IRRIGATION TECHNIQUES AND QUALITY OF IRRIGATION WATER

"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."

Crop Requirement :- Different types of plants require different quantities of water, and at different times, till they grow up completely.

Water is normally supplied to these plants through direct rain or through the flood waters of rivers which inundate large land areas during floods → By Nature.

Sometimes, there may be heavy rains creating serious floods & damaging the crops, and sometimes, there may not be rains at all, creating 'scarcity of water for the crops'.

So man discovered various methods by which the water can be stored during the periods of excess rainfall, and to use that stored water during periods of 'less rainfall' or 'no rainfall'.

NECESSITY OF IRRIGATION IN INDIA

- India is a tropical country with vast diversity of climate, topography and vegetation. Annual avg. rainfall of the country is 1170 mm.
- Rainfall in India, varies considerably in its place of occurrence, as well as in its amount.
- Even at a particular place, the rainfall is highly erratic & irregular as it occurs only during a few particular months of a year.
- Crops cannot, therefore, be raised successfully, over the entire land, without providing artificial irrigation of fields.

Statistics. World over, the irrigation sector is the largest user of water — almost 80% of water in world is taken up by irrigation. (In India, the irrigation sector uses ~ 85% of its available water resources). Almost 50% of this water is lost to evaporation, percolation, sub-surface flows to ocean.

	Utilization (mha)	Capacity (mha)
Major & Medium	28.02	32.69
Minor : Groundwater	42.50	45.73
Surface	10.12	10.89

Source: Gulati et. al. (2005)

Irrigation in India includes a network of major & minor canals from Indian rivers, groundwater well based systems, tanks, & Other rainwater harvesting projects for agricultural activities.

- Of these groundwater system is the largest.

- In 2010, only about 35 % of total agricultural land in India was reliably irrigated.

- About 2/3rd cultivated land in India is dependent on monsoons.

- Irrigation in India helps improve
  (i) food security (ii) reduce dependence on munsoons
  (iii) improve agricultural productivity
  (iv) creat rural job opportunities.

NEED FOR IRRIGATION.

→ India is a big country & stands next to china when we talk about population & so irrigation facilities are needed to grow more food to feed our teaming millions.

→ The distribution in rainfall is uneven & uncertain which either causes famines or drought. By means of irrigation we can check both the problems.

→ Different water requirements of different crops can only be met through irrigation facilities.

→ India, being a tropical country the temperature is high & evaporation more rapid, so, artificial irrigation is necessary for ample supply of water & also to prevent water scarcity in the long dry winter season.

Mixed cropping.

= Mixed cropping is an insurance against crop failure due to abnormal weather conditions or irregular waterings.

- Mixed cropping is done to reduce the competition between Component crops for light, nutrients & water.
  If one crop fails due to shortage of moisture or insufficient availability of nutrients, the other crop can cover the risk of complete failure.

- One crop requires comparatively lesser water than the other.

Groundnut + Sunflower
Wheat + Mustard
Cotton + Groundnut.
Maize + Black gram (udad dal).
e.g; Pea + Green gram (Mung-dal).

Improvement of soil fertility
- Growth of cereal crops depletes the nutrients of soil. Growing legumes will help increase the nitrogen content of soil.

ADVANTAGES OF IRRIGATION

1. Increase in Food Production

Helps in increasing crop yields and to attain self-sufficiency in food.

2. Optimum Benefits

Obtaining maximum crop yield with required amount of water.

3. Elimination of Mixed Cropping. (Also known as multiple cropping).

In the areas, where irrigation is not assured, generally mixed cropping is adopted (mixed cropping means sowing together of two or more crops in the same field) Mixed cropping is found necessary & also economical when irrigation facilities are lacking. But if irrigation is assured, mixed cropping can be eliminated.

(Mixed cropping is generally not acceptable, because different crops require different types of field preparations & different types of waterings, manurings etc. Moreover, during the time of harvesting, the crops gets intermixed with each other, reducing the purity of each other)

But when regular & permanent water supply is assured, a single superior crop can be sown, depending upon the conditions of the soil & the needs of the country.

4. General Prosperity.

Revenue returns with well developed irrigations are sometimes quite high, and helps in all round developement of the country and prosperity of the entire nation & community.

5. Generation of Hydro-electric power

cheaper power generation can be obtained from water development projects primarily designed for irrigation alone.

6. Domestic Water Supply

Developement of irrigation facilities in an area helps in augmenting the water supply in nearby villages & towns, where other sources of water are not available or are scarcely available.

7. Facilities of Communication.

Irrigation channels are generally provided with embankments & inspection roads.

8. Inland Navigation.

Sometimes, larger irrigation canals can be used & developed for navigation purposes.

9. Afforestation.

Trees are generally grown along the banks of the channels which increase the timber wealth of the country & also helps in reducing soil erosion & air pollution.

DISADVANTAGES OF IRRIGATION

1. Water Pollution

   Irrigation leads to seepage & seepage of nitrates into the ground water, that have been applied to the soil as fertilizer. As such the underground water gets polluted, and if consumed by people through wells or tube wells etc. it is likely to cause disease such as anemia.

2. Dampness

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

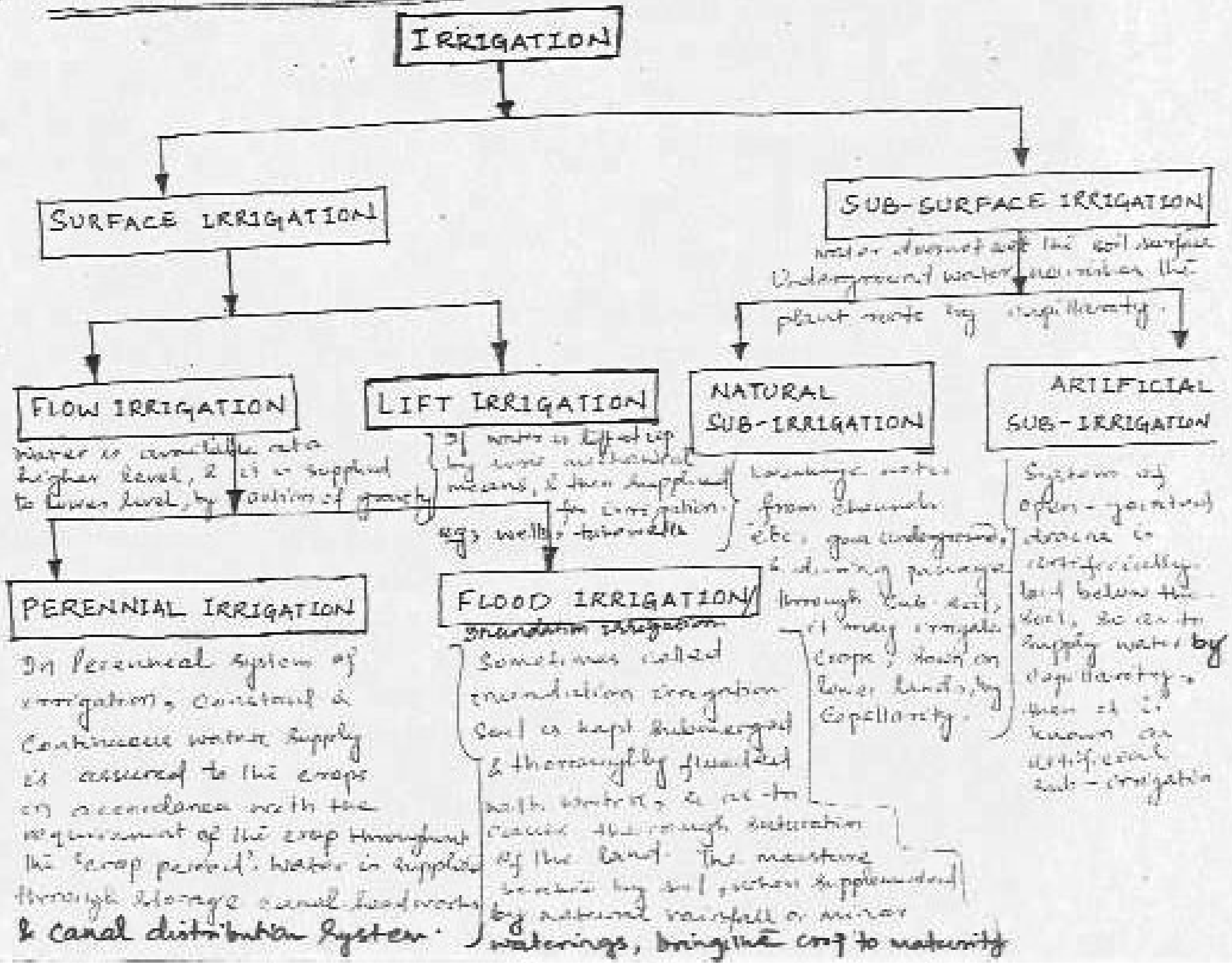
3. Water-Logging

   Over-irrigation may lead to water-logging & may reduce crop yield.

4. Expensive

   Procuring and supplying irrigation water is complex and expensive in itself. Sometimes, subsidised cheaper water has to be provided at the cost of the government, which reduces revenue returns.

TYPES OF IRRIGATION :-



TECHNIQUES OF WATER DISTRIBUTION IN FARMS

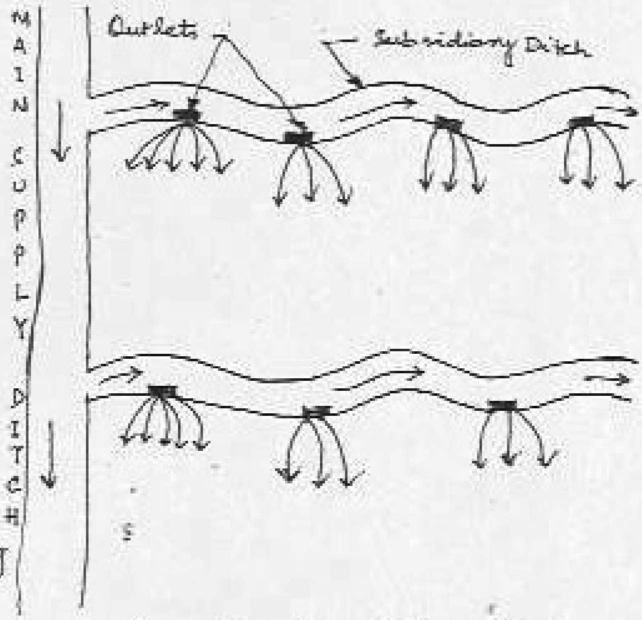
There are various ways in which the irrigation water can be applied to the fields.

The main classification is as follows:

(1) Free flooding
(2) Border flooding
(3) Check flooding
(4) Basin flooding
(5) Furrow irrigation method
(6) Sprinkler irrigation method } Micro-Irrigation.
(7) Drip irrigation method.

(1) FREE FLOODING (OR) ORDINARY FLOODING

- In this method, ditches are excavated in the fields, and they may be either on the contour or up & down the slope.
- 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, etc. Since the movement of water is not restricted, it is sometimes called 'Wild Flooding'.
- Contour ditches called laterals or subsidiary ditches, are generally spaced at about 20 - 50 metres apart, depending upon the slopes, texture of soil, crops to be grown etc.



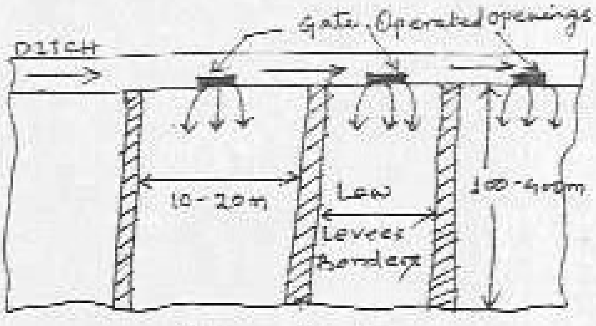
Free flooding (plan view)

Advantages :- Initial cost of land preparation is low.

Disadvantages :- Labour requirements are usually high.
Water application efficiency is low.

Suitability :- This method may be used on rolling land (steep land) where borders, checks, basins & furrows are not feasible.

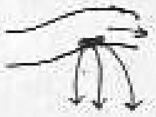
(2)
BORDER FLOODING



(plan view)

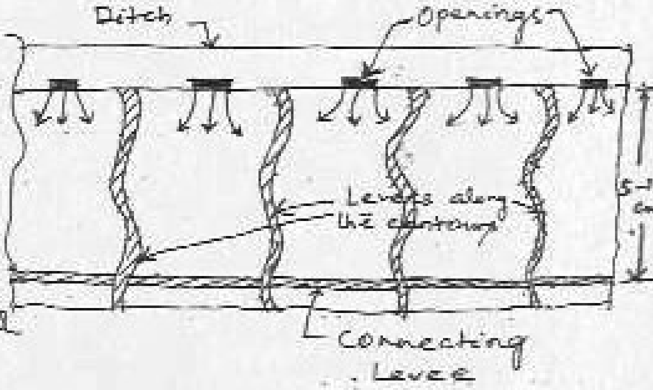
- In this method, the land is divided into a number of strips separated by low levees called borders.
- The land areas confined in each strip is of the order of 10-20 m in width, & 100 to 400 m in length.
- The water flows slowly towards the lower end from the supply ditch into each strip & infilterates into soil as it advances. When the advancing water reaches the lower end of the strip, the supply of water to the strip is turned off.

[* Shorter & narrower strips are found to be more efficient]



Supply Ditch :- Also called irrigation stream, may either be earthen channel or a lined channel or an underground concrete pipe.
- The size of the supply ditch depends upon the
- Infilterate rate
- Width of the border strip.

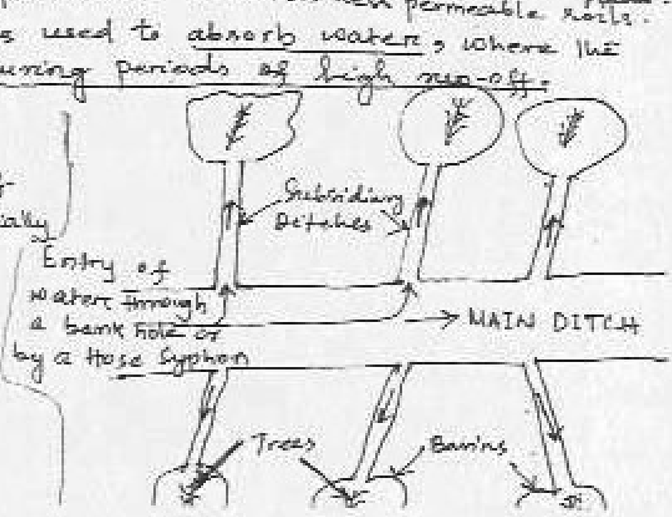
(3)
CHECK FLOODING



- Check flooding is similiar to Ordinary flooding except that the water is controlled by surrounding the check area with low & flat levees.
- Levees are generally constructed along the contours, having vertical interval of about 5 to 10 cm.
- Levees are connected with cross-levees at convenient places.
- In check flooding, the check is filled with water at a fairly high rate & allowed to stand still until the water infilterates.

Suitability.
- Method is suitable for more permeable as well as less permeable soils. Deep rooted plants.
- These checks, are sometimes used to absorb water, where the stream-flow is diverted during periods of high run-off.

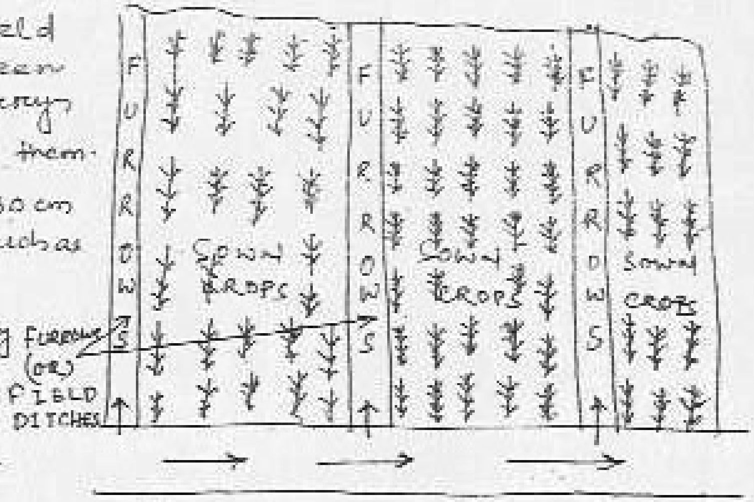
(4)
BASIN FLOODING



- This method is a special type of check flooding & is adopted specially for Orchard trees.
- One or more trees are placed in the basin, and the surface is flooded as in check method.

(5) FURROW IRRIGATION METHOD

- Furrows are narrow field ditches, excavated between rows of plants and carry irrigation water through them.
- Furrows vary from 8 – 30 cm deep, and may be as much as 400 m long.
- Deep furrows are widely used for row crops.
- Small shallow furrows called '<u>corrugations</u>' are particularly suitable for relatively irregular topography and close growing crops, such as meadows & small grains.



ENTRY OF WATER THROUGH A BANK HOLE OR BY A HOSE SYPHON.

(Plan view)

- Water may be directed into the furrows by an opening in the bank of the supply ditch or preferably by using a rubber hose tubing, which can be primed by immersion in the ditch. The use of hose, prevents the necessity of breaking the ditch bank, and provides a uniform flow into the furrow.

ADVANTAGES :-

In flooding methods, water covers the entire surface; while in furrow irrigation method, only one-fifth to one-half of the land surface is wetted by water. Therefore, it results in less evaporation, less pudding of soil, and permits ~~irrigation~~ cultivation sooner after irrigation.

DISADVANTAGES :-

Excessive long furrows may result in too much percolation near the upper end, and too little water near the down-slope end.

(6) SPRINKLER IRRIGATION METHOD ("More crop per drop")

Micro-irrigation encompasses Drip & Sprinkler technologies. In both these technologies, water is available in quantities & location more suitable to the plant growth & near the root zone.

- In this farm-water application method, water is applied to the soil in the <u>form of spray</u> through a network of pipes and pumps.
- It is a kind of <u>artificial rain</u> and, therefore gives very good results.
- The system is to be designed in such a way that the <u>entire sprayed water seeps into the soil</u>, and there is <u>no runoff</u> from the irrigated area.
- Application of micro-irrigation devices leads to 30 – 70% water savings relative to flood irrigation.

Conditions favoring the adoption of this method are

1. Land topography is irregular, hence unsuitable for surface irrigation.
2. Land gradient is steeper, & soil is easily erodible.
3. Water table is high.
4. Land soil is excessively permeable, so as not to permit good water distribution by surface irrigation; or when the soil is highly impermeable.
5. Area is such that seasonal water requirement is low, such as near the coasts (as the water is available with difficulty & is scarce.
6. When the crops to be grown are such:
   (a) as to require humidity control, as in tobbacco;
   (b) crops having shallow roots; or
   (c) crops requiring high & frequent irrigation.

WORKING

- In the sprinkler irrigation network, there are mains & sub-mains, through which water under pressure is made to flow.
- Revolving sprinkler heads are then usually mounted on rising pipes attached to the laterals.
- When sprinkler heads are not provided, perforations are made in pipes, and they are provided with nozzles, through which water jets out. Such perforated pipe system operates at low head.
- Revolving head sprinklers operate on high as well as low heads, depending upon the type of rotary head used.

ADVANTAGES :-

1. Seepage losses are completely eliminated. Only optimum quantity of water is used in this method.
2. Land levelling is not required, avoiding removal of top fertile soil.
3. No cultivation area is lost for making ditches, thus increasing about 16% of the cropped area.
4. Fertilisers can be uniformly applied as they are mixed with irrigation water itself.
5. This method leaches down salt & prevents water-logging & salinity.
6. Less labour-oriented.
7. Upto 80% efficiency can be achieved, i.e., upto 80% of applied water can be stored in the root zone of plants. Increasing water-application efficiency.

LIMITATIONS :-

1. High winds may distort sprinkler pattern, causing non-uniform spreading of water on crops.

2. Considerable evaporation losses of water in the areas of high temperature & high wind velocity.

3. Not suited to crops requiring larger depths of irrigation such as paddy.

4. Initial cost of the system is very high, and the system requires a high technical skill.

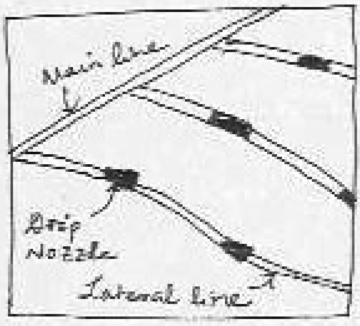
5. Only sand & silt free water can be used, or otherwise pump impellers lifting such waters will get damaged.

6. Requires larger electrical power.

7. Constant water supply is needed for commercial use of equipment.

(7) DRIP IRRIGATION (Sub-Surface Irrigation)

- Drip irrigation, also called trickle irrigation, is the latest field irrigation technique, and is meant for adoption at places where there exists acute scarcity of irrigation water & other salt problems.
- In this method, water is slowly and directly applied to the root zone of the plants, thereby minimising the losses by evaporation & percolation.
- This system involves laying of a system of head, mains, sub-mains, laterals and drop nozzles.



(Layout of mains, laterals and drip nozzles)

HEAD :- Head consists of a pump to lift water, so as to produce the desired pressure of about 2.5 atm, for ensuring proper flow of water through the system. The lifted irrigation water is passed through a fertiliser tank, so as to mix the fertiliser directly in the irrigation water, and then through a filter, so as to remove the suspended particles from the water, to avoid clogging of drip nozzles.

MAINS & SUB-MAINS :- are the specially designed small sized pipes, made of flexible material like black PVC. Generally buried or laid on the ground. Their sizes should be sufficient to carry the design discharge of the system.

LATERALS :- Laterals are very small sized (usually 1 to 1.25 cm dia), specially designed, black PVC pipes, taking off from the mains or sub-mains. Laterals can usually be up to 50 m long, & one lateral line is laid for each row of crop.

DRIP NOZZLES :- Drip nozzles, also called emitters, or valves, are fixed on laterals, at regular intervals of about 0.5 or 1 m or so, discharging water at very small rates of the order of 2 to 10 litres per hr.

QUALITY OF IRRIGATION WATER

[A certain quality of irrigation water which is suitable for a particular soil may not suited to other soil because constituents differ from soil to soil]

- Quality of suitable irrigation water is very much influenced by its the constituents of the soil which is to be irrigated.
- The various types of impurities, which make the water unfit for irrigation, are classified as,
  - (i) Sediment Concentration in water.
  - (ii) Total concentration of soluble salts in water
  - (iii) Proportion of sodium ions to other cations
  - (iv) Concentration of potentially toxic elements present in water.
  - (V) Bicarbonate concentration as related to the concentration of calcium plus magnesium.
  - (vi) Bacterial contamination.

* The effect of these impurities are discussed below.

1. Sediment –

- The effect of sediment present in the irrigation water depends upon the type of irrigated land. (When fine sediment from water is deposited on sandy soils, the fertility is improved. If the sediment has been derived from the eroded areas, it may reduce the fertility or decrease soil permeability).

2. Total concentration of soluble salts

- Salts of calcium, magnesium, sodium and potassium, present in the irrigation water may reduce the osmotic activities of the plants & may prevent adequate aeration, causing injuries to plant growth.
- The injurious effects of salts on the plant growth depends upon the concentration of salts left in the soil.

The salinity concentration of the soil solution (C_s) after the consumptive water (C_u) has been extracted from the soil, is given by

$$C_s = \frac{C \cdot Q}{[Q - (C_u - P_{eff.})]}$$

where,

Q = quantity of water applied.

C_u = Consumptive use of water, i.e; the total amount of water used by the plant for its growth.

$P_{eff.}$ = Useful rainfall.

$C_u - P_{eff.}$ = Used up irrigation water.

C = concentration of salt in irrigation water.

CQ = Total salt applied to soil with Q amount of irrigation water.

Leaching

In this process, the land is flooded with adequate depth of water. The alkali salts present in the soil, gets dissolved in this water, which percolate down to join the watertable or drained away by surface & sub-surface drains. The process is repeated till the salts in the top layer of the land are reduced to such an extent that some salt resistant crops can be grown. This process is known as 'leaching'.

$C_s > 700$ ppm, harmfull to some plants
$C_s < 2000$ ppm; injurious to all crops.

- The amount of salt concentration in excess of 700 ppm are harmfull to some plants, and more than 2000 ppm are injurious to all crops.

Salt concentration in irrigation water is measured ... → mg/l or ppm, MEQ/L, EC μmhos/cm

Salt concentration ∝ Electrical Conductivity (EC)

Low Salinity (C1) EC ranges from 100 – 250 micro mhos/cm @ 25°C
Permissible under normal irrigation practices; Very little salinity may develop, which may require slight leaching. Can be used for irrigating almost all crops and for almost all kinds of soils.

Medium Salinity (C2) 250 < EC < 750 micro mhos/cm @ 25°C
Normal salt-tolerant plants can be grown without much salinity control.

High Salinity (C3) 750 < EC < 2250 micro mhos/cm @ 25°C
Cannot be used on soils with restricted drainage. Special precautions & measures are undertaken for salinity control & only high-salt tolerant plants can be grown. eg; Fooder, tobbacco, bajra

Very High Salinity (C4) EC > 2250 micro mhos/cm @ 25°C
Generally not suitable for irrigation.

3. Proportion of sodium ions to other cations.

The percentage of the sodium ions is generally less than 5% of the total exchangeable cations. % Na^+ < 5% of total exchangeable cations

If this percentage increases to about 10% or more, the aggregation of soil grains break down. The soil becomes less permeable & of poorer tilth. It starts crusting when dry and its pH increases towards that of an alkaline soil. (Permeability decreases & pH increasing)
High sodium soils are, therefore, plastic, sticky when wet, and hard crust on drying. Reclamation of such soil is more difficult.

- The proportion of sodium ions present in soils, is generally measured by a factor called Sodium-Absorption Ratio (SAR) represents sodium hazards of water.

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

where, the concentration of the ions is expressed in equivalent per million (epm);

$$epm = \frac{C_s}{\text{Combining Weight}};$$

C_s = conc^n of salt (mg/l or ppm)

$$\text{Combining Weight} = \frac{\text{Atomic wt.}}{\text{Valance}}$$

mpfull crops.

0 < SAR < 10 — Low sodium water (S1)
10 < SAR < 18 — Medium sodium water (S2)
18 < SAR < 26 — High sodium water (S3)
SAR > 26 — Very high sodium water (S4)

4. Concentration of potentially toxic elements

— Boron & Selenium etc. may be toxic to plants.

Concentration of Boron (C_B)

C_B above 0.3 ppm, may prove toxic to certain plants.

C_B > 0.5 ppm, dangerous to nuts, citrus fruits & deciduous fruits.

Cotton, cereals & certain truck crops are moderately tolerant to boron.

Dates, Beets, Asparagus etc. are quite tolerant.

C_B ≯ 4 ppm, even for most tolerant crops.

* Selenium, even in low concentration, is toxic, & must be avoided.

5. Bicarbonate concentration as related to concentration of calcium plus magnesium

High concentration of bi-carbonate ions may result in precipitation of calcium & magnesium bicarbonates from the soil solution, increasing the relative proportion of sodium ions & causing sodium hazards.

6. Bacterial contamination

{Bacterial contamination may not be directly harmful to the plants, but it may be injurious to persons or animal eating those plants.}

Bacterial contamination of irrigation water is not a serious problem, unless the crops irrigated with highly contaminated water are directly eaten, without being cooked. Cash crops like cotton, nursery stock, etc. which are processed after harvesting, can, therefore, use contaminated waste waters, without any trouble.

FUNCTIONS OF IRRIGATION WATER

The functions of soil moisture in plant growth are very important. Water & nutrients are two most important requirements of the crops. Following are the main functions of irrigation water,

(1) Water act as a solvent for the nutrients. Water forms the solution of the nutrients, and this solution is absorbed by the roots.

(2) Irrigation water supplies moisture which is essential for the chemical action within the plant leading to its growth.

(3) Some salts present in soil react to produce nourishing food products only in the presence of water.

A good irrigation water is the one which performs the above mentioned functions without any side effects which retard the plant growth.

— Irrigation water may be said to be unsatisfactory for its intended use if it contains

(1) Chemicals toxic to plants or the persons using plants as food.

(2) Chemicals which react with the soil to produce unsatisfactory moisture characteristics.

(3) bacteria injurious to persons or animals eating plants irrigated with water.

⟨Chapter-2⟩ WATER REQUIREMENTS OF CROPS

'Water requirements of a crop' means the total quantity and the way in which a crop requires water, from the time it is sown to the time it is harvested.

In other words, different crops will have different water requirements, and the same crop may have different water requirements at different places of the same country, depending upon the variation in climates, types of soils, method of cultivation, and useful rainfalls, etc.

CROP SEASONS

From the agricultural point of view, the year can be divided into two principal cropping seasons, i.e; Rabi & Kharif.

(Spring)

RABI CROPS :- Rabi starts from 1st october and ends on 31st March.

- Rabi crops are wheat, barley, gram, linseed, mustard, potatoes etc.
- Rabi crops are winter crops.

(Autumn's in Arabic)

KHARIF CROPS :- Kharif starts from 1st April and ends on 30th September.

- kharif crops are rice, bajra, jowar, maize, cotton, tobacco, groundnut etc.
- kharif crops are also called ~~winter~~ Summer crops.
- Kharif crops require about two to three times the quantity of water required by Rabi crops.

CERTAIN IMPORTANT DEFINITIONS

1) CROP RATIO (KHARIF - RABI RATIO) :-

The area to be irrigated for Rabi crops is generally more than that for the Kharif crop.

The ratio of proposed areas, to be irrigated in kharif season to that in the Rabi season is called kharif - rabi ratio.

Generally this ratio is 1:2 i.e; kharif area is one-half of the Rabi area.

2) PALEO IRRIGATION :-

Sometimes, in the initial stages before the crop is sown, the land is very dry. This particularly happens at the time of sowing of Rabi crops because of hot september, when the soil may be too dry to be sown easily. In such a case, the soil is moistened with water, so as to help in sowing of the crops. This is known as paleo irrigation.

3) KOR - WATERING :-

The first watering which is given to a crop, when the crop is a few centimeters high, is called kor - watering.

It is usually the maximum single watering followed by other waterings at usual intervals.

- The optimum depth of kor-watering for different crops are different.

Eg: Optimum depth of kor-watering for Rice = 17 cm. (Kharif)
for wheat = 13.5 cm (Rabi)
for Sugarcane = 16.5 cm. (All season)

'kor period' is the fixed limited period in which kor-watering must be applied. Kor-period depends upon climate. It is less for humid climates & more for dry climates.

kor-period for rice varies from 2-4 weeks, and
kor-period for wheat varies from 3-8 weeks.

OVERLAP ALLOWANCE :-

When a crop requires water for its crop season, and for some time in the beginning of the next crop season, allowance has to be made for this overlap. This allowance is known as overlap allowance. Sugarcane is an example of this kind of crop.

FREQUENCY OF IRRIGATION / ROTATION PERIOD :-

The time interval between two consecutive waterings is called frequency of irrigation (or) rotation period.

CROP PERIOD (OR) BASE PERIOD :

CROP PERIOD – The time period that elapses from the instant of its sowing to the instant of its harvesting is called crop-period.

BASE PERIOD – The time between the first watering of a crop at the time of its sowing to its last watering before harvesting is called Base period (or) Base of the crop.

Crop period is slightly more than the Base period.
But for all practical purposes they are taken as the same.
It is represented by B (in days).

DELTA OF A CROP :–

Total depth of water (in cm) required by a crop to come to maturity is called its delta.
It is represented by Δ (cm).

– The total quantity of water required by the crop for its full growth (maturity) may be expressed in hectare – meter or in million cubic meters or, simply as depth to which water would stand on the irrigated area, without percolation or evaporation.

Delta for sugarcane = 120 cm
Δ for Rice = 120 cm
Δ for wheat = 40 cm
Δ for Barley = 30 cm
Δ for Tobacco = 75 cm
Δ for Cotton = 50 cm.

} field values (which includes evaporation & percolation losses)

DUTY OF WATER :– [Duty represents the irrigation capacity of a unit water]

Duty of water represents the relationship between the volume of water and the area of crop it matures.
It is defined as the number of hectares of land irrigated for full growth of a given crop by supply of 1 m^3/s of water continuously during the entire base period (B) of that crop.
It is generally represented by D (hectares/cumec)

RELATIONSHIP BETWEEN D, Δ & B

Let 1 cumec (m^3/s) of water be applied to a crop for B days.
Now, the volume of water applied to the crop during B days

$$= V = (1 \times 60 \times 60 \times 24) B \ m^3$$

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

This quantity (V) matures D hectares of land or $10^4 D \ m^2$ of area.

Total depth of water applied on this land

$$= \frac{\text{Volume}}{\text{Area}} = \frac{86400 B}{10^4 D} = \frac{8.64 B}{D}$$

$$\boxed{\Delta = \frac{8.64 B}{D} (m)} = \frac{864 B}{D} \ (cm);$$

where Δ is in cm, B is in days, D is in hectares/cumec.