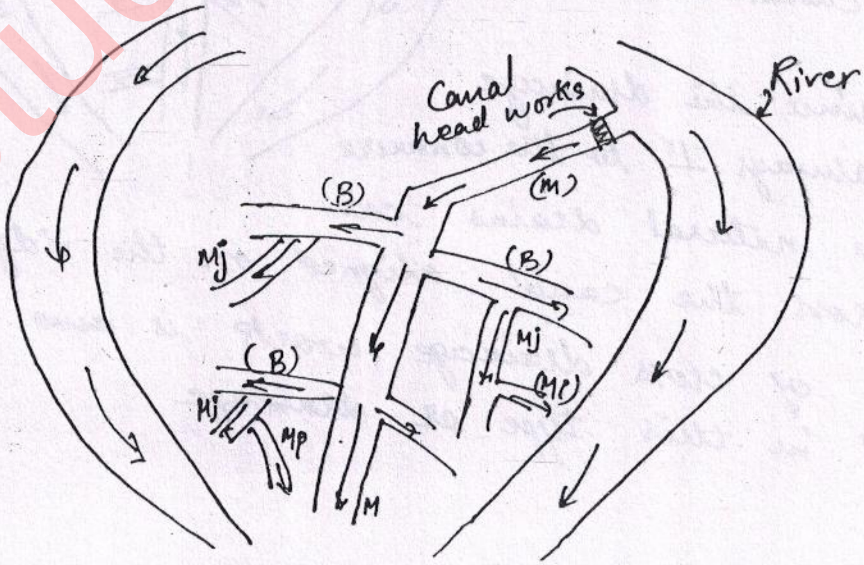
$K_p$ = pan coefficient = 0.3 for wheat

= 0.8 – 0.9 for Rice

= 0.621 for sugarcane

→ pan coefficient is area specific.

## ⇛ CANAL IRRIGATION SYSTEM :-



M = main canal

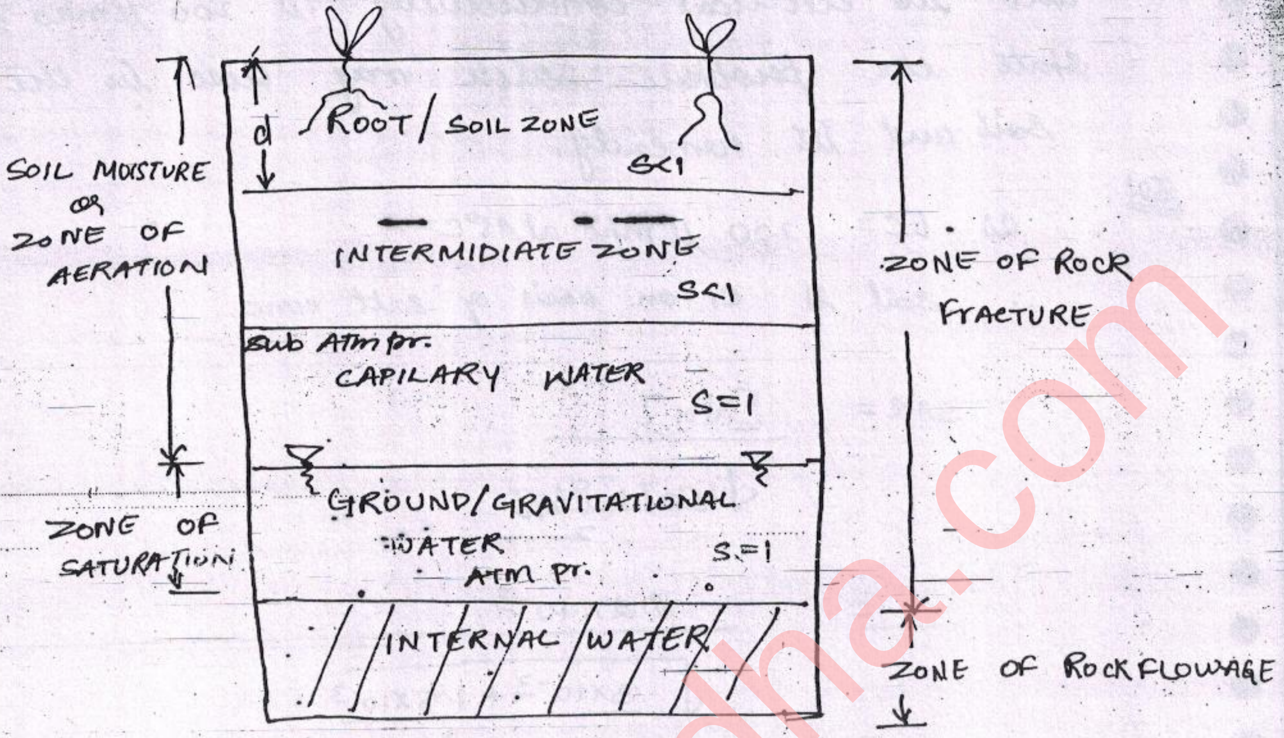
Mj = Major Distributory

B = Branch canal

Mi = Minor Distributory

⇒ V.Imp

# CROP WATER REQUIREMENT

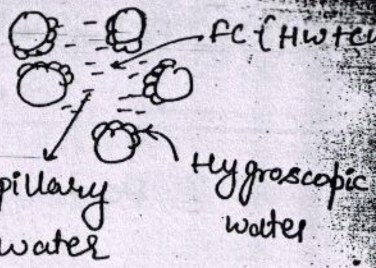


## → FIELD CAPACITY or SPECIFIC RETENTION

- Immediately after the rain or irrigation water application, when all the gravity has drained down and mixed with GW, certain amount of water is retained in the voids of soils under the effect of molecular attraction or electrical forces. (Adsorption)
- This water cannot be easily drained by gravity and is called field capacity.
- field capacity is defined as the ratio of wt. of water retained in the soil against the effect of gravity to the total wt of soil is drained.
- This field capacity can further be divided into:-
  - → capillary water
  - → Hygroscopic water.

→ **Capillary water :-**

- Water attached to the soil molecules by the effect of surface tension
- Can be extracted by the plants by the capillary forces.



→ **Hygroscopic water :-**

- Water which is attached to the soil molecules by the strong electrical forces and cannot be extracted by plants by capillary forces.
- It is not available for the growth of the plants.

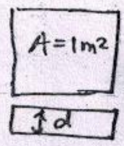
Imp

→

$$F.C. = \frac{\text{wt. of water retained in soil against gravity}}{\text{wt. of soil drained.}}$$

→ considering 1m² → of field Area Eg

d → as the depth of root zone



→ wt. of soil in the root zone = Vol. of soil in root zone × density of soil

$$= (1 \times d) \times \gamma_s$$

$$= d.\gamma_s.$$

→ wt. of water retained in soil = $F \times d \times \gamma_s = Fd\gamma_s$

→ Vol. of water retained in soil = $\frac{Fd\gamma_s}{\gamma_w}$

→ depth of water retained in soil = $\frac{\text{Vol.}}{\text{Area}} = \frac{Fd\gamma_s/\gamma_w}{1}$

$$= \frac{F.d.\gamma_s}{\gamma_w}$$

→ $$FC = \frac{\text{wt. of water retained}}{\text{wt. of soil drained.}}$$

$$FC = \frac{\text{Vol. of water} \times \gamma_w}{\text{Vol. of soil} \times \gamma_s}$$

$$= \frac{V_v \; \gamma_w}{V. \; \gamma_s}$$

$$F = \eta \frac{\gamma_w}{\gamma_s}$$

$$\boxed{FC = \eta \frac{\gamma_w}{\gamma_s}}$$ field capacity of soil

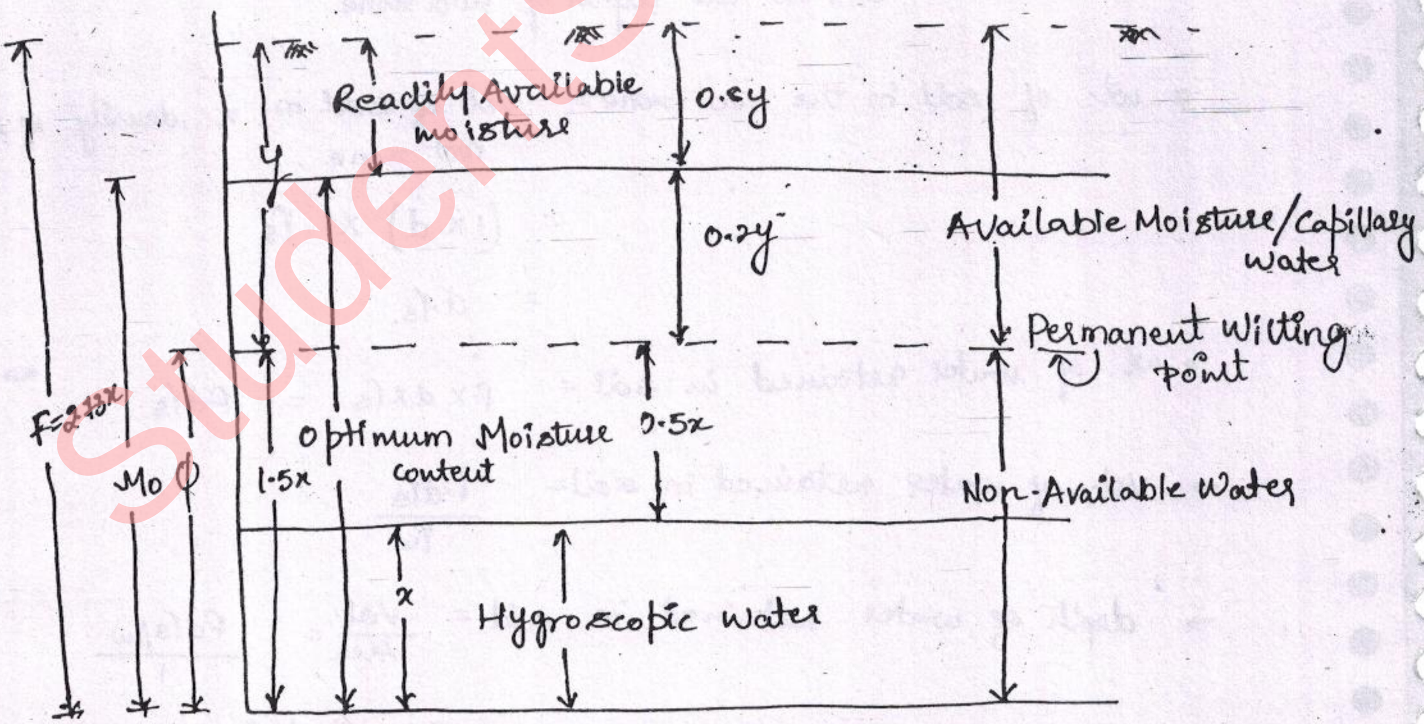
Valid only when soil is fully saturated

i.e $S = 1$

$V_w = V_v$

~~Depth of Root zone~~

→ depth of water in soil (Retained) $= F \times d \times \frac{\gamma_s}{\gamma_w}$.



## → PERMANENT WILTING POINT :-

- Total water corresponding to the field capacity can not be utilized by the plants for their growth.
- Plants can extract the water from the soil only uptill permanent wilting point is reached.
- PWP is that point which corresponds to the amount of water below which plants can no longer extract the water for their growth and becomes compelety dry. (i.e wilts up).

→ Let the hygroscopic water corresponds to $\textcircled{x}$.

→ Moisture content upto the PWP = $\underline{1.5x}$.

→ Moisture content upto field capacity, $\underline{F = 2.73x}$

→ ∴ Available moisture in the moisture, ~~fxy~~ = $\underline{F - \phi} = \underline{1.23x}$

This is the moisture which can be utilised by plants for their growth.

$= (2.73 - 1.5)x$

$= \underline{1.23x}$

→ ∴ Depth of water corresponding to available moisture content

$$= (F - \phi) \cdot d \cdot \frac{\gamma_s}{\gamma_w}$$

## → Readily Available Moisture :-

- It is the portion of the available ~~uo~~ moisture which should be present for the optimum growth of plants.

→ It is approx (75 – 80%) of available moisture

→ Water is applied to field as soon as the moisture content in the soil drops to optimum moisture content level.

→ Readily available moisture = $F - M_o$

→ Readily available moisture content

$$= 75 \text{ to } 80\% \text{ available moisture content}$$

$$= (F - \phi) \times 0.8$$

→ Depth of water corresponding to readily available moisture content

$$= (F - \phi) \cdot 0.8 \cdot \frac{d\gamma_s}{\gamma_w}$$

$$= (F - M_0)\, d \cdot \frac{\gamma_s}{\gamma_w}$$

→ If (Cu) is the consumptive use.

than frequency of irrigation (f)

$$f = \frac{\text{Readily available moisture (depth)}}{Cu \text{ (in cm)}}$$

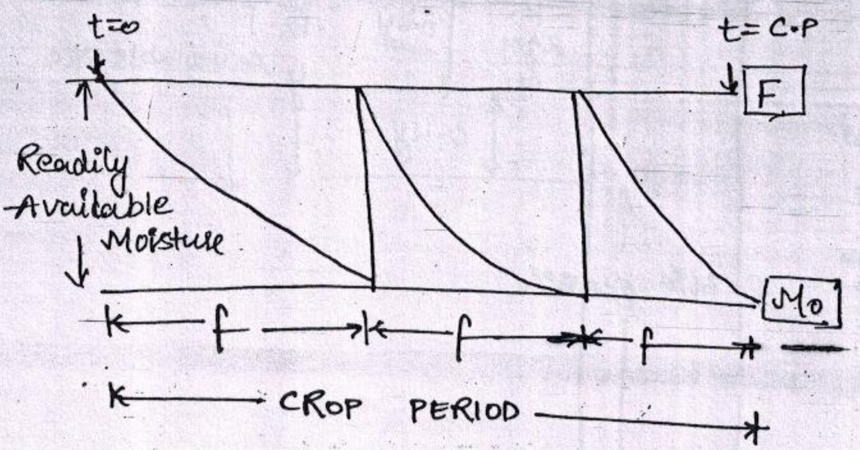
$$\boxed{f = \frac{(F - M_0) \cdot d \cdot \gamma_s}{\gamma_w} \times \left(\frac{1}{cu}\right)}$$

→ SOIL DEFICIENCY:-

- It corresponds to the amount of water content required to bring the moisture ~~coment~~ content of soil back to its field capacity.

→ EQUIVALENT MOISTURE :-

→ It is the amount of water retained in the soil against the force of 1000 times the gravity (ie 1000g) which is acting for 30min.



Q. After how many days will you supply water to the soil in order to ensure sufficient irrigation of the given crop. field capacity of soil = 28%. PWP=13%. $\gamma_s = 1.3$ gm/cm3. Affective depth of root zone 70 cm. Daily consumptive use of water is 12mm. Assume any other data required.

Sol:-

$f = 28\%$ , $\phi = 13\%$.

∴ Available M/C = 28 − 13 = 15%.

Readily available M/C = 0.8 × 15 = 12%. = $f - M_0$

assuming readily available M/C = 80% available M/C.

$$\text{frequency} = f = (f - M_0) \times d \cdot \frac{\gamma_s}{\gamma_w} \times \frac{1}{cu}$$

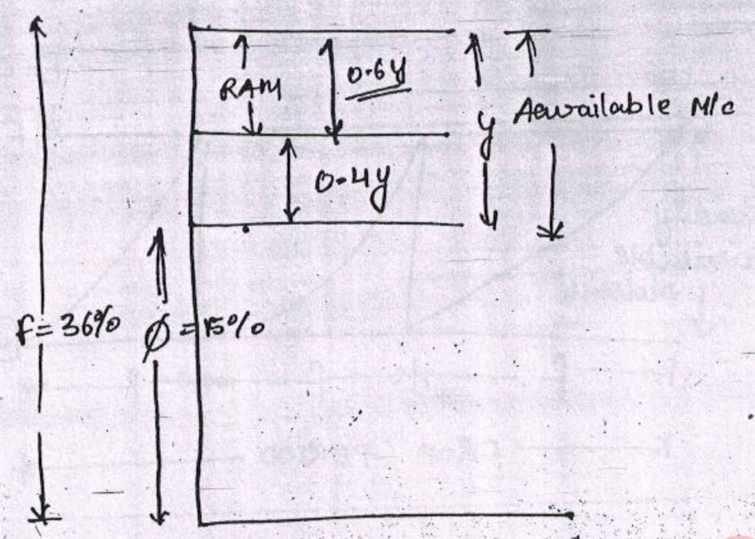
$$= \frac{12 \times 70 \times 1.3 \times 1}{100 \quad 1 \times 12 \times 10^{-1}}$$

$$= 9.1 \text{ day}$$

Q. 800 m³ of water is applied to a farmers field of 0.6 hac. When the moisture content in the soil falls to 40% of the available moisture between the field capacity (=36%) and PWP (15%) of the soil crop combination. Determine the field application efficiency if the root zone depth is 60 cm. Assume the porosity to be 0.4.

Sol:-

Note when M/c start from bottom. the 40% should be taken from BOttom of available MCc.



Available M/c = 36 − 15 = 21%

RAM/C = 0.6×21 = 12.6%

Actual M/c = $M_A$ = f − RAM/c = 36 − 12.6 = 23.4%.

Depth of water corresponding to readily available M/c

$$= (F - M_A) \times d \times \frac{\gamma_s}{\gamma_w}$$

Assuming the degree of saturation = 1

$$\rightarrow \quad f = \eta \frac{\gamma_w}{\gamma_s}$$

$$\frac{\gamma_s}{\gamma_w} = \frac{\eta}{F} = \frac{0.4}{0.36}$$

$$\underline{\gamma_s = 1.11}$$

$$\therefore \text{depth} = \frac{12.6}{100} \times 60 \times \frac{1.11}{1} = \underline{\underline{8.4\text{ cm}}}.$$

∴ Volume of water reqd by crop = depth × Area

$= 8.4\times10^{-2} \times 0.6\times10^4$

$= 504\ m^3$

∴ Efficiency of water application = $\frac{504}{800}$

$= \underline{\underline{63\%}}$

Q Determine the field capacity of the soil for the following data. Depth of root zone = 1.8m.

Existing moisture = 8%

$\gamma_d$ = 1450 kg/m3.

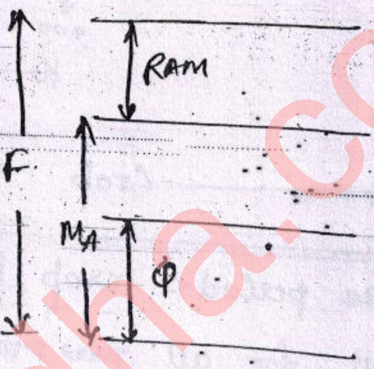
quantity of water applied to soil = 650 m3.

Water lost due to evaporation and percolation = 10%.

Area to ~~isrigte~~ irrigated = 1000 m².

Sol → Vol. of water applied = 650 m3.

Loss = 10%.



→ Vol. of water entering into field = (1-0.1) x650

= 585 m3.

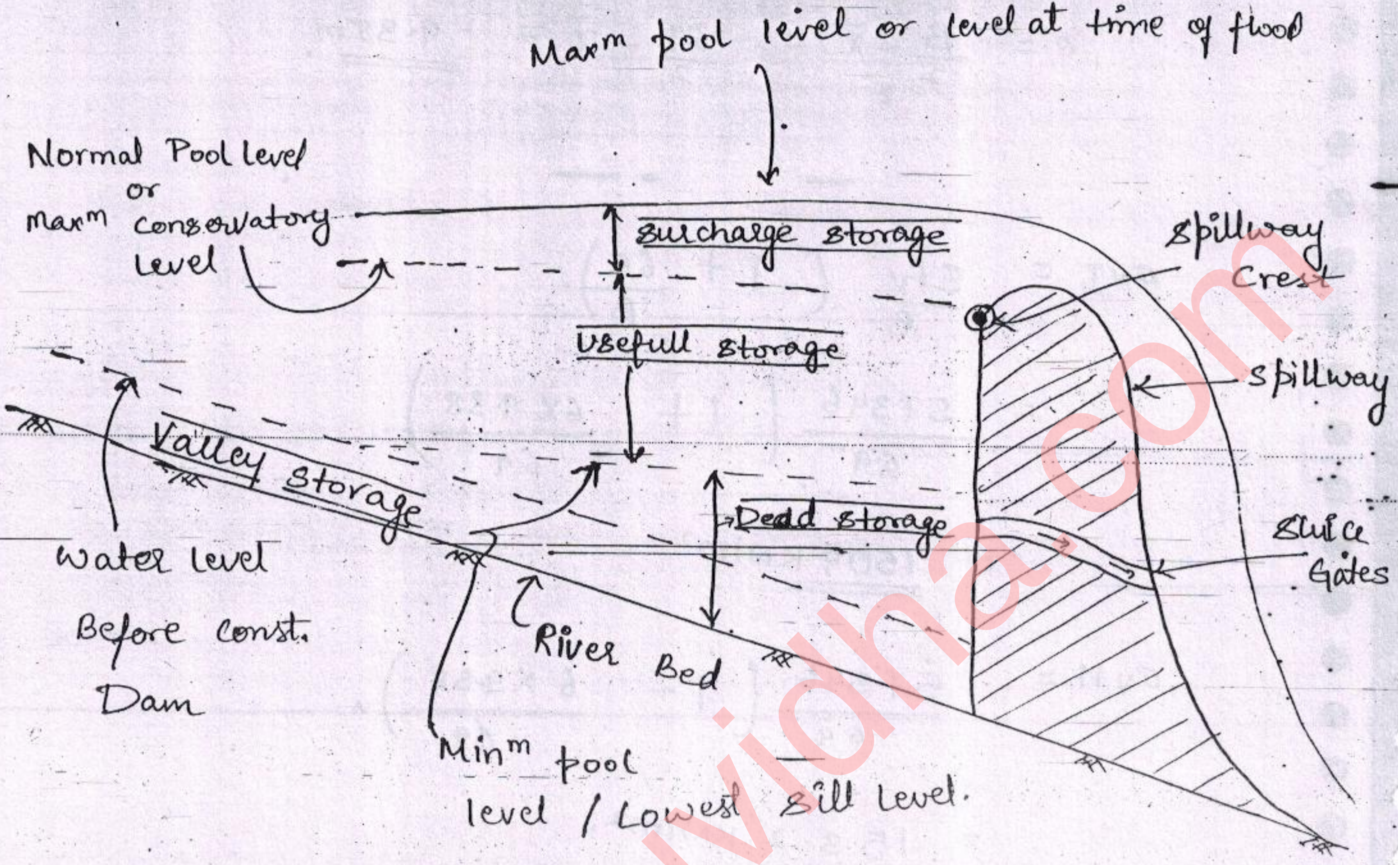
→ depth of water applied = $\frac{585}{1000}$ = 0.585m.

→ depth = $(F - M_A) \times d \times \frac{\gamma_s}{\gamma_w}$

$0.585 = (f - 0.08) \times 1.8 \times \frac{1450}{1000}$

f = 30.40%

# ⇒ STORAGE ZONES IN RESERVOIR



→ **MIN. POOL LEVEL**

→ it is the level corresponding to minm quantity of water that has to be kept in the reservoir for the ~~non~~ normal working of the reservoir.

→ it is decided on the basis of Lowest outlet level of the Reservoir.

→ And minm Head reqd. for the efficient working of the turbine (if any)

⇒ NORMAL POOL LEVEL:-

it is the water level corresponding to the maxm quantity of water that can be stored in the reservoir for its normal working.

⇒ USEFUL STORAGE

→ Quantity of water stored b/w normal pool level and minm pool level.

→ the water stored in this zone can be used for following purposes:-

(i) Net crop water requirement
(ii) flood mitigation "
(iii) Power Generation "
(iv) Conservation of water

→ The reservoir used for more than one of the purposes is called multi purpose.

⇒ DEAD STORAGE → Water stored below the minm pool level.

→ The soul purpose of providing dead storage is to accomodate the silt deposited at the base of the reservoir and it doesnot serve any engineering purpose (mentioned above).

## SURCHARGE STORAGE

→ quantity of water stored b/w the Maxm pool level and the normal pool level.

↳ it is uncontrolled storage as it occurs only at the time of flood and cannot be used latter for any engineering purposes.

## BANK STORAGE :-

↳ When the reservoir is full some quantity of water seeps into the permeable soil below the dam. and comes out into the reservoir when the water level starts falling.

↳ Hence Bank storage effectively, ↑ the Capacity of the reservoir.

↳ But is not considered for the design purpose

## VALLEY STORAGE

↳ Even Before the construction of dam certain variable amount of water is present in the valley flowing over the valley is known as Valley storage

↳ Valley storage effectively, ↓ capacity of Reservoir.

⇒ $\boxed{\text{Gross storage} = S.S + U.S. + V.S + D.S.}$

⇒ Effectively storage = S.S + U.S + D.S
or
Gross storage − V.S.

⇒ Effective storage = U.S + S.S. | or GS − VS − DS

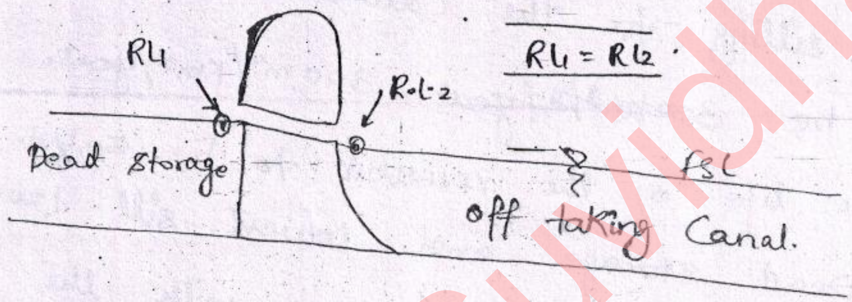
**Note** if any engineering purpose is mentioned than D.S. will not be considered.

- Dead storage is generally taken as Maxm of :-

① D.S. = Rate of silting × Life of Reservoir.

(II) D.S. = 10% of G.S. or net water demand.

(III) Dead storage level = full supply level of the off taking canal.



→ **CAPACITY** = MINIMUM of

① Dependable yield of Reservoir

(ii) Gross Capacity to fulfill all the demands

Eg:-

Dependable — 580 hacm.
G.C. — 220 hac.m

||

Dependable — 180 hacm.
G.C — 200 hcam

Q THE lowest portion of the capacity elevation curve of ~~the~~ ~~pro~~ a purposed irrigation reservoir draining 20Km² of the catchment is represented by the following data:-

| ELEVATION (m) | CAPACITY (HAC-m) |
|---|---|
| 600 | 24.2 |
| 602 | 26.6 |
| 604 | 30.3 |
| 606 | 36.8 |

The rate of silting for the catchment has been assesd to be ~~300km²/s/year~~. 300 m³/Km²/year. Assuming the life of the resevoir to be 50 yrs. Compute Dead storage and lowest sill level, if the main canal is 6Km long with the canal bed slope of 1 in 1000 and the canal bed level at the tail end is 594.5 m. if the full supply depth of the canal at the Head is 80 cm. and the crop water requirement is 250 Hac-m. What will be the gross capacity of reservoir if dependable yield of the catchment is estimated to be 0.29m

Sol^n ① D-S = R.O.S × D.C

$= 300 \times 20 \times 50 = 3 \times 10^5 \, m^3$

$\frac{m^3}{\cancel{K^2} \times year} \times \cancel{year} \times \cancel{Km^2} = ~~3000~~ \; 30$ hacm.

② Dead Storage = 10% G.S or Net water demand

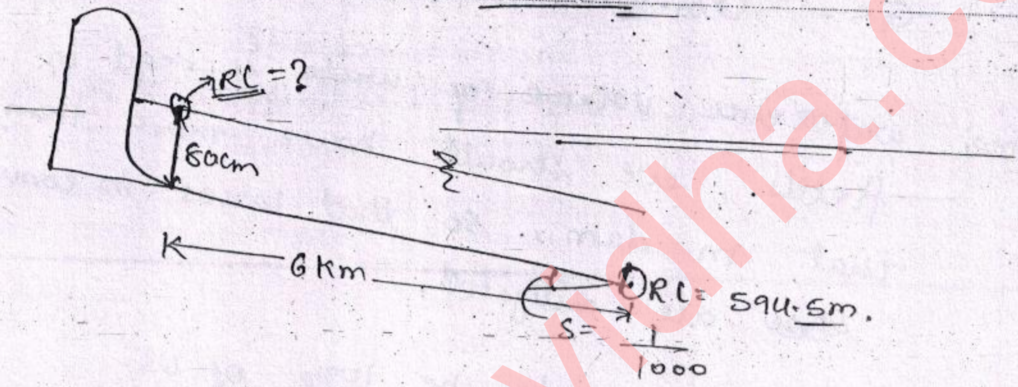
= 10% × 250 hac-m

= 25 hac m.

③. Dead storage level. = full supply level of off taking Canal.

$= 594.5 + (6 \times 1000) \times \frac{1}{1000} + 80 \times 10^{-2}$

$= 601.3 m.$



Now, from elevation curve, D.S corresponding to RL of 601.3.

$D.S. = 24.2 + \frac{(26.6 - 24.2) \times 1.3}{2}$

$= 25.6$ hac-m.

⇒ D.S is max^m of ① ② & ③.

$\boxed{D.S = 30 \text{ Hac-m}}$

⇒ for lowest sill level, we need to find the elevation corresponding to the above capacity.

∴ Min^m sill level $= 602 + \frac{2 \; (30 - 26.6)}{(-26.6 + 30.3)}$

$= 603.837$

Gross Capacity is minm of

① Dependable yield $= 0.29m \times Area$

$= 0.29m \times 20 \times 10^6 \times 10^{-4}$

$= 580$ Hacm

② Gross storage to meet all the demand.

$$G.S = \overset{\nearrow 0}{\underset{\text{(not given)}}{\cancel{V}.S}} + D.S + U.S + \overset{\nearrow 0}{\cancel{S}.S}$$

$$G.S = U.S. + D.S.$$

Now, whatever volume of water is reqd in fields, we should have more than that in dam., so that losses in conveyance are mitigated.

③ Assume losses to be 10% of US.

$$\therefore\ G.S = US + \text{Losses} + D.S$$

$$= 280 + \frac{15}{100} \times 280 + 30.$$

$$= \underline{317.5 \text{ hac-m}}$$

GS = 317.5 hac-m.

DS = 30 hac-m.

$$Ros = 300 \frac{m^3}{Km^2} \times \frac{20 Km^2}{year} \times 10^{-4}$$

$$= \underline{0.6 \text{ hac-m}}.$$

$$\text{Life of Reservoir} = \frac{G.S}{R.O.S} = \frac{317.5}{0.6} = \underline{\underline{529 yrs}}$$

<u>Note</u> Here R.O.S is assumed to be constant