Practical manual of Irrigation water management
Course No: [ASAG1206]

COURSE STRUCTURE
B. Sc. (Agriculture)

M.S.SWAMINATHAN SCHOOL OF AGRICULTURE
CENTURION UNIVERSITY OF TECHNOLOGY & MANAGEMENT
Odisha-761211,
INDIA
Web Site: - www.cutm.ac.in

M.S.SWAMINATHAN SCHOOL OF AGRICULTURE
CENTURION UNIVERSITY OF TECHNOLOGY & MANAGEMENT
Odisha-761211, INDIA

Dr. Devendra Reddy

Dean

FOREWORD

A large population of the country is dependent on agriculture. India has only about 4 per cent of the world's renewable water resources but is home to nearly 18 per cent of the world's population. It receives an average annual precipitation of 4,000 billion cubic metres (BCM) which is the principle source of fresh water in the country. However, there is wide variation in precipitation across different regions of the country. Groundwater plays an important part in India's economy. It caters to about 85 per cent of rural demand, 50 per cent urban requirements and more than 60 per cent of our irrigation needs. Unregulated groundwater extraction has led to overuse in many parts of the country, causing the groundwater table to plummet, drying springs and aquifiers.

We acknowledge the immense interest

PREFACE

The authors duly acknowledge the inspiration, guidance and technical support from Professor Prof. M. Devender Reddy, Dean, M.S. Swaminathan School of Agriculture for preparation of this manual.

January, 2019

Parlakhemundi Authors

CENTURION UNIVERSITY OF TECHNOLOGY AND MANAGEMENT

M.S.SWAMINATHAN SCHOOL OF AGRICULTURE SCIENCE, PARLAKHEMUNDI

DEPARTMENT OF ____________________________

CERTIFICATE

This is to certify that

Mr/Ms. ____

With Registration No. _______________________________________

Of B.Sc/ B.Tech Ag. ____________ *Semester has conducted* ________*Experiments in*

____ *Laboratory*

Faculty in –Charge *Head of the Department*

CONTENTS

CENTURION UNIVERSITY OF TECHNOLOGY AND MANAGEMENT
M.S.SWAMINATHAN SCHOOL OF AGRICULTURE SCIENCE, PARLAKHEMUNDI

DEPARTMENT OF ______________________________

Name of the Laboratory: ___________________________________

Name of Student:

Semester: **Regd.No:**

EVALUATION SHEET

S.No	Exp.No	Date	Attendance (1M)	Lab Work (4M)	Report (2M)	Viva (3M)	Total (10M)
						Total	
						Internal Marks = (0.5×Total)	

Note: Internal Weightage is 50%

Signature of the Faculty – In-Charge

1. DETERMINATION OF BULK DENSITY

Aim:

To Estimate the Bulk density of the Soil

Introduction:

Bulk density is defined as the weight per unit volume of soil or it is the ratio of the weight of a given quantity of soil, including pore space, to weight of an equal volume of water. It is numerically equal to the weight of oven dry soil to its bulk maximum volume. It refers to the ratio of a given mass of an oven dried soil to that of its field volume (i.e., solids + pore spaces). Knowledge of bulk density is of particular importance in the determination of depth of water for a given depth of soil and total, capillary and non-capillary porosity. The permeability of soil for water, air and penetration of plant roots is also influenced by bulk density. Compression or compaction of soil particles increases bulk density, consequently it lowers the porosity in turn the soil water storage capacity; this directly affects the crop performance particularly where water availability is sub-optimal, which is a characteristic feature of light soils.

Bulk density values of various soil types (USDA - SCS)

Soil texture	Bulk density (g/cm3)
1. Sandy	1.60 – 1.70
2. Loamy sand	1.60 – 1.70
3. Sandy loam	1.55 – 1.65
4. Fine sandy loam	1.50 – 1.60
5. Loamy soil	1.45 – 1.55
6. Silty loam	1.40 – 1.50
7. Silty clay loam	1.35 – 1.45
8. Sandy clay loam	1.40 – 1.50
9. Clay loam	1.30 – 1.50
10.Clay soil	1.25 – 1.35

Materials:

Core sampler, scales, hot air oven, aluminium moisture boxes and top pan balance, Irrigation water source, mulching material, vernier calipers.

Procedure:

1. Saturate the soil with water and cover it with some mulch to reduce the loss of water by evaporation (as done while determining the field capacity).

2. Allow the soil in this condition for 24 hours to reach field capacity.

3. Take a core sampler; determine its volume ($\pi r^2 h$) by finding out the radius and height using vernier calipers.

4. Drive the cylinder into the soil to the desired depth.

5. Dig out the soil surrounding the cylinder without disturbing the soil core.

6. Weigh the soil contained in the core sampler and record the fresh weight.

7. Take a representative sample in a moisture can and determine moisture percentage on oven dry basis. Calculate the total weight of dry soil contained in the core sampler.

8. Determine the bulk density of soil contained in the core sampler by using the formula.

$$BD = \frac{\text{Weight of oven dry soil}}{\text{Volume of wet soil}}$$

Observations:

Calculations:

Result:

Bulk density of soil is: ____ g / cc.

2. STUDY OF SOIL MOISTURE MEASURING DEVICES

Objectives: To study about the following soil moisture measurement devices.

1. Soil sampling augers
2. Neutron probe
3. Time-domain reflectometer (TDR)
4. Electrical resistance block/ Gypsum blocks
5. Tensiometer
6. Pressure membrane or pressure plate apparatus

Introduction:

Soil acts as water reservoir for plants. Therefore, it is essential to have a clear understanding between soil-water and plant relationship. Soil holds water on its particle's surface as a thin film by adhesive force. The space between soil particles, which is called pore space, contains both air and water in varying proportion. Just after the irrigation/rainfall, when the soil is fully saturated, all the pore spaces are completely filled with water. With the loss of water in the soil through deep percolation, plants use and evaporation, the percentage of water decreases resulting in increase of air in pore spaces. The water thus present in the soil or held by the soil particles, against various forces acting to draw the absorbed water from the soil particles is called soil water or soil moisture. Following are certain instruments that have been developed to giv information about soil moisture content.

1. Soil sampling augers:

Soil sampling augers are used for extracting the soil samples from deeper layers. Augers of different types are used for taking soil samples. Small diameter post-hole augers have the advantage of not getting struck in the soil as every sample from the soil has to be removed before the auger advances further.

Soil sampling tube and core samplers are the common soil sampling tube. This consists of three parts- a driving head, a tube of stainless steel of desired length and a point apart of the tube is cut away for easier insertion, inspection and removal of soil samples.

Different types of soil sampling augers:

Sl No	Type of soil sample	Type of auger
a)	Dry soil and sample spill out	Tube auger
b)	Wet soil	Screw auger
c)	Distribution of irrigation water in soil	Post-hole auger
d)	Greater depths	Puller auger (Two automobile jacks mounted on a base) short tubes 30cm
e)	Faster with greater precision	Power auger attaching to the rear of tractor

2. Neutron probe:

Soil moisture determination with neutron is becoming popular in recent times as it is a convenient and accurate method. It consists of two main parts viz., the probe and a scalar or count recorder. The probe contains fast neutron source, which may be a mixture of radium and beryllium or americium and beryllium. Access tubes are made of Aluminium 50-100 cm length and are placed on the desired place of moisture estimation. Fast neutrons are released from the probe that scatters into the soil. When the neutrons encounter nuclei of hydrogen atoms of water, their speed decreases, which is measured on the scalar. The scalar monitors the flux of slow neutrons, which can be converted into moisture content using a precisely developed ‘calibration curve’ between moisture content and counting rate. The capital and maintenance cost of this instrument is high and high precautions are needed in using radioactive materials. This method is not useful in shallow soils, rocky or gravelly soils.

3. Time-domain Reflectometer (TDR):

Water is a strong absorber of electromagnetic radiation in the microwave portion of the spectrum. The use of microwave radiation for non-destructive determination of water contents in the soil is a recent technique. The TDR unit consists of a pulse generator, sampling head and oscilloscope to record voltage amplitudes and transmit times as the input energy is transmitted into soil.

The probe consisting of 5cm diameter brass or steel rod from 10-100 cm length which are inserted into soil with a distance of 5cm between the rods. The measured volumetric water content is representative of the average value for the volume of soil enclosed between parallel rods. The probe may be inserted vertically or horizontally. When the microwave energy is transmitted through the probe, changes in the voltage occur when the input of the microwave pulse is reflected back to the domain reflectometer. The electric constant of the soil is directly related to soil water. The liquid water content of the soil increases with the transmission time.

The apparent dielectric constant is computed from the transmission time and probe length. A calibration curve is constructed relating volumetric water content and apparent electric constant. The curve is unaffected by the effect of soil texture, bulk density, organic matter content, soil salinity and temperature.

4. Gypsum blocks:

Gypsum blocks or small plaster of Paris resistance units are used for measurement of soil moisture in-situ. Bouyoucos and Mick (1940) first invented these. At present, nylon blocks or fiber glass blocks are also used for this purpose. Gypsum blocks are small porous blocks of about 5.5 cm length, 3.75cm width and 2cm thickness made up of gypsum. Two electrodes are embedded with the block and are connected with the electric wires which are in turn connected to a resistance meter or Bouyoucos water bridge. Resistance in the transmission of electricity between two electrodes indirectly related to water content, which is measured in resistance meter. Gypsum blocks are buried at desired depth in the soil.

The gypsum blocks absorb soil moisture and maintain equilibrium with that. The blocks are kept fixed in soil and whenever required, the resistance is measured with Bouyoucos moisture meter. The moisture content is known from the calibration curve. It is designed on wheat-stone bridge principle. Resistance blocks can be used to schedule irrigation, to irrigate greenhouse beds, to determine rooting zone and soil properties and to evaluate fluctuation in water table. Resistance blocks do not work properly at higher moisture levels. Their efficiency is better at lower moisture levels up to wilting point. Resistance blocks do not give precise results in saline conditions because soluble salts interfere with conductance of the blocks. Resistance units are barely used in fine textured soils.

5. Tensiometer:

Tensiometer or irrometer measures soil moisture on the basis of tension. It consists of 7.5 cm long porous clay cup unglaged, protective metallic tube, vacuum gauge and metallic hollow tube holding all parts together.

The porous cup is fitted to the metallic tube at one end. The other end of the tube is closed with rubber cork. The vacuum gauge is fitted to the tube on ¾ upper side. The length of the tube varies from 30-100 cm dpending on the depth at which soil moisture is to be estimated. With the help of crow bar, a hole is made in the soil to the desired depth for moisture estimation.

Then the tensiometer is placed in the hole and soil is firmly pressed from all side do that soil may have a close contact with the porous cup. After fixing the tensiometer, metallic tube is slowly filled with water in such a way that can avoid the formation of air bubbles. The water filled in metaliic tube move in the soil through porous cup as the soil dries out and as such, the vacuum is created which is measured by vacuum gauge. Refilling of water in tube is necessary after each irrigation/ rainfall. Tensiometer measures soil moisture tension directly. It is used in coarse soil and the practical limit about 0.85 bars. The porous ceramic cup may be clogged in clay soils. The cup is sensitive to salts to certain extent. So, it is not suitable for clayey and salty soils.

6. Pressure membrane or Pressure plate apparatus:

These are generally used to estimate field capacity, permanent wilting point and soil moisture content at different pressures. The required pressure is applied through the compressure. The water from soil sample, which is held at less than the pressure applied, trickles out from the outlet till equilibrium against applied pressure is achieved. After that, the soil samples are taken out and oven dried for determining the moisture content.

This equipment consists of ceramic pressure plate or membrane of high air entry valve contained in airtight strong metallic chamber that can tolerate high pressure (up to 15 bars). The porous plate is saturated and thereafter-saturated soil samples are placed. Them the etallic plates are transferred to metallic chamber. The chamber is closed air-tightly and pressure is applied from the compressure.

Formulas

1. Moisture % in soil (Qw) $= \frac{(F.W. - O.D.W.)}{O.D.W.} \times 100$

2. Per cent Moisture (By volume) $= Qw \times Db$

3. Depth of soil moisture (cm.) $= Qw \times Db \times d$

Where,

Qw = Soil moisture content (%) (Dry weight basis)

F.W. = Fresh weight of soil

O.D.W. = Oven dry weight of soil

Db = Bulk density of soil gm/cc

d = Depth in cm.

3. DETERMINATION OF FIELD CAPACITY AND PERMANENT WILTING POINT (PWP) OF SOIL

Aim:

1. To determine the Field capacity of the soil
2. To determine the Permanent wilting point of the soil.

Information:

Field capacity is the moisture content in percentage of soil on oven dry basis when it has been completely saturated and downward movement of excess water has practically ceased. Such a stage is reached generally 24-72 hours after saturation. Sandy soils reach field capacity earlier than clayey soils. Field capacity is the upper limit of available soil moisture range in soil moisture and plant relations. The force with which the moisture is held at this point varies from 1/10 to 1/3 to an atmosphere.

Permanent wilting point is the moisture percentage of soil at which nearly all plants wilts and do not recover unless water is added from an outside source. This is the lower limit of available water. Moisture held by the soil at this stage corresponds to 15 atmospheres. It is necessary to have many replications in this trial as the PWP is a range of moisture.

Field Capacity Determination:

Materials:

Straw or a black polythene sheet, spade, water, soil auger, moisture cans, top pan balance and hot air oven.

Procedure:

1. Select a representative spot in the field; ensure that water table is not within two metres.
2. Bund an area of about 2 sq. metres on all four sides and removes all weeds to avoid transpiration.
3. Pour water till the desired depths get sufficiently wet. Spread straw mulch of at least 30 cm thickness on the surface to prevent evaporation. Polythene sheet can be conveniently used.
4. Take soil samples from the desired layer with a soil auger after 24 hours and determine the moisture content after drying in an oven at 105^0C.
5. Do this on successive day (s) till the values become nearly the same. Calculate the moisture percentage on oven-dry weight basis.

Observations

1. Weight of empty moisture box(W_1)=____________ g
2. Weight of moisture box + moist soil sample(W_2)= _________ g

3. Weight of moisture box+ oven dry soil(W_3)= _____________ g

Calculations:

$$FC\ (\%\ \text{dry weight}) = \frac{W2 - W3}{W3 - W1} \times 100$$

Results:

Field capacity of soil is: _________________ %

Permanent Wilting Point Determination:

Materials:

600 g capacity cans with lid, sunflower seeds, glass tubes, sealing wax, moisture cans, top pan balance, hot air oven, bell jar, water trays and soil sampler.

Procedure

1. Fill the cans with 500 or 600 g of soil taken from a plot of which permanent wilting point is to be determined. Sow 5 seeds of sunflower and allow them to germinate by providing adequate moisture.

2. After emergence thin the plants to two. Allow them to pass through the two holes in the lid and place the lid.

3. Avoid heating the cans by keeping them in moist saw dust or straw. Grow them for about 6 weeks or till they develop 3 pairs of leaves.

4. Insert a glass tube in the soil for aeration and plug it with cotton wool. Seal the drainage hole with sealing wax. Before sealing, sufficient water should be added to the soil to bring it to field capacity.

5. Allow the plants to wilt. When they show wilting symptoms, transfer them to a dark humid chamber. Keep the cans in a small tray containing water. Leave the plants to recover overnight. If they gain turgidity, transfer them back to atmosphere for a couple of hours and then transfer back to humid dark chamber. Repeat till they do not recover.

At this stage, remove the lid and cut the plants and remove the roots. Determine the moisture percentage of soil.

Observations

Weight of empty moisture box (W_1) = __________ g

Weight of moisture box + moist soil sample (W_2) = __________ g

Weight of moisture box + oven dry soil (W_3) = __________ g

Calculations

$$\text{Moisture content(\%)} = \frac{W_2 - W_3}{W3 - W1} \times 100$$

Results

Permanent wilting point of soil is____________%.

4. **MEASUREMENT OF IRRIGATION WATER**

Aim:

To study about different water measuring devices

Information:

Measurement of irrigation stream is essential for the studies on soil-water-plant relations and for judicious management of water on the farm to obtain high efficiency in irrigation. Irrigation water is generally measured under two conditions:

i) **At rest** and ii) **In motion**

Units of volume:

i) Litre: It is a volume equal to 1/1000 cubic metre (1000 cm3).

ii) Cubic-metre : It is a volume to that of a 1 metre long, 1 metre wide and 1 metre deep container (1 cubic metre = 1000 litres)

iii) Hectare -centimetre (ha-cm): It is a volume of water necessary to cover an area of 1 hectare to a depth of 1 cm (100 cubic metres = 100,000 litres)

iv) Hectare- metre (ha- m) : A volume necessary to cover an area of 1 hectare to a depth of 1 metre (10,000 cubic metres = 10 million litres)

Units of flow:

i) **Litre per second:** A continuous flow amounting to 1 litre passing through a point each second. It is generally used to denote the discharge of a pump, small stream or pipe line.

ii) **Cubic- metre pre second**: A flow of water equivalent to a stream 1 metre wide and 1 m deep, flowing at a velocity of 1 metre per second.

Methods of water measurement

Several devices are commonly used for measuring irrigation water on the farm.

They can be grouped into three categories:

(i) Volumetric measurements

(ii) Velocity area method

(iii) Measuring structures.

Volume method of water measurement

A simple method of measuring small irrigation streams is to collect it in a container of known volume for a measured period of time. An ordinary bucket or barrel is used as the container. The time required to fill the container is reckoned with a stop watch or a wrist watch. The rate of flow is measured by the formula:

$$\text{Discharge rate (litres /sec)} = \frac{\text{Volume of container, litres}}{\text{Time required filling, seconds}}$$

For example, a 20 litre capacity bucket is filled in 10 seconds by the discharge from a persian wheel, then the rate of flow will be 20/10 = 2 litres /sec. or 120 litres / min.

Velocity – area methods

The rate of flow passing a point in pipe or open channel is determined by multiplying the cross sectional area of water at right angles to the direction of flow by the average velocity of the water.

Discharge = Area x Velocity

$Q = a \times v$

Where,

Q = discharge rate, m^3 /sec

a = Area of cross section of channel or pipe, m^2

v = velocity of flow, m/sec.

The cross sectional area is determined by direct measurements while velocity isgenerally measured by float method or current meter.

1. **Float method:** A straight length of a stream about 30 m long is selected and a block of wood can be used as a float. The time taken by float to travel througha known length of the steam is recorded. This would determine the surface velocity of the stream. The average of several observations (about 4 or 5) gives a nearly correct surface velocity. Average velocity of the stream is often taken as 0.8 to 0.9 of the average surface velocity.

$$\text{Velocity (m/sec.)} = \frac{\text{Distance travelled in metres}}{\text{Time required in seconds}}$$

2. **Current meter method**: The velocity of water in a stream or river may be measured directly with a current meter and the discharge estimated by multiplying the mean velocity of water by the area of cross section of the stream. When mean velocity of a stream is determined with current meter the cross section of flow is divided into a number of sub-areas and separate measurements are made for each sub area. It has been found that the average of readings taken at 0.2 and 0.8 of the depth below the surface is an accurate estimate of the mean velocity in a vertical plane.

Measuring structures

In farm irrigation practice, the most commonly used devices for measuring water are weirs, parshall flumes, orifices, siphons and water meters. In these devices the rate of flow is measured directly by making a reading on a scale which is a part of the instrument and computing the discharge rate from standard formula. The discharge rate can also be obtained from ready reckoners prepared for the instrument.

Weirs

A weir is a notch of regular form through which water may flow. Notch may be rectangular, trapezoidal or triangular (900-V). Rectangular and 900 V-notch weirs are commonly used on the farm.

i) **Rectangular weir**

It is used to measure comparatively large discharges. The length of a rectangular weir may be equal to the width of the channel (suppressed rectangular weir) or less (contracted rectangular weir). The discharge through a rectangular weir may be calculated by the following equation :

Suppressed rectangular weir:

$$Q = 0.0184\ LH^{3/2}$$

Where,

Q = Discharge (litres/sec.)

L = Length of crest (cm)

H = Head over the crest (cm)

Contracted rectangular weir:

$$Q = 0.0184\ (L-0.2H)\ H^{3/2}$$

Where,

Q = Discharge (litres/sec.)

L = Length of crest (cm)

H = Head over the crest (cm)

ii) **Trapezoidal or cipolletti weir:**

The discharge of water through this type of weir may be computed by the formula given below:

$$Q = 0.0186\ LH^{3/2}$$

Where,

Q = Discharge (litres/sec.)

L = Length of crest (cm)

H = Head over the crest (cm)

iii) **900 V-notch weir**

It is commonly used to measure small and medium sized streams. The advantage of the V-notch weir is its ability to measure small flow accurately. The discharge through a 900 V-notch weir may be computed by the following formula:

$$Q = 0.0138\ H^{5/2}$$

Where,

Q = Discharge (litres/sec.)

H = Head over the crest (cm)

Orifices

Orifice plates can be used to measure comparatively small streams like flow into border strips, furrows or check basins. It consists of iron, steel or aluminium plate that contains accurately circular opening usually ranging from 2.5 cm to 7.5 cm in diameter. A plastic scale may be fixed directly on the upstream face of the orifice plate with its zero reading coinciding with centre of the orifice.

The discharge through an orifice is calculated by the formula:

$$Q = 0.61 \times 10\text{-}3 \times a\ \sqrt{}2\ gH$$

Where,

Q = Discharge through orifice, litres /sec.

a = Area of cross section of the orifice, cm^2

g = Acceleration due to gravity, cm /sec^2 (981 cm/sec^2)

H = Depth of water over the centre of the orifice, cm.

Parshall flume

Parshall (1950) has developed a device to measure the flow in which the discharge rate of water is obtained by measuring the drop in head. It is a self-cleaning device. It is suitable for measuring a wide range of stream sizes, from a few litres/sec. to several cubic metres/sec. It can be used in relatively shallow channels like irrigation furrows. It may also be used to measure the flow of large streams. The Parshall flume consists of a metal or concrete channel structure having three principal sections:

1. Converging section at upstream end

2. Constricted section or throat.
3. Diverging or expanding section at downward.

The size of the flume is determined by the width of the throat of the flume. The flumes of about 7.5, 15.0 and 22.5 cm sizes are used in field measurements.

Discharge through the flume can occur under the following conditions:

1. **Free flow:** When elevation of the water surface near the downstream end of the throat section is not high enough to cause any retardation of the flow due to a back flow of water is termed as free flow. Under this condition, only one measurement of the head or water level (Ha) in the converging section is required to estimate the rate of flow.
2. **Submerged flow:** When the elevation of the water surface downstream from the flume is high enough to retard the rate of discharge, the flow is said to be submerged flow. The important point in Parshall flumes is the ratio between the reading at Hb and Ha heads. This ratio should not exceed 0.6 for 7.5, 15.0 and 22.5 cm size flumes. If the ratio exceeds 0.6, it is termed as submerged flow. To determine this ratio, Ha and Hb are provided at the upstream and downstream sections of the flume. In this case a correction is subtracted from free flow conditions to obtain the correct rate of flow.

Syphons:

These are generally used to irrigate the field from canals and channels. Syphons are the pipes usually made of rubber or plastic or aluminium. Following formula can be used to measure the discharge rate of syphons:

$$Q = 0.61 \times 10^{-3} \times A \sqrt{2gh}$$

Where,

Q = Discharge rate of water (lit. /sec.)

g = Acceleration due to gravity (981 cm/ sec.^{2})

h = Height of water (cm)

A = Cross sectional area of the water in the syphon (cm^2).

Problems:

1. Calculate the discharge rate of water of a suppressed rectangular weir 50 cm long with a head of 12 cm.

Solution:

2. Calculate the discharge rate of water of a contracted rectangular weir 40 cm long with a head of 10 cm?

Solution:

3. Calculate the discharge rate of water of a 900 V-notch with a head of 12 cm.

Solution:

5. SCHEDULING OF IRRIGATION BY IW/CPE RATIO METHOD

Bumper harvest is the key to prosperity, which entirely depends on the proper and judicious use of irrigation water. A judicious use of irrigation water involves the knowledge about the quantum of irrigation water application as and when needed by the crops. This is referred to as scheduling of irrigation. The main point of scheduling irrigation is to irrigate and how much water to be applied in a particular crop situation. Scientific irrigation scheduling is a technique providing knowledge on correct time and optimum quantity of water application at each irrigation to optimize crop yields with maximum water use efficiency and at the same time ensuring minimum damage to the soil properties.

Scheduling of irrigation based on IW /CPE ratio approach. According to the recent concept water requirement of crops is dependent upon climatic parameters and therefore, the cumulative pan evaporation values are used for scheduling irrigation. It is well known that the consumptive use of water is physical phenomena governed by the incident energy at a place and is not a physiological process. Based on this fact, the climatological approach of scheduling irrigation has been developed and it involves the depth of irrigation water (IW) and the cumulative pan evaporation (CPE). The ratio IW/CPE serves as a soil moisture stress index. The lower the ratio, the more will be the stress and vice-versa.

Example

Taking experimental data, an example for scheduling irrigation based on pan evaporation is given below:

Irrigation water to be applied = 7.0 cm

IW /CPE ratio = 0.9

Date of sowing of wheat = 15th November, 2007

Solution:

Ratio = IW/CPE

0.9 = 7.0 / CPE

CPE = 0.7/0.9 cm = 7.78 cm = 77.8 mm

Problems:

1) We will irrigate the wheat crop after 5^{th} day. If IW/CPE ratio of wheat is 0.9, than what is the amount of irrigation water require?
2) We will irrigate the wheat crop after 7^{th} day. If IW/CPE ratio of maize is 0.8, than what is the amount of irrigation water require?

Table: Pan evaporation data

Date	Pan evaporation / day (mm)	Cumulative pan evaporation (mm)
1st Nov, 2018	2.4	
2nd Nov, 2018	2.6	
3rd Nov, 2018	2.5	
4th Nov, 2018	2.6	
5th Nov, 2018	4.1	
6th Nov, 2018	3.5	
7th Nov, 2018	2.9	
8th Nov, 2018	2.6	
9th Nov, 2018	2.7	
10th Nov, 2018	2.6	

6. SOIL MOISTURE MEASUREMENT BY GRAVIMETRIC AND VOLUMETRIC METHODS

Aim:

To determine the soil moisture measurement by gravimetric and volumetric methods

Introduction:

Soil serves as a reservoir of water for the use of plants. Soil moisture or soil water is expressed as percentage on oven dry basis either on weight basis or volume basis e.g. when a soil is stated to contain 10% moisture on dry weight basis, it means 100 g of dry soil holds 10 g of water. When expressed on volume basis, it means 100 cubic feet of soil holds 10 cubic feet of water. The moisture percentage is generally expressed on weight basis. The moisture percentage on weight basis (Pw) can be converted into moisture percentage on volume basis (Pv) if bulk density (BD) of soil is known.

Materials

Screw auger, aluminum moisture cans, plastic sheet, top pan balance and dryingoven.

Procedure

1. Take soil samples up to required depth at random in the plot. Avoid places of water logging like the corners of the plot.
2. Draw the soil sample with an auger from the desired depth and remove it from the grooves of the auger on a plastic sheet. Select about 50 g of soil and transfer it to the moisture box quickly so that soil moisture is not lost through evaporation due to exposure for a long time. Close the bore with soil and tap it with a metal rod. The hole after refilling must be at the same level as the rest of the soil surface.
3. While sampling in a crop, select the spot in a row between the two plants. During early seedling stage, take the sample as near the plant as possible (about 10 cm away from the plant). With the advance in age of crop, the sample may be drawn at a point midway between the two rows.

i) Gravimetric method (weight basis) Materials

Soil auger, moisture cans, top pan balance, drying oven.

Procedure:

Take a composite sample of soil about 100 g in a moisture can and cover it immediately with its lid. Cover the cans with a wet gunny bag in the field to avoid heating due to insulation if numbers of samples are large. Carry the samples to the laboratory. Weigh the sample on a top pan balance (WS_1 g). Dry the sample in an oven to a constant weight at 105 ^{0}C. This takes about 48 hours. Weigh the dried sample (WS_2, g).

Observations:

1 Fresh weight of soil(WS_1)= _________ g

2 Oven dry weight of soil(WS_2)= ___________ g

3 Weight of empty moisture box= ___________ g

Calculate the moisture percentage by the formula:

$$PW = \frac{WS_1 - WS_2}{WS_2} \times 100$$

ii)Volumetric method (volume basis)

Materials:

Sampling tube or a core sampler, moisture cans, balance and hot air oven.

Procedure:

Take a sample of soil with a core sampler or a tube auger whose volume is known (VS_1). Weigh the sample in a moisture can (WS_1). Dry it in an oven to a constant weight at 105^{0}C (WS_2).

Calculate the moisture percentage by the relationship

$$PV = \frac{WS_1 - WS_2}{DW \times VS_1} \times 100$$, where DW is the density of water

PV can also be calculated by the formula PV = Pw x BD

Calculations:

Result:

Moisture Percentage through gravimetric method= _____________ %

Moisture Percentage through volumetric method= _____________ %

7. CALCULATION ON IRRIGATION WATER NEEDS

Aim: To know the water requirement of crop.

The water requirement of crop is the amount of water that is required to meet the evapotranspiration rate so that crops may thrive. The evapotranspiration rate is the amount of water that is lost to the atmosphere through the leaves of the plant, as well as the soil surface. Therefore, in order to estimate the water requirement of a crop we first need to measure the evapotranspiration rate. The reference rate, ET0, is the estimate of the amount of water that is used by a well-watered grass surface that is roughly 8 to 15 centimeters in height. Once ET_0 is known, the water requirement of the crop can be calculated.

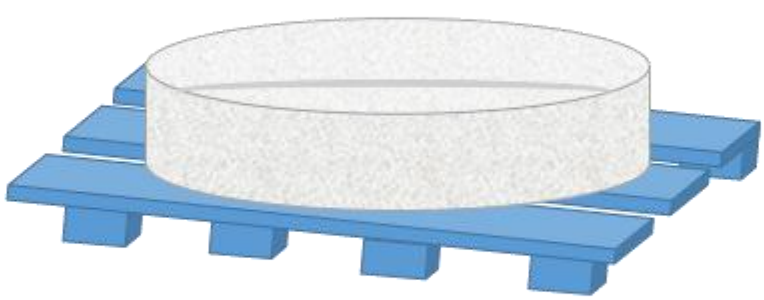
METHODS TO MEASURE THE EVAPOTRANSPIRATION RATES OF CROPS

There are at least two methods that can be used to measure or predict the evapotranspiration rate of crops:

- Evaporation pan
- Using equations that predict the evapotranspiration rate based on climatic parameters.

EVAPORATION PAN:

In this method, pan is filled with water and the loss of water from the pan is measured. Provided that there is no rainfall, the evaporation rate, which is recorded as millimeters per day, is quite easy to measure. This method of measurement takes into account wind, temperature, radiation and humidity, which are the same factors that affect crop transpiration rate. However, there are a few factors that prevent this recording from being entirely accurate. For one, the solar radiation results in heat storage in the pan. This can lead to increased reading of the evaporation rates at night, when transpiration usually does not occur. In addition, temperature and humidity levels above the pan surface will vary from what would naturally occur.



Evaporation Pan

In this method, different kinds of pans are used to measure the water requirements of crops, with Kp representing the pan coefficient, according to the kind of pan, solar radiation, wind, humidity and the surroundings.

ETo = K pan × E pan.

ESTIMATING THE WATER REQUIREMENTS OF THE CROP

ET0 represents the maximum, or potential, evapotranspiration rate that can occur. However, the water requirement of the crop is usually less than ET0, as there are factors of the crop itself that have to be taken into account.

These include the growth stage of the plant, the leaf coverage that provides shade to the ground, and other particulars of the crops that make them vary from each other. With these factors taken into account, ET_0 is converted into ETc, through the crop-specific coefficient, Kc.

ETc represents the evapotranspiration rate of the crop under standard conditions (no stress conditions).

When calculating ETc, one must identify the growth stages of the crop, their duration and select the proper Kc coefficient that need to be used.

ETc = Kc*ET_0.

EXAMPLE FOR CALCULATING THE WATER REQUIREMENT OF A CROP

Crop: potato

Growth stage: Initial growth

Kc for initial stage: 0.45

E_{Pan} (measured by a local meteorological station): 9 mm/day

K_{pan} is 0.7

Calculate the water requirement of potato crop fro that day?

Ans:

8. DUTY OF WATER AND IRRIGATION EFFICIENCIES

Aim: To study about duty of water and irrigation efficiencies

Duty of water:

Duty of water or Duty of irrigation water refers to the area of land that can be irrigated with unit volume of irrigation water.

Quantitatively, duty is defined as the area of land expressed in hectares that can be irrigated with unit discharge, that is, 1 cumec flowing throughout the base period, expressed in days. It's generally represented as '**D**'. Its unit is **hectare/cumec**.

Duty varies from point to point. It increases as one moves to downstream from head of the main canal to the head of the branches. It is due to transmission losses in the canal.

Factors affecting duty of water:

a) Soil characteristics: Porous and coarse grained soil leads to more seepage loss resulting in low water duty. In alluvial soil, percolation loss is less and soil retains moisture foe a longer period thereby increasing the water duty.

b) Climatic condition: Higher temperature in the command area leads to high evaporation loss. Hence, duty is low.

c) Rainfall: If rainfall is sufficient during the cop period, the duty will be more and vice versa.

d) Base period: When the base period is longer, water requirement will be more. Hence, water duty will be low.

e) Topography of agricultural land: if the land is uneven, duty will be low. As the ground slope increases, duty decreases because there is wastage of water.

Relationship between Duty and Delta:

Duty and Delta are basic definitions used in calculation of irrigation water demand of crops. **Duty** is the area of land that can be irrigated with a unit volume of water supplied across the base period. Whereas, **Delta** is the depth of water required to raise a crop over unit area.

If the water supplied is just enough to raise the crop within D hectares of the field, then a relationship may be found out amongst all the variables as:

Volume of water supplied = $B \times 60 \times 60 \times 24$ m^3

Area of crop irrigated = $D \times 104$ m^2

By the definition of duty, it is clear that it matures D hectares of land.

Then the total depth of water supplied during base period B = (1*B*24*60*60)/(D*10000)

=8.64B/D meters

Delta=8.64B/D meters

Where, B= Base period
D= Duty of irrigation water

Q.1 A canal was designed to supply irrigation needs of 1 ha of land growing rice of 140 days base period and having a delta of 134 cm. Calculate the duty of water?

IRRIGATION EFFICIENCIES:

The ratio of the amount of water available (output) to the amount of water supplied (input) is called Irrigation efficiency. It is expressed in terms of **percentage.**

There are four types of Irrigation efficiency:

a) Water conveyance efficiency:

It indicates the efficiency with which water is conveyed from source/reservoir of supply to the field. It estimated the conveyance losses and expressed as:

$$E_c = \frac{W_f}{W_s} \times 100$$

Where, Ec is water conveyance efficiency (%); W*f* is water delivered at the field and W*s* is water delivered from the source.

b) Water application efficiency:

The percentage ratio of the amount of water stored in the crop root zone during the irrigation to the amount of water delivered to the field. It is expressed as:

$$E_a = \frac{W_s}{W_f} \times 100$$

Where, W*s* is the amount of water stored in the crop root zone.

W*f* is the amount of water delivered to the field.

c) Water use efficiency:

It refers to the amount of marketable end product obtained per unit of water used by the crop.

$$\text{WUE (kg ha}^{-1}\text{ mm}^{-1}) = \frac{\text{Total economic yield (kg ha}^{-1})}{\text{Total consumptive use (mm)}}$$

d) Water distribution efficiency:

It gives a measure of the uniformity of the depth of irrigation all over the field and expressed as:

$$E_d = 1 - \frac{Y}{D} \times 100$$

Where, Y is average numerical deviation

D is average depth of water stored during irrigation.

e) Water use efficiency

The water utilization by the crop is generally described in terms of water use efficiency (kg/ha- mm or q/ha- cm). It can be defined in following ways:

(i) Crop water use efficiency: It is the ratio of crop yield (y) to the amount of water depleted by the crop in the process of evapotranspiration (ET).

$$\text{Crop water use efficiency} = \frac{Y}{ET}$$

(ii) Field water use efficiency : It is the ratio of crop yield (y) to the total amount of water used in the field (WR)

$$\text{Field water use efficiency} = \frac{Y}{WR}$$

Significance of irrigation efficiencies:

A low value of any of the irrigation efficiencies in general implies that the land, water and the crops are not being managed properly. Low conveyance efficiency implies that much of the water released from the source is lost in transit form source to the field. Low application efficiency means wastage of water in the form of deep percolation or runoff losses. Poor storage efficiency means water has been applied inadequately. A poor distribution efficiency results due to uneven land surface. There are low patches where water will penetrate more and there are high patches where water cannot reach. Low water use efficiency also results due to over application of water or inability of the crops to utilize the applied water due to poor vegetative growth or adverse chemical properties of root zone soil and water. The net effects of poor irrigation efficiencies are crop loss and wastage of water and nutrients.

Problem 1:

A stream of 135 litres/sec. was diverted from a canal and 100 litres /sec. were delivered to the field. An area of 1.6 ha was irrigated in 8 hours. The effective depth of root zone was 1.8 m. The run off loss in the field was 432 m^3. The depth of water penetration varied linearly from 1.8 m at the head end of the field to 1.2 m at the tail end. Available moisture holding capacity of the soil is 20 cm/m depth of soil. Calculate water conveyance efficiency, water application efficiency, water storage efficiency andWater distribution efficiency, irrigation was started at a moisture depletion level of 50 per cent of the available moisture.

Solution:

9. DIFFERENT METHODS OF SURFACE IRRIGATIONS

Aim:

To Study about the different Layouts, advantages and Disadvantages of surface irrigation methods.

Information:

Irrigation water may be applied to crops by flooding it on the field surface, by applying it beneath the soil surface, by spraying it under pressure or by applying it in drops. The land has to be laid out into convenient blocks or strips to achieve uniform wetting without much wastage of soil or water. The water supply, type of soil, slope of the land and the crop to be irrigated determine the method of irrigation and layout of land. It is, therefore, necessary to design the system for the most efficient use of water by thecrop.

Surface irrigation systems (Gravity irrigation)

In surface irrigation water is convened in the point of infiltration, directly on the surface by gravity flow from the channels.

Adaptability: Can be used nearly on irrigable soils and for most crops with a wide range of steam size and still can maintain high water application efficiency.

Flexibility: Meets ample emergencies. Capacity is more and can meet changing seasonal requirements since water is applied by gravity flow.

Dependability: More dependable than other systems since less likelihood of mechanical failures.

Layouts of methods of surface irrigation

1. **Free flooding**: Water is brought perpendicular to the slope in a channel and applied directly to the field without any control of the flow. The advancing sheet of water is controlled primarily by the topography of the field with some guidance from the cultivators spade.

Advantages:

1) Suitable for all irrigable soils and close growing crops.
2) Can be followed in highly sloppy lands (up to 10% slope).
3) Initial cost is low.

Limitations:

1) Distribution of water is not uniform and water application efficiency is low
2) There will be erosion hazard.

II. Controlled flooding layouts:

i) **Border strips**: Here the field is divided into number of long parallel strips called borders that are separated by low ridges. The width of border usually varies from 3 to 15 meters and the length varies from 60 to 120 meters in sandy and sandy loam soils and 150 to 300 meters in clay soils. An essential feature of border strip irrigation is to provide an even surface over which the water can flow down the slope with nearly uniform depth in the entire width of the border. Normally, the direction of the border strip is in the direction of the slope, but when the land slope exceeds non-erosive limits, border strips may be laid across the slope.

Advantages

1) Suited well for close growing crops such as wheat, barley and fodder crops especially in black soils which need light irrigations.
2) Water application efficiency is better and initial cost in low.

Limitations

1) Extensive land grading is necessary
2) Relatively large stream flows are required.

ii) **Flat bed or check basin method:** A check basin is an area completely leveled and surrounded by a bund. Here, water is conveyed by a stream of supply channels and lateral field channels. The supply channel is assigned on the upper side of the area and there is usually one for every two rows of check basins. Water from the laterals isturned into the beds and cut off when sufficient water has been admitted to the basin. Water is retained in the basin until it soaks into the soil.

Advantages:

1) Ideally suited for orchard crops and close growing crops like transplanted paddy, wheat, barley etc.

2) There is good control of irrigation water and fairly high water application efficiency.
3) Useful when leaching is required to remove salts from the soil profile.

Limitations

(i) Ridges or bunds occupy considerable land and interfere with the movement of farm machinery for intercultural operations.
(ii) Labour requirement in land preparation and irrigation is much higher.
(iii) Not suitable for crops which are sensitive to wet soil conditions like maize, potato etc.

ii) Ridge and furrow method: This method is used to irrigate row crops with furrows developed between the rows where water is applied by running small streams. It is the most suitable method of irrigation for crops sensitive to the pounded surface water or susceptible to fungal root rot, root injury etc. Irrigation furrows may be classified as graded furrows, level furrows, contour furrows, corrugations and alternate furrows. Straight ridges and furrows are formed on a leveled topography while contour ridgesand furrows are formed on steep slopes. This method is suitable for irrigating maize, sorghum, sugarcane, cotton, potato and other vegetables.

Advantages:

1) Suited to all row crops and especially for crops that are sensitive to excess moisture like maize and vegetables.
2) There is good control of water and water application efficiency is high.

Limitations:

1) Labour charge is higher.
2) There is erosion hazard.

iii) Ring and basin method (basin method): This method of irrigation is essentially a check basin method applied to orchards where basins are circular and are made around each tree. The entire land is not wetted in the ring method of basin irrigation of orchards. From the supply ditch water is conveyed to the basin either by flowing through one basin into another, or preferably by small lateral channels. The round furrow is termed ring and the raised portion is known as basin.

Advantages:

1) Best suited to broadly spaced crops like orchards.
2) There is high water application efficiency with uniform distribution.

Limitations:

1) Inter-cultivation by bullock drawn implements is difficult
2) Initial cost is high.

Layout:

10. LAYOUT OF SPRINKLER IRRIGATION AND DRIP IRRIGATION

Aim: To Study about Sprinkler and Drip Irrigation Systems.

Information:

Sprinkler Irrigation:

Sprinkler or overhead irrigation system is a means of applying water to the surface of any soil or crop just like rain-water is sprayed into the air through a sprinkler nozzle under pressure. With careful selection of nozzle sizes, operating pressures and sprinkler spacing, the amount of irrigation water required to refill the crop root zone can be applied nearly uniformly at a rate to suit the infiltration rate of soil, thereby obtaining efficient irrigation.

Two major types of sprinkler system are rotating head system and perforated pipe system. In the rotating head system, small size nozzles are placed in riser pipes fixed at uniform intervals along the length of the lateral pipe. The most common device to rotate the sprinkler head is with a small hammer activated by the thrust of the water striking against a vane connected to it. Most of the sprinklers used in agricultural field are of slowly rotating with either one or two nozzles. The pressure requirement in rotating head system is 2-10 kg/cm^2 and that in perforated pipe system is 0.5 to 2 kg/cm^2.

Components of sprinkler irrigation system:

(i) A pump unit
(ii) Tubings – main / submains and laterals
(iii) Couplers
(iv) Sprinker head
(v) Other accessories such as valves, bends, plugs and risers.

1. **Pumping Unit:** Sprinkler irrigation systems distribute water by spraying it over the fields. The water is pumped under pressure to the fields. The pressure forces the water through sprinklers or through perforations or nozzles in pipelines and then forms a spray. A high speed centrifugal or turbine pump can be used for operating sprinkler irrigation for individual fields. Centrifugal pump is used when the distance from the pump inlet to the water surface is less than eight meters. For pumping water from deep wells or more than eight meters, a turbine pump is suggested. The driving unit may be either an electric motor or an internal combustion engine.
2. **Tubings:** Mains/sub-mains and laterals: The tubings consist of mainline, sub-manins and laterals. Main line conveys water from the source anddistributes it to thesubmains. The submains convey water to the laterals which in turn supply water to the sprinklers. Aluminum or PVC pipes are generally used for portable systems, while steel pipes are

usually used for center-pivot laterals. Asbestos, cement, PVC and wrapped steel are usually used for buried laterals and main lines.

3. **Couplers:** Couplers are used for connecting two pipes and uncoupling quickly and easily.

Essentially a coupler should provide:

(a) A reuse and flexible connection
(b) Not leak at the joint
(c) Be simple and easy to couple and uncouple
(d) Be light, non-corrosive, durable.

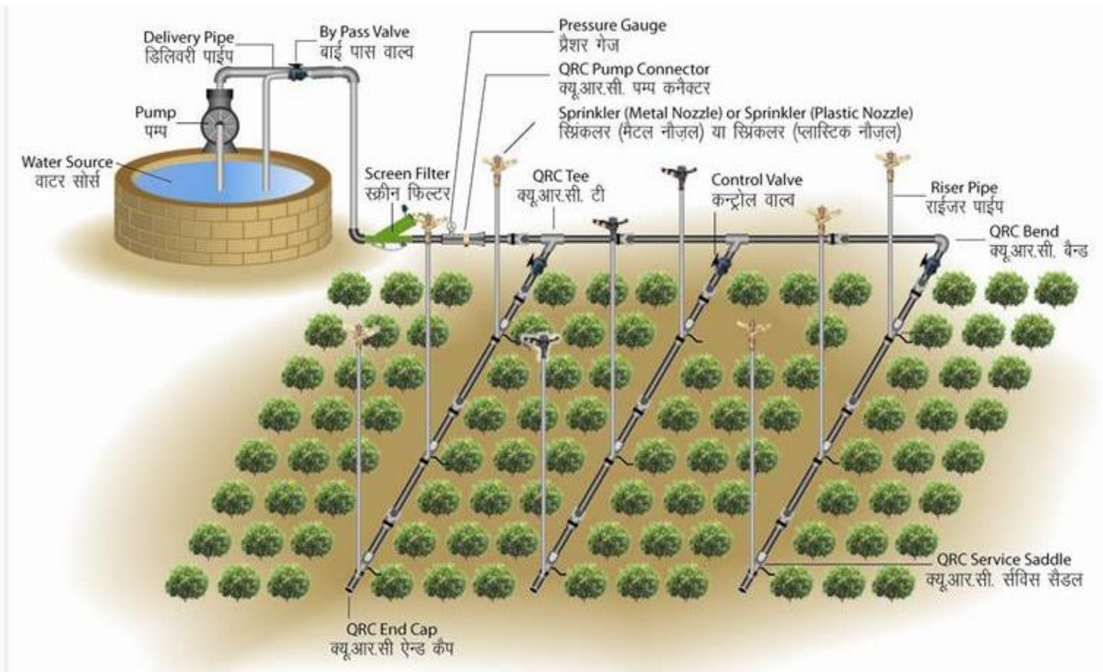
4. **Sprinkler Head**: Sprinkler head distribute water uniformly over the field without runoff or excessive loss due to deep percolation. Different types of sprinklers are available. They are either rotating or fixed type. The rotating type can be adapted for a wide range of application rates and spacing. They are effective with pressure of about 10 to 70 m head at the sprinkler. Pressures ranging from 16 to 40 m head are considered the most practical for most farmers. Fixed head sprinklers are commonly used to irrigate small lawns and gardens. Perforated lateral lines are sometimes used as sprinklers. They require less pressure than rotating sprinklers. They release more water per unit area than rotating sprinklers. Hence fixed head sprinklers are adaptable for soils with high intake rate.

5. **Fittings and accessories**: The following are some of the important fittings and accessories used in sprinkler system.

(a)**Water meters:**It is used to measure the volume of water delivered. This is necessary to operate the system to give the required quantity of water.

(b)Flange, couplings and nipple used for proper connection to the pump, suction and delivery.
(c)**Pressure gauge:** It is necessaryto know whether the sprinkler system is working with desired pressure to ensure application uniformity.
(d)Bend, tees, reducers, elbows, hydrants, butterfly valve and plugs.
(e)**Fertilizer applicator:** Soluble chemical fertilizers can be injected into the sprinkler system and applied to the crop. The equipment for fertiliser application is relatively cheap and simple and can be fabricated locally. The fertilizer applicator consists of a sealed fertilizer tank with necessary tubings and connections. A venturi injector can be arranged in the main line, which creates the differential pressure suction and allows the fertilizer solution to flow in the main water line.

Layout:



Advantages:

1. It is best suited for sandy soils where infiltration rate is high and for shallow soils where the topography prevents proper levelling for surfaceirrigation methods.
2. It is suitable for steep slopes and easily erodablesoils.
3. Water application efficiency is high because surface run off and percolation is very muchreduced.
4. Wastage of land is avoided by eliminating ditches, furrows and borders which generally occupy 5% of totalarea.
5. Soluble fertilizers can be applied throughsprinklers.
6. Sprinkler irrigation can be used to protect the crop from frost damage and scorching temperatures.

Limitations

- ✓ Initial investment is high compared to surface irrigation methods.
- ✓ During windy days distribution of water is not uniform.

Drip Irrigation System:

Drip irrigation also referred to as trickle irrigation is one of the most efficient methods of irrigation. It was first designed in Israel by Simca Blass, a water engineer in 1959. It involves slow application of water to the plant root zone. The losses of water by deep percolation and evaporation are minimized. Precise amount of water is applied to replenish the depleted soil moisture at frequent intervals for optimum plant growth.

In consists of an extensive network of pipes usually of small diameter that deliver filtered water directly to the soil near the plant. Main components of drip irrigation system are storage tank with filters, mains and sub-mains, laterals and drip nozzles or emitters. The water outlet device in the pipe namely emitter discharges only a few litres per hour. From the emitter, water spreads laterally and vertically by soil capillary forces. The area wetted by an emitter depends upon the flow rate, soil type, soil moisture etc. Trickle irrigation is suitable for fruits that contain considerable moisture when harvested such as tomatoes, citrus and grapes. It is not practical or economical for closely planted crops such as cereals.

Drip Irrigation System - Components and their Function

A drip irrigation system consists essentially of mainline, sub mains, lateral, drippers, filters and other small fittings and accessories like valves, pressure regulators, pressure gauge, fertilizer application components etc.

1**. Filter:**

It is the heart of drip irrigation. A filter unit cleans the suspended impurities in the irrigation water so as to prevent blockage of holes and passage of drip nozzles. The type of filtration needed depends on water quality and emitter type. A two-stage filter unit is usually needed.

a) **Gravel Filter (Sand Filter):**

These filters are effective against inorganic suspended solids, biological substances and other organic materials. This type of filter is essential for open reservoir, when algae growth take place. The dirt is stopped and accumulated inside the media in the filter. Gravel filter consist of small basalt gravel or sand (usually 1-2 mm dia) placed in cylindrical tank, made of metal. Water enters form the top and flows through the gravel while leaving the dirt in the filter. The clean water is discharge at the bottom. The filter is cleaned by reversing the direction of flow. Pressure gauges are fitted at the inlet and cutlet of the filter. When the dire accumulates, the pressure difference between the inlet and outlet increase and when the pressure difference is more than 0.5 to 1.o kg/ cm2 (5-10 m), then filters must be cleaned by opening the clover or back washing, Automatic self-cleaning filter are also available. The flow rate of the filters may be 10,15,20,25,30,40,50 cu/m/hr and the tank diameter may range from 10-50 cm depending on the capacity of the system.

b) **Screen Filter:**

These are installed with or without gravel filter, depending upon quality of water. The screens are usually cylindrical shape and are made of non-corrosive metal or plastic material. Screens filters are specified as below:

1. By the diameter of inlet and outlet (range from ¾ “to 4” inches)
2. By the recommended range of flow rate (ranges from 3, 5,7,10,15,20,30, 40, cu. m/hr).
3. By the size of holes in the screen (in mm, micron or in mesh i.e. the number of holes per square inch). As a approximation, 20, 40,80, 100,120,150 and 200 mesh (0.15, 0.1 and 0.08 mm) respectively. The most common mesh selected for drip irrigation is 100 to 200 meshes (0.15 to 0.08 mm dia).

4. By the total surface area of the filter (in sq. m) or the active or net filter area, which is usually about 1/3 of the total filter surface are.
5. By the cleaning methods: manual or automatic. The head loss across the filter should not be more than 3 m and otherwise needs cleaning. The filters are cleaned by flushing the screen with a stream of water. After cleaning the screen is checked for tears and the gasket should be checked and replaced when necessary.
6. With relatively clean water, screen filters can be used alone.

c) **Disc Filter:**

The filtration elements are grooved plastic disc, which are piled together around a telescopic core, acceding to the desired degree of filtration. Both sides of the discs are grooved and the grooves cross each other when piled up and frightened together. The housing is made of plastic or metal and comes in many different sizes mainly 3 ¾ to 3. The water passes through the filter from the outside to the inside. There is no danger of filter tearing. The filtration is affected in two stages: the larger outer surface operates as a screen filters and collects the larger particles. The grooves inside the disc allow the adhesion of fine particles, mainly organic matter. The filter element can be cleaned easily. When opening the core, the discs are released and can easily be rinsed under running water. The pressure drop is slightly higher than screen filter but disc filters have better cleaning capacity than screen filter. The water flow should be on a tangent to the disc to allow them to spin freely.

2. **Main Line:**

The main line conveys the water from filtration system to the sub main. They are normally made of rigid PVC pipes in order to minimize corrosion and clogging. Usually they are placed below the ground i.e. 60 to 90 cm (2 to 3 ft) , so that they will not interfere with cultivation practices. Their diameter is based on the system flow capacity. The velocity of flow in mains should not be greater than 1.5 m/s and the frictional head loss should be less than 5ml /1000 m running length of pipeline.

3. **Submain:**

The Submain conveys the water mainline to the laterals. They are also buried in ground below 2 to 2.5 ft and made of rigid PVC. The diameter of Submain is usually smaller than main line. There may be number of Submain from one mainline depending upon the plot size and crop type.

4. **Laterals:**

Laterals are small diameter flexible pipes or tubing made of low density polyethylene (LDP) or liner low density polyethylene (LLDPE) and of 12 mm, 16mm, and 20 mm size. Their colour is black to avoid the algae growth and effect of ultra- violet radiation. They can withstand the maximum pressure of 2.5 to 4 kg/cm2. They are connected to Submain at predetermined distance. The pressure variation between two extreme points of lateral should not be more than 15-20 % and discharge variation should not be more than 10%. On slopping ground, the laterals are placed along the contour with 1% extra length for sagging purpose.

5. **Emitters or Drippers:**

It is the main component of Drip irrigation system for discharging water from lateral to the soil. i.e. to the plants. There are various types and size of drippers, based on different operating principles. They are made of plastic, such as polythene or polypropylene. Their discharge range is between 1-15 ph. Each dripper has its own characteristics, advantages and disadvantages which determines its use. The drippers can be classified according to working principle, discharge, type, structure, working pressure, designation, durability, regulated and non-regulated discharge. The main principle when planning a dripper is to achieve the minimum discharge with maximum size of water passage. The large water passage is essential to minimize clogging and provide the minimum discharge for cheapest set-up. Therefore, an emitter is necessary, (a hole in a pipe is not a dripper). Emitters may be on the lateral or inside to lateral, accordingly they are called on line or inline emitters.

6. **Controls Valves (Ball Valves):**

These are used to control the flow through particular pipes. Generally, they are installed on filtration system, mainline, and on all Submain. They are made up of gunmetal, PVC cast iron and their size ranges from ½” to more than 5”.

7**. Flush Valve:**

It is provided at the end of each sub main to flush out the water and dirt’s.

8. **Air Release Cum Vacuum Breaker Valve:**

It is provided at the highest point in the main line to release the entrapped air during the start of the system and to break the vacuum during shut off. It is also provided on Submain if Submain length is more.

9. **Non Return Valve:**

It is used to prevent the damage of pump from flow of water hammer in rising main line.

10. **Pressure Gauge:**

It is used to indicate the operating pressure of the drip system.

11. **Gromate and Take-off:**

These are used to connect the lateral to Submain. A hole is punched with hand drill of predetermined size in Submain. Gromate is fixed into the hole. Take off is pressed into the hole. Take off is pressed into the gromate with take of punch upto the step provided. Gromate acts as a seal. The sizes are different for 12 mm, 16mm, and 20 mm lateral.

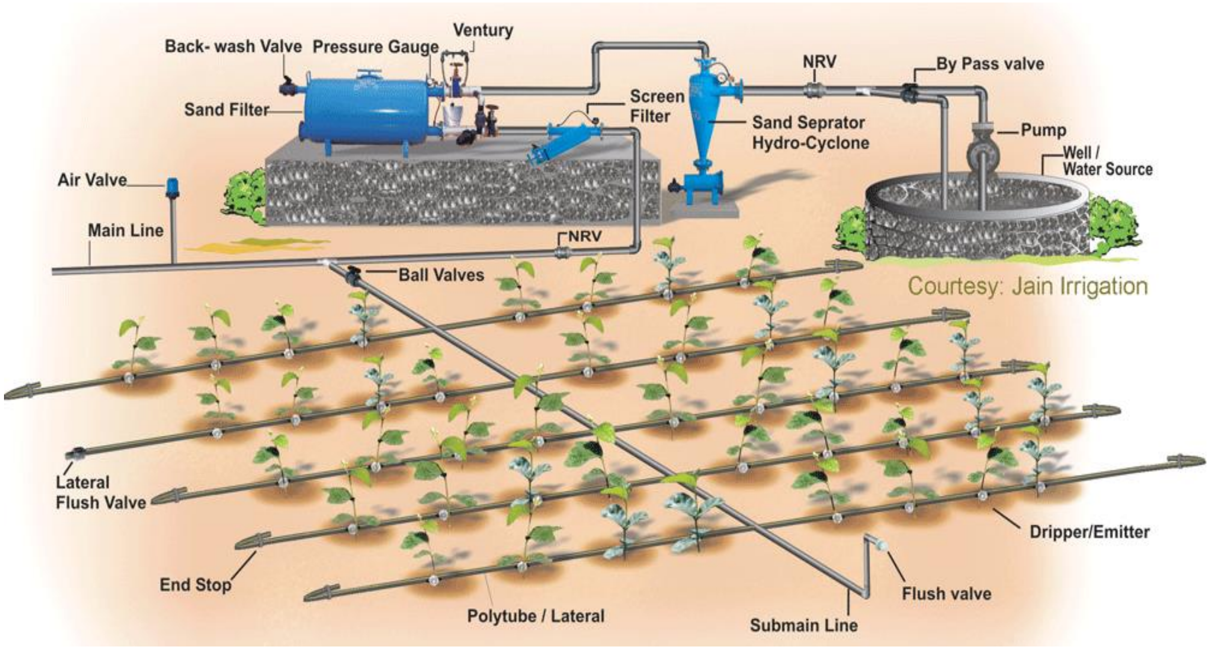
12. **End Caps (End Sets):**

They are used to close the lateral ends, Submain ends or mainline ends. Sub mains and mains are preferably provided with flush valve. They are convenient for flushing the line.

13. **Fertilizing System:**

It is used to add the chemical irrigation water; however, fertigation is not free of hazards. Chemicals added to water may be toxic human begins and animals so, safeguard must be taken to prevent back flow of irrigation water into the water source, which might be used for drinks purpose. Only water-soluble fertilizers should be used to minimize the clogging hazard.

Layout:



Advantages:

1. Water application efficiency is very high and water saving of 30 to 50 per cent over other irrigation methods is obtained in the system.
2. Greater crop yields and better quality are obtained as root zone is moistened constantly.
3. Insect, disease and weed problem are reduced by minimizing the wetting of soil surface.

Limitations:

1. Initial investment is high and cannot be followed in cereals and closely spaced crops.
2. Clogging of emitters is a serious problem.
3. Salt deposition occurs near the edge of wetted zone at the soil surface, severe damage may be caused to crop, if it is flushed to root zone by rains.

11. VISIT TO MICROIRRIGATION SYSTEM UNIT

Aim: To visit micro-irrigation system unit.

Sprinkler or Overhead irrigation: The method of aerial application of water through pipes fitted with sprinkling units. The spray is developed by the flow of water under pressure through small orifices and nozzles.

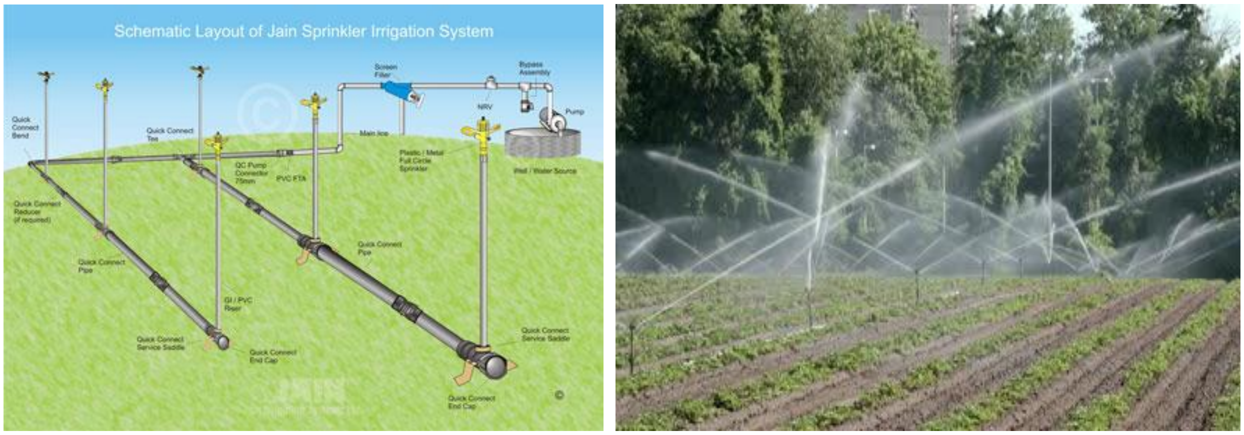


Fig. Sprinkler irrigation

1. **Drip or Trickle irrigation:** Drip irrigation is defined as the precise and slow application of water in the form of discrete or continuous or tiny streams or miniature sprays through mechanical devices called emitters at the specific point. In 1964, Symcha Blasé, an Israeli engineer first developed the irrigation system. USA has the largest area under drip irrigation. In India, Maharashtra has the largest area under drip irrigation.

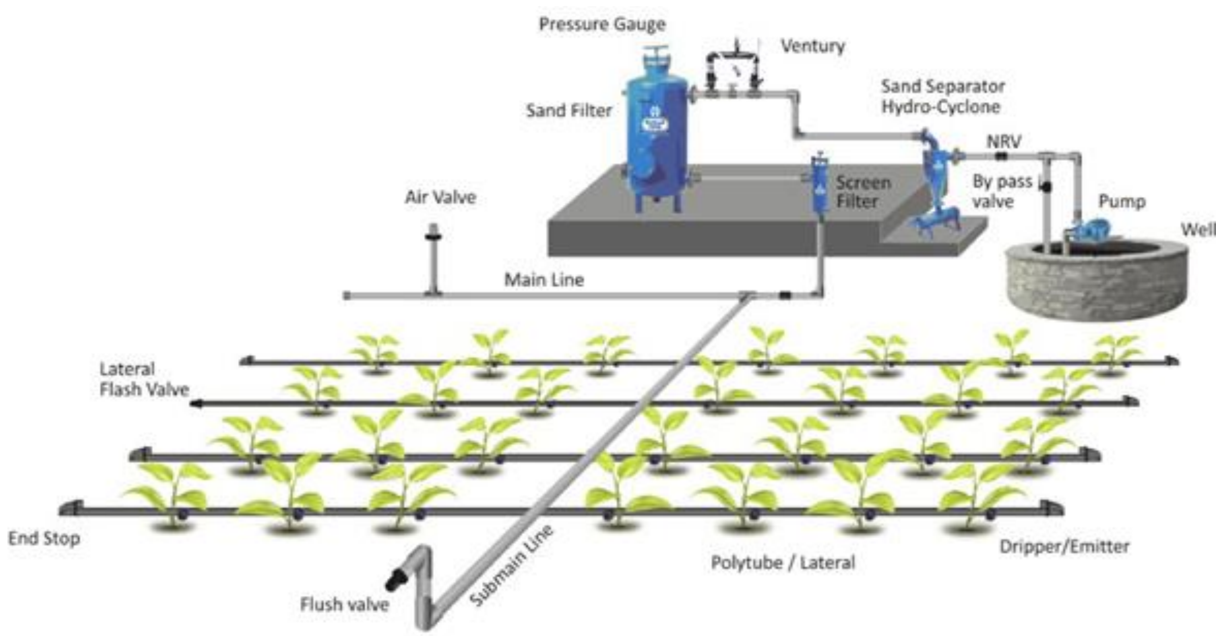


Fig. Drip/ trickle irrigation

A brief report on the visit:

12. WATER MANAGEMENT PRACTICES IN DIFFERENT CROPS

Each method of irrigation has some advantages and disadvantages and is adopted based on certain principles. Some methods may be adopted to a fairly wide range of conditions. In some lands, several methods can be profitably adopted. But choice of a method under a set of conditions should be made carefully as a wrong method may lead to a considerable loss of water by run-off and deep percolation. Further, it may cause soil erosion, rise of water table, development of salinity or alkalinity and ultimately loss of yields.

2. **Surface irrigation:** Surface irrigation refers to irrigating lands by allowing water to flow over the soil surface from a supply channel at upper reach of the field. Principles involved in surface irrigation are:
   i) Field is divided into plots or strips to uniformly irrigate the soil to a desired depth.
   ii) Water is discharged at the highest level of the field allowing water to flow down the gentle slope by gravity.
   iii) Water loss by run-off or deep percolation is avoided
   iv) Efficiency of irrigation is kept at a high
   v) Size of stream should be such as to have an adequate control of water.

Crops in India are irrigated mostly by surface irrigation
Wild flooding: Wild flooding refers to irrigating fields that are relatively flat and level by allowing water from supply channels to flow over the land surface along the natural slope without much guidance by channels and bunds. This method is exclusive for low land rice cultivation. Water is allowed from the channel to the entire field.

Border strip irrigation: In this method, field is laid out into long, narrow strips, boundering with small bunds. Length of the strips ranges from 30 to 300 m and width from 3 to 15 m.

Water from the channel is allowed into each strip at a time. Method is suitable for close growing crops and medium to heavy textured soils, but not suitable for sandy soil.

Check basin irrigation: In this method, field is divided into small plots surrounded by bunds on all the four sides. Water from main channel is supplied to the field channels one after the other. Each field channel supplies water to two rows of check basins and water is applied to one basin after another. Size of check basins ranges from 4 m × 3 m to 6 m × 5 m depending on the stream size and soil texture. This method is the most common method among surface method of irrigation.

Contour ditch irrigation: In topography with sloping and rolling where land leveling is not economical, the contour ditch or contour channel irrigation is adopted. Supply ditches are constructed along with the contours at certain intervals depending on the slope of land. Water is flooded down the slope from the upper ditch to irrigate the lower land between two adjacent ditches.

Furrow method of irrigation: A method of surface irrigation in which water is delivered to the field through shallow ditches between ridges on which plants are grown. The size and slope of the furrow depends upon the crop grown, equipment's used and spacing between two crops. Crops like maize, sorghum, potato, sugarcane, tobacco, sugarcane etc. are suitable for this method of irrigation.

Corrugation: "Corrugation" means miniature furrows that are adopted for irrigating close growing crops. This method is suitable for fine to moderately coarse soil. Corrugation is 'V' shaped or 'U' shaped channels of about 10 cm depth, 40-75 cm apart. The slope should be just enough not to permit soil erosion. Corrugation is usually made after the crops shown but before germination of seed with simple implement called corrugator.

Basin irrigation: A basin is usually made for the tree sapling but it may include more than one sapling when they are not spaced very wide. Basin may be square, circular or rectangular. Water is supplied through laterals and each basin is connected to a lateral with a short and narrow furrow.

Ring irrigation: In this method, a ring is laid at the periphery of the tree canopy. The dimension of ring trenches is 30-50 cm. wide and 30 cm. deep. This method is adopted in orchards.

Sub surface irrigation: Sub surface irrigation or sub irrigation involves irrigation to crops by applying the water from beneath the soil surface either by constructing trenches or installing underground perforated pipe lines or tile lines. The principal crops that can be irrigated through this method are potato, sugar beet, vegetable, alfalfa coconut etc.In India, this method is commonly used in Kashmir for vegetable crops and in Kerala for coconut crop.

Sprinkler or Overhead irrigation: The method of aerial application of water through pipes fitted with sprinkling units. The spray is developed by the flow of water under pressure through small orifices and nozzles.

Drip or Trickle irrigation: Drip irrigation is defined as the precise and slow application of water in the form of discrete or continuous or tiny streams or miniature sprays through mechanical devices called emitters at the specific point. In 1964, Symcha Blasé, an Israeli engineer first developed the irrigation system. USA has the largest area under drip irrigation. In India, Maharashtra has the largest area under drip irrigation.

ACTIVITY:

Write down the water management practices followed in important field crops of India.

RICE:

WHEAT:

MAIZE:

PULSES:

MILLETS:

OILSEEDS:

SUGARCANE: