PANA ACADEMY

NEPAL ENGINEERING COUNCIL
LICENSE EXAM PREPARATION COURSE

FOR

CIVIL ENGINEERS

Er Dilendra Raj Panta

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7. Irrigation and Drainage

7.1 Water demand estimation

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Sub topics

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crop water and irrigation water requirements;
water availability for irrigation;
command areas; irrigation intensity;
duty, delta and their relationship;
water losses and irrigation efficiencies; effective rainfall;
soil-moisture-irrigation relationship;
depth and frequency of irrigation;
design discharge for canals.

Irrigation

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Irrigation can be defined as the science of artificial application of water to crops throughout the growth period to attain full maturity or for maximum crop production

Irrigation does not reduce the crop growing period

Irrigation

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The pH value of irrigating water is 6 to 8.5
The soil becomes practically infertile if its PH is more than 11
Sodium absorption ratio (SAR) should be less than 18

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

SAR Value	Type of water	Suitability
0-10	Low sodium water	Suitable for all types of crops and soil
10-18	Medium sodium water	Suitable for coarse soil with good permeability
18-26	High sodium water	Harmful for all soils and requires good drainage
> 26	Very high sodium water	Not suitable for irrigation

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Irrigation

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Necessity of irrigation

-Inadequate rainfall

-Uneven distribution of rainfall with respect to time and area

-Increasing the crop yield

-Growing number of crop

-Growing perennial crop

Irrigation

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Advantages

1. Increasing in food production and protection from famine
2. General prosperity
3. Elimination of mixed cropping
4. Navigation
5. Flood control
6. Generation of hydropower
7. Domestic and Industrial water supply
8. Afforestation

Irrigation

Disadvantages

1.Water pollution [seepage of fertilizer(nitrate) into the groundwater reservoir]

2. Formation of marshy land
3. Water logging due to over irrigation
4. Colder and damper climate.
5. Loss of valuable lands

History of irrigation in Nepal

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In 1979 B.S (1922 A.D) construction of first irrigation canal of Nepal i.e Chandra canal started and was completed in 1985 B.S (1928 A.D)

Chandra canal was constructed in Triyuga river of Saptari district and having a command area of 10500 ha

First irrigation development policy was developed in 2049 B.S and currently irrigation policy 2070 B.S is in use.

Masterplan 2019 AD

Department of irrigation was developed in 2044 B.S

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Status of irrigation in Nepal

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Total agricultural land = 41,210 km^2 (28%) 28.75%

Total Cultivable area = 26,41,000 ha

Total irrigable area = 17,66,000 ha

1 ha = 10^4 m^2 1 Km^2 = 100 ha

At the end of the fiscal year 2078/2079,

Surface irrigation = 10,16,496 ha

Sub surface irrigation = 5,13,524 ha

Total irrigated area = 15,31,069 ha

Irrigation

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Arid region/zone → Desert

Without irrigation no crops can be grown

Rainfall less than 25 cm per year 10 inch /year

Semi Arid Region/Zone

Without irrigation some low inferior crops can be grown

Rainfall 25 cm to 50 cm per year

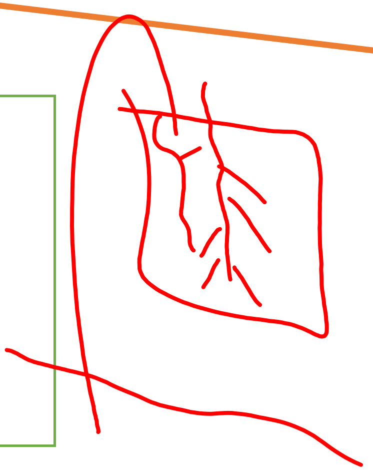
Classificaton/Types of irrigation

Surface Irrigation
Water is applied directly on ground surface

Flow Irrigation
Water flows freely under action of gravity
e.g. flow in canal

Perennial Irrigation
- Controlled Irrigation
- Water is applied to the field throughout the year

Flood/Innundation Irrigation
- Uncontrolled Irrigation
- Agricultural land is kept submerged like flood condition



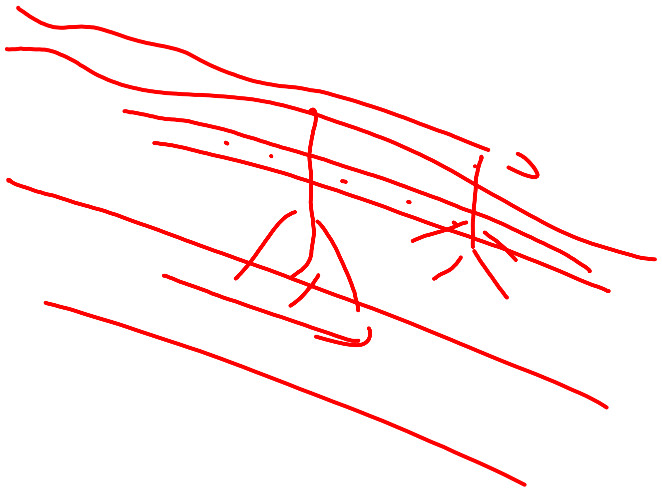
Lift Irrigation
Water is applied by pumping from lower elevation to higher elevation.
e.g. well, tubewell etc

Sub-surface Irrigation
Water is applied directly in the rootzone of plant

Classificaton/Types of irrigation

Surface Irrigation

Water is applied directly on ground surface



Sub-surface Irrigation

Water is applied directly in the rootzone of plant

Natural Sub-surface Irrigation

- Water is applied in the rootzone of plant due to seepage through canals or water bodies.

Artificial sub-surface Irrigation

- Water is applied in the rootzone of plant by using perforated pipe network.
- E.g drip irrigation

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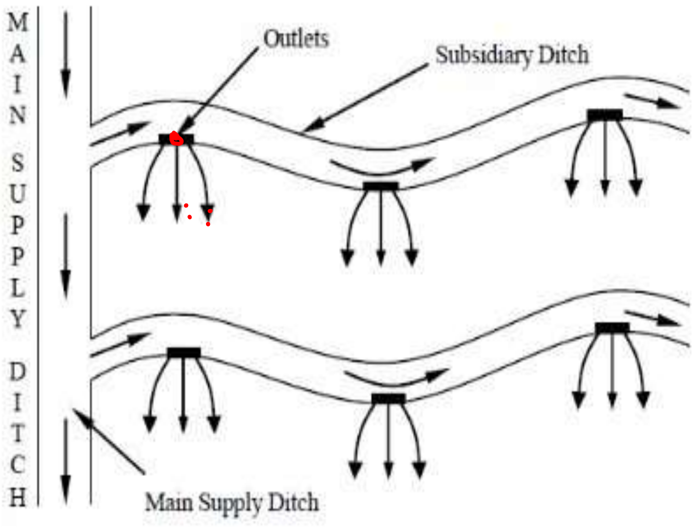
Wild/Free flooding / Ordinary flooding

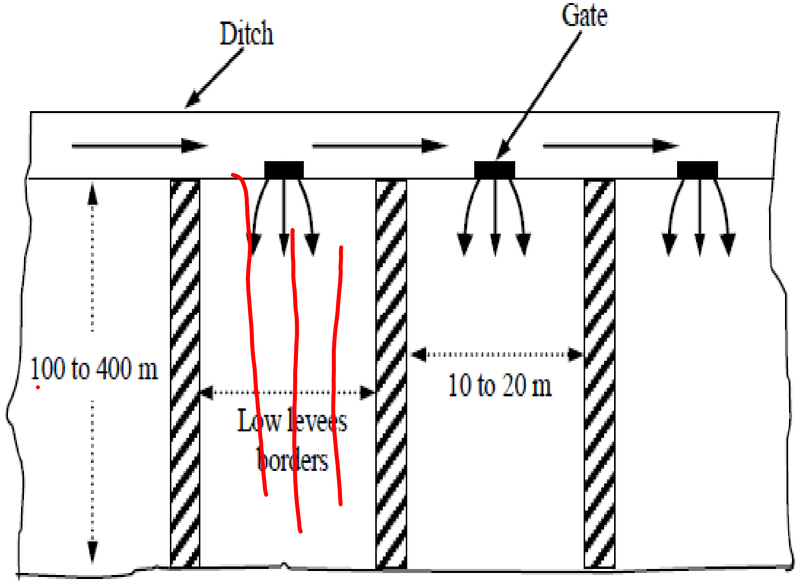
- Water is applied to the field in an uncontrolled way so called as uncontrolled flooding.
- Usually ditches are 20 to 50 meters apart depending upon the slope, soil texture and types of crops sown.
- Suitable on flat rolling land.
- This method has lowest water application efficiency (η_a)



<u>Border strip flooding method</u>

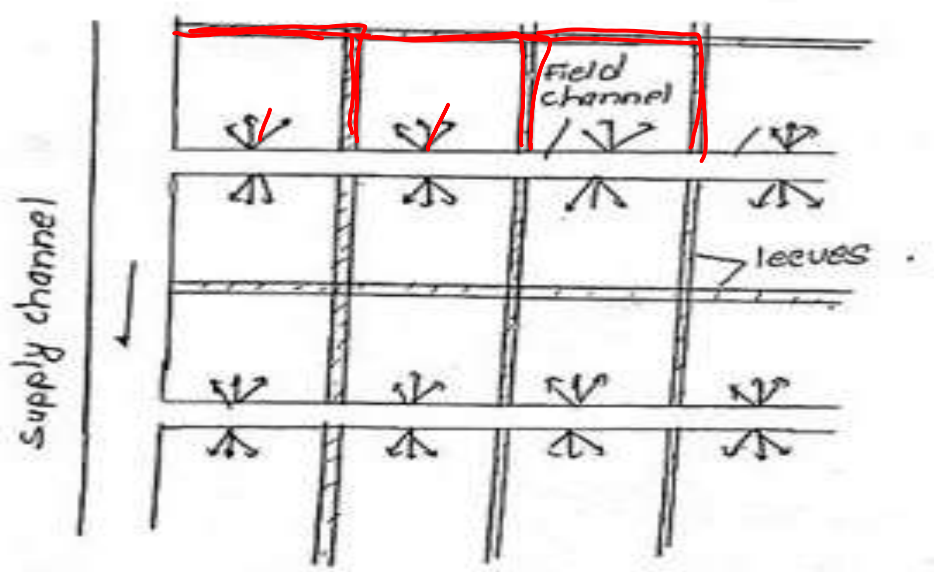
- Land is divided into a number of strips with the help of low levees
- Each strip is generally of 10 to 20 m in width and 100 to 400 m in length
- Suitable for some close crops like rice, pastures etc

levees (झाली)



Check area flooding method

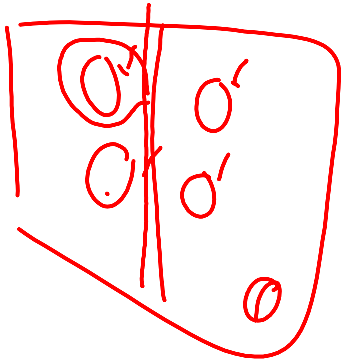
- Most common and widely practiced method in Nepal.
- Area is divided into small plots by low levees called as check areas.
- Check area varies from 0.2 ha to 0.8 ha.
- Suitable method for cereal crops
- Suitable for more permeable soil as compared to border and free flooding method



Check Flooding

Basin Flooding Method

- Most suitable method for orchard farming or gardening
- Basins are made around one or more trees in shape of square, circular etc. but circular is more common so called as Ring basin method.
- Basins are kept submerged.
- This method economize water considerably.



Furrow Irrigation method

- Suitable method for row crops like potatoes, onions, sugarcane etc.
- Furrows are narrow ditches excavated between rows of plants
- Furrow/ditches carry water and crops are planted on ridges.
- Depth of furrows varies from 8 cm to 30 cm and about 400 m long
- About 20% to 50% i.e one-fifth to one half of the land is wetted by water.

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Sprinkler Irrigation Method

- Water is sprayed to crops in form of artificial rain.
- Suitable for any type of land Topography.
- Suitable at water scarce area with pressure
- Pressure of rotating head is 1.4 kg/cm^2 to 2.1 kg/cm^2
- Having high water application efficiency of 80 to 85 %
- Suitable where water table is high.
- Suitable for light soil having high infiltration rate
- Strong wind disturbs sprinkling pattern.
- Suitable for fruits, vegetables, coffee, tea etc.

Drip/Trickle Irrigation Method

- Water is slowly and directly applied to the root zone of plants through the nozzles present in the pipe network buried under surface
- Water is applied drop by drop at the rate of 2 lit/hr to 10 lit/hr.
- This method has highest water application efficiency of more than 90%
- Suitable for any type of land topography.
- Suitable in water scarce area.
- Suitable for fruits vegetables

Different seasons and crops

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1. **Kharif crop season:** (April to September)
- Also called as monsoon crops
- Sown at beginning of summer or end of winter and harvested at end of summer or beginning of winter.
- E.g Rice, maize, millet, groundnut, pulse, cotton, soybean, bajra etc

2. Rabi Crop Season : (October to March)
- Also called as winter crops.
- Sown at beginning of winter or end of summer and harvested at end of winter or beginning of summer.
- E.g Wheat, barley, linseed, potatoes, mustard, gram etc.

Different seasons and crops

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<u>3. Zaid crops</u> (March to June) are summer crops that are grown in India between the kharif (monsoon) and rabi (winter) seasons, typically from March to June. These crops require warm, dry weather for their major growing period and longer day length for flowering

Eg: Watermelon, Cucumber, Bitter gourd, Pumpkin, Strawberry, Arhar, Masur (lentil)

Different seasons and crops

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4. Perennial Crops:

- Crops having base period of more than 300 days.
- E.g sugarcane, flowers, fruits etc.

5. Leguminous Crops:

- Belongs to legume family i.e peas, beans, lentils etc.
- These crops roots have nodules that contains nitrogen fixing bacteria called as Rhizobium bacteria that helps to improve the nitrogen content of the soil.
- E.g peas, beans, hemp, gram, groundnut etc.

Different seasons and crops

6. Cash Crops:

- Also called as profit crops.
- These crops are grown to sell for profit.
- E.g Coffee, tea, vegetables, fruits etc.

Crop Ratio:

- Also called as Rabi-Kharif ratio.
- Defined as ratio of area irrigated during rabi season to area irrigated during kharif season
- Generally taken as 2:1

more area → less

Crop water and irrigation water requirements

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Quantity of water required by the crop from the time it is shown to time it is harvested is called as **crop water requirement**.
Factors affecting crop water requirement are climate, type of soil, effective rainfall etc   Paddy → Rice   120 cm

- **<u>Consumptive Use(Cu):</u>** Total amount of water used by the plants in transpiration (building plant tissue) and evaporation form plant adjoining area in any specified duration of time. Unit mm/day

  Cu = Evapotranspiration + water used in plant metabolism

  Cu= Evapotranspiration

  (Neglecting water used in plant metabolism)

Crop water and irrigation water requirements

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Effective rainfall (Re): Rainfall during crop growing period which is available to meet the consumptive use or evapotranspiration needs requirement of the plant. It is the available water stored in soil within root zone of the crop.

Irrigation water requirement: The amount of water to be supplied artificially by irrigation for Fulfilling crop water requirement.

Irrigation Water Requirement = Crop water requirement + Losses

Crop water and irrigation water requirements

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Consumptive Irrigation Requirement (CIR)

It is the quantity of water actually required by plant. If natural rainfall provides a part of consumptive use, the consumptive irrigation requirement is given as:

$$CIR = Cu - Re$$

Cu= Consumptive Use, Re = Effective Rainfall

Crop water and irrigation water requirements

Net Irrigation Requirement (NIR)

In addition to CIR, NIR takes into consideration of leaching requirement as well as pre sowing requirement.

NIR = CIR + LR + PSR + NWR

where,

LR = Leaching requirement

PSR = Pre-sowing requirement

NWR = Nursery water requirement

Crop water and irrigation water requirements

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Field Irrigation Requirement (FIR)

In addition to NIR, FIR takes into consideration of water application loss i.e amount of water lost as surface runoff and through deep percolation.

$$FIR = NIR + \text{Application Losses}$$

$$FIR = \frac{NIR}{\eta a}$$

ηa = Water application efficiency

Crop water and irrigation water requirements

Gross Irrigation Requirement (FIR)

In addition to FIR, GIR takes into consideration of water conveyance loss through canal system by evaporation and seepage.

GIR = FIR + Conveyance Losses

$$GIR = \frac{FIR}{\eta c}$$

ηc = Water conveyance efficiency

GIR > FIR > NIR > CIR

Gross Command Area (GCA):

Total area that can be irrigated when design discharge is always available

Culturable command area (CCA):

- Part of GCA in which cultivation is possible
- 70% to 80% of GCA

Unculturable command area

- Part of GCA in which cultivation is not possible
- E.g building, bridge, barren land, River etc.

Culturable cultivated area

- That part of CCA which is cultivated during present season.

Culturable uncultivated area

- That part of CCA which is not cultivated during present season

Command Areas

Commanded area is defined as the area that can be irrigated by canal.

Gross Commanded Area (GCA)

It is the total area (cultivable as well as uncultivable like ponds, roads, residential area, etc.), within the irrigation boundary of irrigation project, which can be economically irrigated considering that unlimited quantity of water at design discharge is available.

Culturable/Cultivable Commanded Area (CCA)

- Part of (GCA) in which cultivation is possible.
- CCA is generally taken as 70% to 80% of GCA.

Command Areas

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Unculturable command area:

That part of GCA in which cultivation is not possible. E.g Road, forest, barren land, building etc.

Culturable cultivated area

That part of CCA which is proposed to be irrigated in present season.

Culturable uncultivated area

That part of CCA which is not irrigated during present season.

Intensity of Irrigation (IOI)

IOI = % CCA purposed to be irrigated.

Seasonal Intensity of Irrigation for a season and *Annual Intensity of Irrigation for a year.*

Annual intensity of irrigation is summation of seasonal intensity of irrigation within a year

$$\text{Annual IOI} = (\text{IOI})_R + (\text{IOI})_K$$

Annual IOI can be more than 100% as well.

Intensity of Irrigation (IOI)

(Q) If CCA of an irrigation field is 100 hectares, of which 40 hectares is cultivated in kharif season and 70 hectares in Rabi season.

Ans: 110% .

$IOI_K = \frac{40}{100} = 40\%$

$IOI_R = \frac{70}{100} = 70\%$

$40 + 70 = 110\%$

Intensity of Irrigation (IOI)

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(Q) If CCA of an irrigation field is 100 hectares, of which 40 hectares is cultivated in kharif season and 70 hectares in Rabi season.

Ans: 110% .

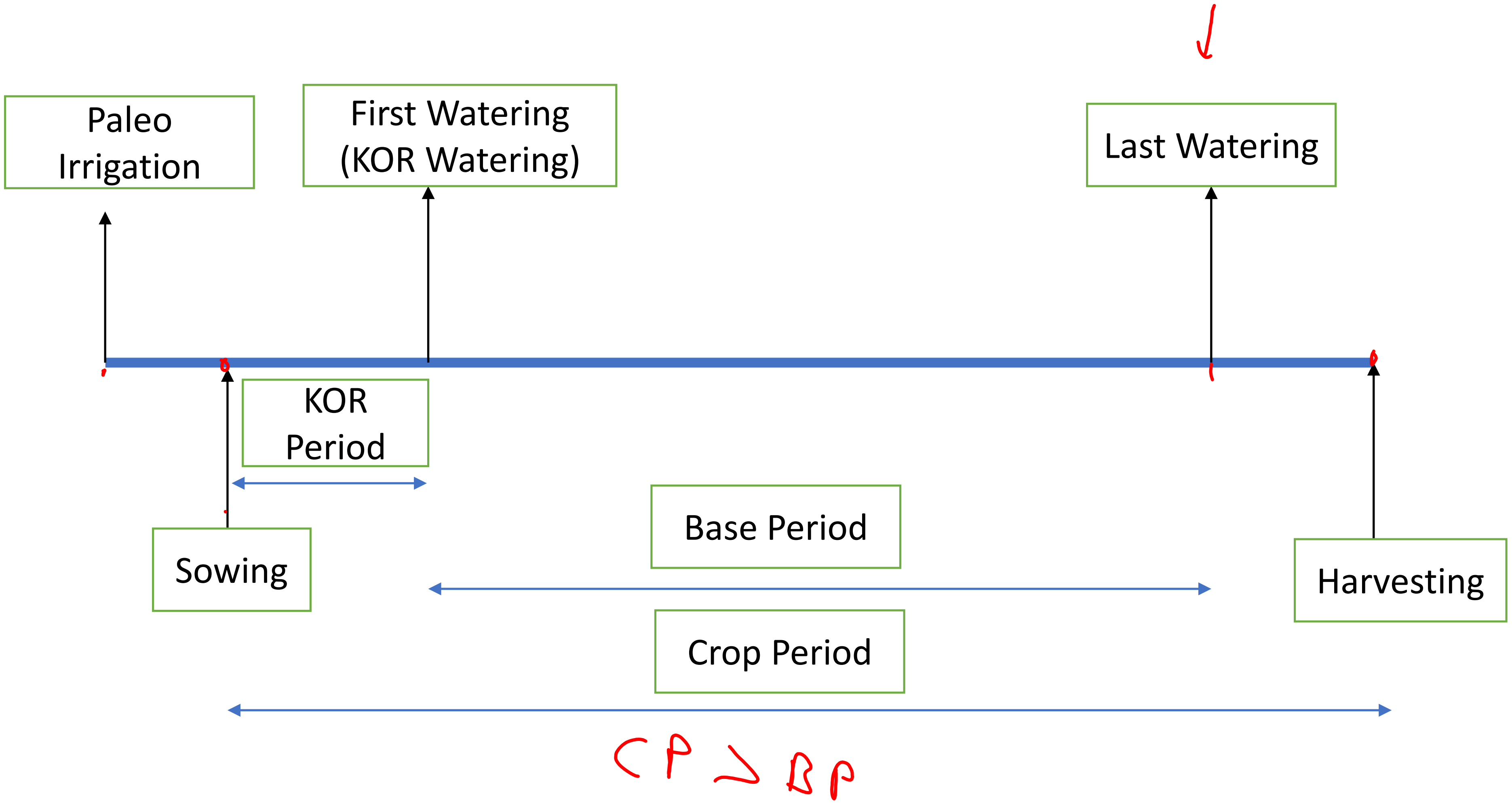
The Intensity of irrigation for Kharif is 40/100 × 100% = 40%

and for Rabi will be 70/100 × 100% = 70%.

The annual intensity = 40% + 70% = 110%.

Annual IOI can be more than 100%

Duty, Delta, Base Period



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Duty, Delta, Base Period

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Crop Period

The time period between sowing of crop to its harvest is called crop period and is expressed in days.

Base Period KOR watering

Time between the first watering of a crop after sowing to the last watering before harvesting is called Base period. It is expressed in days and represented by B.

Generally, Crop period >Base period

Practically, Crop period = Base period

Duty, Delta, Base Period

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<u>Duty(D)</u>

- Duty of water is defined as the hectares of land that can be irrigated by a constant supply of water at one cumecs (m^3/s) throughout the base period (B).
- It's unit is ha/cumecs (m^3/s) .
- As we move from **canal to field** duty of water **increases**.
- Duty is maximum at the field.
- Duty at the head of water course (outlet point) is called as outlet duty or **outlet factor** or outlet discharge factor.
- Factors affecting duty are type of soil, type of crop, temperature, wind velocity, humidity, effective rainfall etc.

Duty, Delta, Base Period

Delta (Δ)

- The total depth of water, in cm, required by a crop to come to maturity is called delta (Δ).

Relation between duty delta and base period

In S.I system

$$\Delta_{kor} = 8.64\frac{B}{D}$$

In F.P.S system

$$\Delta_{kor} = 1.985\frac{B}{D}$$

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Duty, Delta, Base Period

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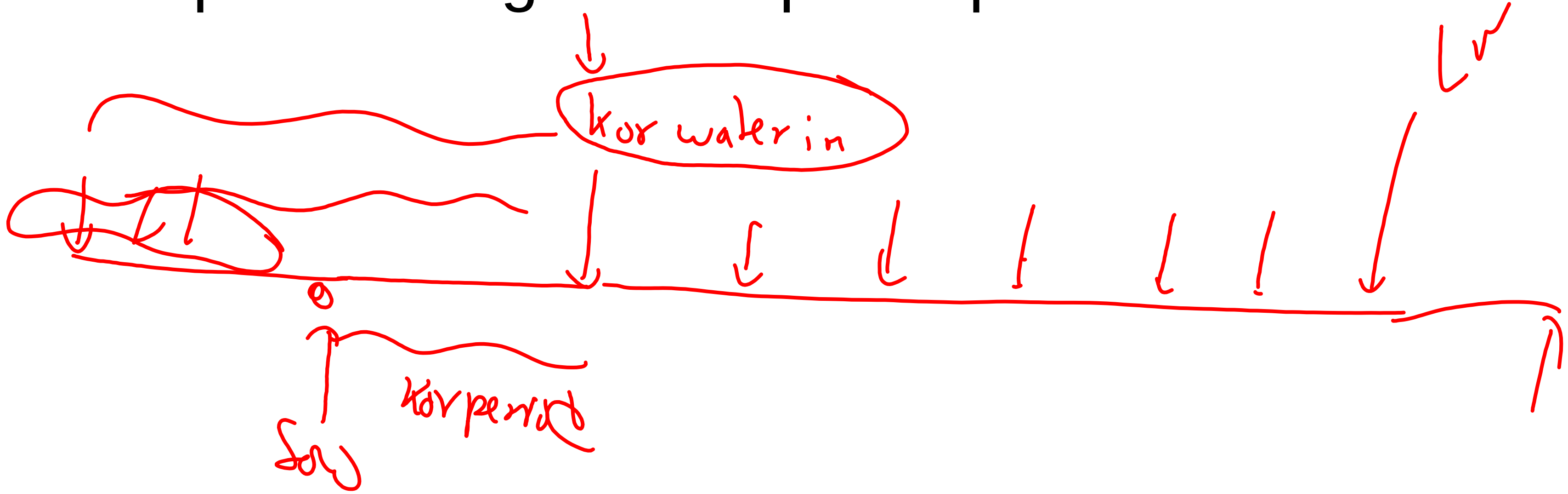
Paleo Irrigation: Irrigation done before sowing for land preparation is called as paleo irrigation.

- It helps in initial growth of plant upto few cm.



Duty, Delta, Base Period

kor-watering: First watering after sowing when the plant has grown few cm is called as kor-watering.

- It is usually **maximum** single watering followed by other watering at regular interval.

kor-depth (Δ_{kor}): Depth of kor-watering is called kor-depth.

kor-period(B_{kor}): Time period between sowing and kor-watering is called as kor-period.

$$\Delta_{kor} = 8.64 \frac{B_{kor}}{Outlet\ factor}$$

Duty, Delta, Base Period

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Crop	Delta	Base period	KOR depth	KOR period	Duty	Root zone depth
	(cm)	(Days)	(cm)	(weeks)	(ha/cumecs)	(cm)
Rice	120	120	19	2-4	775	90
Wheat	40	120	13.5	3-8	1800	100
Sugarcane	120	330	16.5	-	800	150
Cotton	50	-	-	-	-	140
Maize	25	-	-	-	-	100
Tobacco	75	-	-	-	-	80

Paddy

Questions

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(Q). Find the delta for a crop if duty for a base period of 110 days is 1400 hectares/cumec.

Ans: 68 cm

$\Delta \rightarrow$ ~~cm~~ m

$D \rightarrow 1400$ ha/cumec

$B \rightarrow 110$ days

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

B → day

D → ha/cumec

$= 0.68$ m

Questions

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(Q). A crop requires a total depth of 92 cm of water for a base period of 120 days, Find duty of water at field canal. If there is 10% loss in convenience, find duty at head of main canal.

Ans: 1127 ha/cumec, 1024 ha/cumec

$\Delta = 0.92\ m$

$B = 120$

$D_f = \frac{8.64\ B}{\Delta}$

$\frac{1127}{1.1} = 1024 \approx D_m$

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Duty, Delta, Base Period

Overlap Allowance:

The extra discharge required to mature the crop which extends from one season to another season is called as overlap allowance.

Capacity Factor:

Defined as the ratio of mean supply discharge in a canal to its design discharge.

Duty, Delta, Base Period

Time Factor:

Defined as the ratio of actual operating period of canal to the crop period/Base period.

This factor helps to check the danger of over-irrigation.

(Q). *The time factor for rabi season is fixed at 0.75 for a canal. What are the number of days the distributary will receive its full supply if the crop season is 120 days*

Ans: 90 days.

Water losses and irrigation efficiencies;

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Water conveyance efficiency (ηc) – Ratio of water delivered to the fields to the water diverted into canal

$$\eta_c = \frac{Wf}{Wc} * 100$$

Water application efficiency(ηa)- Ratio of the quantity of water stored in the root zone of the plants to the quantity of water delivered to the field.

$$\eta_a = \frac{Wsrz}{Wf} * 100$$

Overall efficiency $(\eta_o) = \eta_c \times \eta_a$

Water losses and irrigation efficiencies;

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Water use efficiency(η_u)- Ratio of quantity of water beneficially used by plant to the quantity of water delivered to the field.

$$\eta_u = \frac{Wu}{Wf} * 100$$

Water storage efficiency (η_s) – Ratio of water stored in the root zone during irrigation to the quantity of water required in root zone

$$\eta_s = \frac{Wsrz}{Wrrz} * 100$$

Water losses and irrigation efficiencies;

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<u>Water distribution efficiency($η_d$)</u>- Uniformity coefficient.

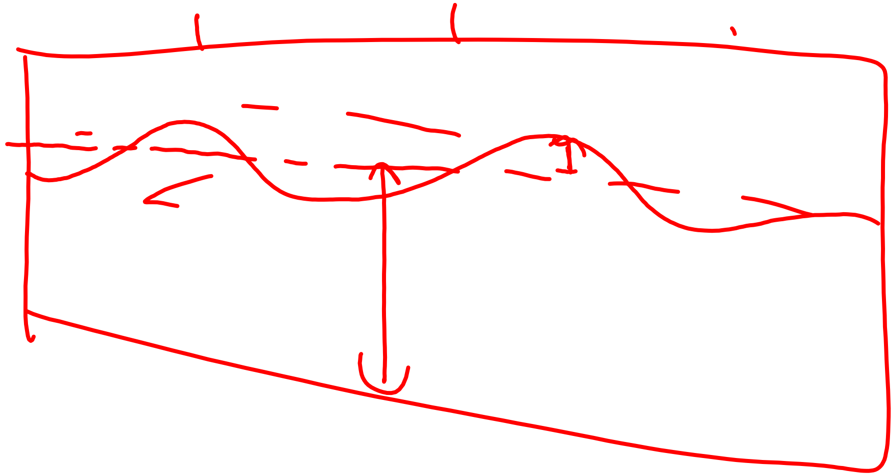
Measures effectiveness of irrigation.

It evaluates the extent to which water is uniformly distributed.

$$η_d = \left(1 - \frac{d}{D}\right) * 100$$

d=average numerical deviation in depth of water stored

D=average depth of water stored in field



Questions

$\frac{W_{srz}}{W_f} \times 100\%$

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(Q) A field having 40 ha area receives supply at the rate of 8 cumecs for 6 hours and 30 cm water was stored in the rootzone. Find the water application efficiency.

Ans: 70% $= \frac{30}{43.2} \times 100\%$

Volume of water $= V = 8\,m^3/s \times 6 \times 60 \times 60$

$= 172800\ m^3$

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

$d = \frac{172800}{40 \times 10^4} = 0.432\,m = 43.2\,cm$

Soil-moisture-irrigation relationship

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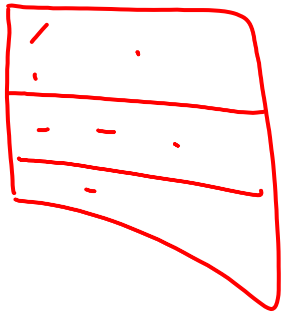
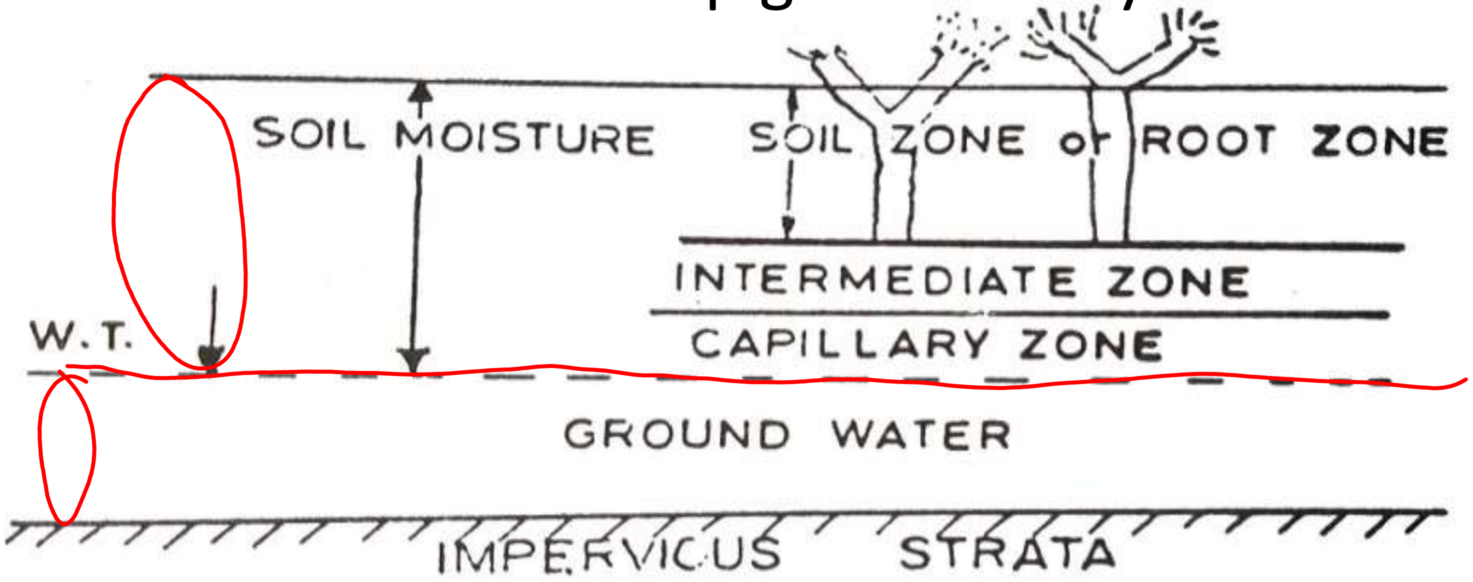
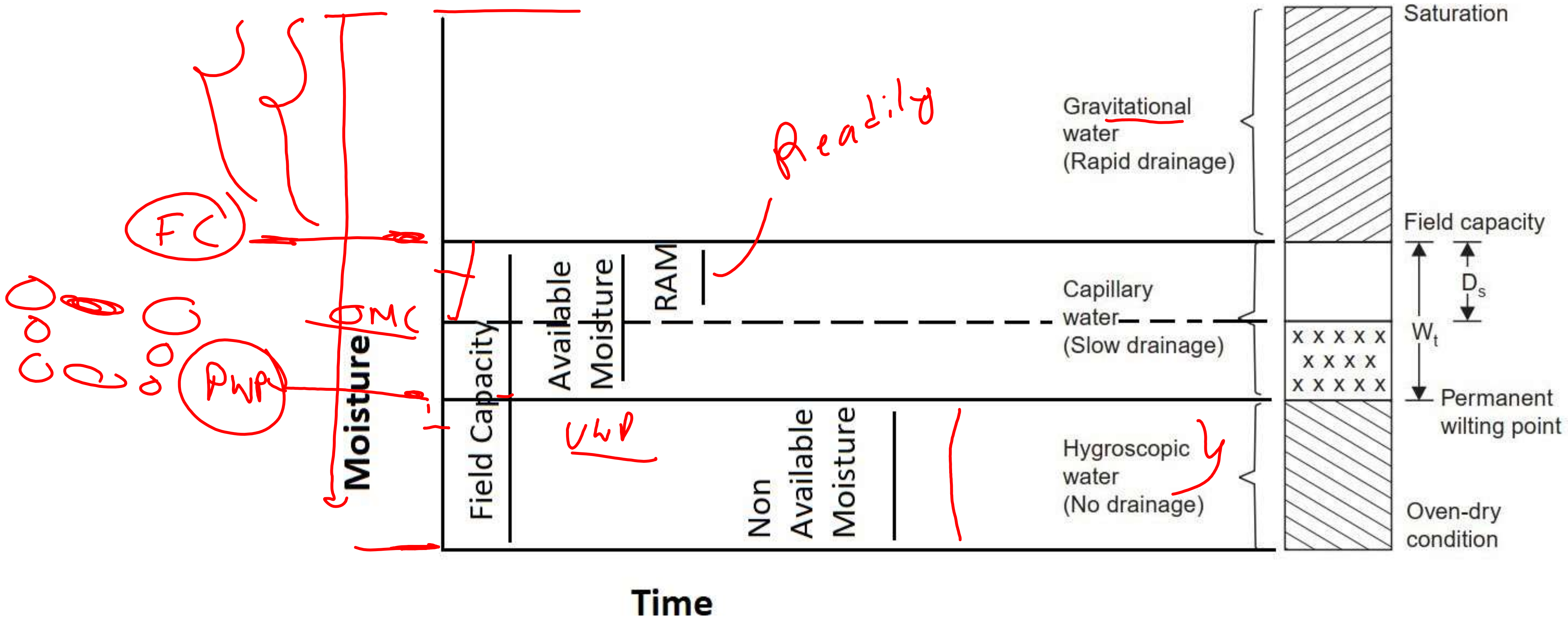
- The water above water table is termed as soil-moisture while below as groundwater.
- ***Root zone depth:*** Maximum depth in soil strata upto which crops spreads its roots to extract water is called as root zone depth.
- Excess and deficit affect crop growth and yield





Soil-moisture-irrigation relationship



Soil-moisture-irrigation relationship

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Gravity water: The part of rainfall or irrigated water that flows down to water table under the action of gravity.

Also called as superfluous water

Not available for plant

Capillary water: Water held by surface tension against gravity that can be extracted by plants by capillary action.

This water is available for plant

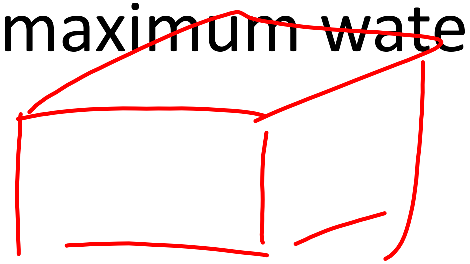
Also called as available water

Hygroscopic water: This water is held as thin film layer on soil surface by loose chemical bond and hence is not available to plants

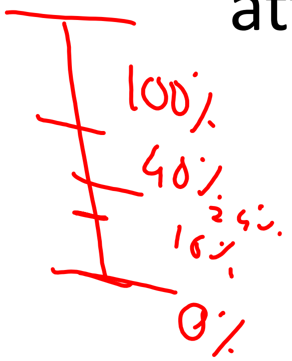
Also called as adsorbed water

Soil-moisture-irrigation relationship

<u>Saturation Capacity:</u> The water content of soil when all the pores are filled with water. It is the maximum water holding capacity of soil in root zone.



<u>Field Capacity:</u> The water which cannot be drained under the action of gravity and is retained on surface of soil grain by molecular attraction or loose chemical bond(adsorption)



$$FC = \frac{Wt.of\ water\ retained\ in\ certain\ volume\ of\ soil}{Wt.of\ same\ volume\ of\ dry\ soil}$$

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Soil-moisture-irrigation relationship

<u>Permanent wilting point(PWP):</u> The water content at which plant can no longer extract sufficient water for its growth and will die.

<u>Ultimate wilting point (UWP):</u> The water content at which plant will die even if we irrigate.

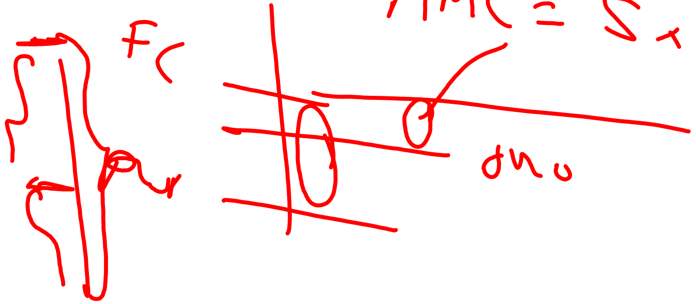
$d_{fc} = S \times D \times FC$

$d_{pwp} = S \times D \times PWP$

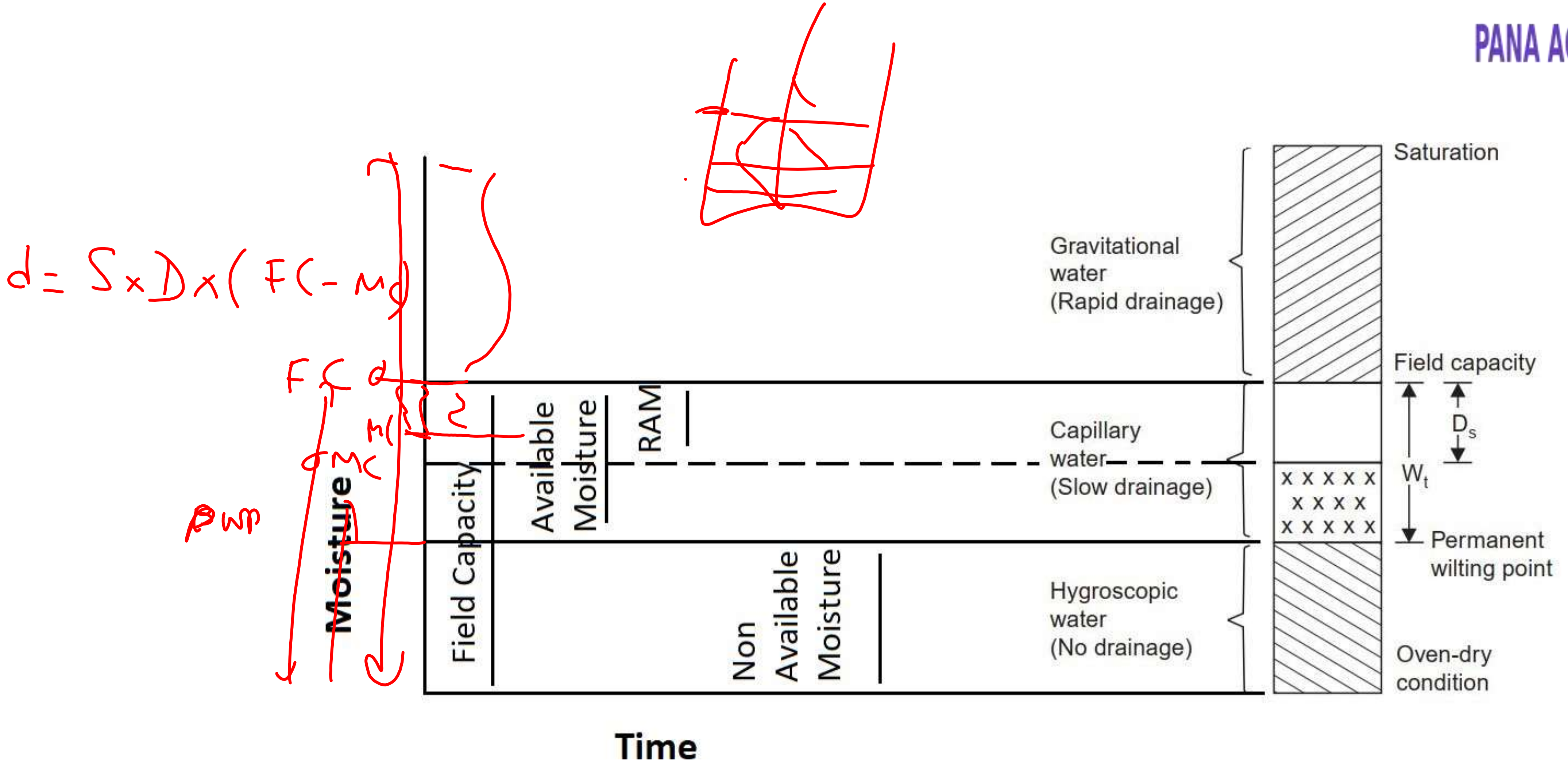
<u>Available moisture content(AMC):</u> Difference of water content between field capacity and permanent wilting point

$AMC = S \times D \times (FC - PWP)$

$RAMC = S \times D \times (FC - OMC)$



Soil-moisture-irrigation relationship



Soil-moisture-irrigation relationship

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Optimum moisture content (OMC): Maximum water level upto which Moisture may be allowed to be depleted in root zone.

Readily available moisture content(RAM): The portion of AMC that is most easily extracted by plants is called RAM. It is generally taken as 75% to 80% of AMC

Soil moisture deficiency: Water required to bring soil at a given water content to its field capacity.

Soil-moisture-irrigation relationship

If D be the root zone depth in meters and d be the equivalent depth of water in the soil of surface area A m^2

Then,

$$FC = \frac{Wt.of\ water\ retained\ in\ certain\ volume\ of\ soil}{Wt.of\ same\ volume\ of\ dry\ soil}$$

Let, γd = dry unit weight of soil (KN/m^3)

$$FC = \frac{\gamma w * A * d}{\gamma d * A * D}$$

$$d = \frac{\gamma d * D * FC}{\gamma w} = S * D * FC$$

This is depth of water stored in the soil upto root field capacity

Soil-moisture-irrigation relationship

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Let, γd = dry unit weight of soil (KN/m³)

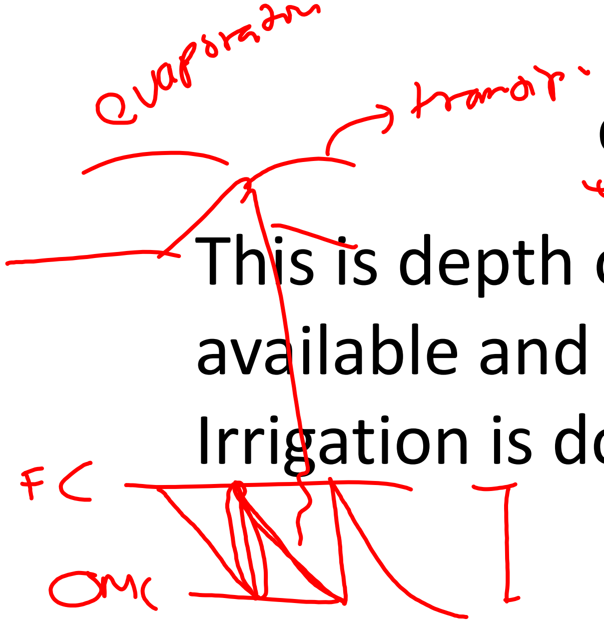
$$FC = \frac{\gamma w * A * d}{\gamma d * A * D}$$

$$\mathrm{d}_{\mathrm{availiable}} = \frac{\gamma d * D * (FC - PWP)}{\gamma w}$$

$$\mathrm{d}_{Readily\ \mathrm{availiable}} = \frac{\gamma d * D * (FC - OMC)}{\gamma w}$$

Depth and frequency of irrigation

PANA ACADEMY



$$d_{Readily\ \text{available}} = \frac{\gamma d * D * (FC - OMC)}{\gamma w}$$

This is depth of water stored in the soil upto moisture is readily available and plant is not stressed.

Irrigation is done to increase moisture from OMC to FC

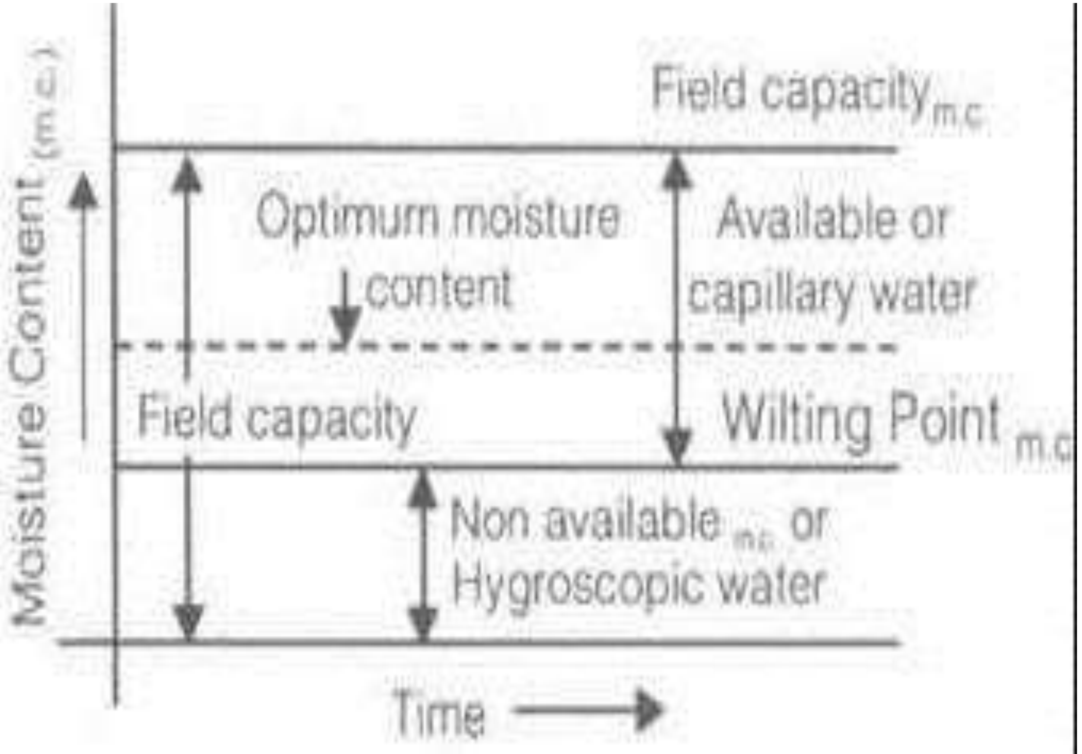
$$d_{\text{irr}} = d_{Readily\ \text{available}}$$

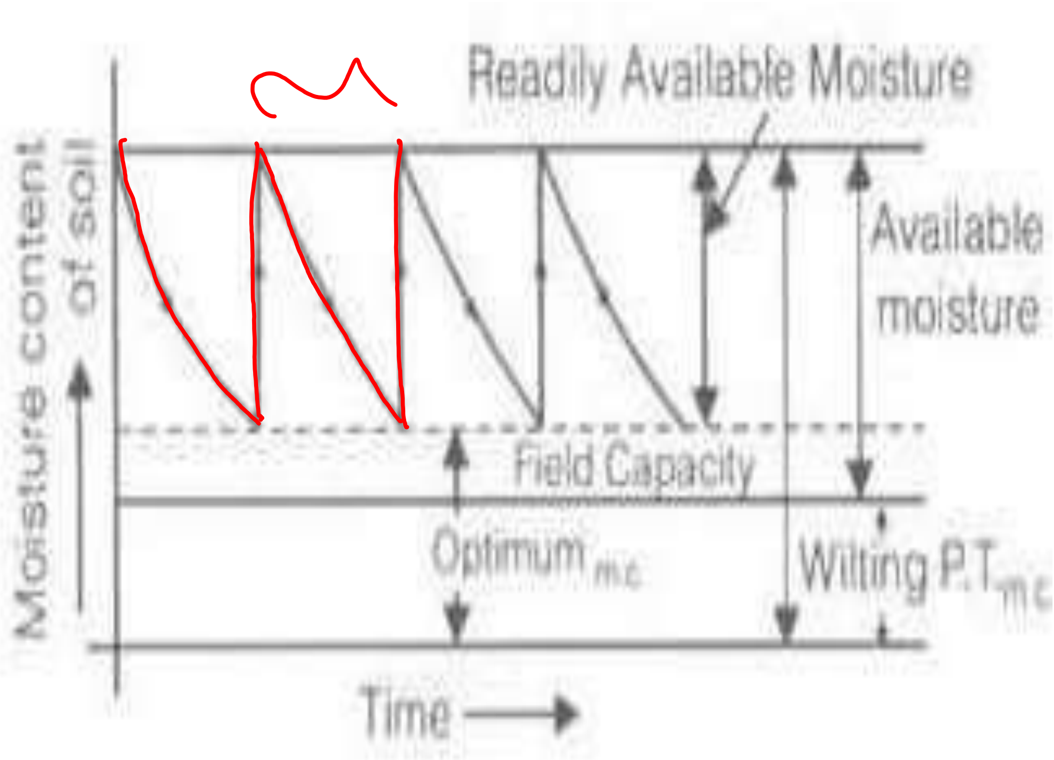
Water required by plants = ETcrop mm/day

Thus, Irrigation interval = $\frac{Depth\ of\ water\ required}{\text{ETcrop}}$

Time interval between two consecutive watering is called as frequency of irrigation (FOI) or Rotation period

Depth and frequency of irrigation

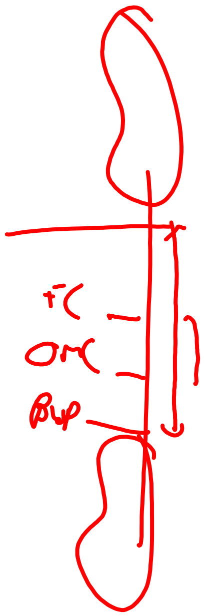




Questions

Q) Calculate the storage capacity of soil, depth of water available for consumptive use and irrigation interval with given data.

Field Capacity = 40%, Permanent Wilting Point = 16%, Effective depth of root zone = 70 cm , Dry Density of Soil = 1.5 gm/cc , Consumptive Use of Water , ETc = 5mm/day , RAM = 80% of available moisture



Ans:

Storage = 25.2 cm ,

RAM Depth = 20.16 cm and Irrigation interval = 40 days

$\frac{201.6 \text{ mm}}{5} = 40$ ..

$S = 1.5$

$d_{FC} = S \times D \times FC$
$= 1.5 \times 70 \times 0.4$
$= 42 \text{ cm}$

$d_{PWP} = S \times D \times 0.16$
$= 16.8 \text{ cm}$

Design discharge of canal

PANA ACADEMY

Design discharge is:

- **Maximum of discharge** required if **two season** is given
- **Sum of discharge** if crops are of **same season** or crops have **overlapping growing season**

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

Questions

PANA ACADEMY

$CCA = 85\%\ 80000$

$= 68117.6\ ha$

(Q). An irrigation canal has GCA of 80000 ha out of which culturable irrigable is 85%. The intensity of irrigation for Kharif season is 30% and for Rabi season is 60%. Find the discharge required at the head of canal if the duty at its head is 800 ha/cumec for Kharif and 1700 ha/cumec for Rabi.

Ans: 25.5 cumec

$$Q_k = \frac{A_k}{D} = \frac{68000 \times 0.3}{800} = 25.5$$

$$Q_R = \frac{A_r}{D} = \frac{CCA \times 0.6}{1700} = 24$$

Questions

PANA ACADEMY

CCA

(Q). The culturable command area for a distributary channel is 10000 hectares. The intensity of irrigation is 30 per cent for wheat and 15 per cent for rice. The kor period for wheat is 4 weeks, and for rice 3 weeks. Kor watering depths for wheat and rice are 135 mm and 190 mm, respectively. Estimate the outlet discharge.

Ans: 1.674 cumecs

R Sw

$$D = \frac{8.64 \times 3 \times 7}{190/1000}$$

$$Q_R = \frac{0.15 \times 10000}{954.54} = 1.57$$

$$Q_w = \frac{0.3 \times 10000}{1792} = 1.674 \qquad D = \frac{8.64 \times 4 \times 7}{135/1000}$$

Questions

PANA ACADEMY

(Q). An irrigation canal has CCA of 2600 ha out of which intensity of irrigation for perennial sugarcane is 20% and for rice is 40%. Find the discharge required at the head of canal if the peak demand is 120% of ave. requirement, if duty at its head is 750 ha/cumec and 1800 ha/cumec respectively.

Ans: 1.53 cumec