ARBA MINCH UNIVERSITY
Water Technology Institute
Faculty of Meteorology and Hydrology

Course Name:-Irrigated Lands Hydrology

Course Code:- MHH1403

CHAPTER ONE

INTRODUCTION TO IRRIGATION AND IRRIGATION METHODS

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Objectivs

- At the end of this chapter student will able to
  - Understand the basics of irrigation
  - Understand importance of using irrigation
  - Know advantage of using irrigation
  - Know disadvantage of irrigation
  - Understand different irrigation methods
  - Know how to choice the best of irrigation method

1.1 Definition of Irrigation

- Plants are living beings and do require water and air for their survival, as do human beings require.
- Their requirement of water varies with their type.
- 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 by nature through **direct rain**.

Cont…

- These natural process, whereby, the water is supplied to the crops for their growth are dependent upon nature or "**God**"

- Sometimes, there maybe very heavy rains creating serious floods and **damaging** the crops, and sometimes there may not be any rains at all, creating **scarcity** of water for crops.

- To control the nature man discovered various methods by which the water can be stored during the period of **excess rainfall** and to use that stored water during period of **less rainfall** or **no rainfall**.

Cont…

- The **art** or the **science** by which it is accomplished is generally termed as **irrigation**.

- Irrigation, may therefore be defined as the science of **artificial application** of water to the land, in accordance with the crop requirement throughout the crop period for full-fledged nourishment of the crops.

Cont…

- Irrigation is any process, other than natural precipitation, which supplies water to crops for their successful growth.

Cont…

- Irrigation, the addition of water to lands via artificial means, is essential to profit-able crop production in **arid climates**.

- Irrigation is also practiced in humid and sub-humid climates to protect crops during periods of drought.

- Irrigation is practiced in **all environments** to maximize production and, therefore, profit by applying water when the plant needs it.

1.2 Advantage of Irrigation

- Every irrigation project is designed, keeping in view of its economics, i.e. the **expenditure** likely to be **incurred** and the benefit likely to occur.

- There is hardly any point in emphasizing the importance and advantage of irrigation during the times of acute food shortages and growing population of the country.

Cont…

- Some advantage of irrigation are summarized below.

1. **Increase in food production:-** irrigation help in increase crop yields, and hence to attain sufficiency in food

2. **Optimum benefits:-** optimum utilization of water is made possible by irrigation.

✓ By optimum utilization, we generally mean obtaining maximum crop yield with required amount of water.

Cont…

- ✓ In other word, yield will be smaller for any quantity lesser than or in excess of these optimum quantity.

3. **Elimination of mixed cropping:-** in the area, where irrigation is not assumed, generally mixed cropping is adopted.

- By mixed cropping, we mean sowing together of two or more crops in the some field.
- If the weather condition are not favorable to one of the crops, they may be better suitable for the other and thus the farmer may get at least some yield.

Cont…

- **Mixed cropping**, is thus found necessary and also economically and when irrigation facilities are lacking, and especially during periods of crash programmers in under-developed countries.
- But if irrigation is assumed mixed cropping can be eliminated.
- Mixed farming is generally not acceptable because different crops require different types of **land preparation** and different type of **watering**, **manurings** etc…

Cont…

4. **General prosperity:-** revenue returns with well developed irrigation are sometimes quit high and helps in all round development of the country and prosperity of the entire nation and community.
5. **Generation of hydro-electric power:-** cheaper power generation can be obtained from water development projects, primarily designed for irrigation alone.

- ✓ Canal outlets from dames and canal falls on irrigation canals can be used for power generation.

Cont…

6. **Domestic water supply:-** development of irrigation facilities in an area helps in augmenting the water supply in nearby villages and towns, where other sources of water are **not available** or are **scarcely** available.

- ✓ It also helps in providing drinking water for animals, and water for swimming, bathing etc.

7. **Facilities of communication:-** irrigation cannels are generally provided with embankments and inspection roads.

Cont…

- These inspection paths provide good roadways to the villagers for walking, cycling or even for motoring

8. **Inland navigation:-** sometimes, larger irrigation canals can be used and developed for navigation purposes.
9. **Afforestation:-** trees are generally grown along the banks of the cannel, which increase the timber wealth of the country and also help in reducing soil erosion and air pollution.

1.3 Disadvantage of Irrigation

1. Irrigation may contribute in various ways to the problem of water pollution.

- ✓ One of these is the seepage in to the ground water of the nitrates, that have been applied to the soil as fertilizer.
- ✓ Sometimes up to 50% of nitrates applied to the soil sinks into the underground reservoir.
- ✓ The underground water may thus get polluted and if consumed by people through wells it likely to cause diseases such as **anemia**.
- ✓ Whether it will ultimately affect the fishing on the way to the sea.

Cont…

2. Irrigation may result in colder and damper climate, resulting in marshy lands and breeding of mosquitoes, cause out break of disease like **malaria**
3. Over irrigation may lead to **water logging** and may reduce crop yield.
4. Procuring and supplying irrigation water is complex and expensive in itself

1.4 IRRIGATION METHODS

a) **Surface Irrigation:** Just flooding water. About 90% of the irrigated areas in the world are by this method.

b) **Sprinkler Irrigation:** Applying water under pressure. About 5 % of the irrigated areas are by this method.

c) **Drip or Trickle Irrigation:** Applying water slowly to the soil ideally at the same rate with crop consumption.

d) **Sub-Surface Irrigation:** Flooding water underground and allowing it to come up by capillarity to crop roots.

1. Surface irrigation

General characteristics of surface irrigation:

- Old-age method
- The most extensively used method worldwide
- Water application is directly on the soil surface
- Requires relatively minimal capital investment
- Doesn't require complicated and expensive equipment
- Energy costs are substantially lower

Cont…

- Labor requirements is relatively high
- Operation and maintenance costs are high
- Relatively inefficient method
- Limited to land already having small and even slopes
- Entirely practiced where water is abundant.
- More affected by water logging and salinity problems
- Land leveling costs are high

a. Furrow irrigation

- Furrows are small, parallel channels, made to carry water in order to irrigate the crop.
- The crop is usually grown on the **ridges** between the furrows
- Furrow irrigation is suitable for many crops, especially **row crops**.
- Crops that would be damaged if water covered their stem or crown should be irrigated by furrows.
- Normally stream sizes up to 0.5 l/sec will provide an adequate irrigation provided the furrows are not too long.

Cont…

- Uniform flat or gentle slopes are preferred for furrow irrigation.
- These should not exceed 0.5%. Usually a gentle furrow slope is provided up to 0.05% to assist drainage following irrigation or excessive rainfall with high intensity.
- Furrows can be used on most soil types.
- However, as with all surface irrigation methods, very coarse sands are not recommended as percolation losses can be high.

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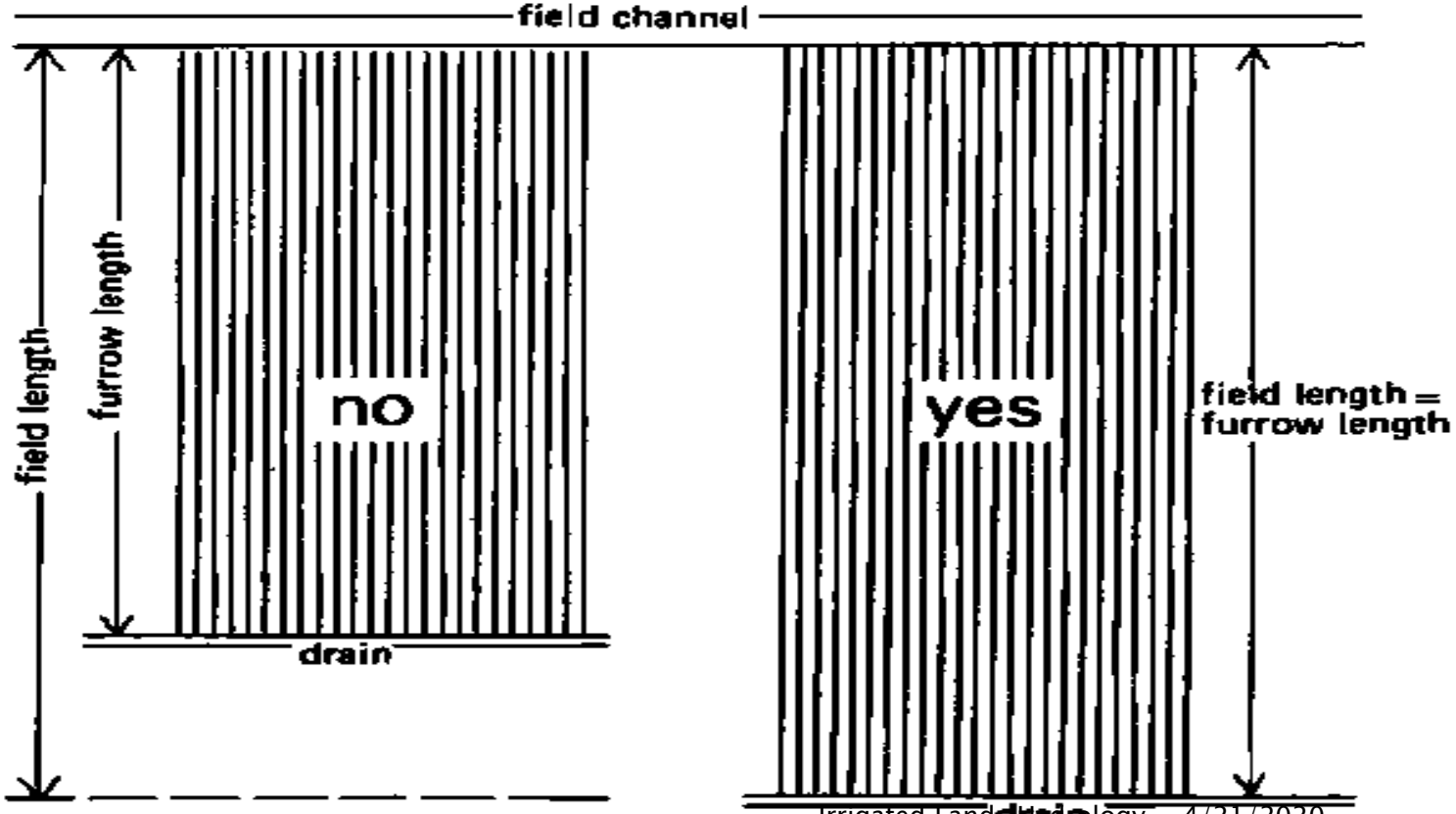
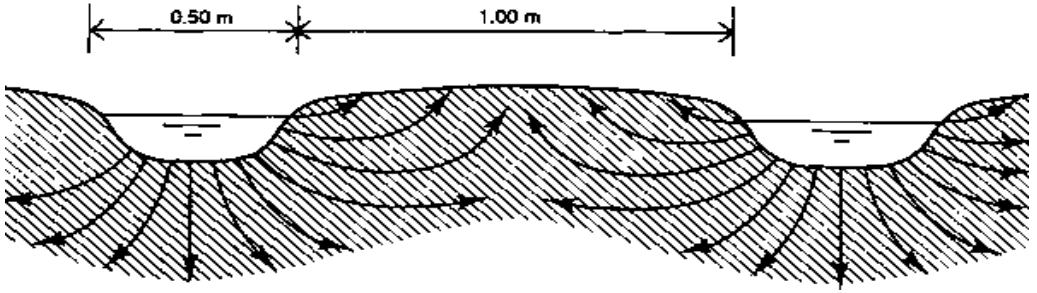
- It may be more practical to make the furrow length equal to the length of the field, instead of the ideal length, when this would result In a small piece of land left over.



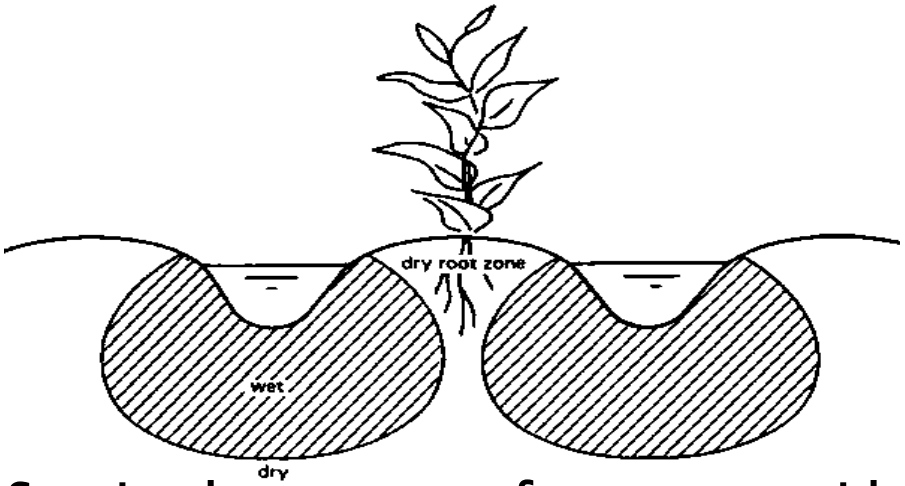
Cont…

- The spacing of furrows is influenced by the soil type and the cultivation practice.
- ✓ As a rule, for sandy soils the spacing should be between 30 and 60 cm, i.e. 30 cm for coarse sand and 60 cm for fine sand.
- ✓ On clay soils, the spacing between two adjacent furrows should be 75-150 cm.
- ✓ On clay soils, double-ridged furrows - sometimes called beds - can also be used.
- ✓ Their advantage is that more plant rows are possible on each ridge, facilitating manual weeding.

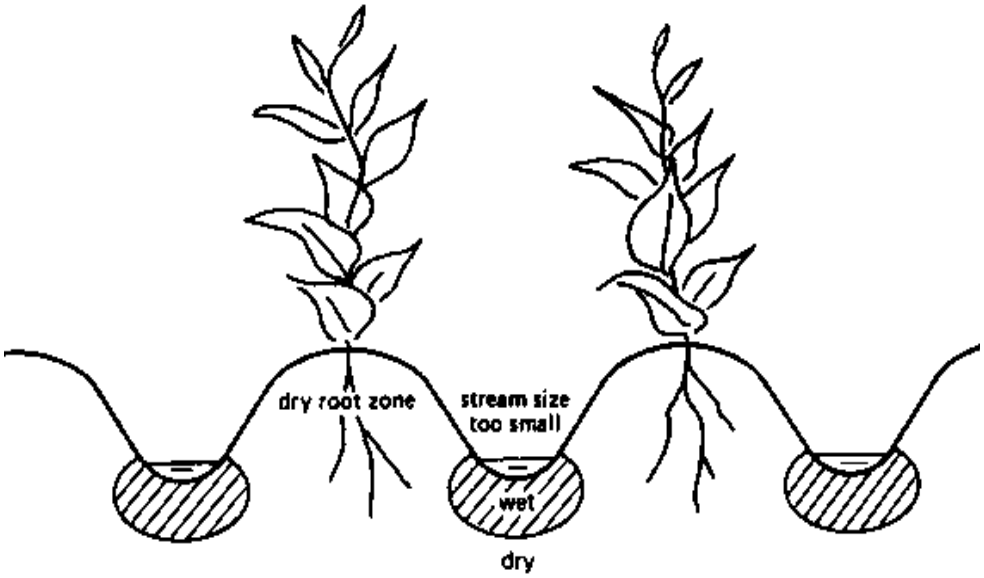
A double-ridged furrow



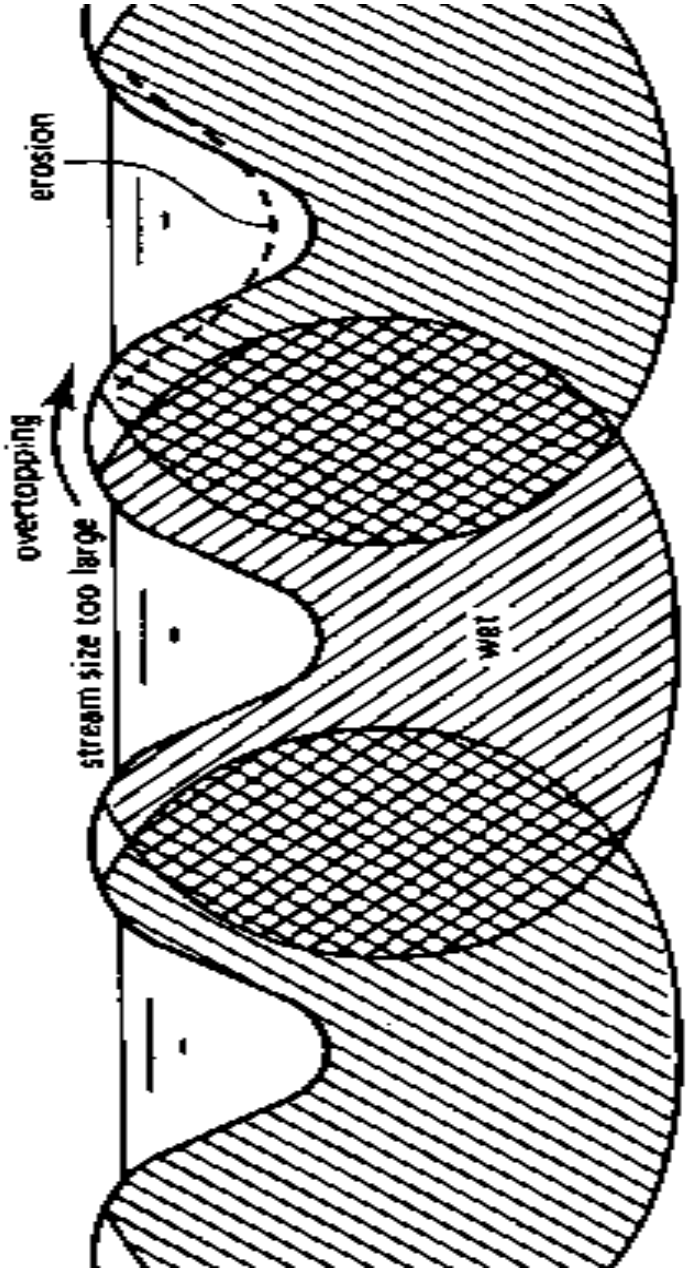
Irrigating Furrows



Spacing between two furrows too wide



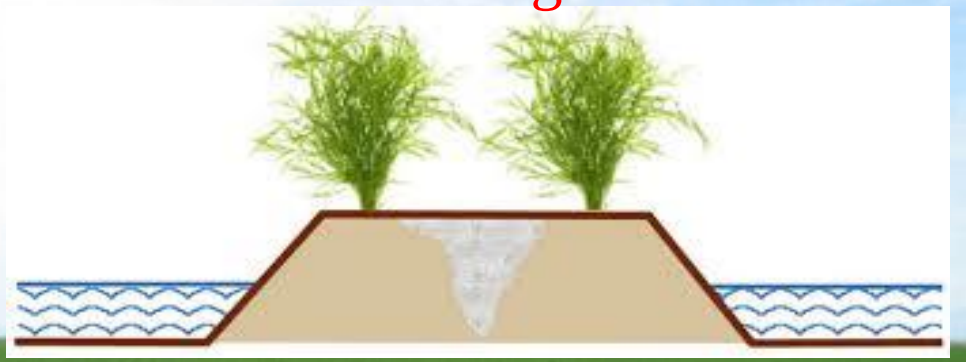
Stream size is too small to wet the ridge



Stream size too large causing overtopping or erosion

Furrow irrigation

Double-ridged furrows



b. Border irrigation

- In this method the land is divided in to a number of strips, separated by low levees called borders.
- The land areas confined in each strip is of the order of 10 to 20 meters in width, and 100 to 400 meters in length.
- **Ridges** between borders should be sufficiently high to **prevent overtopping** during irrigation.
- To prevent water from concentrating on either side of the border, the land should be leveled perpendicular to the flow.
- Water is made to flow from the supply ditch into each strip.

Cont…

- The water flow slowly towards the lower end, and infiltrates in to the soil as it advanced.
- When the advancing water reaches the lower end of the strip, the supply of water to the strip is turned off.
- The supply ditch, also called irrigation stream, may either be in the form of an earthen channel or a lined channel or underground concrete pipe having risers at intervals.
- The size of supply ditch depend up on infiltration **rate of the soil**, and the width of the border strip.

Cont…

- Course textured soil with high infiltration rates will require high discharge rates and **larger supply ditch** in order to spread water over the entire strip rapidly, and to avoid excessive losses due to deep percolation at the upper reaches.
- Fine textured soil with low infiltration rates **require smaller ditches** to avoid excessive losses due to runoff at the lower ditch.
- A relation between the discharge through the supply ditch (Q), the average depth of water flowing over the strip (Y), the of infiltration of soil (F), the area of the land irrigated (A), and the approximate time required to cover the given area (T) is given by

Cont…

$$t = 2.3 * \frac{y}{f} log\left(\frac{Q}{Q - fA}\right)$$

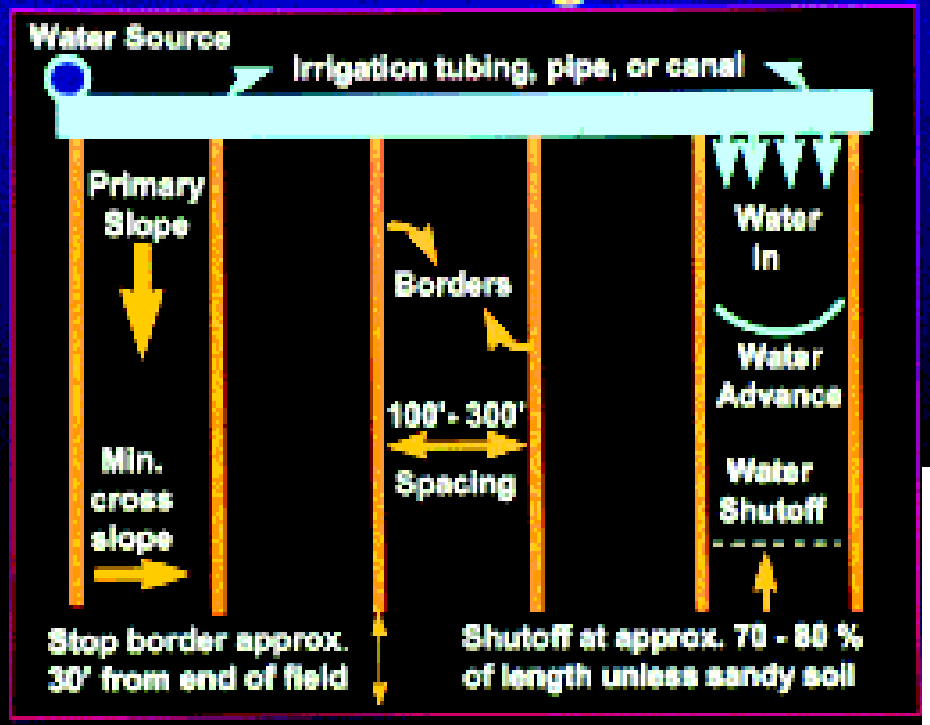
Where Q= Discharge through supply ditch
y=depth of water flowing over the border strip
f=rate of infiltration of soil
A=area of land strip to be irrigated
t=time required to cover the given area A

Prove that $$Amax = \frac{Q}{f}$$

- The equation enables us to determine the maximum area that can be irrigated with a supply ditch of discharge Q and soil infiltration f.

It can also be inferred from this equation that the discharge per unit area of the border strip (Q/A) should be varied according to the infiltration capacity of the soil (f), otherwise loss of water will take place.

Border Irrigation



A Border Strip System

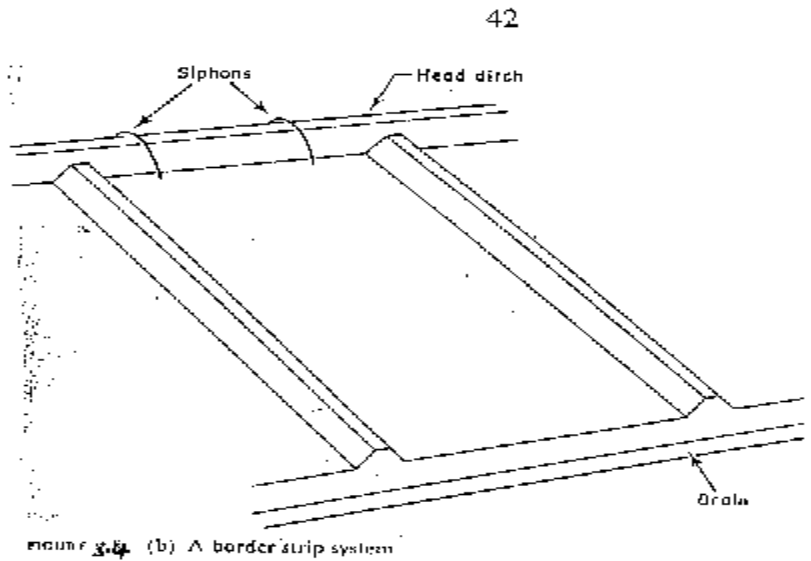
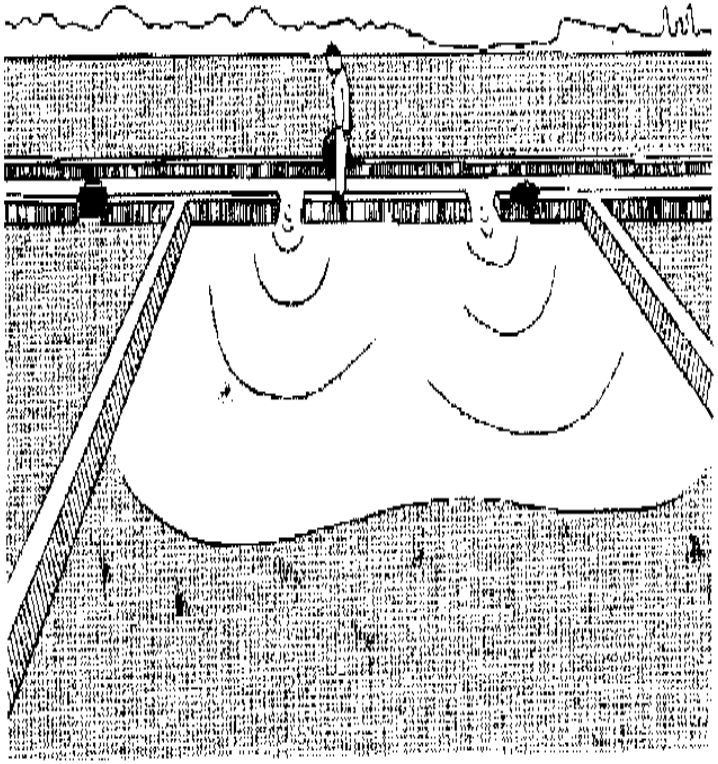
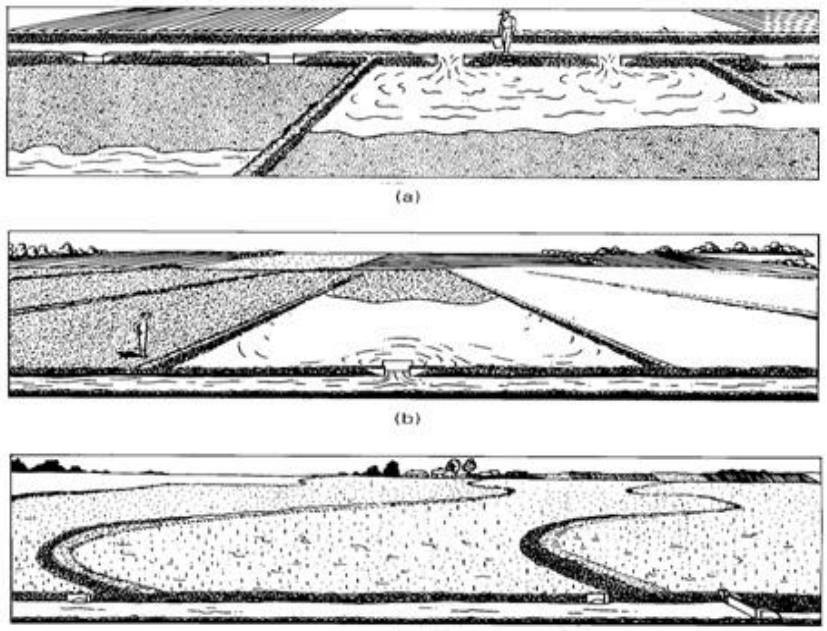
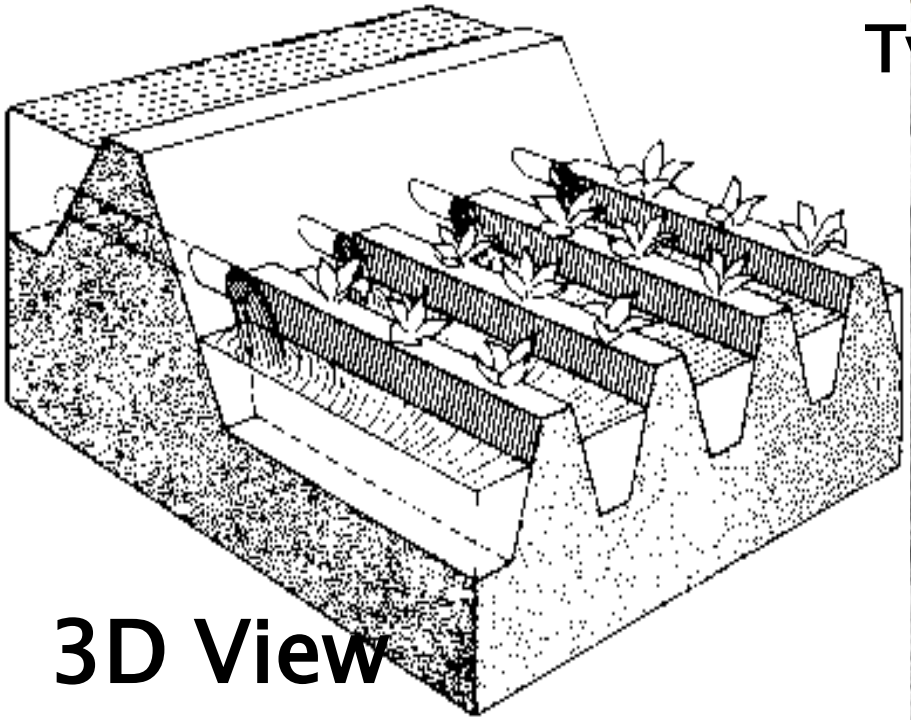


FIGURE 9.4 (b) A border strip system





Typical Border Irrigation Field



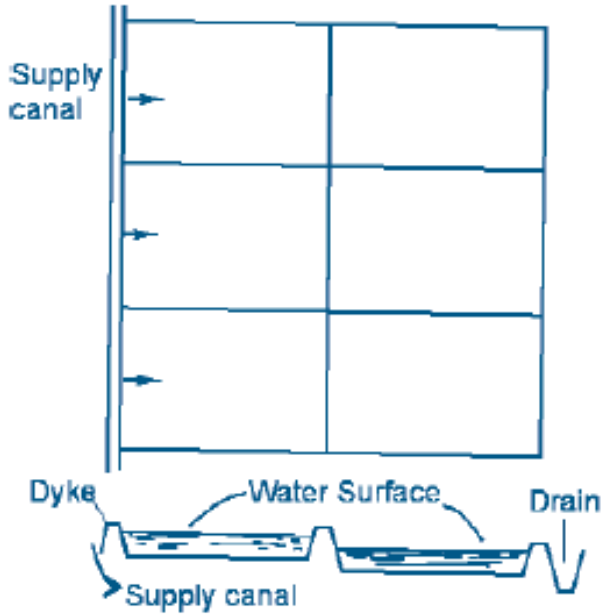
3D View

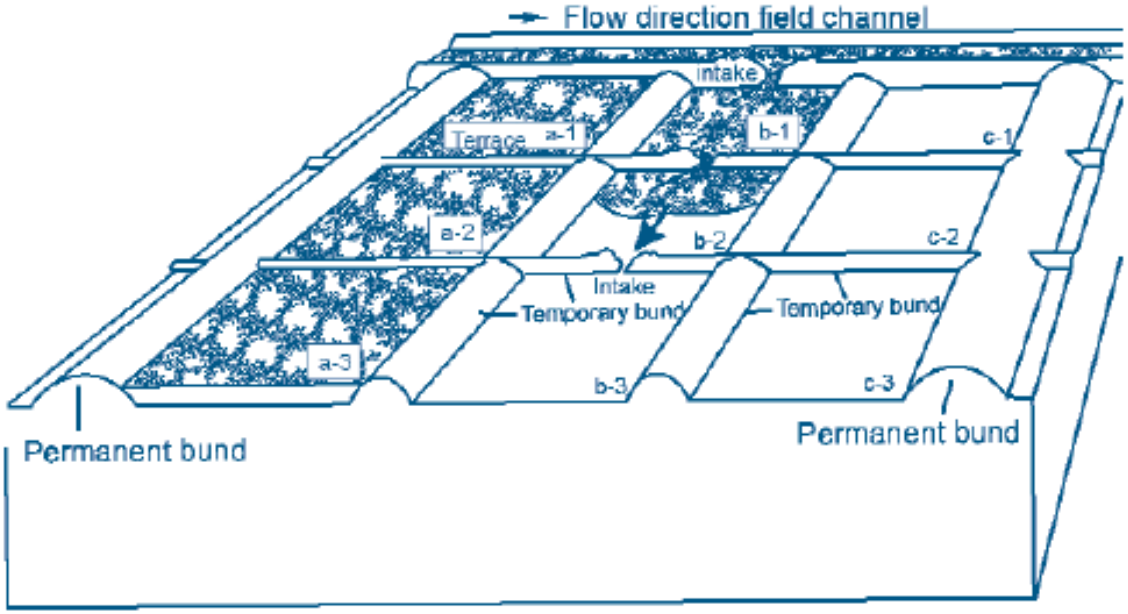
Exercise 1.1 Determine the time required to irrigate a strip of land of 0.04 hectares in area from a tube well with a discharge of 0.02 cumec. The infiltration capacity of the soil may be taken as 5 cm/hr, and the average depth of flow on the field as 10 cm. Also determine the maximum area that can be irrigated from this tube well.

c. Basin Irrigation System

- It involves dividing the field into a number of small strips of land called basins.
- Each basin is a level area of land surrounded by earth bunds in which water can be pounded until it infiltrates in to the soil.

  - **The area is normally flat.**


Supply canal
Dyke
Water Surface
Drain
Supply canal


Flow direction field channel
Intake
Terrace
a-1
b-1
c-1
a-2
b-2
c-2
Intake
Temporary bund
Temporary bund
a-3
b-3
c-3
Permanent bund
Permanent bund

1.6 Sprinkler Irrigation

- It is a system by which water is applied above the ground in the form of spray some what resembling rainfall.
- A sprinkler system conveys water under pressure through pipes network and applies it with a minimum amount of losses.

Types of Systems

❖**Single sprinkler**: Only one sprinkler that is moved or automatically moves

Solid Set

- Laterals are permanently placed (enough to irrigate the entire area)

Portable Solid-Set Sprinkler System

Fairway Runoff Research Plots

Periodically Moved Lateral

- Single lateral is moved and used in multiple locations
  - ✓Hand-move
  - ✓Side-roll
- Fairly high labor requirement

Side-Roll Sprinkler Lateral in Peanuts

Moving Lateral

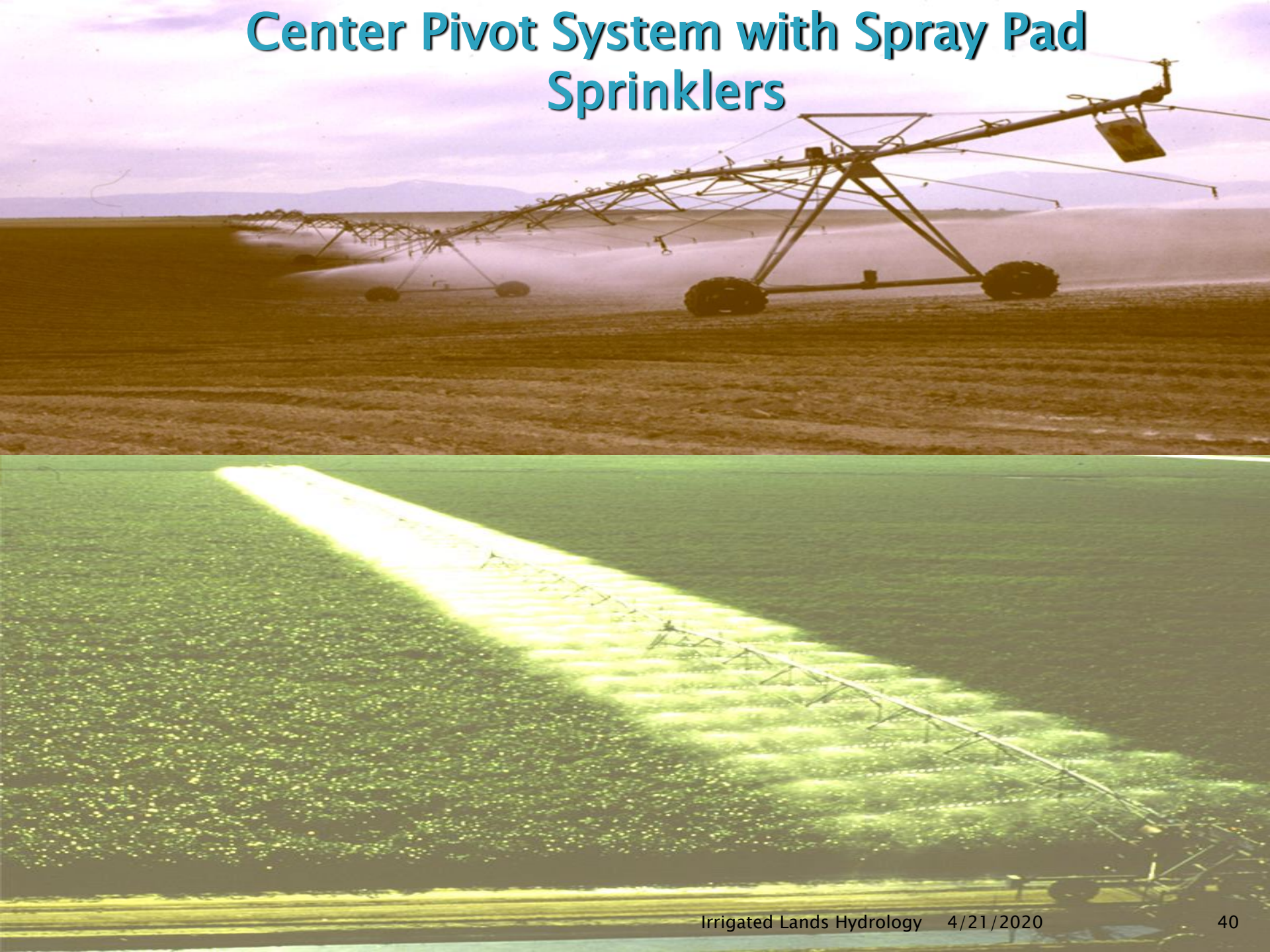
Single lateral moves automatically (mounted on wheeled towers)

Examples:

- ✓Center pivots (lateral pivots in a circle)
- ✓Linear or lateral move systems (lateral moves in a straight line)

- Fairly high capital investment

Center Pivot System with Spray Pad Sprinklers



Advantages:

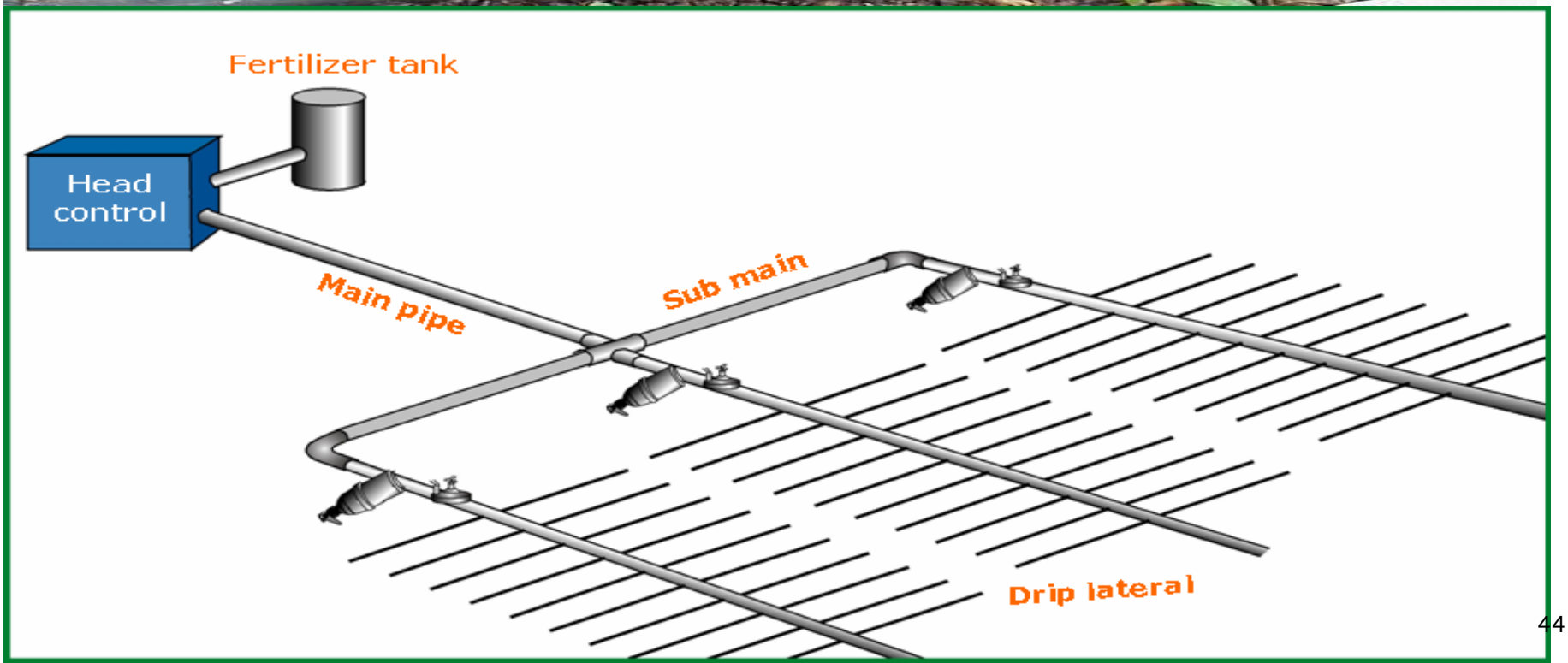
- ✓Accurate water distribution and high water application efficiency
- ✓Used to grow any type of crop
- ✓Eliminates excessive water losses by deep percolation and run off.
- ✓No contamination of water due to use of closed conveyance system
- ✓Sloping lands and Land with irregular topography can be irrigated
- ✓Do not require field channels

Disadvantages:

- ✓High initial investment
- ✓High energy cost.
- ✓Design and operation needs technical knowledge
- ✓Sensitivity to wind conditions
- ✓Water losses by evaporation from soil surface and plant canopy
- ✓Induction of leaf diseases in over-head application
- ✓Washout of pesticides from the **foliage** in overhead application.
- ✓Interference of irrigation with various farm activities like tillage, spraying, harvest, etc.

Drip Irrigation

- It is the method of watering plants
  - at the plant location,
  - frequently., and
  - with a volume of water approaching the consumptive use of the crop.
- Water is delivered by a pipe distribution network under low pressure.
- Water application is by small diameter plastic lateral pipes with devices called 'emitters' or 'drippers' connected at selected spacing.
- There is reduced evaporation, only potential transpiration is considered.
- There is no need for a drainage system.


Fertilizer tank
Head control
Main pipe
Sub main
Drip lateral

Advantages:

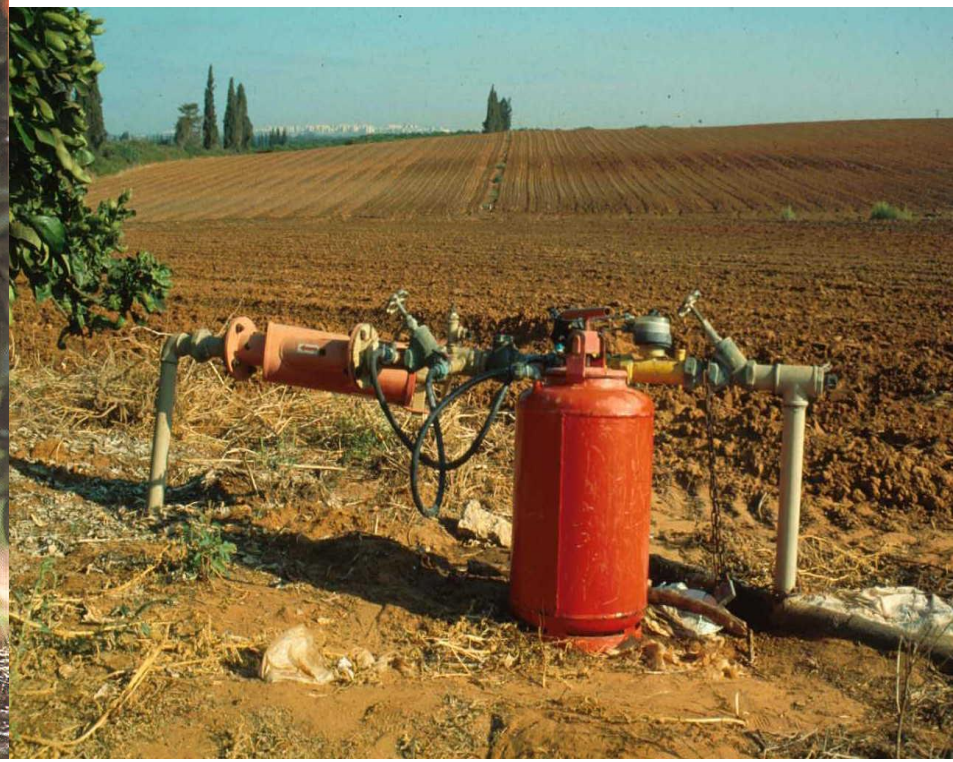
- Partial soil wetting and good control of water

Exact amount of water for each and every plant

- Weed control
- Equipment movement
- Reduces compaction
- less energy and operating cost

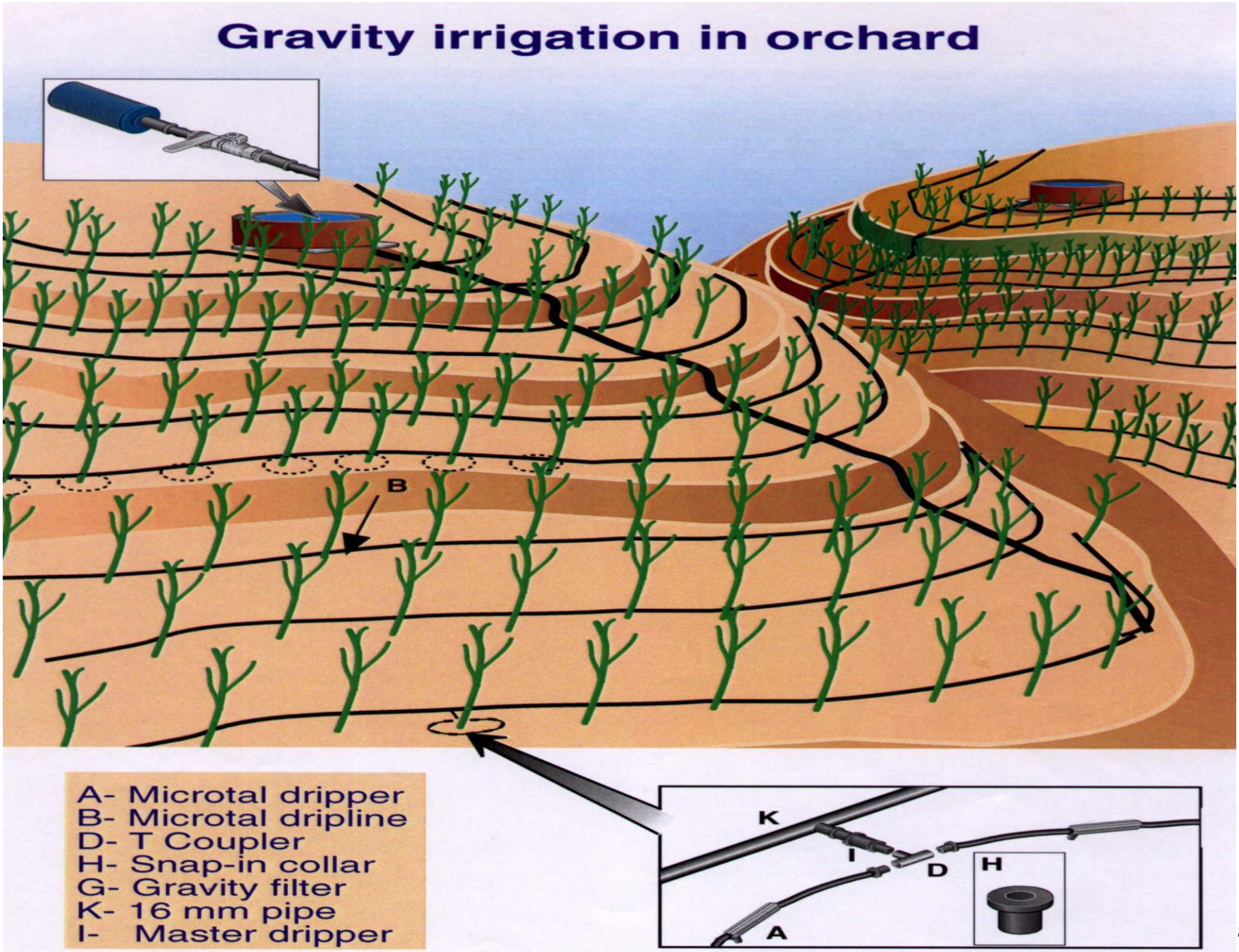
- Foliage remains dry
- Fertigation and chemigation – possibility of applying fertilizer and chemicals with water

- **Good water saving**



- Can used on almost any type of soil
  - Clay soil
  - Marginal/infertile soil
  - Stony soil
- Creates favorable condition for plant growth
- Used almost on any topography

Gravity irrigation in orchard



Other advantages:

Wind effect

No wind effect

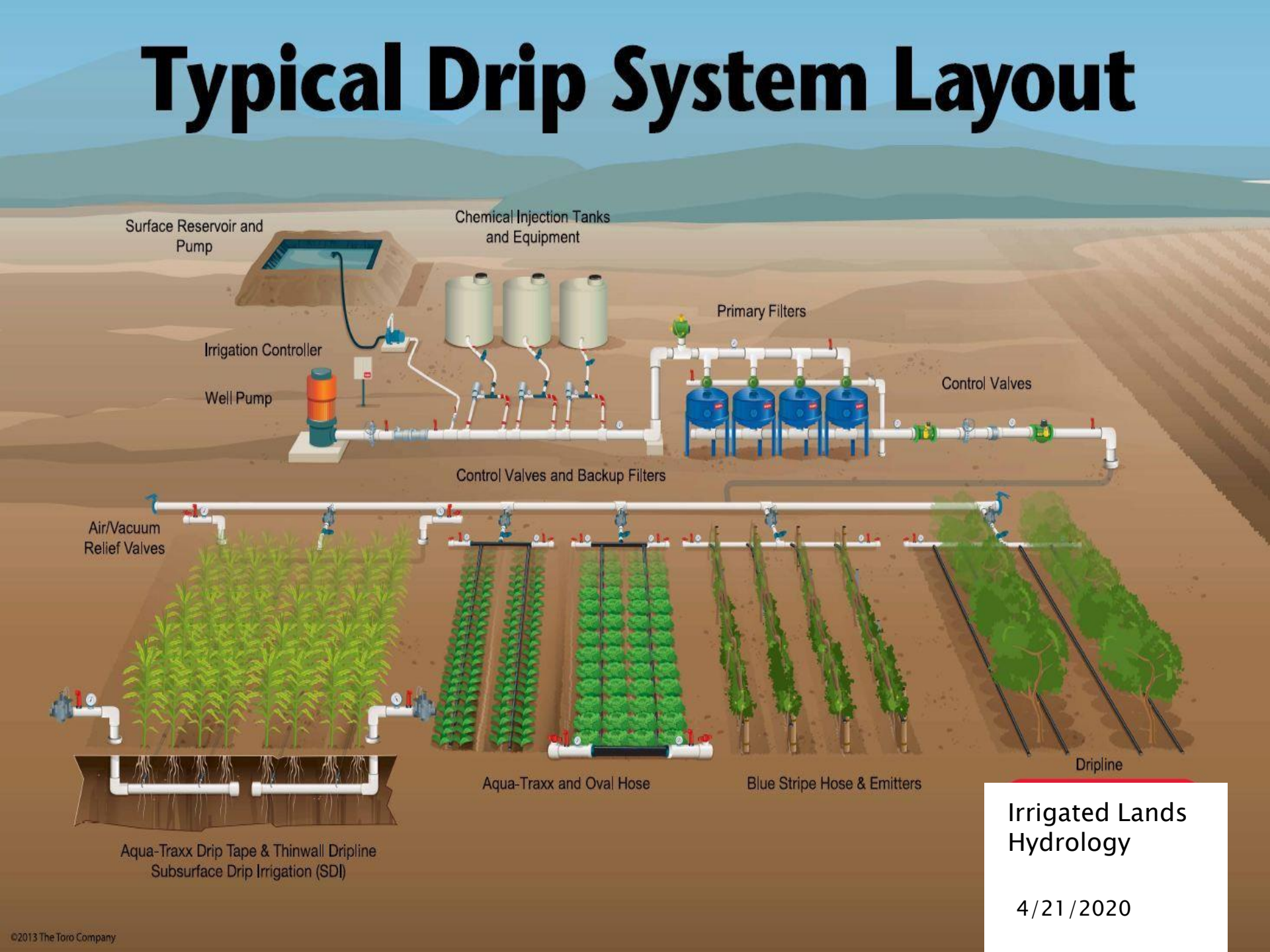
Fixed System

Limitations:

- Clogging

- Insufficient filtration
- No flushing

- Salt accumulation if marginal water is used and irrigation is interrupted



Irrigated Lands Hydrology

4/21/2020

1.5 SUB-SURFACE IRRIGATION

- Applied in places where natural soil and topographic condition favor water application to the soil under the surface, a practice called sub-surface irrigation.
- These conditions include:
    a) Impervious layer at 15 cm depth or more
    b) Pervious soil underlying the restricting layer.
    c) Uniform topographic condition
    d) Moderate slopes.
- The operation of the system involves a huge reservoir of water and level is controlled by inflow and outflow.
- The inflow is water application and rainfall while the outflow is evapotranspiration and deep percolation.
- It does not disturb normal farm operations. Excess water can be removed by pumping.

sub-surface irrigation

1.6 CHOICE OF IRRIGATION METHODS:

- Application Methods- selection criteria for optimal water Management

- **Compatibility.** The irrigation system for a field or a farm must be compatible with the other existing farm operations, such as
  - Land preparation
  - Cultivation and harvest
  - Level of Mechanization
  - Size of Fields
  - Pest Control

Example:

Surface irrigation require good Land preparation.

Cont…

- **Economic Considerations.** The type of irrigation system selected is also an economic decision.
- Important costs include:
  - Energy
  - Water
  - Land preparation
  - Maintenance
  - Labor
  - Taxes

Example:

✓ Surface irrigation requires low initial investment but labor and maintenance cost is high

- Topographic Limitations. Restrictions on irrigation system selection due to topography include:
  - The location and relative elevation of the water source
  - Field boundaries
  - Size of each field
  - The location of roads
  - Power and water lines and other obstructions
  - The shape and slope of the field

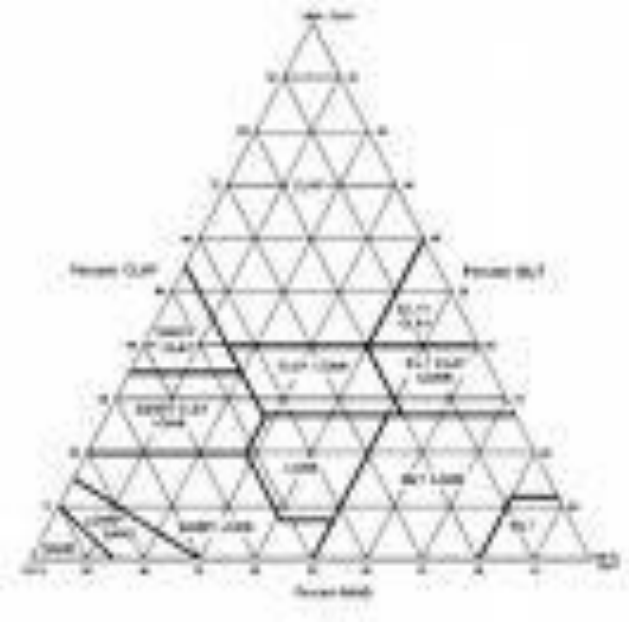
Example:

- ✓ Surface irrigation is limited to 2 to 6% slope
- ✓ Sprinkler works up to 20% slope and
- ✓ Drip may work up to 60%slope.

- Soil Characteristics. The soil type usually defines:
  - Soil moisture-holding capacity
  - The intake rate
  - Effective soil depth
  - Agricultural potential

Example:

✓ Surface irrigation is best suited in heavy textured soil while pressurized systems perform best on light textured soils.



Water Supply. The quality, quantity, and temporal distribution of the source of irrigation water have a significant bearing on the irrigation practice.

Example:

- ✓ Surface irrigation practiced if abundant water is available.

- **Crop Factors.** Crop characteristics that influence the choice of irrigation system are:
  - ❖ The tolerance of the crop during germination, development and maturation to soil salinity, aeration, and various substances, such as boron
  - ❖ The magnitude and temporal distribution of water needs for maximum production
  - ❖ The economic value of the crop
  - ❖ Check preference by people, market potential, adaptability to area, etc.

Example:

✓ Drip system is usually preferred for growing high value crops like flower, strawberry, coffee, etc.

External Factors – Selection may be affected by things completely unrelated to the science.

Example:

- History of People and Irrigation in the area
- Check past exposure of people to irrigation and land tenure and level of possible re-settlement or otherwise.
- There must be a political will !!!

Problems

i. Define irrigation and explain its necessity in a developing tropical country like Ethiopia. What are the advantages and ill-effects of assured irrigation?
ii. Discuss briefly the various techniques used for distributing water in the farm
iii. Differentiate between surface and sub-surface irrigation and what are their types?
iv. What is flood irrigation? Where is it practiced?
v. List different types of soil and recommend suitable irrigation method for each soil type and give strong reason for your recommendation based on efficient water use.
vi. The drip system of irrigation is an excellent method but not usually used in Ethiopia. Why? Discuss critically and briefly.

THANK YOU!!!