BCS written, note.

Irrigation Engineering

Prepared by.

Engr. Mohammad Elias.
BCS (Public Works)
Merit position-01
01735-440910

☐ Irrigation engineering

- Important of irrigation, source of irrigation, quality of irrigation water. soil-water relationship;
- consumptive use, field-irrigation structures.
- land drainage; flood and its mitigation, methods of river training and bank protection. = N.N. Basak

18 - Basak

C-1, 2, 8, 9, 18, 20, 2

- Estimation of irrigation water requirements, methods of irrigation, irrigation canal system, irrigation pumps and wells, problems of irrigated lands. = S.K. Garge

water logging - Basak

c-12, 6, 7.48, 8, 16, 2

Engr. Mohammad Elias.
Asst. Engr. PWD. (Recomm.).
38th. BCS.
Mob. 01735-440910.
Fb. Engr Mohammad Elias.

ⓐ Define irrigation

Irrigation is defined as the science of artificial application of water to the land in accordance with the crop requirements throughout the crop period for full-fledged nourishment of the crops.

ⓑ Importance of irrigation:

Adequate quantities of water is required near the root zone of the plants for their growth. During crop period the rainfall may not be adequate to fullfil the water requirement. The intensity of rainfall is practically uncertain and beyond the control of human power. and it may not be well distributed throughout the crop season or the culturable area. So irrigation becomes absolutely necessary to fullfil the water requirement of crops. Irrigation is important for the following factors:

9✓

a) Insufficient rainfall: When the seasonal rainfall is less than the minimum requirement for the satisfactory growth of crops, the irrigation system is essential.

b) Uneven distribution of rainfall: When the rainfall is not evenly distributed during the crop period or throughout the cultrable area the irrigation is extremely necessary.

c) Impraovement of perennial crops: Some perennial crops like sugarcane, cotton etc require water throughout the major part of the year. But rainfall may fulfil the water requirement in rainy season only. So, for the remaining part of the year, irrigation becomes necessary.

d) Development of agricultre in Desert area. Irrigation is highly required for the development of agricultre where the rainfall is very scanty.

⊘ What are the advantages of irrigation and its ill effects ??.

Advantages:

1. Increase in food production: Irrigation helps in increasing crops yields, and hence to attain self-sufficiency in food.

2. Improvement of ash crops: Irrigation helps to improve the cultivation of cash crops like tobacco, vegetables, fruits etc.

3. Prosperity of farmers: when the supply of irrigation water is assured. The farmers can grow too or more crops in a year on the same land. thus the farmers may earn more money and improve their living standard.

4. Source of revenue: When irrigation water is supplied to the cultivators in lieu of some taxes, it helps to earn revenue which may be spent on other development schemes.

5. Navigation: Irrigation canals may be utilised for inland navigation which is further usefull

for communication and transportation of agricultural goods.

6. Water Supply: The irrigation canal may be the source of water supply for domestic and industrial purposes.

7. General Communication: The inspection road along the canal banks provides good roadways to the villagers for walking, cycling etc.

8. Afforestation: Trees are generally grown along the banks of the channels which increase the timber wealth of the country and also help in reducing soil erosion and air pollution.

ⓑ Ill-Effects of irrigation:

a) Irrigation may result in colder and damper climate, resulting in marshy lands and breeding of mosquitoes, causing outbreak of diseases like malaria and dengue.

b) Over irrigation may lead to water-logging and may reduce crop yields.

c) Procerring and supplying irrigation water is complex and expensive in itself.

d) Sometimes, subsidised cheaper water has to be provided at the cost of the government which reduces revenue returns.

▨ Source of irrigation water.

1. River: It is the main natural sources of irrigation water. Most of the irrigation project are constructed based on the river flow like tista, Meghna, padma etc.
2. Rain water: It is the another source of irrigation water.
3. Tube wells are also important sources of irrigation.
4. Well is also a frequently used source of irrigation.

⑩ What are the quality of irrigation water ??

P- 38. Basak

The quality of suitable irrigation water is much influenced by the constitients of the soil which is to be irrigated. The following are the impurities which make the water unfit for irrigation.

1. Sediment concentration in water: sediment of

2. fine silt improve the soil fertility. All other sediment decreases the fertility.

2. Total concentration of soluble salts in water:

The presence of Calcium, Magnesium, Sodium and K may harmful to crops if it exceeds 700 P.P.M. Electrical conductivity of saline water is helpful t upto 250 micro mhos/cm.

low conductivity water	C_1 = 250 mic mh
Medium " "	C_2 = 250-250
High " "	C_3 = 750-2250
very high " "	C_4 > 2250

3. Proportion of sodium ions to other cations:

The percentage of solium ions should be less tha 5. If the percentage increases to more than 1 it is injurious to crops. The proportion of sodium ions is designated by a factor which is know

a) Sodium Absorption Ratio (SAR)

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

SAR:	1~10	low Sodum water	(S_1)
	10~18	Medium " "	(S_2)
	18~26	High " "	(S_3)
	>26	very high	(S_4)

(SAR can be reduced by adding gypsum $CaSO_4$ to H_2O)

4. <u>concentration of potentially toxic elements present in water.</u>

Some elements are toxic to the crops. Intially Boron is useful for the growth of crops up to 0.3 ppm. More than this limit it may be toxic to the plants. The concentration of selenium is also toxic to the plant.

5. Bi-carbonate concentration: The concentration of Ca and Mg bi-carbonates increases the proportion of sodium ions which is hazardous for the plants life.

6. Bacterial contamination: The bacterial contaminatio is not directly harmful to the plants. But the food grains or fruits which are grown by the bacterial contaminated water may be harmful to humans being.

⑪ Soil-Water Relationship. P-34 Basak

When water is spread over the soil either by irrigati or rainfall, The water is absorbed by the pores of the soil. This water is termed as soil water/soil moistu following are the various forms of soil-water.

a. Gravitational water: The surface water which starts flowing downwards due to the influence of gravity is known as gravitational water. It is not useful fo plant as it flow out rapidly and it can not be absorbe by the rootzone.

b. Capillary Water: The portion of water retained by the soil after completely eliminating the gravitatio water is known as capillary water. This water gets absorbed by the roots of the plants. So it is a vital for the growth of crops.

c. Permenent Wilting point: It is defined as the ~~ab~~ amount of moisture held by soil which can not be extracted by the plants roots for transpira At this point wilting of the plant occurs.

d. Hydroscopic Water: The water content below the permanent wilting point is known as hydroscopic water. This water can not be extracted or absorbed by the root of the plants. So at this stage growth of the plants is stopped and ultimately the plants are dead.

e. Field capacity: It is defined as the max^n moisture that can be held by the soil against gravity. It is expressed as percentage.

—

*** Relation between Duty and delta.

Let. D = duty of water in hectares/cumec.
B = base in days.
Δ = Delta in m.

from definition, One cumec of water flowing continously for 'B' day gives a depth of water 'Δ' over an area 'D' hectares. That is.

1 cumec for B days gives Δ over D hectares

$\because$ 1 " " 1 " $\frac{\Delta}{B}$ " D "

$\because$ 1 " " 1 " $= \frac{\Delta}{B} \times D$ hectares.m.

So 1 cumec-day $= \frac{D}{B} \times \Delta$ hec.m.

Again. 1 cumec-day = 1×24×60×60 = 86400 m³
= 8.64 hectares-m

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

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

$= \frac{864\ B}{D}$ cm — (Ans)

◫ Consumptive use. ***

Consumptive use of water is defined as the total amount of water used for the growth of the plants by transpiration and evaporation from adjacent soil or from plant leaves.

It is ascertained to know the water requirement for each crop. The value of consumptive use of water varies from time to time, crop to crop, and even from place to place.

7.34.2.3

● factors affecting consumptive use. P-57. Basak
P-265 - Garg

following factors affect the consumptive use of water.

1. Area of the water surface. If the area of the water surface is large the evaporation will be more and vice-versa.

2. Depth of water: If depth of water is less the evaporation will be more and vice-versa.

3. Humidity: If the humidity of the atmosphere is more evaporation will be less and vice versa.

4. Temperature: The process of evaporation also depend on the temperature. If the temperature is more the saturation vapor pressure increases and the evaporation increases. and vice versa.

5. Wind Velocity: If the wind velocity is more, the process of vaporization becomes easier. and loss of evaporation becomes more and vice-versa.

6. Atmospheric pressure: If the atmospheric pressure is more, the evaporation will be less and vice-versa.

2. Quality of water: Quality of water also affect the consumptive use. Dissolved salts, turbidity reduces the saturated vapor pressure of water. Which consequently reduces the rate of evaporation.

Methods of consumptive use. (P-66. Garg)

Various methods have been developed in order to estimate consumptive use. Most simple and commonly used methods are.

1. Blaney-Criddle Equation.
2. Hargreaves clas. A pan evaporation method
3. Penman's equation.

Blaney-Criddle equation: It states that the monthly consumptive use is given by

$$C_u = \frac{K.P}{40}(1.8t+32).$$

C_u = Monthly consum. use (cm)
K = Crop factor
t = Mean monthly tem(°C)
P = Monthly % of annual daylight hours.

2. Hargreaves class A pan evaporation method.

In this method evapotranspiration /consumptive use is related to pan evaporation by a constant K, called consumptive use co-efficient. The formula can be written as: $K = \frac{\text{Evapotranspiration } (C_u \text{ or } E_t)}{\text{Pan evaporation } (E_p)}$.

$\Rightarrow E_t$ or $C_u = K \cdot E_p$.

3. Penman's equation: It is given by :

$$E_t = \frac{A H_n + E_a \gamma}{A + \gamma}$$

E_t = Daily potential consump. use.

A = Slope of saturation vapour pressure vs temp.

H_n = Net incoming solar radiation.

E_a = A parameter including wind velocity and saturation deficit.

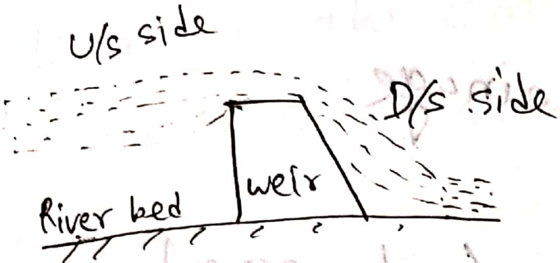
γ = Psychromatic constant = 0. 49 mm of Hg/°C

⊘ field irrigation structures: (P- 6. N.N. Basak)

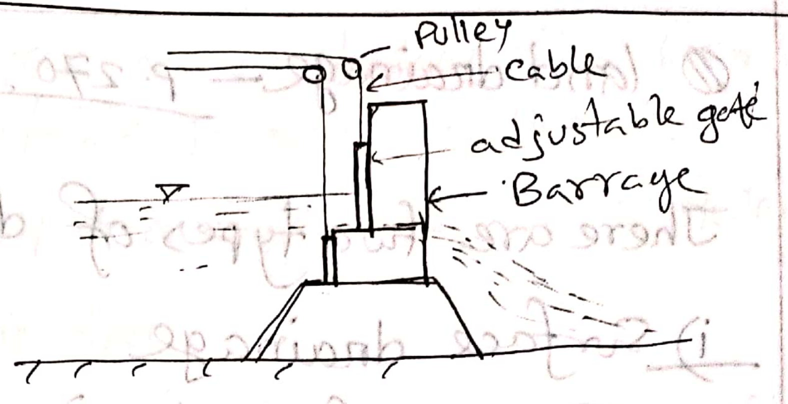
Weir: An impervious barrier which is constructe across a river to raise the water level on the upstream side is known as weir. Here the water leve is raised upto the required height and the surplus water is allowed to flow over the weir.

Barrage: When adjustable gates are installed over a weir to maintain water surface at different leve at different times. Then its known as barrage

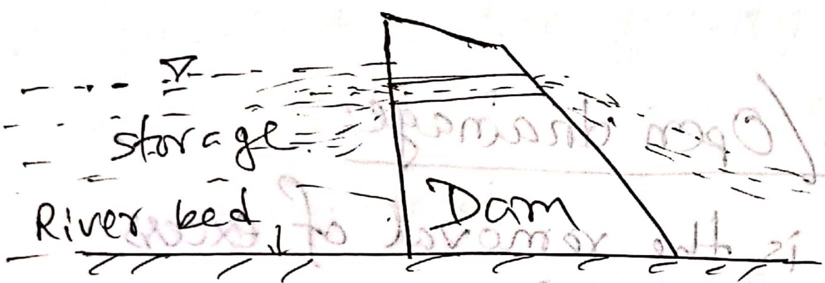
Dam: The high impervious barrier constructed across a river valley to form a deep storage reservoir is known as dam. The surplus water is not allowed to flow over the dam but it flows through the spillways provided at some designed level.



Weir.



Barrage



Dam

figure: Field irrigation structures.

⊘ land drainage — p. 270. Basak / 251-G.

There are two types of drainage
i) Surface drainage
ii) Sub-surface drainage / underground drainage.

Surface drainage / Open drainage:

Surface drainage is the removal of excess rain water falling on the fields or the excess irrigation water applied to the field. by constructing open ditches, field drains, and other related structures. The land is sloped towards these ditches or drains as to make the excess water flow in to these drains.

Sub-Surface Drainage:

Underground drainage is provided to remove the excess irrigation farm water. As a result plants get air as well as moisture in their root zones for their survival.

If no impervious layer occurs below the farm land and the watertable is low (lower than 3m from G.L) internal soil drainage may be sufficient. and no tile drains needed.

Advantages of tile drains/Underground drainage:

i. Removes the free gravity water.

ii. Increase the volume of soil from which roots can obtain food.

iii. Increase air circulation.

iv. Increases bacterial activity in soil. which makes the soil fertile.

v) Reduce soil erosion.

vi) Reduces and removes toxic substances such as sodium and other soluble salts.

[Math. P-262]

tile drain

⊘ Flood and its mitigation. (Math-420.6)

Flood: In rainy season, When heavy rainfall occurs in the catchment Area, The discharge of the river is increased and sometimes it exceeds the normal carrying capacity of the river. The surplus water overtops the bank of the river and submerges the sorrounding areas consisting of villages and agricultural lans. this phenomenon is knoan as flood.

Causes of flood: (P-298. Basak)

1. **Intensity of rainfall:** The intensity of rainfall in the catchment area is the main causes of flood. If the rainfall is heavy and storm duration is longer, then the surface run-off will be increased unexpectedly and it may exceed the normal carrying capacity of the river. and hence overtoping the river bank occurs flood.
2. **Sedimentation of River:** If the tributaries of a river carry heavy sediment load the river bank goes on silting up gradually every year.

Thus the carrying capacity of the river goes on reducing every year. Ultimately the cross-section of the river will be shallow and it will not be able to carry high flood discharge.

3. Obstruction in the river flow: In hilly catchment area, sometimes debrises from the landslides may form an obstruction in the river valley like a dam. and thus a deep reservoir may be formed in u/s. Due to heavy rainfall suddenly that obstruction may be removed and high column of water may may rush downstream destroying roads and towns and villages.

4. contraction of river section: While constructing road or railway bridges across a river, the approach works are done on both banks which reduce the x-section of the river. Again, the waterways provided by constructing pier may not be sufficient for the outlet of the high flood discharge.

5. **Inadequate Cross-drainage Works:**

In cross drainage works like aqueduct the river passes below the canal. Here the river may loss the normal carrying capacity during high flood discharge thus water level may rise on the u/s side and may submerges the sorrounding area.

Effects of flood:

1. **loss of life:** If the flood water submerges the villages or inhabitant areas suddenly under high depth and with high velocity the loss of life is more. The loss of life is maximum if flood water suddenly enters the inhabitant areas at night.

Loss of crops: If the flood water enters in agricultural land where the crops are nearly matured, they get totally spoiled. This loss of crops has financial implication for the cultivators.

Loss of works: During flood all types of works such as road works, building works agricultural work ~~etc~~ remain suspended. So the labours becomes unemployed during flood. and their life becomes miserable as they live a hand to mouth.

Damage of property: When the villages or towns are submerges under considerable depth of water with high velocity of flow then many houses may collapse, furniture, and other valuable things may get damaged.

Disruption of communication: During flood. roads, railways, bridges, culverts may get damaged. In some cases communication may be disrupted.

Rise of price of ~~ge~~ food grains: When the road and railway communication is disrupted due to damag by flood. The movement of food grains and essentia commodities is hampered. This leads to the rise of price of ~~ge~~ food grains and other essential materials.

Water logging: flood water may cause waterlogging in agriculteral land making the soil alkaline in nature and reducing the yield of crop. if the water remains stagnant for months the coltivation of the land get totally hampered.

Epidemic: During flood, the water gets contaminate and whole environment becomes polluted. Due to the water pollution, the fishes carry germs of some dieses like cholera, dysentry etc. There is very chance of outbreak of epidemic of these ~~area~~ diseases.

** Good effects:

The only good effect is that the agriculteral land becomes enriched with silt which has got a good value and hence the yield of crop becomes high.

Flood mitigation actions:

P- 303 - Basak

The following are the general methods of flood control works:

1. construction of Check Dam.
2. Construction of Contour Bunds
3. Construction of flood control reservoirs. ***

{a. Detention reservoirs. ?
b. Retarding reservoirs.}

4. Provison for flood control in multipurpose reserva
5. Construction of levees / Dykes. ***
6. Construction of flood walls. ***
7. The construction of flood ways.
8. Construction of diversion channel. ***
9. Construction of cut-off ***

⊞ Methods of river training and Bank protection - P- 290, 297 Basak

Define river training works: River training covers all those engineering works which are constructed on a river to guide and confine the flow to the river chanel ~~and~~ to control and regulate the river bed configuration ensuring safe and effective disposal of floods and sediment load.

P- 500 Garge

⊘ objective of river training works.

1. To prevent the river from changing its course.

ii. To provide a safe passage for the flood waters without overtoping the banks.

iii) To proteck the river banks.

iv) To ensure effective disposal of sediment load.

v) To provide minimum water depth required for navigation.

Types of river training works.

1. High water training or Training for discharge
2. low water training or training for depth
3. Mean water training or training for sediment.

⊞ methods of river training works.

Following are the generally adopted methods for training rivers including bank protection.

1. Margenal embankments. / levees.
2. Guide banks
3. Groynes or spurs.
4. Artificial cut-offs.

} P- 289. Basak

5. Pitching of banks and provision of launching apron.
6. Pitched islands.
7. Miscellaneous methods, such as Silks, Bandalling etc

(iii) Estimation of irrigation water requirement

Example-3.7: A pump is installed on a well to lift water and to irrigat rice crops, sown over 3 hectares of land if duty of rice is 864 hec/cumec on the field and pump efficiency is 48%. Determine the minimum required input (H.P) of pump if the lowest water level is 8 m below the highest portion of the field. Neglect any other losses.

Solution: Area of the rice to be irrigated = 3 hectare

Duty = 864 hectar/cumec

$$\therefore \text{Discharge } Q = \frac{A}{D} = \frac{3}{864} = \frac{1}{288} \text{ cumec.}$$

$$\therefore \text{Pump (B.H.P)} = \frac{wQH}{75\eta} = \frac{1000 \times 1 \times 8}{75 \times 0.98 \times 288} = 0.77 \text{ (H.P) (Ans)}$$

$H = 8$ m

$w = 1000$ kg/m3

$\eta = 48\%$

Example-3.4. The culturable commanded Area for a distributary is 15000 hect. The intensity of irrigation I.I for Robi (wheat) is 40% for kharif (rice) 15%. If if total water water requirements of both crops is 37.5 c 120 cm. Their periods of growths are 160 day and 140 days. respectively,

Determine ① the outlet discharge

(ii) Determine the peak demand discharge

~~(iii)~~

Assume kor water depth for two crops are 13.5 cm and 19 cm. and their kor period is 4 weeks and 2 weeks

Sol^n: C.C.A = 15000 hect.

I.I of wheat ~~15%~~ = 40%

∴ Wheat area (Rabi) = I.I × C.C.A

$$= \frac{40 \times 15000}{100} \text{ hec.}$$

= 6000 hect.

Rice (Kharif) = 15000 × 15 = 2250 hectrs.

Δ for wheat = 37.5 cm

Δ for Rice = 120 cm

B for wheat = 160 days

B for Rice = 140 day.

$$\therefore \text{Average duty for wheat} = \frac{864 \times 160}{37.5} = 3686 \text{ h/cum}$$

Average duty for rice = $\frac{864 \times 140}{120}$ = 1008 h/cume.

∴ Outlet discharge for wheat = $\frac{A}{D} = \frac{6000}{3686}$

= 1.63 cumec.

∴ 〃 Rice = $\frac{2250}{1008}$ = 2.23 cumec.

∴ Design discharge at outlet = 2.23 cumec (Max^{m})

Ans)

(ii) Kor water depth for wheat = 13.5 cm

〃 period of 〃 = 4×7 = 28 days.

∴ Duty for wheat (kor demand) = $\frac{864 \times 28}{13.5}$

= 1792 h/cume.

∴ Duty for Rice = $\frac{864 \times 2 \times 7}{19}$ = 636 h/cume

∴ Outlet discharge for rice (kor demand)

= $\frac{2250}{636}$ = 3.54 cumec. (A)

∴ The required design discharge at the outlet from peak demand consideration is maximum of these two = 3.54 cumec.

Example-3.3: The culturable commanded Area of a water course is 1200 hectres. Intensities of sugarcane and wheat are 20% and 40% respectively. The duties for the crop at the head of the watercou are 730 h/cumec and 1800 h/cumec respectively. find - (i) Discharge at the head of the watercourse (ii) Design discharge at the outlet assume time factor is 0.8.

Solution: C.C.A = 1200 hectars

I.I for sugar = 20%
" wheat = 40%

D for sugar = 730 h
" Wheat = 1800 h/cu

∴ Area to be irrigated for sugar
= 1200 × 0.20
= 240 hectr

∴ Area " for wheat = 1200×0.40
= 480 hectr.

Discharge required for sugar = $\frac{A}{D}$ = $\frac{240}{730}$
= 0.329 cumec.

" wheat = $\frac{240}{1800}$ = 0.271 cumec.

Since sugarcan requires water whole year. so the discharge at the head of the watercourse will be the sum of the two = 0.329 + 0.271
= 0.6 cumi.

(b) time factor = 0.8.

∴ Design discharge at the outlet $= \frac{0.6}{0.8} = 0.75$ cum.

(Ans)

Example-3.1: The gross commanded area for a distributory is 6000 hectares. 80% of which is culturable irrigable. I.I for Rabi season is 50%. and for Kharif season is 25%. If the average duty at the head of the distributory is 2000 h/cumec. for Robi season and 900 h/cumec. for kharif season.

find out the ① Discharge at the head of the distributory from average demand considerations

(ii) Discharge required for max. crop requirement. Assume suitable values for kor depth and kor period.

Sol^n: G.C.A = 6000 hect

∴ C.C.A = 6000 × .80 = 4800 hectr.

∴ Area to be irrigated in Robi season = 4800 × .50 = 2400 heet

Area to be irrigated in kharif season = 4800 × 25 = 1200 h

∴ Discharge at the distributary for Robi $= \frac{2400}{2000}$

$= 2.4$ cumec

" " khanif $= \frac{2400}{900} = 1.33$ cumec.

∴ Required discharge = 2.4 cumec (max. of two).

(b) Assume kor depth = 13.5 cm ~~for~~ for robi
and kor period ~~for~~ for robi = 4 week
kor depth for kharif = 19 cm
and " period for kharif = 2.5 weeks.

Now. Duty for robi = $\frac{864 \times 4 \times 7}{13.5}$ = 1792 hec/cumec

Duty for kharif = $\frac{864 \times 2.5 \times 7}{19}$ = 796 h/cumec

∴ Area to be irrigated in Robi = 2400 hect
Kharif = 1200 hect

∴ Water required at the head of the distributary
for robi = $\frac{2400}{1792}$ = 1.34 cumec

for kharif = $\frac{1200}{796}$ = 1.51 cumec.

∴ The required discharge is 1.51 max of the two. (Ai)

⊞ Irrigation efficiencies: P-61. Garge

1. **Efficiency of water conveyane (η_c):** It is the ratio water delivered into the fields from the outlet point of the channel, to the water entering into the channel. at its starting point. It takes the conveyance losses into consideration.

$$\therefore \eta_c = \frac{\text{Output}}{\text{Input}} \times 100\%$$

ii) **Efficiency of water application:** It is the ratio of the water stored into the root zone of the crops to the quantity of water actually delivered into the field. It may be represented by η_a.

$$\eta_a = \frac{\text{water stored in the root zone during irrigation}}{\text{water delivered to the field.}} \times 10$$

iii) **Efficiency of water storage (η_s):** It is the ratio of the water stored in root zone during irrigation to the water needed in the root zone prior to irrigation.

$$\eta_s = \frac{\text{water stored in the root zone during Irr.}}{\text{water needed prior to irrigation}} \times 100\%$$

29

iv) Efficiency of water use: It is the ratio of the water beneficially used including leaching water to the quantity of water delivered.

$$\therefore \eta_U = \frac{\text{used water including leaching}}{\text{delivered water to the field}} \times 100\%$$

v) Uniformity co-efficient / Water distribution efficiency:

The effectiveness of irrigation is measured by water distribution efficiency. It is expressed as η_d

$$\therefore \eta_d = \left(1 - \frac{d}{D}\right) \times 100\%$$

Here.

d = Average of the absolute values of deviation from mean

D = Mean depth of water during irrigation

Example - 2.7 A stream of 130 liter/sec was delivered from a canal and 100 litre/sec were delivered to the field. An area of 1.6 hectares was irrigated in 8 hours. The effective depth of root zone was 1.7m. The run-off loss in the field was 420 cub.m. The depth of water varied linearly from 1.7m to 1.1 m. Available moisture holding capacity of the soil is 20 cm. per m depth of soil.

Determine the
(i) conveyance efficiency.
(ii) water application efficiency
(iii) Water storage efficiency.
(iv) water distribution efficiency.

Assume irrigation was started at a moisture extraction level of 50 % of the available moisture

Solution: (i) Water conveyance efficiency.

$$\eta_c = \frac{\text{water delivered to the field}}{\text{water applied to the canal head}} \times 100 \%$$

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

(ii) Water application efficiency.

$$\eta_a = \frac{\text{Water stored in the root zone}}{\text{water delivered}} \times 100\%$$

$$= \frac{2480}{2880} \times 100 = 85.4\%$$

water ~~applied~~ delivered to the field in 8 hr. $= 8 \times 100 \times 3600$

$= 2880$ cum.m

Run-off loss $=$ 420 cum.m.

$\therefore$ water stored in the root zone $= 2880 - 420$

$= 2460$ cum.m

(iii) Water storage efficiency:

$$\eta_s = \frac{\text{water stored in root zone}}{\text{water needed in root zone}} \times 100\%$$

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

$= 90\%$

moisture holding capacity

$= 20$ cm per m $\times 1.7$ m

$= 34$ cm

Moisture available 50%

$= \frac{50 \times 34}{100} = 17$ cm

Additional water reqn

$= 34 - 17 = 17$ cm

Quantity of water

$= \frac{17}{100} \times 1.6 \times 10^4$ cum.m

$= 2720$ cum.m

(iv) Water distribution efficiency.

$$\eta_d = \left(1 - \frac{d}{D}\right) \times 100\%$$

$$= \left(1 - \frac{0.3}{1.4}\right) \times 100\%$$

$$= 78.6\%$$

d = deviation average

$$= \frac{(1.4 - 1.1) + (1.7 - 1.4)}{2}$$

$$= 0.3$$

$$D = \text{Mean depth} = \frac{1.7 + 1.1}{2}$$

$$= 1.4$$

⊞ Effective rainfall (Re):

Precipitation falling during the growing period of crop that is available to meet the evapo-transpirat needs of the crop, is called effective rainfall.

It does not include surface run-off or deep percolation lost.

Example-2.9: From the following table determine the evapo. transpiration and consumptive irrigation require of wheat crop. Also determine the field irrigation req if the water application efficiency is 80%. crop factor o. use Blaney criddle equation.

Month	Mean mothly tem °c	Monthly day light hour	Use full rainfall (cm)
Nov	18	7.2	1.7
Dec.	15	7.15	1.92
Jan	13.5	7.30	3.01
Feb	14.5	7.10	2.25

Solution: Blaney criddle equation is

$$C_u = k.\frac{p}{40}(1.8t+32).$$

$$= 0.8\times\left\{\frac{7.2}{40}(1.8\times18+32)+\frac{7.15}{40}(1.8\times15+32)+\frac{7.30}{40}(1.8\times13.5+3\right.$$

$$\left.+\frac{7.10}{40}(1.8\times14.5+32)\right\}$$

$$= 34.18 \text{ cm}$$

$\therefore$ Consumptive use $C_u = 34.18$ cm.

Consumptive irrigation Requirement $= C_u - R_e$

$$= 34.18-(1.7+1.42+3.10+2.25)$$

$$= 34.18-8.47$$

$$= 25.71 \text{ cm}$$

Field irrigation requirement $= \frac{CIR}{\eta_a}$

$$FIR = \frac{25.71}{0.8} =$$

$$= 32.14 \text{ cm}$$

Example-2.15 After how many days will you supply water to soil in order to ensure sufficient irrigation of the given crop. If

i) field capacity of the soil = 28%
ii) Permanent wilting point = 13%
iii) Dry density of soil = 1.3 gm/cc
iv) effective root zone depth = 70 cm
v) Daily consumptive use = 12 mm;

Solution: Available moisture = F.C − P.W.P

$= 28 - 13 = 15\%$

Readily available moisture = 0.80 × 15% = 12%

∴ Optimum moisture = 28 − 12 = 16%

∴ Depth of water stored in root zone $= \frac{\gamma_d}{\gamma_w} \cdot d \cdot (F.C - O.M.C$

$= \frac{1.3}{1.0} \times 0.70 \times (0.28 - 0.1$

$= 0.1092\ m$

$= 10.92\ cm$.

Hence, water available for evapo-transpiration = 10.92 cm

1.2 cm of water is utilised by the plant in 1 day

∴ 10.92 cm " " $= \frac{10.92}{1.2}$ "

$= 9.1 \simeq 9$ days

Hence after 9 days, water should be supplied to the given crop. (Ans)

Scanned with CamScanner

Example - 2.16: Wheat is to be grown in a field having a field capacity equal to 27% and the permanent wilting point is 13%. find the storage capacity in 80 cm depth of the soil. if dry unit wt is $14.72 kN/m^3$.

If irrigation water is to be supplied when the average soil moistre falls to 18% find the water depth required to be supplied to the field if the water application efficiency is 80%. What is the amount of water needed at the canal outlet. if water lost in the water-course is (5)% of the outlet discharge?

Soln:

Max. storage capacity $= \frac{\gamma_d}{\gamma_w} \times d\,(F.C - O.M.C)$

$$= \frac{14.72}{9.81} \times 0.8 \times (0.27 - 0.13)$$

$$= 0.168 \text{ m}$$

$$= 16.8 \text{ cm} \quad \underline{(A_1)}$$

Since Moistre falls to 18% from 27%

The dificiency creates $= \frac{\gamma_d}{\gamma_w} \times 0.8 \times (0.27 - 0.18)$

$$= \frac{14.72}{9.81} \times 0.8 \times 0.9 = 10.8 \text{ cm}$$

Hence 10.8 cm depth of water is the Net Irrigation requirement ∴ NIR = 10.8 cm

Quantity of water required to be supplied to the field

$$FIR = \frac{NIR}{\eta_a} = \frac{10.8}{0.8} = 13.5 \text{ cm. } \underline{(Ans)}$$

Quantity of water needed at the canal outlet

$$(15\% \text{ loss}) = \frac{13.5}{0.85} = 15.88 \text{ cm. } \underline{(Ans)}$$

Example-2.17: 800 m³ of water is applied to a farmers rice field of 0.60 hectares, when the moisture content in the soil falls to 40% of the available water between the field capacity 36% and permanent wilting point 15% of the soil. Determine the field application efficiency. The root zone depth is 60 cm and porosity is 0.4.

Sol^n: We know,

$$\text{field capacity} = \frac{\text{Wt of water contained in a certain vol}^n\text{ of soil}}{\text{Wt of same vol}^n\text{ of same}}$$

$$= \frac{\gamma_w \times V_v}{\gamma_d \times V} = \frac{\gamma_w}{\gamma_d} \times n.$$

$\Rightarrow F = \frac{\gamma_d}{\gamma_d} \times 0.4$ | F.C = 0.36

$\Rightarrow \frac{\gamma_d}{\gamma_w} = \frac{0.4}{0.36} = 1.11$

∴ Max quantity of water stored between FC and permanent wilting point.

$= \frac{\gamma_d}{\gamma_w} \times 0.60 \times (0.36 - 0.15) = 0.14m$.

Deficiency of water created when irrigation is done

$= 0.60 \times 0.14 = 0.084m$

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

∴ Volume of water required to fill up created deficiency is $= 0.084 \times 0.6 \times 10^4 = 504 m^3$.

Actual irrigation water supplied $= 800 m^3$.

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

$= 63\%$ (Ans)

Example-2·18: 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 6 mm/day. The area to be irrigated is 60 ha. and water can be diverted at 28 lps. The surface irrigation application efficiency is 40%. There are no rainfull.

Determine.

i) Allowable depletion depth between irrigation.
ii) frequency of irrigation.
iii) Net application depth of water.
iv) Volm of water required.
v) time to irrigate 4 ha. plot.

Solution: Moisture holding capacity = 140 mm/m. depth

Depth of root zone = 30 cm = 0.3 m.

∴ Moisture holding capacity of root zone = 0.3 × 0.14 = 4.2 cm

Allowable depletion = 35%

∴ ⓘ Available depletion depth = 0.35 × 4.2 = 1.47 cm. (Ans)

(iii) Daily use of water = consumptive use = 5 mm/day

∴ frequency of irrigation $= \frac{1.47}{0.5} = 2.94 \simeq 3$ days.

Net water depth to be applied each time after 3 days.

$= 3 \times 0.5 = 1.5$ cm. (An)

(iv) Field irrigation requirement $= \frac{NIR}{\eta_a}$

$= \frac{1.5}{0.4} = 3.75$ cm

∴ Quantity of water required $= \frac{3.75 \times 10^4 \times 60}{100}$

$= 22500\ m^3$

Hence vol^n of water required at 3 days interval is 22500 m3 (An)

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

vol^n of water required to irrigate 4 h plot

$= 4 \times 10^4 \times \frac{3.75}{100} = 1500\ m^3$.

Time during 1500 m^3 of water can be supplied

$t = \frac{1500}{\frac{28}{1000} \times \cancel{3600}} = 14.88$ hr (An)

Example-2.20: Determine the field capacity of a soil for the following data.

i) Depth of root zone = 1.8m

ii) Existing moisture = 8%

iii) γ_d = 1450 kg/m3

iv) Quantity of water applied to the soil = 650 m^3

vi) Water lost due to deep percolation = 10%

vii) Area to be irrigated = 1000 m^2

Solⁿ: Volume of water = 650 m^3

Water wasted $= \frac{10 \times 650}{100} = 65\ m^3$

Water used $= 650 - 65 = 585\ m^3$.

Depth of water used in raising m.c to field capacity from the existing 8% $= \frac{585}{1000} = 0.585$ m.

We know: ~~F.C =~~

$$\text{Water depth at root zone} = \frac{\gamma_d}{\gamma_w} \times d \times (F.C - O.M.C)$$

$$0.585 = \frac{1.45\ t/m^3}{1\ t/m^3} \times 1.8\ (F.C - 0.08)$$

$$\Rightarrow F.C - 0.08 = 0.224$$

$$\Rightarrow F.C = 0.144.$$

Hence F.C = 14.4% Ans

(ii) Methods of irrigation.

1. Free flooding
2. Border flooding
3. check flooding
4. Basin flooding
5. Furrow irrigation method.
6. Sprinkler irrigation method
7, Drip irrigation method.

Free flooding: In this method, ditches are excavat in the field. Water from these ditches flows across the field. After the water leaves the ditches, no attempt is made to control the flow by means of levees.

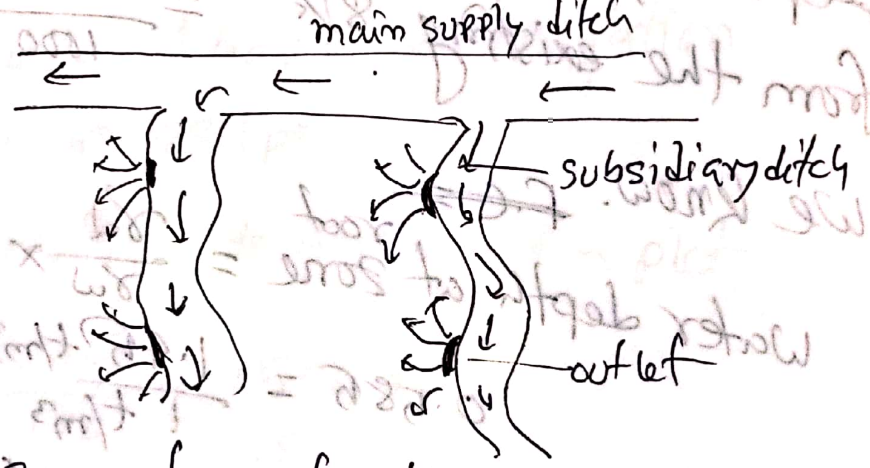


Fig: free flooding

Border flooding: In this method, the land is divided into a number of strips seperated by low levees called border. Water is made to flow from the supply ditch into each strip. The water flows slowly towards the lower end and infiltrates into the soil. as it advantages. When the advancing water reaches the lower end of the strip, the supply of water of to the strip is turned of.

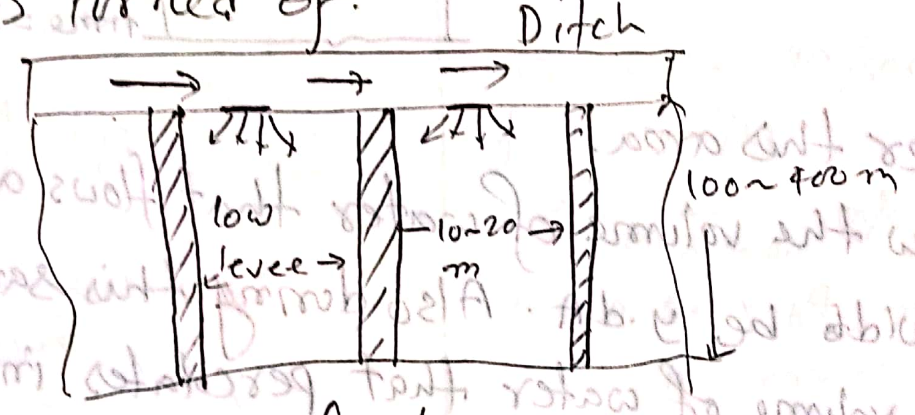


Fig: Border flooding-

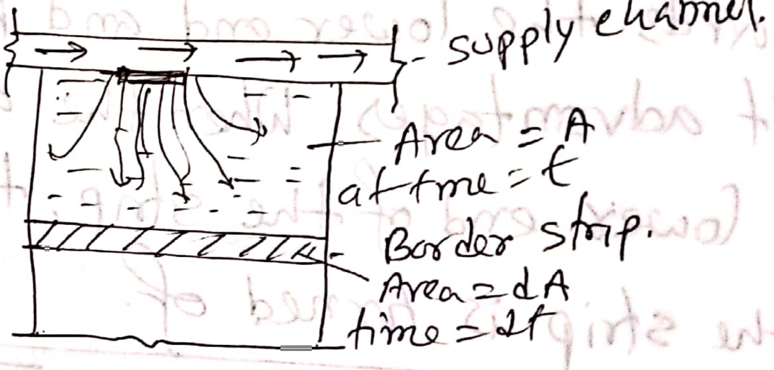
$$\boxed{t = 2.3\,\frac{y}{f}\,\log\frac{Q}{Q-fA}}$$

t = time
Q = discharge
f = infiltration rate.
y = depth of water flowing over the strip.

$$A_{max} = \frac{Q}{f}$$

Derive $t = 2.3 \frac{y}{f} \cdot \log \frac{Q}{Q-fA}$.

consider a small area dA. of the border strip area A, let us assume at time dt, water advancing



over this area.

Now the volume of water that flows over this area wouldb be y.dA. Also during this same time. dt, the volume of water that percolates into the soil would be f.A.dt. So the total quantity of water supply to the strip. would be Q.dt. and also equal to

$$Q\,dt = f.dt.A + y.dA$$

$$\Rightarrow dt(Q - fA) = y \cdot dA$$

$$\Rightarrow dt = y . \frac{dA}{Q-fA} = y . \frac{dA}{Q-fA}$$

$$\Rightarrow \int dt = \int \frac{Q}{Q-fA}$$

$$\Rightarrow t = 2.3 \frac{y}{f} \log \frac{Q}{Q-fA}$$

$$\Rightarrow t = 2.3 \frac{y}{f} . \log \frac{Q}{Q-fA} .$$ Ae

Example-1.1 Determine the time required to irrigate a strip of land of 0.04 hect. in area from a tube-well with a discharge of 0.02 cumec. the infiltration capacity of the soil is 5 cm/hr. and the average depth of flow in the field is 10 cm.

Also determine the max. Area that can be irrigated from this well. P-38. Garge.

Solⁿ: We know.

$$t = 2.3 \frac{y}{f} \log \frac{Q}{Q - fA}$$

$$= 2.3 \times \frac{0.1 \times 3600 \times 100}{5 \times 9} \times \log\left(\frac{0.02}{0.02 - \frac{5 \times 400}{100 \times 3600}}\right)$$

$= 2340.4$ sec $= 0.65$ hour $= 39$ min. (Ans)

Given.

$Q = 0.02\ m^3/sec$

$f = 5\ cm/hr$

$= \frac{5}{100 \times 3600}\ m/s.$

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

$= 400\ m^2$

$t = ?$

$y = 0.1\ m$

Max Arear can be irrigated $A_{max} = \frac{Q}{f} = \frac{0.02}{\frac{5}{100 \times 3600}}$

$= 1440\ m^2$

$= 0.144$ ha. (Ans)

Example - 1.2: Determine the required flow to cover a strip of land of 0.02 hectares in area from a tube-well with a time of 45 min. The infiltration capacity of the soil is 3 cm/hr. Average depth of flow is 12cm.

Sol^n: We know.

$$t = 2.3\,\frac{y}{f}\log\frac{Q}{Q-fA}$$

$$\Rightarrow \log\frac{Q}{Q-fA} = \frac{tf}{2.3y}$$

$$= \frac{45\times3}{2.3\times0.12\times6000}$$

$$= 0.681527$$

$$\therefore \frac{Q}{Q-fA} = 1.206$$

Given,

$t = 45$ min

$A = 0.02\times10^4\ m^2$

$= 200\ m^2$

$f = 3$ cm/hr

$= \frac{3}{100\times60}$ m/min.

$y = 0.12m$

$$\Rightarrow Q = 1.206Q - fA\times1.206$$

$$\Rightarrow Q = \frac{fA\times1.206}{0.206} = \frac{3\times200\times1.206}{6000\times0.206}$$

$= 0.585$ ~~cumec~~. (A) m3/min

$= 35.1$ m3/hr. (A)

≈ 0.01 cumec.

3. **Check flooding**: Check flooding is similar to ordinary flooding except that the water is controlled by surrounding check area. with low and flat levees. levees are generally constructed along the contors. having vertical interval of about 5~10cm.

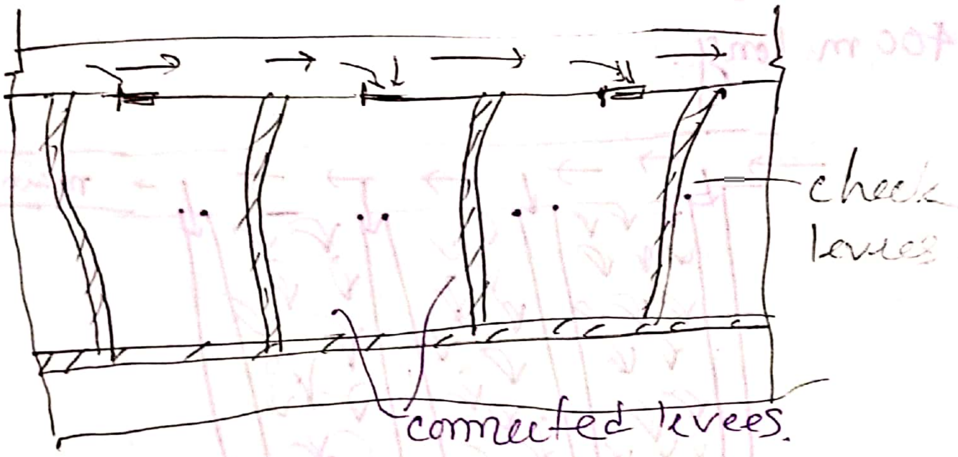
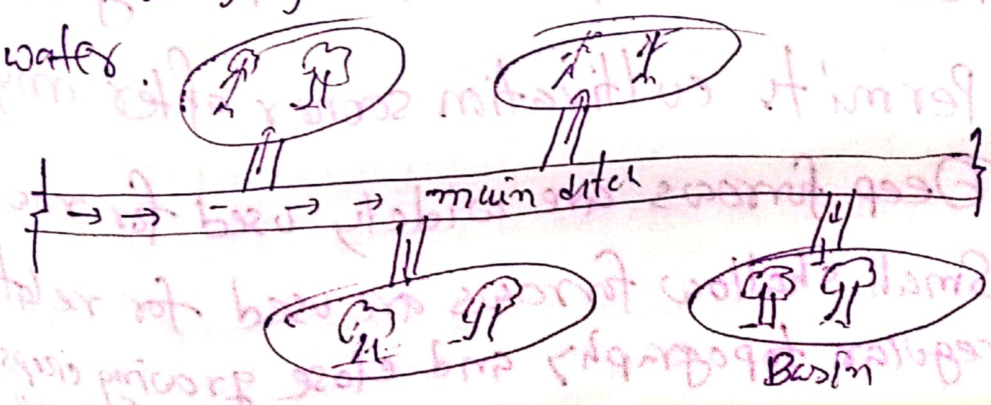


fig. check flooding

4. **Basin flooding**: This method is a special type of check flooding and is adopted specially for orchard trees. One or more trees are generally placed in the basin and the surface is flooded as in check method. by ditch water.



5. Furrow irrigation method:

→ Furrows are narrow field ditches, excavated between rows of plants and carry irrigation water through them.

→ Furrows vary 8~30 cm deep and may be as much as 400 m long.

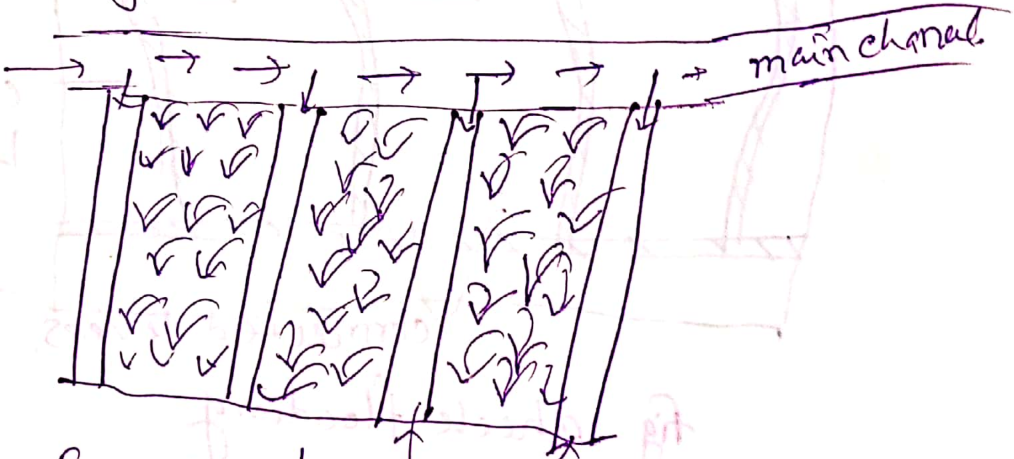


Fig: furrow irrigation.

Advantages: In this method.

1. On fifth to one half of the land surface is wetted by water. therefore ~~less~~
2. Results less evaporation, less pudding of soil.
3. Permits cultivation sooner after irrigation.
4. Deep furrows are widely used for row crops.
5. Small shallow furrows are used for relatively irregular topography and close growing crops, meadows, small grains etc.

Disadvantages:

1. Execessive long furrows may result in too much percolation near the upper end and too little water near the down-slope end.
2. Extra labour is need to dig furrows.

Sprinkler irrigation method: In this method water is applied to the soil in the form of a spray through a network of pipes and pumps. It is a kind of an artificial rain. and gives very good results.
- It can be used for all types of soils and for widely different topgraphies and slopes.

**** Why sprinkler is not suitable to our country:

Inspite of the numerous advantages of sprinkler metho over other methods, It has not become popular because ours is a poor and developing ~~country~~ nation, This method is not only costly but also requires a lots of technicatities. Correct design and efficient operation are very important for the success of this method. Special steps have to taken for preventing entry of silt and debris which are very harmful for the sprinkler equipment.

⊘ Conditions for adopting Sprinkler method

1. When the land topography is irregular and unsuitable for surface irrigation.

2. When the land gradient is steeper and soil is easily erodible

3. When the soil is excessive permeable or highly impermeable.

4. When the watertable is high.

6. When the water is available with dificulty and scarce.

Advantages of sprinkler methods—

1. land levelling is not required.

2. No need to excavate ditches which increases the cultivable land 16%.

3. Reduce loss of water and washing of top soil.

4. Fertilizer can be uniformly applied mixing with irrigation water.

5. This method leaches down salts and prevent water-logging.

Limitation of Sprinkler method.

1. High winds may distort sprinkler pattern.
11. In area of high wind and high temperature considerable evaporation losses may take place.
111. They are not suited to crops requiring frequent and larger depth of irrigation such as paddy.
iv) Initial cost of this system is very high. and it requires a high technical skill.
v) Only sand and silt free water can be used as otherwise pump impellers will get damaged.
vi) It requires larger electrical power.

sprinkler irrigation

7. Drip irrigation method:

In this method water is supplied slowly and directly to the root zone of the plants. This system includes laying of a system of head, mains, sub-mains, lateral and drop nozzles.

Water oozes out from these small drip nozzles uniformly and at a very small rate directly into the plant roots area.

Determine the size of a tile at the outlet of a 6 ha. drainage system. if D.C. is 1 cm and tile grade is 0.3%. Assume $n = 0.011$.

Solⁿ: 1 cm D.C means that 1 cm of water from an area of 6 ha is entering the tiles per day.

∴ Volume of water passing the drain is in

$$1 \text{ day} = \frac{1}{100} \times 6 \times 10^4 \text{ m}^3/\text{day} = 600 \text{ m}^3/\text{day}$$

$$= \frac{600}{24 \times 60 \times 60} = \frac{1}{144} \text{ m}^3/\text{s}$$

$$\therefore Q = \frac{1}{144} \text{ m}^3/\text{s}.$$

$$\Rightarrow \frac{1}{144} = \frac{1}{n} R^{2/3} S^{1/2} \times A$$

$$\Rightarrow \frac{1}{144} = \frac{1}{0.011} \times \left(\frac{D}{4}\right)^{2/3} \times \left(\frac{0.3}{100}\right)^{1/2} \times \frac{\pi}{4} \times D^2$$

$$\Rightarrow D = 13.2 \text{ cm}$$

Adopt: D = 15 cm Ans

$$R = \frac{\frac{\pi}{4} D^2}{\pi D} = \frac{D}{4}.$$

tile dia = D

$$S = \frac{0.3}{100}$$