Chapter 3

Irrigation

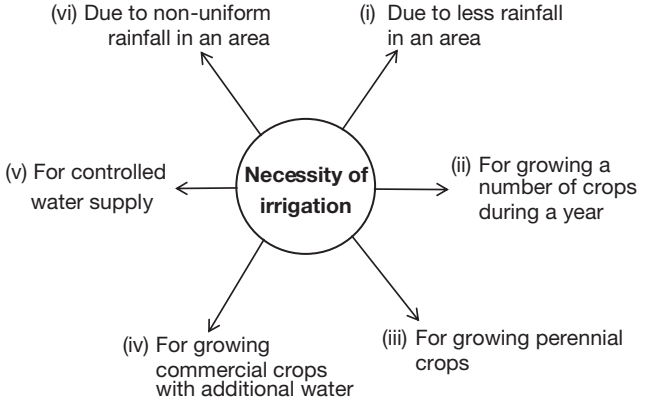
CHAPTER HIGHLIGHTS

- *Introduction*
- *Types of irrigation*
- *Methods of irrigation*
- *Water requirements of crops*
- *Irrigation efficiencies*
- *Irrigation requirements of crops*
- *Crop seasons*
- *Quality of irrigation water and sodic soils*
- *Water logging and drainage*

Introduction

Irrigation is the process of artificially supplying water to the soil for raising crops. This chapter consists of irrigation, its necessities, ill effects and methods of irrigation and the technical terminologies related to irrigation.

Necessity of Irrigation



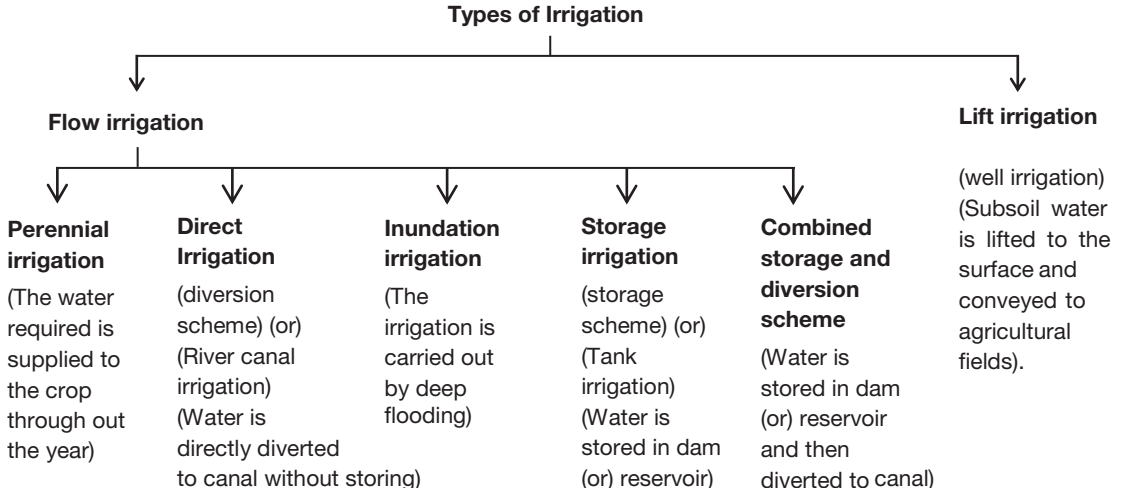
Benefits of Irrigation

1. Increase in food production
2. Protection from famine
3. Cultivation of cash crops
4. Eliminating mixed cropping
5. Addition to the wealth of the country
6. Generation of hydroelectric power
7. Domestic and industrial water supply
8. Inland navigation
9. Canal planting
10. Improvement of ground water storage

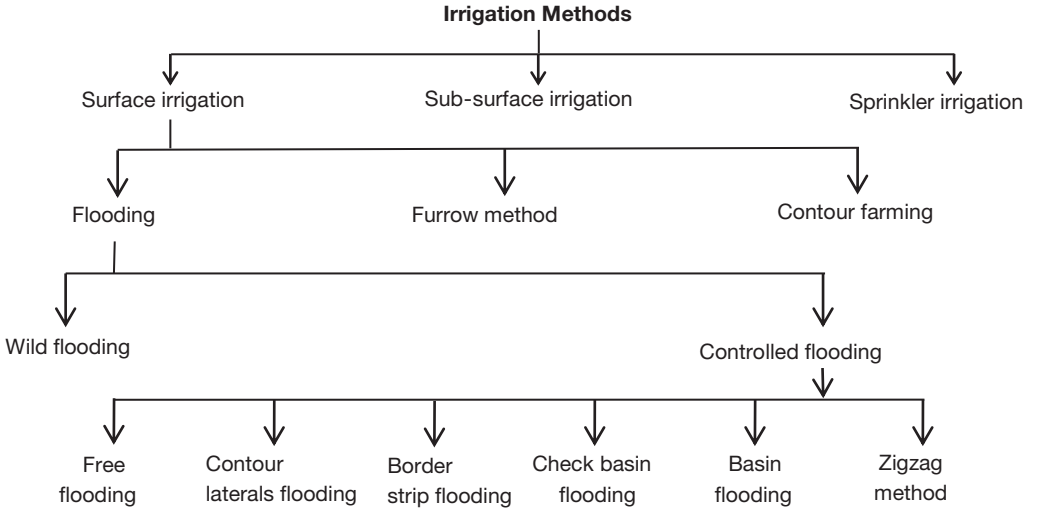
Ill Effects of Irrigation

1. Breeding places of mosquitoes
2. Water logging
3. Damp climate

Types of Irrigation



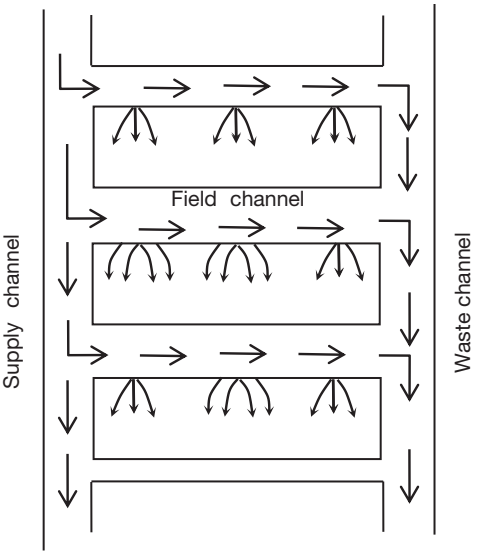
Methods of Irrigation



Surface Irrigation

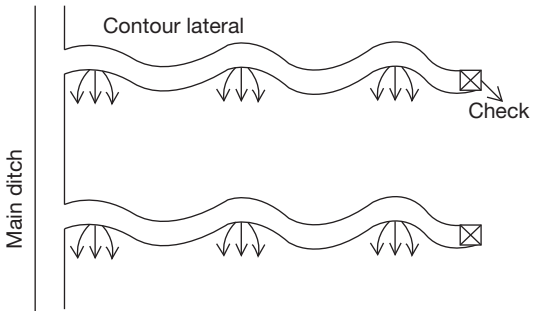
The surface irrigation is the method of supplying water by spreading on land.

1. **Uncontrolled flooding:** Water is spread on the surface of land without any control. It is practiced largely where irrigation is abundant and inexpensive or controlled by field channels.
2. **Free flooding or controlled flooding by field channels:** Water is spread over a land with proper method of control and depth of application.



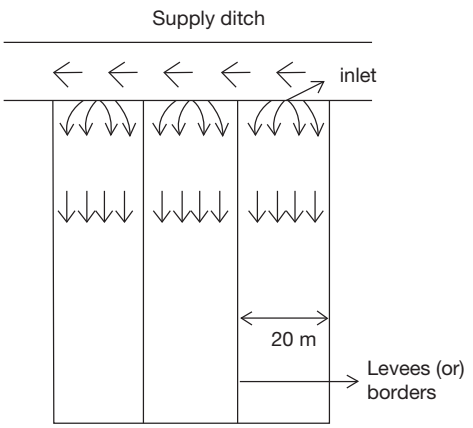
Field channel

3. **Flooding by contour laterals:** This is a type of flooding in which the field channels or laterals are aligned along the contour lines. This is mostly preferred in areas of steeper terrain.



Counter laterals

4. **Border strip flooding method:** A farm is divided into series of strips of 10 to 20 metres wide and 100 to 300 metres long. The strips are separated by borders that run down the predominant or any other desired slope.



Border strip method

The time required to cover area A using border strip method is

$$t = \frac{y}{I} \log_e \frac{Q}{Q - IA}$$

Where

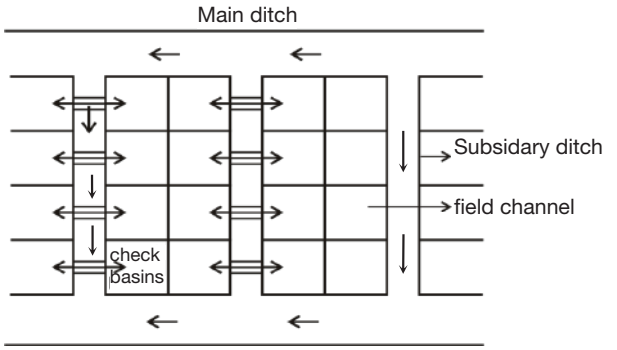
A = Area of land covered at any time t.

y = Average depth of sheet of flowing water, in metres

I = Rate of infiltration in m/hour

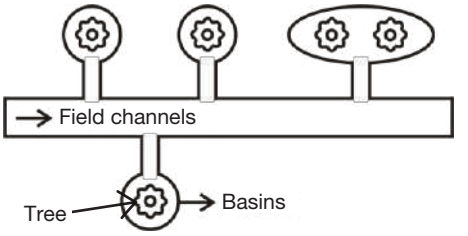
Q = discharge of strip in ha-m/hour

5. **Check flooding:** In check flooding the water is controlled by surrounding the check area with low, flat levees surrounding each check. This method is also known as irrigation by plots.



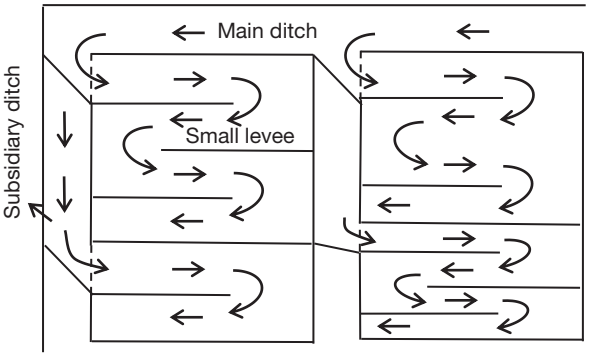
Check flooding

6. **Basin flooding:** It is generally adopted for orchards. In this method basins are formed of each tree or two or more trees. Water is supplied to these basins through supply ditch.



Basin flooding

7. **The zigzag method:** The whole area is divided into number of square or rectangular plots. Each plot is then sub divided into low bunds or levees. This method is generally suitable for level plots.



Zigzag method

8. **Furrow method:** This method is much used for maize, jowar, sugarcane, cotton, etc. This method consists of narrow ditches of length 3 m each. The spacing of furrows is kept from 1 m to 2 m and the depth of furrow varies from 20 to 30 cm. The furrows can be straight furrows, and contour furrows.

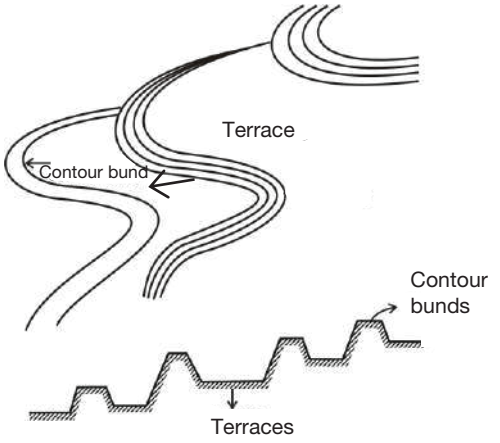
The average depth of water application

$$d = \frac{3600qt}{WL}$$

Where

q = Discharge in the furrow, in lit/s
t = Duration of irrigation, in hours
W = Spacing of furrows, in metres
L = Length of furrows, in meters

9. **Contour farming:** It is generally practiced in hilly areas with steep slopes. The land is prepared in the form of bunds with terraces in between. It is most suitable method for tea plantations.



Counter farming

Sub-surface Irrigation

The supply of water directly to the roots of the plants is known as sub-surface irrigation. This can be done in two ways:

1. Natural sub-surface irrigation
2. Artificial sub-surface irrigation

Sprinkler Irrigation

The water is applied in the form of a spray. It can be done by permanent system, semi-permanent system, and portable system. The discharge required through each rotating sprinkler is given by

$$q = \frac{S_l \times S_m \times I}{3600}$$

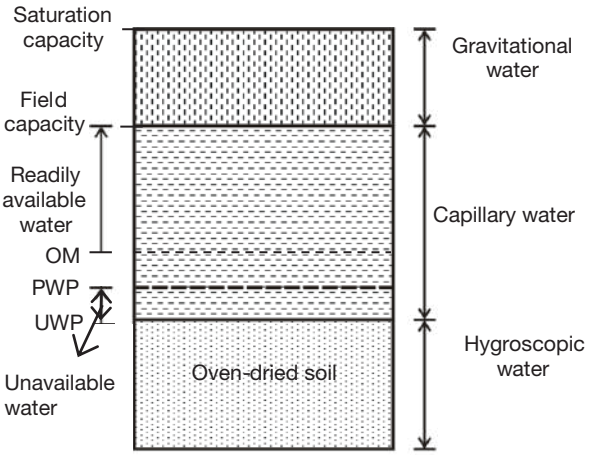
Where

q = Discharge required from each sprinkler (lit/s)
S_l = Spacing of sprinklers along the laterals (m)
S_m = Spacing of laterals along mains (m)
I = Optimum water application rate (mm/h)

Water Requirements of Crops

The water holding capacity of soil is the main characteristics which has to be taken into account for ideal irrigation. Thus the following topics deal with the water holding characteristics of soil and the parameters which help to measure it.

Classes of Soil Water



1. **Saturation capacity:** The amount of water required to fill the pore spaces between soil particles by replacing all air held in pore spaces. It is also called maximum moisture holding capacity or total capacity.
2. **Field capacity:** It is the moisture content of soil after free drainage has removed most of gravity water. It is the upper limit of water content available to plant roots.
3. **Permanent wilting point:** Plants can no longer extract sufficient water from the soil for its growth. This is also known as wilting coefficient. If the plant does not get sufficient water to meet its needs, it will wilt permanently. For most of the soils wilting coefficient is about 150% of hygroscopic water.
4. **Temporary wilting:** This will take place on a hot windy day but plant will recover in cooler day.
5. **Ultimate wilting:** At ultimate wilting point the plant will not regain its turgidity even after addition of sufficient water to the soil and the plant will die. It is similar to hygroscopic coefficient.

   Hygroscopic coefficient = $\frac{2}{3}$ (permanent wilting point)
6. **Available moisture:** Moisture content of soil between field capacity and permanent wilting point.
7. **Readily available moisture:** 75% of available moisture is known as readily available moisture.

   Readily available moisture depth, $d_w = S \times d$ (Field capacity – Optimum moisture) = Sd (FC – OM)
8. Moisture equivalent = Field capacity = (1.8 to 2) × (Permanent wilting point) = 2.7 (Hygroscopic coefficient)
9. Available moisture depth = (d_w)
   $= S_g \times d \times [F_C - w_C]$

Where

S_g = Apparent specific gravity of soil

$= \frac{\gamma_d}{\gamma_w}$

F_c = Field capacity

w_c = Wilting coefficient.

SOLVED EXAMPLES

Example 1

The root zone of an irrigation soil has dry weight of 15 kN/m^3 and field capacity of 30%. The root zone depth of a certain crop, having permanent wilting percentage 8% is 0.8 m. Determine:

1. Depth of moisture in root zone at field capacity.
2. Depth of moisture in root zone at permanent wilting point.

Solution

Depth of soil = 0.8 m

Depth of water in root zone at field

$$= \frac{\gamma_d}{\gamma_w} \times F_C \times d = \frac{15}{9.81} \times 0.3 \times 0.8 = 0.367 \text{ m} = 367 \text{ mm}$$

Depth of water in root zone at permanent wilting point $= \frac{\gamma_d}{\gamma_w} \times$ permanent wilting point $\times\, d = \frac{15}{9.81} \times 0.08 \times 0.8$

$= 0.0978$ m/m $= 97.8$ mm/m.

10. **Frequency of irrigation**

$$f = \frac{d_w}{c_u}$$

Where

d_w = Readily available moisture depth

c_u = Evapotranspiration loss

11. **Base period:** Total time between first watering done for preparation of land for sowing of crop and last watering done before its harvesting is called base period.
12. **Crop period:** Total time elapsed between sowing of crop and its harvesting is called crop period.
13. **Duty (D):** It is the area of land in hectares which can be irrigated for growing any crop if one cumec of water is supplied continuously to the land for entire base period of crop.
14. **Delta (Δ):** Total depth of water over the irrigated land required by a crop grown on it during the entire base period of the crop.

Crop	Average Delta (cm)
Rice	120
Wheat	37.5
Cotton	45
Tobacco	60
Sugarcane	90

$$\text{Duty} = 8.64 \times \frac{\text{Base period}}{\text{Delta}}$$

$$\therefore \boxed{D = \frac{8.64\,B}{\Delta}} \text{ ha/cumec}$$

B = Base period in days

Δ = delta in metres.

Example 2

What is the discharge capacity required at the outlet to irrigate 2200 hectares of sugarcane having a kor depth of 17 cm and a kor period of 30 days?

Solution

$A = 2200$ ha

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

$$= 8.64 \times \frac{30}{0.17}$$

$= 1524.78$ ha/cumec

$$Q = \frac{A}{D}$$

$$= \frac{2200}{1524.78} = 1.44 \text{ m}^3/\text{s}.$$

(1 cumes = 1 m^3/s)

15. **Consumptive use or evapotranspiration:** It is the total loss of water due to plants transpiration and evaporation from the land. Lysimeter is used to measure C_u.

One cumec day = 8.64 hectare metres, it is a volumetric unit. It is total volume of water supplied @ 1 cumec in a day.

IRRIGATION EFFICIENCIES

1. **Water conveyance efficiency (η_c):** It is the ratio of quantity of water delivered to the field to the quantity of water diverted into the canal system from reservoir.
2. **Water application efficiency (η_a):** It is the ratio of quantity of water stored in the root zone of plants to the quantity of water delivered to the fields.
3. **Water use efficiency (η_u):** It is the ratio of quantity of water used beneficially including the water required for leaching to the quantity of water delivered.
4. **Water storage efficiency [η_s]:** Ratio of quantity of water stored in the root zone during irrigation to the quantity of water needed to bring water content of the soil to field capacity.

Irrigation Requirements of Crops

1. **Consumptive irrigation requirements (CIR):** It is the amount of water required to meet the evapotranspiration needs of a crop

$$\text{CIR} = C_u - R_e$$

R_e = Effective rainfall

2. **Net irrigation requirement (NIR):** Amount of irrigation water required to be delivered at the field to meet evapotranspiration and other needs such as leaching

$$\text{NIR} = C_u - R_e + L_e$$

Where, L_e = leaching

3. Field irrigation requirement (FIR) $= \dfrac{\text{NIR}}{\eta_a}$

4. Gross irrigation requirement (GIR) $= \dfrac{\text{FIR}}{\eta_c}$

Example 3

In an irrigated plot the net irrigation requirement of crop is found to be 14.9 cm, the application efficiency is 80% and the water conveyance efficiency is 70%. What is the gross irrigation requirement (GIR)?

Solution

$\eta_a = 0.8$, $\eta_c = 0.7$

Net irrigation requirement,

NIR = 4.9 cm

Field irrigation requirement,

$$\text{FIR} = \frac{\text{NIR}}{\eta_a} = \frac{14.9}{0.8} = 18.625 \text{ cm}$$

$\therefore$ Gross irrigation requirement, GIR

$$= \frac{\text{FIR}}{\eta_c} = \frac{18.625}{0.7} = 26.607 \text{ cm.}$$

5. **Paleo irrigation:** It is the watering done prior to sowing of crop.
6. **Kor watering:** The first watering after the plants have grown few cm high is known as kor watering
7. **Outlet factor:** Duty of water at canal outlet is known as outlet factor.
8. **Gross command area (GCA):** Total area which can be irrigated by canal system if unlimited quantity of water is available is known as gross command area.
10. **Culturable command area (CCA):** The portion of the GCA which is culturable or cultivable.

$$\text{CCA} = \text{GCA} - \text{Uncultivable area}$$

11. **Culturable cultivated area:** That portion of CCA which is actually cultivated during a crop season.
12. **Capacity factor:** Ratio of mean discharge of canal for a certain duration to its maximum discharge capacity.
13. **Time factor:** Ratio of number of days the canal has actually run during a watering period to the total number of days of the watering period.

Crop Seasons

1. **Kharif crops:** These are the crops which are sown in the month of April and harvested in the month of September.

   Examples: Rice, maize.

2. **Rabi crops:** These are the crops which are sown in October and harvested in March. (Also called winter crops)

   Examples: Wheat, tobacco.

3. **Perennial crops:** These are the crops for which the water is supplied throughout the year.

   Example: Sugarcane

4. **Hot weather crops:** These are the crops which are grown between Kharif and Rabi season, i.e., from February to June.
5. **Summer crops:** The hot weather crops and Kharif crops are combinedly called as summer crops.
6. **Dry crops:** Crops grown without irrigation and depend only on rainfall for survival.
7. **Wet crops:** The crops which require irrigation are known as wet crops.

Example 4

The gross commanded area for a distributary is 6000 hectares, 80% of which is culturable and irrigable. The intensity of irrigation for Kharif season is 25% and that for Rabi season is 50%. If the average duty at the head of distributary is 700 hectares/cumec for Kharif season and 1700 hectares/cumec for Rabi season, find the discharge required for design at the head of distributary.

Solution

GCA = 6000 ha

CCA = 6000 × 0.8 = 4800 ha

Area under Kharif, A = 25% of CCA

$$= \frac{25}{100} \times 4800 = 1200 \text{ ha}$$

Area under Rabi = 50% of CCA

$$= \frac{50}{100} \times 4800 = 2400 \text{ ha}$$

Discharge required for Kharif,

$$Q = \frac{A}{D} = \frac{1200}{700} = 1.714 \text{ m}^3/\text{s}$$

Discharge required for Rabi, $Q = \frac{A}{D} = \frac{2400}{1700} = 1.411 \text{ m}^3/\text{s}$

Design discharge = Higher discharge value required = 1.714 m^3/s.

Quality of Irrigation Water and Sodic Soils

The salt is natural element in soil and water. The main ions responsible for salination are: Na^+, K^+, Ca^{2+}, Mg^{2+}. With the increase of Na^+ ions, soils become sodic.

1. **Exchangeable sodium ratio (ESR):** The concentration of exchangeable sodium ions divided by the sum of concentrations of exchangeable calcium, magnesium, sodium and potassium ions.

$$\text{ESR} = \frac{Na^{++}}{Ca^{++} + Mg^{++} + Na^{++} + K^{+}}$$

   The concentration of all elements are expressed in milli equivalents per liter which is also known as concentration in ppm divided by the equivalent weight of the element.

2. **Sodium adsorption ratio (SAR)**

$$\text{SAR} = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

SAR	Type of water
0–10	Low-sodium water (S_1)
10–18	Medium – Sodium water (S_2)
18–26	High – Sodium water (S_3)
> 26	Very-high sodium water (S_4)

3. **Salt efflorescence:** The phenomenon of the salts coming in solution and forming a thin crust on the surface after evaporating of water is called '*salt efflorescence*'. The saline soils are commonly termed as 'white alkali' soils.

   The electrical conductivity of saline soils is greater than 4 milli mhos/cm (at 25°C) and ESP is less than 15 and pH value is < 8.5.

4. **Sodic soils:** These soils have high concentration of sodium and also called sodiumized or alkaline soil. Alkali soils have electrical conductivity less than 4 milli mhos/cm and pH value > 8.5 and ESP > 15%. These soils are termed as black alkali soils because a black crust forms on the surface of these soils.

   Example: Na_2CO_3.

Water Logging and Drainage

Water Logging

It is the condition in which there is excessive moisture in the soil making the land less productive. The depth of water table at which it tends to make the land, water logged, depends on the

1. height of capillary fringe and
2. type of crop.

Causes of Water Logging

1. Excessive rainfall in the area
2. Flat ground profile
3. Improper drainage of surface run-off
4. Excessive irrigation

Effects of Water Logging

1. Causes anaerobic conditions near roots of plants.
2. Causes salinity of soil.
3. Causes growth of wild aquatic plants.
4. Lowers the soil temperature which effects the activities of bacteria.
5. It makes cultivation difficult as the water logged areas cannot be easily cultivated.

Water Logging Control

1. By providing efficient under drainage
2. By preventing seepage from reservoirs
3. By introducing crop rotation
4. By improving natural drainage of area
5. By introducing lift irrigation

Drainage

It is the means of preventing land from getting water logged as well as to receive the land already water logged.

Exercises

1. If duty (D) is 1428 (hectares/cumec) and base period (B) is 120 days for an irrigated crop, then delta (Δ) in metres is given by
(A) 102.8 (B) 0.73
(C) 1.38 (D) 0.01

2. The total irrigation depth of water required by a certain crop in its entire growing period of 150 days is 25.92 cm. The culturable command area for a distributary channel is 1,00,000 hectares. The distributary channel shall be designed for a discharge of
(A) less than 2 cumecs (B) 2 cumecs
(C) 20 cumecs (D) more than 20 cumecs

3. The moisture content of soil in the root zone of an agricultural crop at certain stage is found to be 0.05, the field capacity of soil is 0.15. The root zone depth is 1.1 m. The consumptive use of crop at this stage is 2.5 mm/day and there is no precipitation during this period. The irrigation efficiency is 65%. It is intended to raise the moisture content to the field capacity in 8 days through irrigation. The necessary depth of irrigation is
(A) 115 mm (B) 169 mm
(C) 200 mm (D) 285 mm

4. A sprinkler irrigation system is suitable when
(A) the land gradient is steep and the soil is easily erodable.
(B) the soil is having low permeability.
(C) the water table is low.
(D) the crops to be grown have deep roots.

5. A canal was designed to supply the irrigation needs of 1000 ha of land growing rice of 140 days base period and having a delta of 130 cm. If the canal water is used to irrigate wheat of base period 119 days and having a delta of 50 cm, the area that can be irrigated as
I. 452 ha
II. 904 ha
III. 1105 ha
IV. 2210 ha
(A) 10 days (B) 15 days
(C) 20 days (D) 25 days

6. A tube well having capacity of 4 m^3/h operates for 20 hours each day during the irrigation season. How much area can be commanded if the irrigation interval is 20 days and depth of irrigation is 7 cm?
(A) 1.71×10^4 m^2
(B) 1.14×10^4 m^2
(C) 22.9×10^4 m^2
(D) 2.29×10^4 m^2

7. A field was supplied water from an irrigation tank at a rate of 120 lit/s to irrigate an area of 2.5 hectares. The duration of irrigation is 8 hours. It was found that the actual delivery at the field, which is about 4 km from the tank was 100 lit/s. The run-off loss in the field was estimated as 800 m^3. The application efficiency situation is
(A) 62% (B) 72%
(C) 76% (D) 80%

8. The canal was designed to supply the irrigation needs of 1200 hectares of land growing rice of 140 days base period having a delta of 134 cms. If the canal water is used to irrigate wheat of base period 120 days having a delta of 52 cms, the area can be irrigated in hectares is
(A) 2650
(B) 3608
(C) 543
(D) None of these

9. A canal irrigates a portion of culturable command area to grow sugarcane and wheat. The average discharge required to grow sugarcane and wheat are, respectively 0.36 and 0.27 cumecs. The time factor is 0.9. The required design capacity of canal is
(A) 0.36 cumecs (B) 0.4 cumecs
(C) 0.63 cumecs (D) 0.7 cumecs

10. What is the moisture depth available for evapotranspiration in root zone of 1 m depth soil, if dry weight of soil is 1.5 gm/cc, field capacity is 30% and permanent wilting point is 10%?
(A) 450 mm (B) 300 mm
(C) 200 mm (D) 150 mm

11. The culturable command area for a distributary is 2×10^8 m^2. The intensity of irrigation for a crop is 40%. If Kor depth and kor period for crop are 14 cm and 4 week respectively, the demand discharge is
(A) 2.63 m^3/s (B) 4.63 m^3/s
(C) 8.58 m^3/s (D) 11.58 m^3/s

12. In a cultivated area the soil has porosity of 45% and the field capacity of 38%. For a particular crop, the root zone depth is 1 m, the permanent wilting point is 10% and consumptive use is 15 mm/d. If the irrigation efficiency is 60%, what would be the frequency of irrigation such that moisture content does not fall below 50% of maximum available moisture?
(A) 5d (B) 6d
(C) 9d (D) 15d

13. In a canal irrigation project, 76% of the culturable command area (CCA) remained without water during kharif season; and 58% of CCA remained without water during Rabi season in a particular year. Rest of the areas got irrigated in each crop respectively. What is the intensity of irrigation for the project in the year?
(A) 134% (B) 76%
(C) 66% (D) 58%

14. Consider the following zones:
I. Saturation zone
II. Capillary zone
III. Intermediate zone
IV. Soil water zone

Which of these does not relate to the zone of aeration in the soil profile?
(A) I and II (B) II and III
(C) IV only (D) I only

15. **Assertion (A):** If the soil moisture is only slightly more than the slightly more than the wilting coefficient, the plant must expend extra energy to obtain the water and hence the plant will not grow healthily.

Reason (R): Excessive water supply retards plant growth.
(A) A and R are true R is the correct explanation of A.
(B) A and R are the true R is not correct explanation of A.
(C) A is true R is false.
(D) A is false R is true.

16. Consumptive use of water for a crop is equal to the depth of water
(A) evaporated by the crop.
(B) transpired by the crop.
(C) transpired and evaporated by the crop
(D) used by the crop in transpiration, evaporation and also the quantity of water evaporated from adjacent soil.

17. Effective Precipitation for a crop may be defined as
(A) total precipitation from sowing of seeds to cutting of crop.
(B) total precipitation minus loss due to evaporation and infiltration.
(C) total precipitation minus runoff.
(D) available water stored in soil within root zone of the crop.

18. The best method of irrigation for mango trees is
(A) border strip method.
(B) basin method.
(C) checks or leeves method.
(D) furrow method.

19. Main causes of water logging are
(A) surface run-off.
(B) steep ground profile.
(C) excessive irrigation.
(D) All of these

20. If pH < 8.5, the soil is called
(A) acidic soil. (B) saline soil.
(C) basic soil. (D) alkaline soil.

21. To irrigate a strip of area of size 100 m × 5 m, the time taken is 50 minutes. Assuming average depth of water is 8 cm and average infiltration is 4 cm/h. Find the discharge of stream flow in cumecs?
(A) 0.04 cumecs (B) 0.0163 cumecs
(C) 0.023 cumecs (D) 0.0368 cumecs

22. Find the Exchangeable Sodium Ratio (ESR) where the concentrations of all Sodium, Calcium, Magnesium and Potassium are 161, 200, 108, and 156 in ppm respectively.
(A) 83.33% (B) 43.63%
(C) 68.73% (D) 23.33%

23. An area of 1 hectare has a root zone depth of 1.2 m and available moisture holding capacity is 14 cm per metre depth. It is irrigated through a stream of 0.04 m^3/s. Water is applied to field when 60% of the available moisture is depleted. Irrigation period is 9 hours. If the water application efficiency is 70%, determine the storage efficiency.
(A) 64.3% (B) 72%
(C) 58% (D) 49%

24. The moisture content of soil in the root zone of an agricultural crop at certain stage is found to be 0.06. The field capacity of the soil is 0.14. The root zone depth is 1.6 m. The consumption use of crop at this stage is 3 mm/day and there is no precipitation during this period. Irrigation efficiency is 60%. It is intended to raise the moisture content to the field capacity in 9 days through irrigation. The necessary depth of irrigation in (mm) is _____.
(A) 250 (B) 257
(C) 300 (D) 310

25. The transplantation of chilli crop takes 20 days and the total depth of irrigation water required by the crop is 50 cm on field. During this period, useful rainfall on field is 10 cm. Find the duty of irrigation water for this crop on the field during transplantation period. Assuming 30% losses of water in water course, find the duty at the head of water course in hectares/cumec.
(A) 208 (B) 250
(C) 302 (D) 350

26. Moisture equivalent is equal to
(A) field capacity. (B) saturation capacity.
(C) available moisture. (D) ultimate wilting.

27. Indentify the incorrect statement related to the adverse effects of soil salinity or alkalinity, from the following:
(A) Causing low yields of crops
(B) Limiting of the type of crops
(C) Rendering the quality of folder poor
(D) Causing high infiltration, resulting in damage to crops

Direction for questions 28 and 29:
A 600 sq. km watershed received a 8 hours storm which produced hourly intensities of 4, 10, 16, 20, 11, 2, 13, 4 mm/h. If the initial abstractions are estimated to be 14 mm and ϕ-index is 5 mm/h.

28. What would be the run-off volume produced by the storm (in h.m)
(A) 2400 (B) 2000
(C) 3000 (D) 2800

29. What would be the area that can be irrigated, if the above run-off is utilized without wastage to irrigate a land where the depth of irrigation required is 20 cm.
(A) 12000 ha (B) 10000 ha
(C) 15000 ha (D) 14000 ha

30. The following data pertains to the healthy growth of a crop. Field capacity of soil = 40%, permanent witting percentage = 11%, density of soil = 1400 kg/m^3, effective depth of root zone = 800 mm, daily consumptive use of water for the given crop = 15 mm. For healthy growth moisture content must not fall below 25% of the water holding capacity between the field capacity and the permanent witting point. Determine the watering interval in days.
(A) 13 (B) 14
(C) 15 (D) 16

31. Match List I with List II

	List I		List II
P.	CIR	**1.**	$\frac{C_u + R_e + w}{\eta_a}$
Q.	NIR	**2.**	$\frac{C_u - R_e + w}{\eta_a \cdot \eta_c}$
R.	FIR	**3.**	$C_u - R_e$
S.	GIR	**4.**	$C_u - R_e + w$

CIR – Consumptive Irrigation Requirement
NIR – Net Irrigation Requirement
FIR – Field Irrigation Requirement
GIR – Gross Irrigation Requirement
C_u – Consumptive Use
R_e – Effective Rainfall
w – Water lost in deep percolation
η_a – water application efficiency
η_c – water conveyance efficiency

	P	Q	R	S		P	Q	R	S
(A)	4	3	1	2	(B)	3	4	1	2
(C)	3	4	2	1	(D)	4	3	2	1

Direction for questions 32 and 33:

For border strip method of irrigation, discharge in an area from tube well was 0.01 cumecs. The infiltration capacity of the soil may be taken as 6 cm/h and the average depth of the flow on the field as 10 cm.

32. Determine the time required to irrigate strip of land of 0.05 hectares.
(A) 0.48 hours (B) 48 minutes
(C) 2.98 hours (D) 298 minutes

33. Determine the maximum area that can be irrigated from this tube well.
(A) 0.001 ha (B) 0.02 ha
(C) 0.06 ha (D) 0.2 ha

34. The moisture tension of soil is 8 atm. The soil is then at
(A) permanent wilting point.
(B) field capacity.
(C) optimum moisture content.
(D) equivalent moisture.

35. A field measures 40 hectares. When 8 cumecs of water was supplied for 6 hours, 30 cm of water was stored in root zone. The field application efficiency is nearly.
(A) 70% (B) 80%
(C) 85% (D) 90%

36. The discharge capacity required at the outlet to irrigate 300 ha of sugar cane having a kor depth of 173 mm and a kor period of 30 days is
(A) 2 m^3/s (B) 1 m^3/s
(C) 20 m^3/s (D) 0.2 m^3/s

37. An identified source of irrigation water has ion connect rations of Na^+, Ca^{++} and Mg^{++} as 20, 10 and 8 millequivalent per litre respectively. The SAR of this water is approximately.
(A) 2.06 (B) 6.67
(C) 2.67 (D) zero

38. Given that the base period is 100 days and the duty of the canal is 100 hectares per cumecs, the depth of water will be.
(A) 0.864 cm (B) 8.64 cm
(C) 86.4 cm (D) 864 cm

39. Duty of a crop is defined as
(A) water required for irrigating unit area of land.
(B) area irrigated by unit volume of water.
(C) depth of water required for irrigating unit area of land.
(D) Both A and B

40. The following is not an advantage of trough stage/alluvial plain in a river
(A) the water contains silt and other fertilizing material.
(B) subsoil flow is comparatively less.
(C) cross-drainage works across the canals are less.
(D) less river training works are required.

41. The transplantation of rice crop takes 15 days and the total depth of irrigation water required by the crop is 50 cm on the field. During this transplantation period, the useful rain falling on the field is 6 cm. Find the duty of irrigation water for this crop at the head of water course assuming 25% losses of water in water course.
(A) 186.9 ha/cumec
(B) 200.9 ha/cumec
(C) 220.9 ha/cumec
(D) 243.9 ha/cumec

42. A small village has shortage of power supply and so a pump connected to a tube well can be operated only for an hour to irrigate a land of 0.2 hectares having Rabi crops. Average depth of flow is expected to be 9.5 cm. Find the discharge required from the tube well if infiltration rate for the soil is 6 cm/h.

(A) 0.069 m^3/s
(B) 0.042 m^3/s
(C) 0.035 m^3/s
(D) 0.021 m^3/s

Previous Years' Questions

1. The consumptive use of water for a crop during a particular stage of growth is 2 mm/day. The maximum depth of available water in the root zone is 60 mm. Irrigation is required when the amount of available water is 50% of the maximum available water in root zone. Frequency of irrigation should be _____. **[GATE, 2007]**

2. The culturable command area for a distributary channel is 20,000 hectares. Wheat is grown in entire area and intensity of irrigation is 50%. The kor period for wheat is 30 days and kor water depth is 120 mm. The outlet discharge for distributary should be **[GATE, 2007]**

(A) 2.85 m^3/s (B) 3.21 m^3/s
(C) 4.63 m^3/s (D) 5.23 m^3/s

3. A outlet irrigates an area of 20 ha. The discharge (*l*/*s*) required at this outlet to meet the evapotranspiration requirements of 20 mm occurring uniformly in 20 days neglecting other field losses is _____. **[GATE, 2008]**

(A) 2.52 (B) 2.31
(C) 2.01 (D) 1.52

4. An agricultural land of 437 ha is to be irrigated for a particular crop. The base period of crop is 90 days and the total depth of water required by the crop is 105 cm. If the rainfall of 15 cm occurs during base period, the duty of irrigation water is **[GATE, 2009]**

(A) 437 ha/cumec (B) 486 ha/cumec
(C) 741 ha/cumec (D) 864 ha/cumec

Direction for questions 5 and 6:
Moisture holding capacity of soil in a 100 hectare farm is 18 cm/m. The field is to be irrigated when 50 per cent of the available moisture in root zone is depleted. The irrigation water is to be supplied by a pump working for 10 hours a day and water application efficiency is 75%. Details of crops planned for cultivation are as follows: **[GATE, 2010]**

Crop	Root Zone (m)	Peak Rate of Moisture Use (mm/day)
X	1.0	5.0
Y	0.8	4.0

5. The capacity of irrigation system required to irrigate crop X in 36 hectares is

(A) 83 lit/s (B) 67 lit/s
(C) 57 lit/s (D) 53 lit/s

6. The area of crop Y that can be irrigated when the available capacity of irrigation system is 40 lit/s is

(A) 40 hectares (B) 36 hectares
(C) 30 hectares (D) 27 hectares

7. Wheat requires 55 cm of water during 120 days of base period. The total rainfall during this period is 100 mm. Assuming the irrigation efficiency to be 60%. The area of land which can be irrigated with canal flow of 0.01 m^3/s is **[GATE, 2012]**

(A) 13.82 (B) 18.85
(C) 23.04 (D) 230.4

8. The transplantation of rice requires 10 days and total depth of water required during transplantation is 48 cm. During transplantation, there is an effective rainfall of 8 cm. The duty of irrigation water in hectare/cumec is **[GATE, 2013]**

(A) 612 (B) 216
(C) 30 (D) 108

9. Irrigation water is to be provided to a crop in a field to bring the moisture content of the soil from the existing 18% to the field capacity of soil at 28%, the effective root zone of the crop is 70 cm. If the densities of soil and water are 1.3 g/cm^3 and 1 g/cm^3 respectively, the depth of irrigation water required for irrigating crop is **[GATE, 2014]**

(A) 91 mm (B) 89 mm
(C) 83 mm (D) 95 mm

10. The two columns below show some parameters and their possible values. **[GATE, 2015]**

Parameter	Value
P. Gross Command Area	I. 100 hectares/cumec
Q. Permanent Wilting Point	II. 6°C
R. Duty of canal water	III. 1000 hectares
S. Delta of wheat	IV. 1000 cm
	V. 40 cm
	VI. 0.12

Which of the following options matches the parameters and the values correctly?

(A) P-I, Q-II, R-III, S-IV
(B) P-III, Q-VI, R-I, S-V
(C) P-I, Q-V, R-VI, S-II
(D) P-III, Q-II, R-V, S-IV

11. The channel has cultivable commanded area of 2000 hectares. The intensities of irrigation for gram and wheat are 30% and 50% respectively. Gram has a kor period of 18 days, kor depth of 12 cm, while has a kor period of 18 days and a kor depth of 15 cm. The discharge (in m^3/s) required in the field channel to supply water to the commanded area during the kor period is _____. **[GATE, 2015]**

Answer Keys

Exercises

1. B	**2.** D	**3.** D	**4.** A	**5.** D	**6.** D	**7.** B	**8.** A	**9.** D	**10.** B
11. B	**12.** B	**13.** C	**14.** D	**15.** B	**16.** D	**17.** D	**18.** B	**19.** C	**20.** B
21. B	**22.** D	**23.** A	**24.** C	**25.** C	**26.** A	**27.** D	**28.** A	**29.** A	**30.** D
31. B	**32.** C	**33.** C	**34.** A	**35.** A	**36.** A	**37.** B	**38.** C	**39.** B	**40.** D
41. C	**42.** A								

Previous Years' Questions

1. B	**2.** C	**3.** B	**4.** D	**5.** B	**6.** D	**7.** A	**8.** B	**9.** A	**10.** B
11. 1.4275									