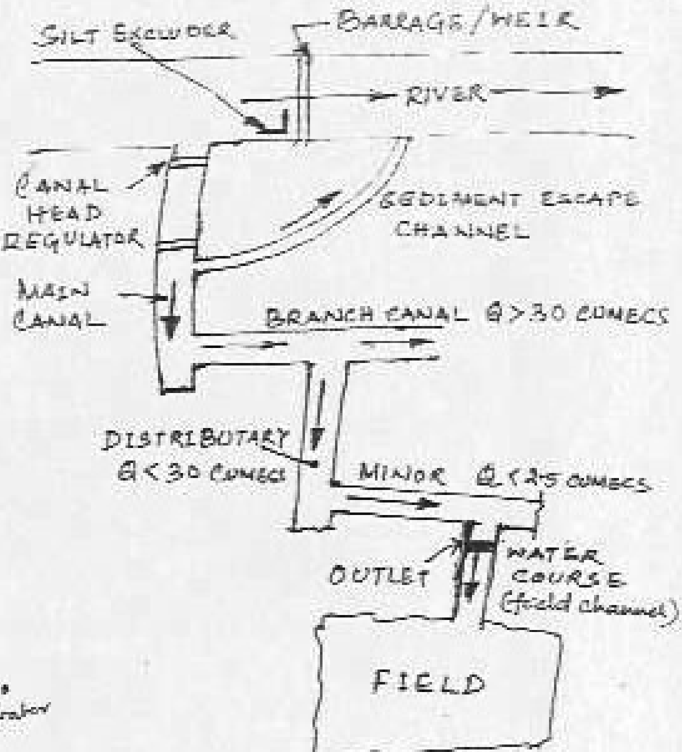
DUTY AT VARIOUS PLACES



Canal Irrigation System (CIS)

Main Canal → Branch Canal → Distributary → Minor → field channels (water-courses) → Fields.

During the passage of water from these irrigation channels water is lost due to evaporation and percolation. These losses are called **Transit or Transmission or Conveyance losses** in channels.

- If water consumed by a crop of a given base period is more, its duty will be less (since lesser [1 cumec of water] no. of hectare of land it will irrigate.)

Duty of water increases → Main canal → Branch canal → Distributary → Minor → water course → Field.

- Duty of water at the head of water-course will be less than the duty of water 'on the field'; because when water flows from the head of the water-course & reaches the field, some water is lost. (Transit losses)

Likewise, duty of water at the head of main canal will be less than the duty at the head of a branch canal.

As such Duty of water increases as one moves d/s from the head of the main canal towards the head of branches or watercourses.

- Duty for a channel is usually calculated on head discharge.

OUTLET DISCHARGE FACTOR :- The duty of water at the head of water course (i.e; at the outlet point of the minor) is quite important, since this outlet point (minor) is generally the end point of the irrigation Department. The "control" of Irrigation Department finishes at this outlet point, and the water is carried into the fields through water-courses by the beneficiary cultivators themselves. Duty based on discharge passed through the outlet & thus excluding all losses in the canal system, is called "outlet discharge factor".

FLOW DUTY AND QUANTITY DUTY

- **FLOW DUTY** → In direct irrigation, duty is always expressed in hectares/cumec. It is then called flow duty or duty.
- **QUANTITY DUTY** → In storage irrigation, duty is expressed in hectares/million cubic meter of water available in the reservoir. It eventually means that every million cubic meter of water available in the reservoir will mature so many hectares of a particular crop. Hence, the irrigation capacity of the reservoir is directly known. When duty is expressed in this manner, it is called Quantity duty or Storage duty.

Total water requirement of Rice for Kalahandi district = 587 mm

FACTORS ON WHICH DUTY DEPENDS

- (1) Type of Crop — A crop requiring more water will have less acreage for the same supply of water as compared to that requiring less water. e.g; Kharif crop; duty is less.
- (2) Climate & Season — Duty depends on Transit losses (loss in evapo. & percolation) losses will vary with season. Duty varies from season to season & also time to time in same season.
- (3) Useful rainfall — More useful rainfall, less water requirement, more will be duty. of irrigation water.
- (4) Type of Soil — Permeability of soil is more → duty is less. e.g; sandy soils. more water requirement
- (5) Efficiency of cultivation method. If the cultivation method is faulty & less efficient, resulting in wastage of water & hence duty will be less. more water requirement.

Importance of Duty → It helps us in designing efficient canal irrigation system. Knowing the total available water at the head of a main canal, and the overall duty for all crops required to be irrigated in different seasons of the year, the area which can be irrigated can be worked out. $D = \frac{A}{Q}$ $A = QD$

Inversely, if we know the crops area required to be irrigated and their duties, we can work out the discharge required for designing the channel. $Q = \frac{A}{D}$

IRRIGATION EFFICIENCIES

Water is lost in irrigation during various processes and, therefore there are different kind of irrigation efficiencies, as given below,

(i) Efficiency of water-conveyance:

$$\eta_c = \frac{\text{Water delivered into the fields from the outlet point}}{\text{Water entering into channel at its starting point (head) of M.C}}$$

(ii) Efficiency of water-application:

$$\eta_a = \frac{\text{quantity of water stored into the root zone of crops}}{\text{quantity of water actually delivered into field}}$$

* It takes into consideration the water lost in farm.

(iii) Efficiency of water-storage:

$$\eta_s = \frac{\text{water stored in root zone during irrigation}}{\text{quantity water needed in root zone prior to irrigation}}$$

(ie; field capacity − existing moisture content)

(iv) Efficiency of water use:

$$\eta_w = \frac{\text{Water beneficially used, including leaching}}{\text{quantity of water delivered}}$$

(v) Uniformity co-efficient (or) Water distribution efficiency:

- The effectiveness of irrigation may be measured by its water distribution efficiency, & is given by

$$\eta_d = \left(1 - \frac{d}{D}\right);$$

where η_d = Water distribution efficiency.

D = Mean depth of water stored during irrigation

d = Avg. of the absolute values of deviations from the mean.

- It represents the extent to which water has penetrated to a uniform depth throughout the field. When the water has penetrated uniformly throughout the fields the deviation from the mean depth is zero & the water distribution efficiency is 1.0.

(vi) Consumptive Use Efficiency (η_{cu})

$$\eta_{cu} = \frac{W_{cu}}{W_d} \times 100$$

where W_{cu} or C_u = normal consumptive use of water

W_d = net amount of water depleted from root zone of soil.

The efficiency, therefore, evaluates the loss of water by deep percolation and by excessive surface ~~irrigation~~ evaporation following an irrigation.

PROBLEMS.

1. Find the delta for a crop when its duty is 864 hectares/cumec on the field, the base period of this crop is 120 days.

Soln :- Duty (D) = 864 hectares/cumec.

Base period (B) = 120 days

$$\text{Delta } (\Delta) = \frac{8.64\, B}{D} = \frac{8.64 \times 120}{864} \text{ (m)} = 1.2\text{m} = 120 \text{ cm.}$$

2. A stream of 130 lps was diverted from a canal and 100 lps were delivered to the field. An area of 1.6 hectares was irrigated in 8 hours. The effective depth of root zone was 1.7 m. The run-off loss in the field was 420 m³. The depth of water penetration varied linearly from 1.7 m at the head end of the field to 1.1 m at the tail end. Available moisture holding capacity of the soil is 20 cm per m depth of soil. It is required to determine the water conveyance efficiency, water application efficiency, water storage efficiency, and water distribution efficiency. Irrigation was started at a moisture extraction level of 50% of the available moisture. water is applied to the field when available moisture reduces to 50%.

Soln :-

(i) Water conveyance efficiency (η_c) = $\dfrac{\text{Water delivered to the fields}}{\text{Water entering into canal at the head}} \times 100$

$$= \frac{100}{130} \times 100 = 77\% \text{ (say) Ans.}$$

(ii) Water application efficiency (η_a)

$$= \frac{\text{Water stored in the root zone during irrigation}}{\text{Water delivered to the field}} \times 100$$

Water supplied to field during 8 hours @ 100 lps $1 m^3 = 10^3 L$

$= 100 \times 8 \times 60 \times 60$ litres

$= 2880$ cu.m

Runoff loss in the field $= 420\ m^3$.

∴ Water stored in the root zone $= (2880 - 420)\ m^3$

$= 2460\ m^3$

Water application efficiency $(\eta_a) = \frac{2460}{2880} \times 100$

$\eta_a = 85.4\%$ Ans

(iii) Water storage efficiency (η_s)

$= \frac{\text{Water stored in the root zone during irrigation}}{\text{Water needed in root zone prior to irrigation}} \times 100$

Moisture holding capacity of soil

$= 20$ cm/m depth $\times 1.7$ m depth of root zone

$= 34$ cm.

Moisture already available in root zone at the time of start of irrigation $= \frac{50}{100} \times 34 = 17$ cm.

Additional water required in root zone

$= 34 - 17 = 17$ cm = depth of water needed in the root zone prior to the irrigation.

$= \frac{17}{100} \times (1.6 \times 10^4)$ cu.m

$= 2720$ cu.m.

∴ Water storage efficiency $(\eta_s) = \frac{2460}{2720} \times 100 = 90\%$ (say) Ans

(iv) Water distribution efficiency (η_d)

$\eta_d = \left(1 - \frac{d}{D}\right)$;

where D = mean depth of water stored in root zone

$= \frac{1.7 + 1.1}{2} = 1.4$ m.

d is computed as below:

Deviation from the mean at upper end (absolute value)

$= |1.7 - 1.4| = 0.3$

Deviation from the mean at lower end (absolute value)

$= |1.1 - 1.4| = 0.3$

d = Avg. of absolute values of deviations from mean $= \frac{0.3 + 0.3}{2} = 0.3$.

$\eta_d = \left(1 - \frac{0.3}{1.4}\right) = 0.786 = 78.6\%$

$\eta_d = 78.6\%$ Ans

CONSUMPTIVE USE (OR) EVAPOTRANSPIRATION (C_u)

Consumptive use may be defined as the amount of water used in the evapo-transpiration from an area under vegetation, plus the water used by the plants in their metabolic process for building of plant tissues. Since the quantity of water used in metabolic process is insignificant compared to evapotranspiration

- Consumptive use for a particular crop may be defined as the total amount of water used by the plant in transpiration (building of plant tissues, etc) and evaporation from adjacent soils or from plant leaves, in any specified time.
- Values of consumptive use (C_u) is different for different crops and may be different for the same crop at different times & places.
- Infact consumptive use for a given crop at a given place may vary throughout the day, throughout the month & throughout the crop period. Values of daily consumptive use or monthly consumptive use are generally determined for a given crop and at a given place.
- Values of monthly consumptive use over the entire crop periods are then used to determine the irrigation requirement of the crop.

EFFECTIVE RAINFALL (R_e)

- Precipitation falling during the growing period of a crop that is available to meet the evapo-transpiration needs of the crop, is called effective rainfall.
- It doesnot include precepitation lost through deep percolation below the root zone or the water lost as surface run-off.

~~Contro~~ IRRIGATION REQUIREMENTS (How irrigation water is used up by the plants? & what are the diff requirements?)

(1) CONSUMPTIVE IRRIGATION REQUIREMENT (CIR)

- It is the amount of Irrigation water required inorder to meet the evapotranspiration needs of the crop during its full growth.
- It is the consumptive use itself, but exclusive of effective precipitation, stored soil moisture, or ground water.

$$C \cdot I \cdot R = C_u - R_e$$

(2) NET IRRIGATION REQUIREMENT (NIR)

- It is the amount of irrigation water required inorder to meet the evapotranspiration need of the crop as well as other needs such as leaching.

$$N \cdot I \cdot R = C_u - R_e + \text{water lost as percolation (leaching)}$$

Factors Affecting consumptive use

Consumptive use depends on temperature, sunlight, humidity, wind movement etc.

(3) FIELD IRRIGATION REQUIREMENT (FIR)

Field irrigation requirement is the amount of water required to meet 'net irrigation requirements' plus the water lost in percolation in the field water courses, field channels & in field applications of water. If η_a is water application efficiency, we have $FIR = \frac{NIR}{\eta_a}$

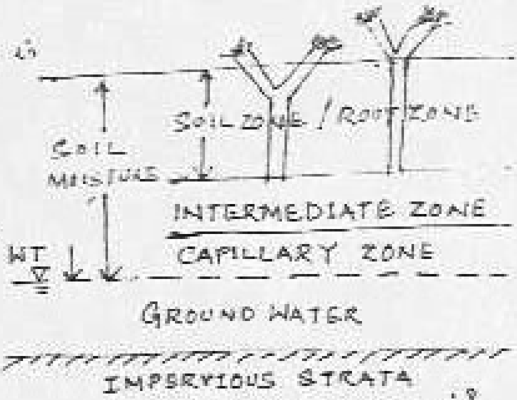
(4) GROSS IRRIGATION REQUIREMENT (GIR)

Gross irrigation requirement is the sum of water required to satisfy the field irrigation requirement & the water lost as conveyance losses in distributaries upto the field. If η_c is the water conveyance efficiency. $GIR = \frac{FIR}{\eta_c}$

Soil-Moisture-Irrigation Relationship.

- The water below the watertable is known as ground water and above the watertable as soil moisture.

SOIL/ROOT ZONE: Depth of overburden that is penetrated by the roots of vegetation. In this zone the plants do take their water supplies.



- When water falls over the grounds, a part of it gets absorbed in this root zone, and the rest flows downward under the action of gravity, called gravity water.

Field Capacity :- Field capacity is thus the water content of a soil after free drainage has taken place for a sufficient period. This period of free gravity drainage is generally taken as 2-5 days.

Field capacity water consists of 2 parts:

- **Capillary water** :- water attached to the soil molecules by surface tension against gravitational forces, & can be extracted by plants by capillarity.
- **Hygroscopic water** :- Water attached to the soil molecules by loose chemical bonds. This water cannot be removed by capillarity & is not available to the plants.

$$\text{Field Capacity} = \frac{\text{Wt. of water retained in a certain vol. of soil}}{\text{Wt. of same volume of dry soil}} \times 100$$

Expression for field Capacity

If we consider $1\,m^2$ area of soil & d meter depth of root zone

volume of soil $= 1 \times d\ m^3$

Dry unit weight of soil $= \gamma_d\ kN/m^3$.

Wt. of d cubic meters of soil $= \gamma_d \times d$ kN. (weight = Density × volume)

$$\text{Field Capacity, } F = \frac{\text{wt. of water retained in unit area of soil}}{\gamma_d \cdot d}$$

Wt. of water retained in unit area of soil $= \gamma_d \cdot d \cdot F\ kN/m^2$.

$$\text{volume of water stored in unit area of soil} = \frac{\gamma_d \cdot d \cdot F\ (kN/m^2)}{\gamma_w\ (kN/m^3)}$$

Total water-storage capacity of soil in (m depth of water)

$$= \frac{\gamma_d d F}{\gamma_w}\ m$$

Hence, the depth of water stored in the root zone in filling the soil upto field capacity $= \dfrac{\gamma_d d F}{\gamma_w}$ (meters)

$$\text{Depth of water stored in root zone (in depth } d) = \frac{\gamma_d\, d\, F_c}{\gamma_w} \text{ (meters)}$$

1. Compute the depth and frequency of irrigation required for a certain crop with data given below:

Root zone depth = 100 cm

Field capacity = 22%

Wilting point = 12%

Apparent Specific gravity of soil = 1.50

Consumptive use = 25 mm/day.

Efficiency of irrigation = 50%

Assume 50% depletion on available moisture before application of irrigation water at field capacity.

2. What is meant by "Duty of water"? What are different ways in which duty can be expressed?
A reservoir with a live storage capacity of 300 million cubic meters is able to irrigate an ayacut of 40,000 hectares with 2 fillings each year. The crop season is 120 days. What is the duty?

3. Write short notes on:
(a) Drip irrigation Method
(b) Sodium Absorption Ratio (SAR)
(c) Overlap Allowance
(d) Paleo-irrigation.
(e) Kor-watering
(f) Crop Ratio
(g) Water-distribution efficiency
(h) Irrigation Requirements

4. A watercourse commands an irrigation area of 800 hectares. The intensity of irrigation of rice in this area is 50%. The transplantation of rice crop takes 15 days & total depth of water required by the crop is 60 cm on the field during the transplantation period, given that the rain falling on the field during this period is 15 cm. (i) find the duty of irrigation water for the crop on the field during transplantation; (ii) at the head of the distributary, assuming losses of water to be 20% in the water courses (iii) calculate the discharge required in the watercourse.

5. What is meant by 'Regime channels'?
Compare briefly the Silt theories of Kennedy & Lacey.
Design a regime channel to carry a discharge of 100 cumecs. Assume Silt factor as 1.0.

6. Write short notes on:
(a) G.C.A & C.C.A
(b) F.S.L
(c) Intensity of irrigation.
(d) True Regime
(e) incoherent alluvium.
(f) Critical velocity ratio.
(g) Time factor.

→ Available moisture depth (d_w) = $\frac{\gamma_d \cdot d}{\gamma_w}$ [Field capacity − Wilting Point]

Permanent Wilting Point (PWP) :-

Total field capacity (FC) cannot be utilised by the plants. The plants can extract water from the soil till permanent wilt point is reached. The water left in the soil after the permanent wilting point is reached, cannot be removed, and is known as Hygroscopic water (or) unavailable moisture.

PWP :- Water content at which plant can no longer extract sufficient water for its growth & wilts up.

Available Moisture (Maximum Storage capacity of soil) :-

Difference in water content of the soil between field capacity and permanent wilting point.

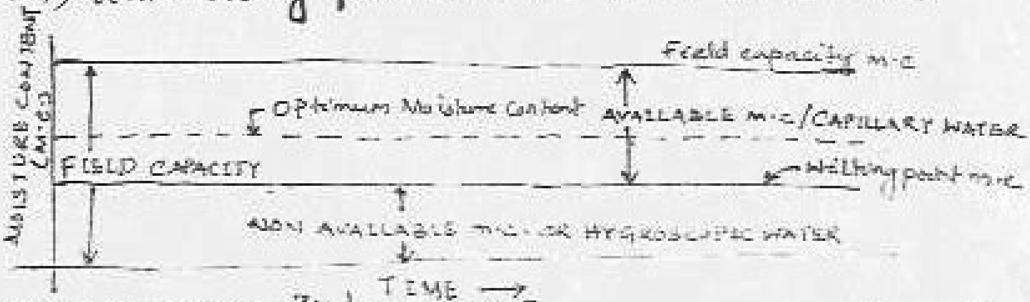
Readily Available Moisture :- It is that portion of the available moisture which is most easily extracted by the plants.

Readily Available Moisture = (0.75 − 0.8) of available moisture.

Soil-moisture deficiency :- Water required to bring the soil moisture content of a given soil to its field capacity is called field / soil − moisture deficiency.

ESTIMATING DEPTH AND FREQUENCY OF IRRIGATION ON THE BASIS OF SOIL MOISTURE REGIME CONCEPT

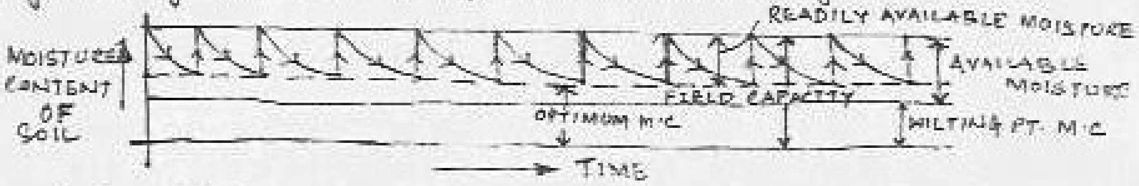
- Soil moisture in the root zone vary between **field capacity** (upper limit) and **wilting point** moisture content (lower limit)



Depth of water b/n F.C & O.M.C = $\frac{\gamma_d \cdot d}{\gamma_w}$ [F.C − OMC]

The optimum level (till wilting point) upto which the soil moisture may be allowed to be depleted in the root zone without fall in crop yield, has to be worked out for every crop & soil, by experimentation.

- The irrigation water should be supplied as soon as the moisture falls upto this optimum level fixing irrigation frequency and its quantity should be just sufficient to bring the moisture content upto its field capacity, making allowance for application losses (fixing water depth.)



Water will be utilised by the plants after the fresh irrigation dose is given, and the soil moisture will start falling. It will again recouped by a fresh dose of irrigation, as soon as soil moisture reaches the optimum level.

Examples:

1. Wheat is to be grown in field having a field capacity equal to 27 % and the permanent wilting point is 13 %. Find the storage capacity in 80 cm depth of soil, if the dry unit weight of the soil is 1.5 g/cc. If the irrigation water is to be supplied when the average soil moisture falls to 18 %, find the water depth required to be supplied to field if the field application efficiency is 80 %. What is the amount of water needed at the canal outlet if the water lost in water course and the field channel is 15 % of the outlet discharge?

$\eta_e = 85\%$ $\quad \eta_e = (100 - 15) = 85\%$

Sol^n :- (a) Maximum storage capacity = available moisture

$$= \frac{\gamma_d\, d}{\gamma_w}\left[F_c - w_t\right] = \frac{1.5 \times 80}{1}\left[0.27 - 0.13\right]$$

$$= 16.8 \text{ cm}$$

(b) Depth of irrigation water $= \frac{\gamma_d\, d}{\gamma_w}\left[F_c - m_0\right]$

$$= \frac{1.5 \times 80}{1}\left[0.27 - 0.18\right]$$

$$= 10.8 \text{ cm}$$

(c) Field irrigation requirement (FIR) $= \frac{NIR}{\eta_a} = \frac{10.8}{0.8} = 13.5$ cm

(d) Amount of water needed at canal outlet $= \frac{13.5}{0.85} = 15.9$ cm.
G.I.R

2. A certain crop is grown in an area of 3000 hectares which is fed by a canal system. The data pertaining to irrigation are as follows:

Field capacity of soil = 26 %
Optimum moisture = 12 %
Permanent wilting point = 10 %
Effective depth of root zone = 80 cm
Relative density of soil = 1.4 (γ_d/γ_w)

If the frequency of irrigation is 10 days & the overall efficiency is 23 %, find (i) the daily consumptive use (ii) the water discharge (in m^3/s) required on the canal feeding the area.

Sol^n :- Depth of irrigation water, $d_w = S_g \cdot d\left[F_c - m_o\right]$

$$= 1.4 \times 80\left[0.26 - 0.12\right]$$

$$= 15.68 \text{ cm}$$

frequency of irrigation = 10 days

Daily consumptive use $= \frac{15.68}{10} = 1.568$ cm.

$$C_u = \frac{\text{Depth of irrigation water}}{\text{frequency of irrigation}}$$

Total water required in 10 days $= A \times d_{10}$

$$= 3000 \times 10^4 \times \frac{15.68}{100} = 4704000 \ m^3$$

$[1 \ ha = 10^4 \ m^2]$

$\therefore$ Discharge in the canal $= \dfrac{4704000}{10 \times 24 \times 3600} \simeq 5.45 \ m^3/s = 5.45$ cumecs

frequency of irrigation → Depth of irrigation water (total amount) → Cu

3. After <u>how many days</u> will you supply water to soil in order to ensure sufficient irrigation of the given crops if

(i) Field capacity of the soil = 28%

(ii) Permanent wilting point = 13%

(iii) Dry density of soil = 1.3 gm/c.c

(iv) Effective depth of root zone = 70 cm

(v) Daily consumptive use of water for the given crop = 12 mm.

Assume any other data, not given.

<u>Solution</u> :- Available Moisture = Field Capacity − Permanent Wilting

$= (28 - 13)$

$= 15\%$

Readily Available Moisture = 80% of Available Moisture

$= 0.80 \times 15\% = 12\%$

Optimum Moisture $= (28 - 12) = 16\%$

It means that the moisture will be filled by irrigation between 16% and 28%

Depth of water stored in root zone (or during each watering) between these two limits

$$= \frac{\gamma_d \cdot d}{\gamma_w} \left[\text{Field capacity m.c} - \text{Optimum m.c} \right]$$

where $\dfrac{\gamma_d}{\gamma_w} = \dfrac{\rho_d \, g}{\rho_w \, g} = \dfrac{\rho_d}{\rho_w} = \dfrac{1.3 \ gm/cc}{1.0 \ gm/cc} = 1.3$

$$= 1.3 \times 0.7 \left[0.28 - 0.16 \right] m = 0.1092 \ m = 10.92 \ cm$$

Hence, water available for evapo-transpiration = 10.92 cm

1.2 cm of water is utilised by the plant in 1 day (Daily consumptive use)

$\therefore$ 10.92 cm of water will be utilised by the plants in

$= \dfrac{1 \times 10.92}{1.2}$ days $= 9.1$ days, say 9 days

frequency of irrigation.

$$Cu_{\text{Daily}} = \frac{\text{Total depth of irrigation water}}{\text{frequency}}$$

Solution [Assignment No. 1]

691 hectares/cumec

2. $V = 300\ Mm^3 = 300 \times 10^6\ m^3$.

$A = 40,000$ hectares $= 40,000 \times 10^4\ m^2$

$B = 120$ days.

Volume of area irrigated by the water $= 300 \times 10^6\ m^3 \rightarrow 120 = 1200$ days

1200 days $\rightarrow 300 \times 10^6\ m^3$

$1200 \times 24 \times 3600$ sec $\rightarrow 300 \times 10^6\ m^3$

$$Q = \frac{300 \times 10^6}{1200 \times 24 \times 3600} \frac{m^3}{s} = ~~114.4676~~ \text{ cumecs}$$

28.9352 cumecs. 28.7352

$$D = \frac{A}{Q} = \frac{40,000 \text{ hectares}}{28.9352 \text{ cumecs}} = 1382.4 \text{ hectares/cumec.}$$

for each filling,

$$D = \frac{1382.4}{2} = 691 \text{ hectares/cumec.}$$

II^nd^ method

$$\frac{300 \times 10^6\ m^3}{40,000 \times 10^4\ m^2}$$

$\frac{3}{4} = 0.75\ m = \Delta$.

$= 75$ cm.

$$\Delta = \frac{8.64B}{D}.$$

$$D = \frac{8.64B}{\Delta} = \frac{8.64 \times 120}{0.75}$$

$D = 1382.4$ hectares/cumec.

(4) Area to be irrigated under transplantation of rice $= 50\%$ of 800 hectares

$= 400$ hectares.

Irrigation water requirement $= 60$ cm $- 15$ cm $= 45$ cm.

$$\Delta = \frac{864B}{D} \quad \text{or} \quad D = \frac{864B}{\Delta}$$

$$D = \frac{864 \times 15}{60} = 216 \text{ hectares/cumec.}$$

4. A sandy loam soil holds water at 140 mm/m depth between field capacity and permanent wilting point. The root depth of the crop is 30 cm and the allowable depletion of water is 35%. The daily water use by the crop is 5 mm/day. The area to be irrigated is 60 ha and water can be diverted at 28 l.p.s. The surface irrigation application efficiency (η_a) is 40%. There are no rainfall & ground water contribution.

Determine

(i) allowable depletion depth between irrigations.
(ii) frequency of irrigation.
(iii) net application depth of water
(iv) volume of water required.
(v) time to irrigate 4 ha plot.

<u>Solution</u> :- Moisture holding capacity of soil = 140 mm/m depth.

Depth of root zone = 30 cm = 0.3 m.

∴ Moisture holding capacity of root zone

$= 140 \frac{mm}{m} \times 0.3\,m = 42\,mm = 4.2\,cm$

Allowable depletion = 35%

(i) Available moisture depth or Allowable depletion depth b/w irrigation

$= 35\% \times 4.2\,cm = \underline{1.47}\,cm$ Ans

Daily use of water = Consumptive use = 5 mm/day.

(ii) Frequency of irrigation = $\frac{\text{Available Moisture}}{\text{Moisture Consumed per day}}$

$= \frac{1.47}{0.5\,cm/day} = 2.94\,days = \underline{3\,days}$ Ans (say)

(iii) Net water depth to be applied while irrigating each time after 3 days

$= 3 \times 0.5 = \underline{1.5\,cm}$ Ans

Field Irrigation requirement (F.I.R) $= \frac{N.I.R}{\eta_a} = \frac{1.5}{0.4} = 3.75\,cm$

(iv) Quantity of water required in the fields

= 3.75 cm of water depth × Area of field

$= 3.75\,cm \times 60\,ha = \frac{3.75}{100}\,m \times (60 \times 10^4)\,m^2$

$= 22,500\,m^3$

Hence, vol. of water reqd. to irrigate 60 ha area, each time @ 3 days intervals = $\underline{22,500\,m^3}$ Ans

(v) Time to irrigate 4 ha plot when irrigation water is supplied @ 28 lps.

Vol. of water reqd. to irrigate 4 ha plot $= \frac{3.75}{100}\,m \times (4 \times 10^4)\,m^2$ $[1\,m^3 = 10^3\,L]$

$= 1500\,m^3$

Time during which 1500 m³ of water can be supplied @ 28 lps.

$= \frac{1500 \times 10^3\,L}{28\,lps} = \frac{1500 \times 10^3}{28}\,s = \frac{1500 \times 10^3}{28} \times \frac{1}{3600}\,hr = \underline{14.88\,hr}$ Ans

Importance of Soil moisture - Irrigation Relationship.   aerenchyma cells

- Both soil & water are essential for plant growth.
- Soil provides structural base to the plants & allows root system (foundation of the plant) to spread & get a strong hold.
- The pores of the soil within the root zone hold moisture which clings to the soil particles by surface tension in the driest state or may fill up the pores partially or fully saturating with it useful nutrient essential for growth of plants.
- Roots of most plants requires oxygen for respiration.
- Since irrigation practice is essentially, an adequate & timely supply of water to the plant root zone for optimum crop yield, the study of the inter-relationship b/w soil pores, its water-holding capacity & plant water absorption rate is fundamentally important.

Classification of Soil water :- (water held in soil pores)

(i) Gravitational water (The volume of water that could easily drain off is termed as gravitational water. This water is not available for plants use as it drains off rapidly from the root zone.)

(ii) Capillary water

(iii) Hygroscopic water.
(The water that an oven dry sample of soil absorbs when exposed to moist air is termed as hygroscopic water. It is held as a very thin film over the surface of the soil particles by loose chemical bonds. It is under tremendous negative (gauge) pressure.)

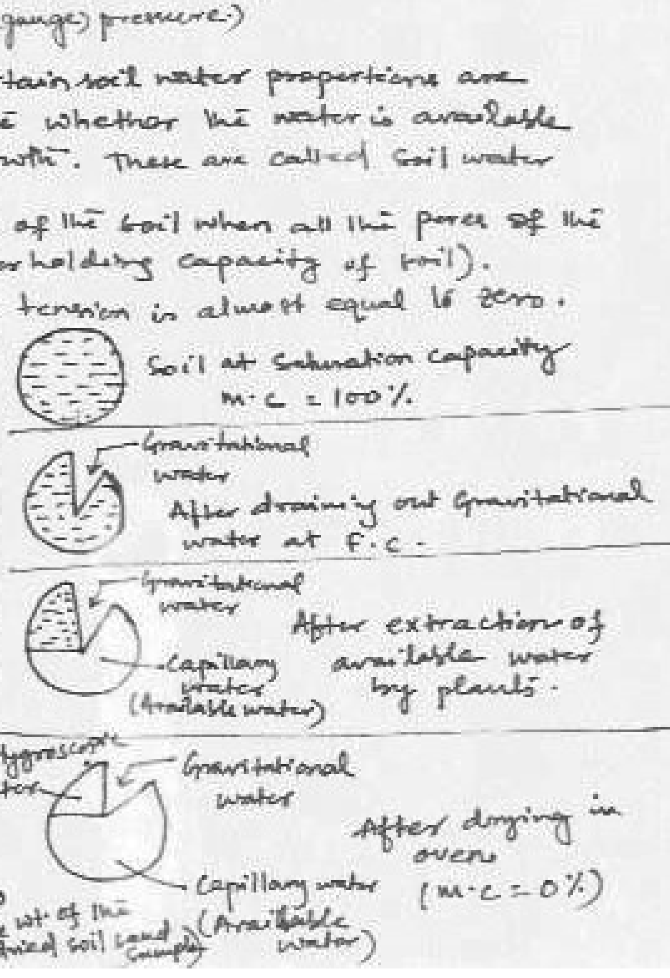
Soil water Constants (For a particular soil, certain soil water properties are defined which dictate whether the water is available or not for plant growth. These are called soil water constants.)

(i) Saturation capacity :- Total water content of the soil when all the pores of the soil are filled with water. (Max^m water holding capacity of soil).
At Saturation capacity, the soil moisture tension is almost equal to zero.

(ii) Field capacity :- This water retained by an initially saturated soil against force of gravity. Hence, as the gravitational water gets drained away from the soil, it is said to reach the F.C
- At F.C macropores of the soil are drained off, but water retained in the micropores.
- Soil moisture tension at F.C varies from soil to soil, normally 1/10 (for clayey soil) & 1/3 (for sandy soil)

(iii) PWP :- As water extraction proceeds, the m.c diminishes & negative (gauge) pressure increases. At a point, the plant cannot extract any further water & thus wilts.

(All the soil constants are expressed as % by wt. of moisture available at that point compared to the wt of the dried soil sample)



1. 800 m^3 of water is applied to a farmer's rice field of 0.6 ha. when the m.c in the soil falls to 40% of the available water between the f.c (36%) of soil & pwp (15%) of the soil combination. Determine the field application efficiency (η_a). The root zone depth of rice is 60 cm. Assume porosity = 0.4

Soln.

$$F = \frac{\text{wt. of water contained in a certain vol}^m \text{ of soil}}{\text{wt. of same vol}^m \text{ of dry soil (i.e; wt. of dry soil retaining that water)}}$$

If a saturated soil contains volume equal to V & the volume of its voids is V_v, then

Weight of water contained in this soil = $\gamma_w \cdot V_v$.

$\gamma_w \rightarrow$ Unit wt. of voids with water.

$$F = \frac{\gamma_w \cdot V_v}{\gamma_d V} = \frac{\gamma_w}{\gamma_d} \cdot n$$

$\gamma_d \rightarrow$ dry unit wt. of soil

$$\frac{\gamma_d}{\gamma_w} = \frac{n}{F} = \frac{0.4}{0.36} = 1.11.$$

Maximum quantity of water stored b/w F.C & P.W.P.

$$= \left(\frac{\gamma_d}{\gamma_w}\right) d \; (F.C - PWP)$$

$$= 1.11 \times 0.60 \left[0.36 - 0.15\right] = 0.14 \text{ m}.$$

Deficiency of water created when irrigation is done

$$= 60\% \text{ of } 0.14 \text{m}$$

$$= 0.6 \times 0.14 = 0.084 \text{ mt}.$$

[∵ irrigation water is applied when m.c falls to 40% of m.c available b/w F.C & PWP]

Hence, irrigation water is supplied to fill up 0.084 m depth of water

Volume (or) Quantity of irrigation water required to fill up the created deficiency $= 0.084 \times 0.6 \times 10^4 \text{ m}^3 = 504 \text{ m}^3$.

Actual irrigation water supplied = 800 m^3 (given)

$$\text{field application Efficiency } (\eta_a) = \frac{504}{800} \times 100\%.$$

$$\boxed{\eta_a = 63\%.}$$ Ans.

2. In a cultivated area, the soil has porosity of 45% & f.c of 38%. for a particular crop, the root zone depth is 1.0 m, p.w.p is 10% & the consumptive use is 15 mm/d. If the irrigation efficiency is 60%, what should be the frequency of irrigation such that the m.c doesnot fall below 50% of the maxm available moisture? Ans. 11 days.

2. The available moisture holding capacity of soil is 13 cm/m depth of soil. If a crop with a root zone of 0.8 m & Cu of 5 mm/day is to be grown, the frequency of irrigation for restricting the moisture depletion to 50% of a available moisture is 10 days?

3. A clayey soil has a f.c of 35% & pwp of 20%. If the Specific wt. of the soil is 12.75 kN/m³, the available moisture holding capacity in 80 cm depth of soil, constituting the root zone depth of a crop, is 15.6 cm?