| | AGRICULTURAL TVET COLLEGE | |
|---|---|---|

# SMALL SCALE IRRIGATION DEVELOPMENT

# LEVEL-II

# MODEL TTLM

## Learning Guide #19

**Unit of competency:** Assist Irrigation schedules

**Module Title:** Assisting Irrigation schedules

**LG code:** AGR SSI1M 19 LO1-LO5

**TTLM Code:** AGR SSI1 TTLM 1218V1

**Nominal Duration:** 35 Hours

| Instruction sheet | Learning guide- 19 |
| --- | --- |

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:–

- Monitoring plant or crop water use.
- Apply a measured amount of water
- Assess efficiency of irrigation and repeat cycles of irrigation
- Record irrigation and scheduling parameter
- Plan for extremes of weather

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Measure and estimating water uses
- Monitor soil water status in the root zone
- Define the crop / plant water requirements
- Predict apre-determined deficit
- Apply irrigation
- Increase water quantities
- Measure effectiveness of irrigation application
- Adjust the estimated soil moisture level
- Recalibrate the scheduling system
- Repeat and establishing cycles of irrigation
- Modify extreme deficits and saturation
- Alter shift areas and application rates

**Learning Activities**

1. Read the specific objectives of this Learning Guide.
2. Read the information written in the "Information Sheets.
3. Accomplish the"Self-check" at the end of each learning outcomes.
4. If you earned a satisfactory evaluation proceed to the next"Information Sheet".However, if you earned is unsatisfactory, see your teacher for further instructions or go back to the Learning Activity.
5. Submit your accomplished Self-check. This will form part of your training portfolio
6. Follow the steps and procedure list on the operation sheet
7. Do the "LAP test" and Request your teacher to evaluate your performance

| Information Sheet-1 | Monitoring plant or crop water use |
|---|---|

### 1.1 Measuring or estimating water uses

#### 1.1.1. The need for water measurement

Water is the valuable asset of irrigated agriculture. Accurate measurement of irrigation water permits intelligent use of this valuable natural resource. Such a measurement reduces excessive waste and allows the water to be distributed among the users according to their needs and rights. Systematic water measurements properly recorded, interpreted and used constitute the foundation upon which increasing efficiencies of water conveyance, application and use must be based. Accuracy in water measurement is, therefore, of prime importance in the operation of any water distribution system.

Water metering is the process of measuring water use. In many developed countries water meters are used to measure the volume of water used for irrigation that are supplied with water by a public water supply system.

#### 1.1.2 Unit of measurement of water

Water is measured under two conditions- at rest and in motion. Water at rest-that is, in the reservoirs, ponds, tanks, soil- is measured in units of volume such as liter, cubic meter and, hectare-meter. Measurement of water in motion, that is flowing in rivers, canals, pipelines, field channels, and channel structures- is expressed in rate of flow units such as liters per second, liters per hour, cubic meters per second, liter per hour, and hectare-meter per day.

Basic units of water measurement. There are two basic units of water measurement from a water management perspective. For water that is in motion, cubic feet per second (cfs) are the unit of measure. For water that is stored or impounded, the acre-foot (af) is how water is measured.

**Cubic feet per second (cfs):**

* 1 cubic foot = 7.4805 gallons.
* 1 cubic foot per second = 7.4805 gallons flowing by a particular point in 1 second.
* 1 cfs = 1.983 acre-feet per day = 646,320 gallons = 2447 cubic meters of water.
* 1 cfs is equivalent to 448.8 gallons of water flowing per minute.
* 1 cfs will produce 724 acre-feet of water per year.
* 1 cfs = 38.4 miner's inches of water.

### 1.1.3. Method of water measurement

Several methods/devices are used for measuring irrigation water on the farm/streams. They can be grouped into four categories: (i) volumetric measurements, (ii) velocity-area methods, (iii) measuring structures (orifices, weirs and flumes), and tracer methods (dilution).

**A/Volume method of water measurement: -**A simple method of measuring small irrigation stream is to collect the flow 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 the second's hand of a wrist watch. The rate of flow is measured by the formula

$$\textbf{Discharge rate, liters/sec} = \frac{\textbf{Volume of container}}{\textbf{Time required to fill}}$$

The method can be used to determine the discharge rate of pump and other water lifts like Persian wheel and leather bucket lift if a barrel of 150 to 200 liters capacity is used to collect the flow. The method is also suitable when the stream is discharged into a reservoir of sufficient capacity. The volume can be calculated by direct measurements with a tape. The flow is determined by noting the time required for the reservoir to fill a certain depth, or for the water surface to rise from one level to another.

**B/Velocity-Area methods:-**The rate of flow passing a point in a pipe or open channels is determined by multiplying the cross-sectional area of the flow section at right angles to the direction of flow by the average velocity of water.

Discharge = Area x velocity

Q = A x v

Where, Q= discharge rate ($m^3/s$)

A = area of cross-section of channel or pipe ($m^2$)

v = velocity of flow (m/s)

The cross-sectional area is determined by direct measurements. The velocity is generally measured with a current meter. Approximate value of a rate of flow may also be obtained by the float method.

### I. Float method

The float method of making a rough estimate of the flow in a channel consists of noting the rate of movement of a float body. A long-necked bottle partly filled with water or a block of wood may be used as the float. A straight section of the channel about 30 meters along with fairly uniform cross-section is selected. Several measurements of depth and width are made within the trial section to arrive at the average cross-sectional area. A string is stretched across each end of the section at right angles to the direction of flow. The float is placed in the channel, a short distance upstream from the trial section. The time the float needs to pass from the upper to the lower section is recorded. Several trials are made to get the average time of travel.

To determine the velocity of water at the surface of the channel, the length of the trial section is divided by the average time taken by the float to cross it. Since the velocity of the float on the surface of the water will be greater than the average velocity of the stream, it is necessary to correct the measurement by multiplying it with a constant factor which is usually assumed to be 0.75-0.85. To obtain the rate of flow, this average velocity (measured velocity x coefficient) is multiplied by the average cross-sectional area of the stream.

### II. 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. The current meter is a small instrument containing a revolving wheel or vane that is turned by the movement of water. ). It may be suspended by a cable for measurements in deep streams or attached to a rod in shallow streams. The propeller is suspended facing the center of the flow in the stream (or the pipe. The propeller is rotated by the flow of water. The speed of the propeller (r.p.m) is proportional to the average velocity of flow in the conduit. The number of revolutions of the wheel in a given time interval is obtained and the corresponding velocity is reckoned from a calibration table or graph of the instrument. Current meter measurements in canals and streams are generally made a metering bridge, at cableways, or at other structures giving convenient access to the stream. The channel at measuring section should be straight, with a fairly regular cross-section. Structures with piers in the channel are avoided as far as possible. Both the float and the current meter methods, however, have very limited application in farm irrigation practice.

### C/Measuring structures

In farm irrigation practice, the most commonly used devices for measuring water are weirs, parshall flumes, orifices and meter gates. In these devices, the rate of flow is measured directly by making a reading on a scale which is usually a part of instruments and computing the discharge rate from standard formulas. The discharge rate can also be obtained from standard tables or calibrated curves prepared specifically for the instruments. All the three devices can be made locally for farm use and give reasonably accurate results when constructed, installed and operated properly. The choice between one or the other depends on the expected flow rate and site condition.

### D/Tracer methods

The tracer methods of water measurement are independent of stream-cross-section and are suitable for the field measurements without installing fixed structures. In these methods, a substance (tracer) in concentrated form is introduced into the flowing water and allowed to thoroughly mix with it. The concentration of the tracer is measured at a downstream section.

Since the only quantity of water necessary to accomplish the dilution is involved, there is no need to measure velocity, depth, head, cross-sectional area, or any other hydraulic factors usually considered in discharge measurements.

In the dilution method of flow measurement, a relatively large quantity of chemicals or dye, called a tracer is dissolved in a small quantity of water and placed in bottle so that the tracer solution can be discharged at a known rate into the water flowing in a channel or pipe.

The discharge at upstream section can be computed by:

$$\boldsymbol{Q = q1\left(\frac{C2 \quad C1}{C0 \quad C2}\right)}$$

Where, q1 is the rate of injection of the solution

C0 is the original tracer concentration of the upstream flow

C1 is the concentration of tracer (weight of trace/weight of water)

C2 is the concentration at the downstream section

Salt concentration, as such as, is difficult to measure directly. However, over a useful range, the electrical conductivity bears a linear relationship with the salt concentration and it is easy measured.

### 1.2. Monitoring soil water status in the root zone

**Monitoring** is the process of controlling a given system by continuous inspection or observation and recording the results and reporting for the concerned body. There for monitoring soil water status is identifying the amount, type and quality of soil moisture taking a remedial measure to the problem inspected and identified.

#### 1.2.1. Measuring soil moisture

**Soil moisture** is always being subjected to pressure gradients and vapor pressure differences that cause water to move. Thus it cannot be constant at any pressure. But for particularly significance in agriculture,

**Soil moisture constants:-**there are different soil moisture constants. Thus are:-

- saturation capacity

- Moisture equivalent
- Available water
- field capacity
- permanent writing point

**Saturation capacity**: - when all the pores in the soil are filled with water. The tension of water at this Level is almost zero and it is equal to free water surface.

**Field capacity**:-soil moisture content after draining excess water and it is relatively stable. the soil moisture tension at field capacity varies from soil to soil, but ranges from 1/10 to 1/3 atmospheres.

**Moisture equivalent:** the amount of water retained by a sample of initially saturated soil material after being subjected to a center fugal force of 1000times that of gravity for a definite period of time, usually hour in hour.

**Permanent wilting point /pwp**: - soil moisture content at which plant cannot longer obtain Enough moisture to meet transpiration requirement, and remain wilted unless water is added to the soil. The moisture tension here ranges from 7 to 32 atmospheres.

**Available water**: - soil moisture between Fc and pwp. It is moisture available for plant use. In general, fine texture soil has a wide range of water b/n Fc and pwp than course textured soil.

**Types of soil moisture**

**A/ hygroscopic water**: - is water held tightly to the surface of soil particles by adsorption forces.

- It is difficult to absorb by the plant root because of strong attraction force.

**B/ Capillary water**: - is water held by forces of surface tension and continuous films around soil particles and in the capillary spaces. it absorbs by plant root

**C/ Gravitational water**: - is water that moves freely in response to gravity and drains out of the soil because it has strong force to resist plant root absorption.

**Measurement of soil moisture**

Soil moisture Measurements are important in the suitable scheduling of irrigation and estimating the amount of water to be applied in each irrigation and to estimate evapotranspiration. There are also many experimental situations where careful measurement and control of soil moisture is necessary if the results of investigation on soil –plant-water relationships are to be interpreted properly.

The principal methods of expressing soil moisture are:-

I. By the amount of water in a given amount of soil and,
II. The stress or tension under which the water held by the soil.

**Methods of measuring soil moisture**

**1. By feel and touch:** - this is by far the easiest method. Assessment by feel is good for experienced people who have sort of calibrated their hands.

Table. Guide lines for evaluating soil moisture by feel and touch

| **% Depiction** | **Loam sandy to fine sandy** | **Fine sandy loam to silt loam** | **Silt loam to clay loam** |
|---|---|---|---|
| At Fc | No free water on ball but wet out line on hand | Same | Same |
| 0-25 | Make ball but breaks easily and doesn't feel stick | Makes tight ball, ribbons easily, slightly sticky and slick | Easily ribbons, slick feeling |
| 25-50 | Balls with pressure but easily breaks | Pliable under pressure or slick, ribbons and feels damp | Pliable ball, ribbons easily , slightly slick |
| 50-70 | Will not ball, feels dry | Balls under pressure but ls powdery and easily breaks | Slightly balls, still pliable |
| 70-100 | Dry loose, flows through fingers | Powdery dry | Hard backed cracked crust |

**2. Gravimetric method**

Known volume of soil samples are taken from the field, weighed, and then dried in an oven for 24 hours at an average temperature of $105^0$ c. After dried, the samples will be taken out from the oven and weighed again. The d/ce in weight before and after drying is the amount of moisture present in the soil.

The amount of moisture that is held by a certain mass or volume of soil can be expressed as weight percent or volume percent. Soil moisture on weight basis is based on the dry weight of sample.

**Soil moisture content percent by weight.**

$$=\mathbf{SM}\ (\%) = \frac{(\mathbf{weightofmoisturesample - weightofovendrysample})\ \mathbf{x100}}{\mathbf{Weightofovendrysample}}$$

**N.B** expression of soil moisture content as % age of dry weight may not indicate the amount of water, available to plant, unless the soil moisture cxs carve or the Fc and pwp are known but it is useful to convert moisture content per units of weight into moisture content per units of volume.

Moisture content (% by volume) = moisture content (% by weight) x balk density.

**Bulk density** is the ratio of the mass of dried particle to total volume of soil (including particles and pores)

Gravimetric method is an accurate method but time consuming and the method is not practical for form use, as the oven cannot orderly be owned by farmers. But it is a standard against w/c other methods of moisture determination are compared.

**3. Neutron probe**

- It is indirect way of determining soil moisture content.
- It uses radioactive sources like beryllium and the sure emits fast neurons, some of which are slowed down when they collide with water molecules (hydrogen molecule)
- A cloud of slow neutrons (thermal neutrons) build up near the probe and are registered by the rate mater or rate scalar w/c measures the number of slowed down neutrons and it is necessary to have a graph of standardized calibrated curve of counts vs. moisture content of soil and used for wide range of soil moisture content but not suitable for small samples.

- ➢ It is dangerous since it is radioactive and must be used with care.

**4. Tensiometer:-**It provides a direct measurement of the tenancy with w/c water is held by soils and used to estimate the soil moisture content.

It consists of porous ceramic cup filled with water which is buried in soil at any desired depth and connected to a water filled tube to a manometer or vacuum gauge which measure the tension, the reading is then taken and correlated to moisture content using a calibration carve.

### 1.3. Defining the crop / plant water requirements

**Crop water requirement (CWR)**:-***crop water requirement*** is the quantity of water required by the plant/crop in a given period of time and is expressed in terms of mm/day, mm/season or the amount of water needed to replace the transpiration and evaporation losses and it is termed as ***consumptive use of crop***.

**Transpiration;** is the process by which water enters to the atmosphere from the crop in the form of water vapor .i.e. vapor removal from the plant canopy to the atmosphere.

**Evaporation**; is a process by which water enters to the atmosphere from the evaporative surface in the form of water vapor. Water evaporates from a variety of surfaces, such as lakes, rivers, pavements, soil and wet vegetation.

**Evapotranspiration**: is the total amount of water losses due to combined effect of evaporation and transpiration.

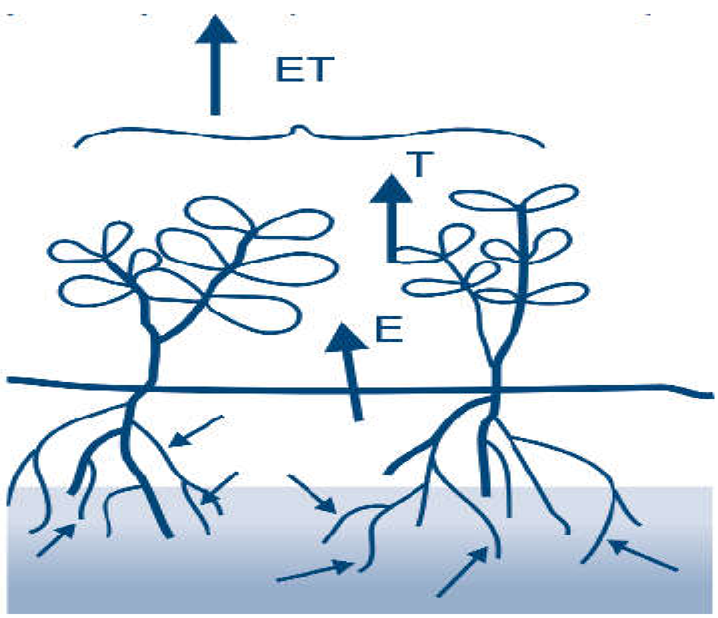

Figure 1 Water loss through Evapotranspiratio

**Reference Evapotranspiration ($ET_o$)**, the evapotranspiration rate from a reference surface is called the reference evapotranspiration and is denoted by $ET_{O.}$ The reference surface is a hypothetical grass with specific characteristics.

As water is abundantly available at the reference evapotranspiring surface, soil factors do not affect ET. The only factors affecting ETo are climatic parameters. Consequently, $ET_o$ is a climatic parameter and can be computed from weather data. $ET_o$express the evaporating power of the atmosphere at a specific location and time of the year and does not consider the crop characteristics and soil factors.

**Actual crop evapotranspiration ($ET_c$),** under standard conditions, it is denoted as $ET_c$ and is the evapotranspiration from disease-free, well-fertilized crops grown in large fields under optimum soil-water conditions and achieving full production under a given climatic conditions. $ET_c$ varies under different soil, water, atmospheric conditions and growing stages of the crop, geographical location and periods of the year.

The amount of water used in evapotranspiration is the quantity which is important for irrigation planning, because in the absence of rain fall irrigation has to provide this water.

Crop water can be affected by;

- climate
- Crop type
- Soil type
- Growing stage ( less water at initial stage & highest demand at mid season stage)

Evapotranspiration varies with climatic conditions in the same way as open water evaporation. When the climate is hot and dry, the rate of evapotranspiration is high, when the condition is cooler and humid it is low. When there is wind it is higher than when the air is still and it varies from crop to crop, soil type and growing season.

**Computing crop water requirement ($ET_C$)**

In order to get actual evapotranspiration, first it is important to determine the reference evapotranspiration. This can be done by using the following methods;

- Data analysis and crop water requirement determination

- Application of statistical models
- Using crop-wat  soft ware

**$ET_o$ estimated from pan evaporation**

$ET_o$can be determined by the help of several methods, but the simplest, reasonably accurate and most commonly used is pan evaporation method. Evaporation rate from the pan filled with water is easily obtained. In the absence of rain fall, the amount of water evaporated during a given period (mm/day) corresponds with the decrease in water depth in that period.

Pan evaporation provides a measurement of the integrated effect of radiation, wind, temperature and humidity on evaporation from specific open water surface. The commonly used standard pan is the u.s class A pan. It has standard size of 120cm diameter and 25cm depth and made of galvanized iron.

For measuring evaporation, the pan should be properly sat on wooden open frame with its bottom 15cm above the ground level.

Pan evaporation (EP) is related with $ET_o$ by a coefficient called pan coefficient, Kp and $ET_o$is given by

$$\mathbf{ET_o = Ep * Kp}$$

Where, Ep= pan evaporation (mm/day) and represents the mean daily value

Kp = the pan coefficient and can be obtained from a table

Then, $\mathbf{ET_c = ET_o * K_c}$

Where, Etc = crop water requirement or crop evapotranspiration (mm/day)

ETo = reference evapotranspiration

Kc = crop factor (crop coefficient)

**Selection of crop coefficient**

Kc value depends on different factors like:-

- time of planting or sowing,
- stage of development
- General climatic conditions.
- Crop growing season

**Crop growing season**

- **Initial stage**; germination early growth when the soil surface is not covered by the crop (ground cover < 10%)

  It may ranges in between 0.35-0.5
- **Crop development stage**; from end of initial stage to attainment of effective full ground cover (ground cover is approximately 70-80%)

  It may ranges between 0.6-0.8
- **Mid season stage:-** from attainment of effective full ground cover to time of start of maturing as indicated by discoloring leaves (e.g. beans) or falling of leaves (e.g. cotton)

  It may ranges in between 0.9- 1.15
- **Late season stage**, from end of mid season stage until maturity or harvest. It may ranges in between 0.3-1.00

Example; ; calculate seasonal crop water requirement of maize which have 25,35,45 and 30 days of initial, crop development, mid-season and late season stages respectively and take $Kc_{ave}$ = 0.65 and $ET_o$ =7mm/day.

Solution, ETc =Kc * ETo =0.65* 7 =4.55 mm/day

ETc = daily ETc *growing period =4.55mm/day(25+35+45+30) =614.25mm/growing season.

**Soil water balance**

Evapotranspiration can also be measured by measuring the various components of the soil water balance. The method consists of assessing the incoming and outgoing water change in to the crop root zone over some period of time. Irrigation (I) and rain fall (P) add water to the root zone. Part of I and P might be lost by surface run off (Ro) and by deep percolation (Dp) that will eventually recharge the water table. If all changes other than evapotranspiration (ET) can be assessed.

Evapotranspiration can be obtained from the change in soil water content over the time period; that is

**ET =I+P-Ro-Dp**

Some changes such as sub surface flow and Dp are difficult to assess in short time of periods. The soil water balance method can usually give only ET estimates over long time of periods of week-long or ten days.

How much water to apply? (Irrigation depth)

Irrigation is normally required to keep the soil water content between Fc and $\theta_c$. This range iscalled Raw. In irrigation system design, net irrigation requirement is interchangeably used with Raw. It is calculated as

**NIR = RAW = (Fc –$\theta_C$) * Dz = MAD *TAW = MAD* (Fc –PWP) *Dz**

Where, NIR = Net irrigation requirement

RAW=real available water

Fc = Field capacity

$\Theta_c$ = temporary wilting point

Dz = effective root zone depth

MAD= maximum allowable depletion = 0.5 for most soil crops

TAW = total available water

PWP = permanent wilting point

**N.B** It is not only NIR that we should divert to the irrigable land, since there are so many losses from diversion to application. Therefore after determining NIR the amount of water that should be diverted in to the field depends on irrigation efficiency.

Irrigation efficiency (Ea) is the ratio of water used by the plant to water diverted from the source. Therefore the amount of water that we want to divert or the amount to be applied is called Gross water requirement which is given by

GIR = NIR /Ea

Irrigation efficiency depends on different efficiencies, these are

Conveyance efficiency; it the ratio of quantity of water used in the farm to water supplied at farm head

Field application efficiency; it is the ratio of water used by the crop to water supplied at the field

Field application efficiency = $\frac{water used by the crop}{water supplied at the field}$ *100

Distribution efficiency = [1- $\frac{y}{di}$ ]* 100 = [1- $\frac{\sum(zi-di)}{n}$ ]* 100

Where y is average absolute deviation from the mean

Di is mean depth of water stored during irrigation

Zi is individual depths infiltrated water with field or test area

Minor efficiency, like field water efficiency, water storage efficiency etc

Therefore, irrigation efficiency is the sum of all the above efficiencies

Irrigation efficiency = conveyance eff * field application eff * distribution eff * minor eff (0.9)

**Field capacity**; is the amount of water held by a soil after excess water has drained away and the rate of down ward movement has materially decreased to negligible value which takes place two to three days after irrigation or rain fall in pervious soil of uniform texture. This point or moisture condition represents the upper limit of available water & this value is not constant since it depends on permeability of the soil.

**Permanent wilting point,** the lowest limit of available water and once plant reaches this stage there is no probability to regain its turgidity unless water is applied.

The relation between Fc and pwp is given by linear expression

PWP =0.447 + 0.28FC

Example. How much water must be added to a field of area 3 ha to increase the volumetric water content of the top 40 cm from 16% to 28%? Assume all water added to the field stays in the top 40 cm.

Given.

Fc =28% =0.28 $\theta_c$ = 16 % = 0.16 Dz = 40cm = 0.4m Ea = 1

Required

GIR =?

SOLUTION

$NIR = (Fc - \theta_c) * Dz = (0.28 - 0.16) * 0.4 = 0.048m$

$GIR = NIR/Ea = 0.048m/1 = 0.048m$

$GIR = 0.048m * 3\ ha = 0.048m * 30{,}000m^2 = 1440m^3$.

**Irrigation interval /frequency.**

Irrigation interval is the number of days between irrigation during periods without rain fall. It depends on the consumptive use rate of a crop and on the amount of available moisture in the crop root zone.

$$II = \frac{Available water to be used by the crop}{crop water requirment}$$

$$II = \frac{(Fc - PWP)\ Rz\ D}{CWR}$$

Where, II is irrigation interval

Rz is depth of root zone (m)

D is depletion factor/ depletion moisture (%)

Fc &pwp are volumetric field capacity & permanent wilting point

CWR is crop water requirement (mm/day)

**Irrigation period**

Irrigation period is the time that can be allowed for applying one irrigation to a given design area, it should not be greater than irrigation interval.

$$\mathbf{IP} = \frac{\boldsymbol{II\ \ Ig\ \ A}}{\mathbf{0.36}\ \boldsymbol{qm}}$$

Where, IP = irrigation period in hour

II = irrigation interval in days

Ig = gross irrigation requirement of crop in mm/day

A =area of irrigated field in ha

qm =manageable discharge in liter/second

**Example**

Calculate irrigation interval and irrigation period for a given conditions, ETc = 10mm/day, root depth = 1m, Fc = 24 %, PWP =8%, qm = 15L/sec, A = 1 ha, Ig = 12mm/day, depletion = 50%

**Solution**

$$II = \frac{(Fc-PWP)\ Rz\ D}{CWR} = \frac{(0.24-0.08\ )\ 1000mm\ \ 0.5}{10\ mm/day} = 8\text{days}$$

$$IP = \frac{II\ \ Ig\ \ A}{0.36\ \ qm} = \frac{8\ \ 12\ \ 1}{0.36\ \ 15} = 17.78\text{hr}$$

| Self-Check 1 | Written Test |
|---|---|

Name: __________________________ Date: ________________

*Directions:* Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. What is the need or objective of measuring irrigation water? (5pts)
2. What are the main water measurement techniques are, explain?(5pts)
3. What is soil moisture constant mean, explain?(5pts)
4. What does crop water requirement mean, what are the factors that affect it?(5pts)

**Note: Satisfactory rating – 10 points and above Unsatisfactory - below 10 points**

you can ask you teacher for the copy of the correct answers

| Information Sheet-2 | Apply a measured amount of water |
|---|---|

## 2.1 Predicting a pre-determined deficit

**Deficit irrigation: -**Deficit irrigation (DI) is a watering strategy that can be applied by different types of irrigation application methods. The correct application of DI requires thorough understanding of the yield response to water (crop sensitivity to drought stress) and of the economic impact of reductions in harvest in regions where water resources are restrictive. It can be more profitable for a farmer to maximize crop water productivity instead of maximizing the harvest per unit land. The saved water can be used for other purposes or to irrigate extra units of land. DI is sometimes referred to as incomplete supplemental irrigation or regulated DI.

"Deficit irrigation is an optimization strategy in which irrigation is applied during drought-sensitive growth stages of a crop. Outside these periods, irrigation is limited or even unnecessary if rainfall provides a minimum supply of water. Water restriction is limited to drought-tolerant phonological stages, often the vegetative stages and the late ripening period. Total irrigation application is therefore not proportional to irrigation requirements throughout the crop cycle. While this inevitably results in plant drought stress and consequently in production loss, DI maximizes irrigation water productivity, which is the main limiting factor (English, 1990). In other words, DI aims at stabilizing yields and at obtaining maximum crop water productivity rather than maximum yields (Zhang and Oweis, 1999)."

**Crop water productivity:-**Crop water productivity (WP) or water use efficiency (WUE) expressed in $kg/m^3$ is an efficiency term, expressing the amount of marketable product (e.g. kilograms of grain) in relation to the amount of input needed to produce that output (cubic meters of water). The water used for crop production is referred to as crop evapotranspiration. This is a combination of water lost by evaporation from the soil surface and transpiration by the plant, occurring simultaneously. Except by modeling, distinguishing between the two processes is difficult. Representative values of WUE for cereals at field level, expressed with evapotranspiration in the denominator, can vary between 0.10 and 4 kg/m3.

**Experiences with deficit irrigation: -**For certain crops, experiments confirm that DI can increase water use efficiency without severe yield reductions. For example for winter wheat in Turkey, planned DI increased yields by 65% as compared to winter wheat under rain fed cultivation, and had double the water use efficiency as compared to rain fed and fully irrigated winter wheat. Similar positive results have been described for cotton. Experiments in Turkey and India indicated that the irrigation water use for cotton could be reduced to up to 60 percent of the total crop water requirement with limited yield losses. In this way, high water productivity and a better nutrient-water balance was obtained.

Certain Underutilized and horticultural crops also respond favorably to DI, such as tested at experimental and farmer level for the crop quinoa. Yields could be stabilized at around 1.6 tons per hectare by supplementing irrigation water if rainwater was lacking during the plant establishment and reproductive stages. Applying irrigation water throughout the whole season (full irrigation) reduced the water productivity. Also in viticulture and fruit tree cultivation, DI is practiced.

For other crops, the application of deficit irrigation will result in a lower water use efficiency and yield. This is the case when crops are sensitive to drought stress throughout the complete season, such as maize.

Apart from university research groups and farmers associations, international organizations such as FAO, ICARDA, IWMI and the CGIAR Challenge Program on Water and Food are studying DI.

Reasons for increased water productivity under deficit irrigation

If crops have certain phonological phases in which they are tolerant to water stress, DI can increase the ratio of yield over crop water consumption (evapotranspiration) by either:-

- Reducing the water loss by unproductive evaporation, and/or
- By increasing the proportion of marketable yield to the totally produced biomass (harvest index), and/or
- By increasing the proportion of total biomass production to transpiration due to hardening of the crop.

Although this effect is very limited due to:-

- The conservative relation between biomass production and crop transpiration
- The adequate fertilizer application and/or
- By avoiding bad agronomic conditions during crop growth, such as water logging in the root zone, pests and diseases, etc.

## 2.2. Applying irrigation

**Irrigation Water Units: -** The application of irrigation water is often referred to in many different units. The most universal unit is inches of water depth. It is referred to as universal since rainfall and ETo as well as the calculated irrigation volumes values use the same term. This convention allows easy manipulation of the values in making scheduling decisions. Once the scheduling decision is made, the unit “inches” must be converted to volume since emitters and water meters use“gallons” of water volume. The convention is to standardize on an area of one acre. The depth of one inch of water on an acre of land area is equal to 27154 gallons. Those familiar with the irrigation system may often use gallons per vine. It is important to note that if vineyards with a different number of vines per acre were irrigated with the same gallons per vine, the volume applied per acre would be different by the ratio of vine numbers. For a 12 × 7 versus 10 × 7 foot vine spacing, the ratio would be 1.2 for a 20% difference in water applied. In this publication, the determination of how much water to apply to the vineyard is in inches of water depth for a given time period. The conversion should be first to gallons per acre. If using a water meter, multiplying the required gallons per acre by the acres irrigated provides a useful number. If using emitter discharge in gallons per hour per vine, divide the gallons per acre desired by the vines per acre to determine the irrigation volume per vine. Finally the volume of water per vine can be converted to system operation on time by dividing the gallons per vine required by the gallons per hour emitter discharge. Water Volume Conversions.

1 acre inch = 27,154 gallons per acre

1 acre foot = 325,000 gallons per acre

1 cubic foot = 7.48 gallons

Often growers use gallons per vine-applied water to compare applications to fields of different vine spacing resulting in error. Additionally, the net application rate is an average over the entire vineyard without any accounting for how uniformly the water is distributed across the vineyard or without regard to irrigation efficiency.

The following section describes in detail how to:

1) Determine the gross application rate and application uniformity of the drip system, and
2) Determine the number of hours to irrigate.
3) Determining the Irrigation Amount

Step 1: Determine the net amount of water you want to apply to the vineyard.

Step 2: Determine the actual application rate and application uniformity of drip system.

Step 3: Determine the number of hours to irrigate.

Step 4: Determine the vineyard's water use:

- ✓ Determine vineyard weekly net water application in inches as described in Section F.
- ✓ Assume for this example vineyard water use is 0.75 inch per week.
- ✓ Convert inches to gallons per acre for use with water meter
- ✓ Gallons/week/acre = net water application (in/wk) × 27,154 gal/ac in.

**Example**: gallons per week per acre = 0.75 in/wk × 27,154 = 20,366

•Convert inches to gallons per vine/week for use with emitter discharge

Gallons/wk/vine = net water application (in/wk) × vine spacing (sq. ft) × 0.623

**Example:** Assume: Water application = 0.75 in/wk × 7 ft × 11 ft

Vinespacing gal per vine /wk = 0.75 in/wk × (7 ft × 11 ft) × 0.623

= 36 gal/wk

Therefore, The Net Irrigation Amount is 36 gallons per vine per week.

Convert gallons applied to inches net water application inches/wk

=gallons/vine/wkspacing (sqft) × 0.623

**Example**: Assume: Water application = 36 gallons/vine/wk× 7 ft× 11 ft vine spacing inches per week =36 gallons/wk (7' x 11') × 0.623The Net Irrigation Amount is 0.75 inches.

**Determine the Emission Uniformity:**

Each drip emitter in the vineyard will be discharging water at a different rate. This discharge variability is due to manufacturing variation between emitters, pressure differences in the system, and any emitter clogging which may be occurring. We need to compensate for the variability when we determine how much to irrigate (gross irrigation application).The drip system's application uniformity is quantified using a measurement called the Emission Uniformity (sometimes referred to as the Distribution Uniformity). Emission Uniformity (EU) is defined as:

Emission Uniformity (%) = $\frac{\text{Avg.discharge rate of the low 25\% sampled emitters}}{\text{Avg.discharge rate of all the sampled emitters}}$ x 100

To determine the average discharge rate of the low 25% of sampled emitters, the discharge rate (gph) of each of the sampled emitters should be ranked from lowest to the highest and the 25% of the emitters with the lowest discharge rate should be averaged together. For example, if 36 emitters were monitored, the average of the 9 emitter's with the lowest discharge rates would be determined.

Example. Calculate Emission Uniformity for the following given data

Average discharge rate of all sampled emitters = 0.48 gph

Average discharge rate of the low 25% sampled emitters = 0.44 gph

**Solution: Emission Uniformity =** $\frac{0.44gph}{0.48gph}$ **x 100 = 92%**

Therefore, Uniformity Emission or Average Emission Uniformity is 92 %( This is quite good)

Example: Determine the number of hours to irrigate: The gross irrigation amount (the amount you actually apply) should include the net water you wish to apply plus some additional water to account for the inefficiencies of the irrigation system. The gross irrigation amount is determined as:

**Gross irrigation amount** = $\frac{\textbf{Netirrigationamount}}{\textbf{Irrigationefficiency}}$ **x 100**

Irrigation efficiency is difficult to quantify. However, when using micro irrigation techniques, if the drainage below the root zone and the runoff from irrigation is minimal, then the irrigation efficiency can be approximated using the emission uniformity. The above equation becomes:

**Gross irrigation amount** = $\frac{\textbf{Netirrigationamount}}{\textbf{EmissionUniformity}}$ **x 100**

Example: Net irrigation amount = 36 gal per vine/wk (see Step 1)

Avg. application rate per vine = 0.96 gph (Step 2A)

Emission uniformity = 92% (see Step 2B)gal/wk

Solution:

**Gross irrigation amount** = $\frac{\textbf{Netirrigationamount}}{\textbf{EmissionUniformity}}$ **x 100**

= $\frac{36gal/wk}{92\%}$ **x 100 = 39**

Irrigation time per week (hrs) $=\frac{\textbf{Grossirrigationamount}}{avgappliucationratepervine}$

Irrigation time per week (hrs) $= \frac{39}{0.96} = 41$hrs

Therefore, Number of hours to irrigate the field is 41 hours/week.

**Water Application Concepts**

The amount of water applied and its uniformity of application is important information for the grower who is managing the irrigation system. In this topic several ways to measure and to evaluate the amount of water applied will be covered. These methods will help a grower to determine how well he/she is doing. The system was designed to apply water at some rate but the grower may not have that information or changes may have occurred since the system was initially built.

Also, the grower must learn to calibrate his watering schedule to match the crop requirements as the crop grows over a season. For an overhead sprinkler system, part of the water applied is going to fall outside the containers and the grower should have an outstanding of the amount of water intercepted and the amount of water that falls to the ground. When runoff from the operation is considered, large spaced containers should be located where the runoff can be captured for reuse or treated. These techniques are required for good water management.

**Maximum Daily Water Applied**

For each management unit you are assessing, determine the maximum daily irrigation water applied (MDWA) in gallons. This can be done in several ways, and is usually recorded on a very hot day in summer. There are different ways to determine the maximum daily water applied for irrigation. Thus are:-

1. A water meter should be part of all nursery or greenhouse irrigation operations because many operations are large enough to be required to record and report water usage information per their state permit.

A water meter on the well or in the pumping station can help to establish the total amount of water used in total and for management unit:

For total water usage, either read the meter daily at the same time of day over a few days in summer and compute the daily average;

For the water usage of a particular management area, read the meter before and after an irrigation event. If the area is watered twice or more times a day, then the meter must obviously be read before and after each watering.

**Water usage, in gallons = final meter reading - initial meter reading, in gallons**

2. The nozzle discharge rate can also be used to calculate the maximum daily application amount. Follow the procedure for measuring nozzle discharge rate given earlier. The average of several nozzles gives a better figure. The equation for determining the water usage in each growing area (management unit) is given below:

This procedure can be used for one or for several houses or growing areas (management unit) as long as the nozzle discharge rates are correct for those areas. Watch the units! Water usage in total gallons discharged equals the average discharge rate of the nozzle, in gallons per minute (gpm), times the number of nozzles times the number of minutes (60 times number of hours) of irrigation.

The "time" to be used here should be the length of time used for one-daily irrigation or the total of individual irrigations throughout the day. Document what the "time" means here for the operation as the information may be needed later, i.e. - to evaluate how and when the operation irrigates the management unit.

A representative growing bed or irrigation zone should be used to make this calculation. The results will be more accurate than taking the gross total water applied to the whole nursery or greenhouse.

3. Alternatively, a series of quality rain gauges or straight-sided cans can be used to determine the average application depth during an irrigation event.

Total the depths of water measured and average the total. Divide the total by the number of measurements. This depth figure times the square feet of the growing area gives cubic feet of water. Convert to gallons by multiplying by 7.48. The Total Applied Water diagram describes this procedure.

4. A less refined method (if a water meter is not present) is to record information on the pump capacity in gallons per minute and daily operating hours, as a way to define the total amount of water pumped and applied daily for the operation.

Pumping rates may not be known accurately but the ballpark figures, in gallons per minute, are useful in the total evaluation process. Try to get a clear understanding of the irrigation process in the operation. Leaching Fraction

For risk assessment purposes, the efficiency of irrigation scheduling and management can be evaluated using the Leaching Fraction (LF) concept.

Leaching Fraction (LF) is a measure of the excess water that is applied during an irrigation event. It is the amount of water that runs out the bottom of the container divided by the total water applied to the container times 100 to convert to percentage. The Leaching Fraction diagram illustrates how this data is collected.

The process assesses how well the irrigator uses container size, substrate knowledge, plant size, and weather conditions in his/her process of applying irrigation water efficiently.

**Leaching fraction (%) = Leachate from plant (gal) / applied irrigation volume (gal), x 100**

The goal in irrigation application should be to maintain an adequate and uniform moisture level in the substrate. Leaching should be minimized if fertilizer is managed efficiently. A leaching fraction of 15% or less is considered a best management practice, unless experience proves otherwise. A leaching fraction test done on plant-occupied containers in the management unit (with normal irrigation practices), serves as a risk assessment test of irrigation scheduling efficiency. It is important to understand how to apply this test. This test should not discussed with the grower / irrigation manager in detail in advance, as it may influence how they irrigate.

You should ask the grower when he/she is going to next water the different management units. Then, prepare the necessary lined containers for the test. Select the management unit area to be

Put your containers in place - one plant-occupied container and one empty lined container next to each other. Place some in the middle and some toward the edges. Ask the irrigation manager to irrigate in his/her normal manner. Then remove your containers and collect the data. Variation from middle of a bed to the edge or at different distances from sprinklers point out non-uniformity of application. This test is to evaluate how well the irrigation manager does; later a best management practice can be written if the leaching fraction is high or non-uniform. The irrigation manager can improve his management practices, if necessary.

**Measuring Leaching Fraction:** The procedure uses 5 to 10 plant occupied plants in each growing area (management unit) you want to test:

**1.** Prepare double this number of empty, lined containers. Place a "spacer" block of wood in half of the lined containers, and then set a plant-occupied container in each empty, lined container.

**2**. Pair the rest of the empty, lined containers and set them near the plant-occupied lined containers in the growing area. When the crop is ready to be irrigated, ask the irrigation manager to operate the irrigation system for the normal length of time.

**3.** Collect all lined containers, allowing the leachate to fully drain from the plant-occupied containers. Take care not to tip the containers with plants as you remove them , as this will allow additional water to drain, affecting your LF measurement.

4. Measure the weight or volume of water in each container: For each pair of containers (one with a plant and one without) divide the volume of leachate collected from the plant by the volume of applied irrigation water caught by the empty container next to it. If the water was weighed, divide the appropriate weights. The Leaching Fraction diagram illustrates this process (see above).

5. Use the formula above to calculate the average LF for the management unit.

**Interception Efficiency:** Interception Efficiency (IE) is a theoretical measure of the amount of applied irrigation water that is captured by the containers in an area during a typical overhead irrigation event.

IE is expressed as a percentage of the applied water and can be calculated using areas. In terms of area, it is the "total container top area" divided by the "total ground area allotted to the container". The decimal value is converted to a percentage by multiplying by 100.

The type of irrigation system and the effects of container size and spacing are evaluated for efficiency by using the IE results. Overhead sprinklers will have higher risk, as the IE will be less than the 95 to 100 percent of drip/trickle systems.

Containers that are jammed together will give a higher IE (near 80 %) than those containers spaced apart. The maturity of the plant (canopy) and the overall size of the container in which it is planted is a factor in spacing containers for maximum light interception (growth). Large containers with large plants are usually spaced further apart.

Interception Efficiency is important because the fraction that misses the container (1.0 - IE) is the water (or water plus soluble nutrients) that theoretically falls onto the ground to create runoff. To repeat, the percentage of water falling onto the ground directly is (100 % - Interception Efficiency, in percent). Interception Efficiency is not a perfect measure because water falling onto foliage may be deflected or shed outward to fall onto the ground or directed inward toward the plant. This is a crop specific factor that is unknown. The angle of the water application, and environmental factors such as wind, may also directly affect IE.

However, IE is a useful practical measurement to assess the efficiency of the various irrigation practices in the nursery or greenhouse, and to give an overall assessment of the risk of potential runoff.

For drip irrigation the interception efficiency is usually near 100 percent because all the water is delivered to the container. Some micro irrigation sprinklers may partially miss the container. Spray stakes are assumed to be placing the water into the container. Containers may be spaced in a rectangular (square) pattern or in a diagonal (offset) pattern. The calculation procedure for overhead irrigation is basically the same for both situations, but the explanation is given separately in the following sections.

**Irrigation System Evaluation**

The objectives of Irrigation System Evaluation are:

- You will learn that a layout sketch of an operation is invaluable for making notes on during an evaluation. Pressures and flow rates can be noted on the sketch for later reference.
- You will learn that pressure in an important measure of application uniformity. A portable pressure gauge is a good management tool.
- You will learn a relatively simple way to measure application uniformity using catch cans.
- You will learn how to measure sprinkler nozzle and drip emitter discharge for comparing for uniformity.
- You will have an understanding of methods by which an irrigation system can be evaluated

The irrigation system can be evaluated each year to check uniformity of pressure and water application. Uniform application is particularly important for container (out-of-ground) production because water cannot move laterally to supply adjacent plants as it can in many soils. Three methods of evaluating uniformity of an irrigation system will be discussed briefly. These are ways to check your system to see if it is working properly.

**Increasing Minimum Available GPM:** How can I get more water out of my existing water supply pipe? How can I increase the minimum available GPM for use in my irrigation design? These questions and variations of them are among the most frequently-asked questions I hear. A typical question would be something like this: "I have a 5/8" meter and a 3/4" copper supply, so according to the Sprinkler System Design Tutorial I only have 10 GPM available. This doesn't seem like very much, so I did a bucket test and got 18 GPM from it! So why can't I use the 18 GPM figure from my bucket test for my Initial Design Flow?" Well, the answer is you can use that higher value. Of course, you can also jump off a cliff if you want to, but it isn't a wise choice. There is more involved in determining your Design Flow than just measuring water in a bucket. The good news is that you MAY be able to use a higher flow. The bad news is it isn't easy or fast to determine if you can! So be patient, and read on. I know this is a long tutorial, but there are a lot of variables and I want to try to give you enough information to make a good decision.

The rest of this FAQ assumes your water is coming to you from a water supplier. If you pump your own water from a well, stream, or pond the only way to increase your water flow is to install a newer and/or larger pump, larger pipe leading to and from it, and possibly drill a deeper well. You will need to see the Irrigation Pumping Systems Tutorial for details on how to do that.

GPM definition: GPM is the standard unit of flow used in the USA, it means "gallons per minute". This tutorial uses GPM as the flow measurement. Metric countries use liters per minute (l/m) to measure flow. Multiply GPM x 3.78 to get liters per minute.

There are obvious advantages to having a higher flow rate available for your sprinkler system. Increasing your available water supply will reduce the number of valves you need, which could result in a less expensive controller, less wire, and, in general, a lower cost. The best way to increase the amount of water you have available is to have the water supplier install a larger pipe to your property. But in most cases these good options are expensive or not even possible. So the next best solution is to try to force more water through the existing pipe. Unfortunately, there is a lot of really bad advice floating around on how to determine the maximum flow for your sprinkler system. Most sprinkler contractors and sprinkler design guides focus on keeping the short-term costs down. After all, they want to make a sale, and the best way to do that is to have the lowest price. They will save you a few bucks up front when buying your system at the expense of hundreds or even thousands of dollars in repairs later on. The theory is that you are happy you saved money today-- and they won't be around when you are unhappy later! I don't play that game, so we're going to look at the risks, and then you can decide if it is worth it.

**The Problems with Higher Flows:** First, this FAQ assumes you have already worked through the process of calculating your flow used in my Sprinkler System Design Tutorial, and that you want to use a higher flow than what was recommended there. If you haven't read through at least the first 3 pages of that Tutorial, I recommend you do it before continuing here. The tutorial describes the best way to determine how much flow you will have to work with in designing your sprinkler system.

Keep in mind that what we are discussing here is the maximum available GPM flow. The maximum available flow is the starting point for your design. The actual GPM you should use for your irrigation system may be lower than this value for any number of reasons. As you work through the tutorial above, you will be able to determine the actual GPM you should use.

Now let's take a look at the significant risks involved in using a higher flow, so you know what you are getting into. The Maximum Available GPM figures I recommend in the Sprinkler System Design Tutorial are set at the maximum safe flow for your pipe size and type, as recommended by the vast majority of experts and the pipe manufacturers. It is correct that you can get a lot more water through that pipe. No doubt about it. You can force an almost unlimited amount of water through a pipe if you put enough pressure on the water. But is that wise?

### 1.3. Increasing water quantities

Most of the earth consists of water, there is much more water than there is land. About 70% of the earth's surface is covered in water. But water also exists in the air as vapors and in aquifers in the soil, as groundwater.

The total water supply of the world is 1.400.000.000 km3. (1 m3 of water equals 1,000 liters.)

Each year, 119.000 km3 of water precipitates on land and 74.200 km3 evaporates into the atmosphere, by evapotranspiration from soil and vegetation. On ocean and sea surface 450.000 km3 of water falls every year and 502.800 km3 evaporates.

Of the freshwater on the Earth, about 2.200 km3 flows in the ground, mostly within half a mile from the surface. About 135.000 km3 of water can be found in the atmosphere as water vapor, in lakes, soil moisture, marshes and wetlands, rivers, plant and animals. Groundwater and fresh water stored in surface bodies and in the atmosphere represent an available resource of fresh water. Most of the freshwater is stored in glaciers and icecaps, mainly in the Polar Regions and in Greenland, and it is unavailable. This is another 24.500.000 km3 of water, forming the 69.5 % of the total fresh water of the Earth.

**How much of the water can be found in oceans?**

As oceans are very wide and there are multiple to be found on earth, oceans store most of the earth's water. This is apparently 97% of the total amount of water on earth, 2% of which is frozen.

Of all the water on earth, which is 97, 14% of the total amount of surface water, only 2.59% is freshwater. Of this 2.59% another percentage is trapped in ice caps and glaciers, which is about 2%. The rest of the freshwater is either groundwater (0,592%), or readily accessible water in lakes, streams, rivers, etc. (0,014%) from the quantities that came up in the questions listed above, one can conclude that less than 1% of the water supply on earth can be used as drinking water.

Humans mainly consist of water; it is in all our organs and in is transported throughout our body to assist physical functions. When a human does not absorb enough water, dehydration is the result. This is not very surprising, given that 66% of the human body consists of water.

**What causes fresh water shortages?**

There are four different causes of water scarcity:

- a dry climate,
- drought (a period in which rainfall is much lower and evaporation is higher than normal),
- drying of the soil due to activities such as deforestation and overgrazing by livestock
- Water stress due to increasing numbers of people that rely on limited levels of run-off.

**How can water supplies be increased?**

There are five ways to increase water supplies in a particular area:

- Build dams and reservoirs to store run-off,
- bring in surface water from another area,
- withdraw groundwater,
- Convert salt water to freshwater (desalination) and improve the efficiency of water use. These methods all have their pros and cons.

**Factors that Affect Water Use**

**Population Numbers and Distribution**: At the most fundamental level, water is needed to supply people's basic domestic needs, in quantities directly proportional to the number of people. Other uses of water include the various municipal, industrial, agricultural, environmental, and other uses described elsewhere in this report. The quantities of water used for these purposes are also related to some degree to the number and spatial distribution of people in the region, but these quantities are also affected by many other factors, discussed below. Finally, people residing in urban areas tend to have different patterns of water use, and they tend to use different quantities of water than people in rural or agricultural areas.

**Technology:** Technology and changes in technology may affect the availability or supply of water, demand for water and levels of water use. Industrialization, for example, typically increases the demand for water, at least initially. However, technological developments that permit users to economize on water such developments as water-efficient indoor plumbing fixtures, closed-conduit irrigation systems like drip and micro sprinkler systems, and computerized irrigation management techniques frequently result in reductions in water use. Technical improvements that improve timing and lower costs of supply can also affect water use. For example, the construction of impoundment facilities permits control and regulation of runoff and allows more constant levels of supply. Over the last century, pumping technology improvements have made new sources of ground water available that previously could not be exploited because of their depth.

**Economics**: Economic conditions, both within and outside the study area may affect water supply and demand. Recent declines in the world price for cotton have caused sharp declines in the potential profits from cultivation of irrigated cotton. In turn, this development has provided both the political

**Environmental Conditions:** Changes in environmental conditions can also significantly influence water supply and demand. Increased precipitation or decreased evapotranspiration are likely to augment water supplies and reduce the water demanded by irrigated agriculture. Increases in temperature or decreases in vegetated area or biological diversity are likely to diminish available supplies and increase the water demanded in many water using sectors. Water quality deterioration due to increased contamination levels reduces the available supply of water as surely as drought.

Changes in the environment can be directly or indirectly caused by human activities, or they can be (apparently) unrelated to human activity. For example, global climate change occurred long before humans or even living organisms inhabited the planet. Such change is likely to continue, but will be continued with global change caused by human activity. The human-induced global climate change may be pervasive and may have already occurred. Global change is likely to have significant or even profound impacts on regional water supplies and demands. However, current understanding of global climate patterns makes it very difficult to assess the impacts of such change regionally and therefore to predict how such critical variables as temperature and precipitation might change in the study area.

**IN stream and Withdrawal Uses of Water:** In characterizing patterns of water use, one fundamental distinction is that between in stream and withdrawal uses of water. The flowing or fleeting nature of water resources means that in many instances, certain uses of water do not impair its availability for further use. These uses are commonly termed in stream: they do not notably alter the properties of the water nor thus the quality or quantity of water to serve subsequent uses. Examples of in stream uses include most recreational uses, support of aquatic habitats and other environmental uses, navigation, and generation of hydroelectric power.

| Self-Check 1 | Written Test |
|---|---|

Name: ___________________________ Date: ________________

*Directions:* Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. What is the concept of water application, explain? (5pts)
2. What is the objective of irrigation system evaluation?(5pts)
3. What does the term water deficit mean, explain?(5pts)
4. Write are the factors that affects water use, explain?(5pts)

**Note: Satisfactory rating – 10 points and above Unsatisfactory - below 10 points** you can ask you teacher for the copy of the correct answers.

| Information- 3 | Assess efficiency of irrigation and repeat cycles of irrigation |
|---|---|

**3.1. Measuring effectiveness of irrigation application**

Irrigation systems should be evaluated in order to limit the following common water losses:

- ❖ Evaporation from the soil and plant surfaces, runoff from the target site, and deep percolation below the root zone.
- ❖ Irrigation systems should be periodically inspected and properly maintained for best performance.
- ❖ Managementpracticessuchasirrigationschedulingandconservationtillagecanhelptoimprove theoverallwateruseefficiency on the farm

Water application efficiency is a measurement of how effective the irrigation system is in storing water in the crop root zone. It is expressed as

The percentage of the total volume of water delivered to the field that is stored in the root zone to meet crop evapo transpiration (ET) needs.

**Irrigation System Performance Testing**

Accurate measurement or estimation of water inputs and use/outputs is required in order to assess overall farm water use. In-field irrigation performance is most commonly defined in terms of how efficiently and uniformly a known volume of water is applied; these themes are discussed below.

**Metering Irrigation Water**: All sites where water is extracted for irrigation must have a water meter installed according to the Natural Resources Management Act 2004. Water meters are important tools and provide information that is fundamental to good irrigation management. Examples of different meters used in the South East and tips on how to read and use your meter can be found in the "Irrigation Systems" section of the "Water and Coast" tab on the "Natural Resources South East" website.

**Irrigation Efficiency:**

Field Application Efficiency = crop water use * water delivered to irrigated field

Irrigation efficiency is defined as the ratio of water used by (or available to) the plant to the water input (i.e. the volume pumped). That is, application efficiency of 85 % indicates that 85 % of the water pumped was stored in the root zone for use by the crop and 15 % was 'lost'.

The goal of irrigation design and management is optimum efficiency, not necessarily maximum efficiency, to deliver irrigation water in the target range.

Efficient water use at the whole farm scale may be found by considering efficiency of the following sub-systems:

- ❖ supply systems (i.e. pumping from groundwater bores and on-farm storage dams or tanks)
- ❖ storage systems (i.e. dams, tanks and ponds)
- ❖ distribution systems (i.e. earthen channels and enclosed, pressurized pipes)
- ❖ application systems (i.e. surface, spray and drip)

- recycling systems (i.e. run-off / tail water dams and wastewater reuse schemes)

Both the input and output water volume can be defined at a range of locations and over a range of time scales within the overall irrigation system. Where and how the manager chooses to measure these will vary according to system design and site characteristics.

Tip Scheduling irrigating to replace crop water use requires that efficiency of the irrigation system be considered in calculations. If distribution efficiency is poor (leaks, atmospheric losses etc.), the volume of water pumped may need to be substantially more than that required by the crop. If this is not accounted for, there is a risk of under-irrigation throughout the season with resultant productivity losses

**Considerations for Improving Efficiency**

**Routine Maintenance:** Irrigation systems should be periodically inspected and properly maintained for best performance. The uniformity of water application is also important to check periodically as irregularities in application patterns can lead to yield losses. For example, a detached normal functioning sprinkler nozzle could lead to leaching of nutrients from over irrigation or dry patches in the field

**Irrigation Scheduling:** The overall efficiency of water use can be improved when irrigation events are scheduled based on soil moisture estimates or measurements. Soil moisture can be tracked with soil sensors and/or weather-based crop ET estimates to determine when and how much irrigation is needed. This can help to avoid over-watering and crop water stress.

**Reduce the Frequency of Irrigations:** With certain types of spray irrigation equipment, application efficiency can be reduced as application frequency increases. With every application, a percentage of the water applied will evaporate from the wet soil and plant surfaces. The rate of evaporation from the crop canopy will depend on climate demand, time available for evaporation to occur, and the surface area of the droplets. Evaporation from crop surfaces is considered the greatest evaporative loss from most sprinkler or spray irrigation systems.

**Water Measurement:** An irrigation flow meter can be used to monitor the total volume of water pumped. Water measurement data can be helpful with determining overall irrigation system efficiency, monitoring system performance, detecting well problems, monitoring pumping plant performance, and simplifying completion of annual water use reports.

**Residue Management:** Conservation tillage practices such as no-till and strip tillage have been shown to improve soil water holding capacity, water infiltration rates, soil moisture retention, and reduce runoff compared to conventional tillage.

**3.2. The estimated soil moisture level in scheduling system is adjusted to match that measured.**

Monitoring soil moisture for irrigation need to:-

- Provide efficient and timely applications of water to crops
- To Provide growers with water management tools to Test equipment in conjunction with growers
- Obtain grower feedback

**Before starting these scheduling three major items should be known**:

- Water holding capacity (WHC) of soil in the root depth
- Estimated Etc of the crop to be grown
- Soil moisture balance at the beginning of the scheduling period

By entering all these in the appropriate column of the worksheet the moisture balance at the end of the week is determined

**Gravitational Water: The** water in the large pores that moves downward freely under the influence of gravity is known as the gravitational water. This is the water between the saturated point and FC. .

**Field Capacity (FC):** Yield capacity is the moisture content of the soil when rapid drainage has essentially ceased and any farther drainage occurs at a very slow rate. The FC corresponds to a soil moisture tension of about 1/10 to 1/3 atmosphere.

**Permanent Wilting Point (PWP)** : The Soil moisture content at which the plant wilts permanently or dies is known as permanent wilting point. The soil still contains some water but it is too difficult for the roots to extract it from the soil as it is held with a suction force of about 15 atm. typically for medium soils the moisture content at PWP is about one-half the FC.

**Available Water**

The water contained in the, soil between FC and PWP is known as the available water.

**Total Available Water (TAW)**

The amount of water, which will be available for plants in the root zone, is known as the total available water. It is the difference in volumetric moisture content at FC and at PWP; multiplied-by root zone depth.

**Management Allowable Depletion (MAD)**

MAD is the degree, to which the water in the soil is allowed to be depleted by management decision.

**Reference Crop Evapotranspiration (ETo)**

The rate of evapotranspiration from an extensive surface of 8 to 15 cm tall green grass cover of uniform height, actively growing, completely shading the ground and of not short of water is known as the reference crop evapotranspiration.

**Crop Evapotranspiration (ETc):** The depth of water needed to meet the water loss through evapotranspiration of a disease-free crop, growing in large fields under non-restricting soil conditions including water and fertility and achieving full production potential under-the given growing environment.

**Crop Coefficient (Kc):** The ratio of ETc / ETo is termed as crop coefficient.

**Effective Rainfall (Re):** Rain that is retained in the root zone and used by plants is considered as effective rainfall.

Effective Rainfall (Re) =Total rainfall(R)-Runoff (R0)-Evaporation (E)-Deeppercolation (P)The amount of water, which will be available for plants in the root zone, is known as the total available water. It is the difference in volumetric moisture content at FC and at PWP; multiplied-by root zone depth.

**Available Water Capacity (AWC)**: is the portion of water in a soil that can be readily absorbed by plant roots of most crops. Soil Moisture Deficit (SMD) or Depletion is the amount of water required to raise the soil-water content of the crop root zone to field capacity.

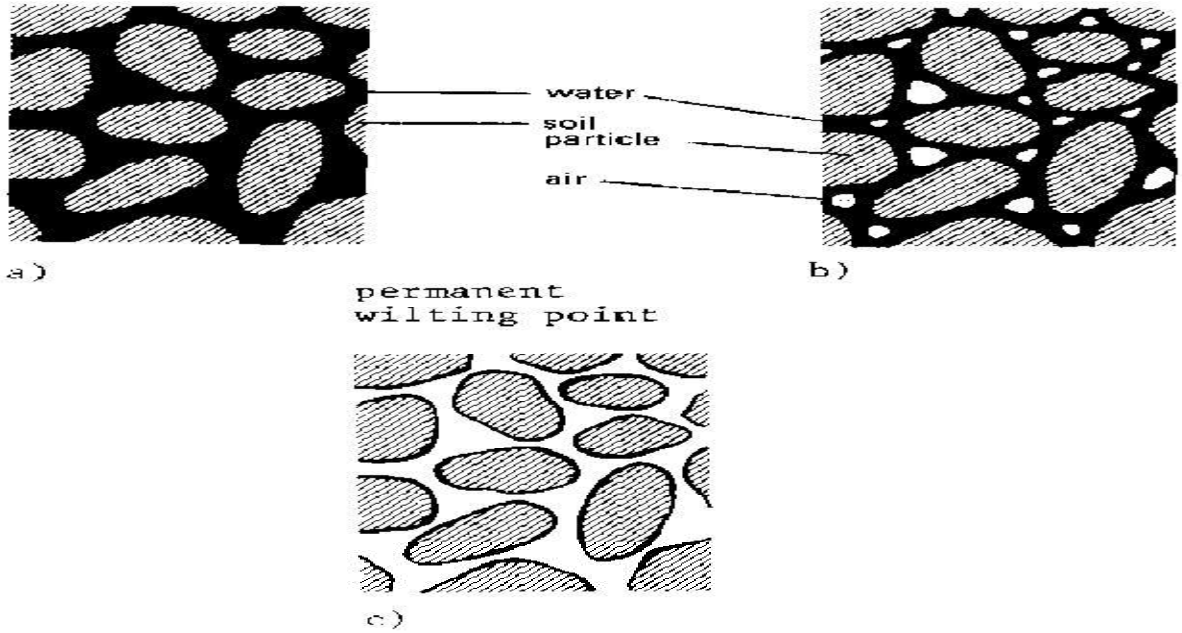


**Fig 3.1** Available soil moisture

**Monitoring equipment for soil moisture for irrigation**

- Soil Moisture Sensor
- Field scout TDR
- Portable instrument
- Capacitance probe
- TDR: time-domain reflector metry determines soil volumetric water content. The principal of measurement is based on measuring the travel time of an electromagnetic wave along a waveguide between the two probes. A built in GPS system is able to pin-point the measured sites which is helpful for re-sampling
- Tensiometers: are installed permanently at the depth of the root zone. They provide a reading of the soil water suction, or tension, caused by the soil water moving away from the ceramic cup (in a drying soil), or moving towards the ceramic cup (in a wetted soil). The water tension is related to the soil water that is available to plants.

Fig.3.2.tensio meter

Watermarks (gypsum blocks): Watermarks: installed permanently in the soil, and determines volumetric water content which is displayed. It works on the same principal as the tensiometer. It measures the electrical resistance to current flow between electrodes embedded in gypsum; as the gypsum dries the electrical resistance increases between the rods.

Fig 3.3. Watermarks

**3.3. Recalibrating the scheduling system**

Irrigation scheduling is planning when and how much water to apply in order to maintain healthy plant growth during the growing season. It is an essential daily management practice for a farm manager growing irrigated crops. Proper timing of irrigation water applications is a crucial decision for a farm manager to:

- meet the water needs of the crop to prevent yield loss due to water stress;
- maximize the irrigation water use efficiency resulting in beneficial use and conservation of the local water resources

- Minimize the leaching potential of nitrates and certain pesticides that may impact the quality of the groundwater.

Effective irrigation is possible only with regular monitoring of soil water and crop development conditions in the field, and with the forecasting of future crop water needs. Delaying irrigation until crop stress is evident, or applying too little water, can result in substantial yield loss. Applying too much water will result in extra pumping costs, wasted water, and increased risk for leaching valuable agrichemicals below the rooting zone and possibly into the groundwater. Several scheduling tools are available to assist a farm manager in irrigation scheduling: soil probes, soil moisture sensors, in-field weather stations, crop water use estimators, daily soil water balance checkbook worksheets, computerized daily soil water balance accounting programs, and private consultants. The purpose of this bulletin is to describe the set-up and operating procedure for a manual soil water balance accounting method, commonly referred to as the CHECKBOOK method. Calibrating an irrigation system has been found to be one of the most effective ways managing water guzzling plants without spending a fortune on water bills. There are several reasons why calibrating an irrigation system is important. Not only is frequent watering is expansive it can also cause lawn problems:

- Fungal disease
- Poor growth
- Bacterial disease
- Insect proliferation

Monitoring exactly how much water is being used help your lawn reaches the ultimate level of growth and long term health. in some areas of the country watering restriction may be imposed to limit water consumption. The time at which watering can be done could also be constrained. This need taken into consideration and worked around when calibrating an irrigation system for your lawn. Oftentimes people will use a simple lawn sprinkler as a way of irrigating their lawns .but they may not deliver the proper amount of water to each area of the lawn. They may also consume more water than is necessary. However they can still be adjusted to become an effective irrigation system for your lawn.

**3.4. Repeating and establishing cycles of irrigation**

To apply water without creating runoff the cycling and repeating of irrigation is more important because runoff carry fertilizers, pesticides and unfiltered soils into the nearest rivers leaks and seas which cause for

- For pollution of ground water
- Water deficit in the soil
- Erosion of top fertile soils
- Loss of irrigation water etc.

The cycle and soak method is used to eliminate thus problems by applying water in a multiple cycles with 30 to 60 minutes in between cycles so water has time to soak deeper into the soil. The first cycle breaks the compacted surface tension of the soil which compacted by storm and irrigation activity and saturates the top layer of the soil. With time the water soaks deeper allowing the second cycle to infiltrate to the soil more efficiently. A third and even a fourth cycle will be beneficial if a slop is involved or if runoff occurs after the sprinklers run for just a few minutes. A new irrigation controller will have a cycle and soak settings. For these controllers you set the maximum runtime and the number of cycles. The controller automatically divides the runtime into the number of cycles you set. if you find your existing controller doesn't have the ability to schedule multiple start times with multiple programs. The cost to upgrade a controller will pay for itself by saving water preventing runoff and effective using every drop of water on your lawn and landscape.

Just remember that lawns only need about 1 inch of water per a week to sustain healthy growth. Also a turnoff irrigation system when rain is in the forecast and leaves it off for a few days or until water is needed. The cycle soak method minimizes runoff and allow for better water filtration into the soil. Also it will assists in the development of extensive root systems which results in drought tolerance .Irrigation scheduling is planning when and how much water to apply in order to maintain healthy plant growth during the growing season. It is an essential daily management practice for a farm manager growing irrigated crops. Proper timing of irrigation water applications is a crucial decision for a farm manager to meet the water needs of the crop to prevent yield loss due to water stress; maximize the irrigation water use efficiency resulting in beneficial use and conservation of the local water resources Minimize the leaching potential of nitrates and certain pesticides that may impact the quality of the groundwater.

| **Self-Check 3** | **Written Test** |
|---|---|

**Name:** ___________________________ **Date:** ________________

***Directions:*** **Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers**

1. How to improving irrigation efficiency?(5pt)
2. List common water losses of irrigation systems to evaluated the irrigation system(5pt)
3. Define irrigation efficiency?(5pt)
4. List monitoring equipment for soil moisture for irrigation(5pt)
5. what is the difference between saturation and field capacity(5pt)

**Note: satisfactory Rating: 12.5 and above pts. Unsatisfactory rating: below 12.5pts.**

You can ask you teacher for the copy of the correct answers

| **Operation sheet #3** | The "feel and appearance method" to check |
|---|---|

The "feel and appearance method" is one of several irrigation scheduling methods used in IWM. It is a way of monitoring soil moisture to determine when to irrigate and how much water to apply. Applying too much water causes excessive runoff and/or deep percolation. As a result, valuable water is lost along with nutrients and chemicals, which may leach into the ground water. The feel and appearance of soil vary with texture and moisture content. Soil moisture conditions can be estimated, with experience, to an accuracy of about 5 percent. Soil moisture is typically sampled in I-foot increments to the root depth of the crop at three or more sites per field. It is best to vary the number of sample sites and depths according to crop, field size, soil texture, and soil stratification. For each sample the "feel and appearance method"involves:

1. Obtaining a soil sample at the selected depth using a probe, auger, or shovel;
2. Squeezing the soil sample firmly in your hand several times to form an irregularly shaped "ball";

3. Squeezing the soil sample out of your hand between thumb and forefinger to form a ribbon;
4. Observing soil texture, ability to ribbon, firmness and surface roughness of ball, water glistening, loose soil particles, soil/water staining on fingers, and soil color. [Note: A very weak ball will disintegrate with one bounce of the hand. A weak ball disintegrates with two to three bounces;

5. Comparing observations with photographs and/or charts to estimate percent water available and the inches depleted below field capacity.

| **Information Sheet-4** | **Record irrigation and scheduling parameter** |
|---|---|

**4.1. Record irrigation and rain fall event**

The events of irrigation related to the positive changes on agricultural production system, such as the increasing and continuity of production, increasing of food supply and its negative impacts on agricultural systems, such as change of hydrological characteristics, and the different environmental impacts.

Environmental impacts of irrigation relate to the changes in quantity and quality of soil and water as a result of irrigation and the effects on natural and social conditions in river basins and downstream of an irrigation scheme. The impacts stem from the altered hydrological conditions caused by the installation and operation of the irrigation scheme. Recording of irrigation events includes:-

- ✓ The positive change of irrigation on agriculture
    - ➢ Increasing of crop production
    - ➢ Improving of crop quality
    - ➢ Improvement of environment
    - ➢ Reduction of water deficit
    - ➢ Improving soil moisture
    - ➢ Reducing of drought
- ✓ Negative changes of irrigation on agriculture

- Change of water quality
- Change of soil texture and structure
- Pollution of ground and surface water
- Increasing of runoff and erosion
- Reducing of downstream water quality
- Affect downstream water users

**Direct effects:** An irrigation scheme draws water from groundwater, rivers, lakes or overland flow, and distributes it over an irrigated agricultural direct, effects of doing this include reduction in downstream river flow, increased evaporation in the irrigated area, increased level in the water table as groundwater recharge in the area is increased and flow increased in the irrigated area. Likewise, irrigation has immediate effects on the provision of moisture to the atmosphere, inducing atmospheric instabilities and increasing downwind rainfall, or in other cases modifies the atmospheric circulation, delivering rain to different downwind areas

**Indirect Effects:** Indirect effects are those that have consequences that take longer to develop and may also be longer-lasting. The indirect effects of irrigation include the following:

- Water logging
- Soil salinization
- Ecological damage
- Socioeconomic impacts

The indirect effects of water logging and soil salinization occur directly on the land being irrigated. The ecological and socioeconomic consequences take longer to happen but can be more far-reaching. Some irrigation schemes use water wells for irrigation. As a result, the overall water level decreases. This may cause water mining, land/soil subsidence, and, along the coast,

Generally for any irrigation projects for agricultural production the direct and indirect effect of the irrigation water and the rain fall should be recorded. The recording of the data is in the form of text, graph or diagram and drawings.

**4.2. Recording system performance data**

Measuring and recording Irrigation System Performance data can be takes place by the use of different recording and measuring device and instruments or structures:

**Water Use Indices:** Water Use Indices (WUIs) are indicators of system performance that relate production to water use and may be used to identify the efficiency of Economic, Agronomic and Volumetric water use. WUIs are useful for assessment of overall farm water use as well as identification of problem areas within the Water Use Efficiency Framework. Commonly used WUIs are presented below.

**Water Use Efficiency = volume of product / unit of water applied**

Water use efficiency is usually expressed in terms of tons per mega litter (i.e. grain, hay or fruit and vegetables) or liters per mega litter (i.e. milk) and describes the combined efficiency of the irrigation

### 4.3. Recording plant or crop environment data

***Recording*** *of* crop environment can be done in different times i.e. before germination there should be a detail records on climatic factors, soil factors and the type of crops selected for production, its water requirement, and the resistance to water deficit etc, until harvesting of the crop. Recording of crop environment could be carried on soil and on atmospheric conditions of a given area.

Recording for soil conditions of an irrigated field can be for;

- soil moisture content,
- level of ground water table,
- salinity of soil,
- Water logging conditions, etc.

**Soil moisture**:- plant absorb water from soil over a wide range of moisture content, field capacity is the upper limit of available moisture and wilting point is the down limit. The moisture between these two limits (potential-0.33 bar to-15 bar) is called the «Ready available moisture». Available moisture is of greater importance for its role in growth and development.

Moisture content out of these ranges has no advantage for crop and if the deviation increases from these two limits, it can result in decrease in yield of crop and other problems, i.e. if moisture content falls below pwp crop may wilt permanently and if moisture content rises above field capacity, there may be water logging problems, decrease in aeration characteristics of soil, salanization of soil if ground water table reaches crop roof zone and so on, these all conditions will result in reduced yield and this implies that the effectiveness of an irrigation is low.

**Salinity of soil**: - if the water source for irrigation is saline:-

- Besides decreasing the crop yield,
- Changes the soil characteristics.
- Is the result of rise in ground water table to root zone. As ground water table rises, it may contain or bring soluble salts to crop root zone usually causes poor stand of crops, stunted growth, reduced yields, leaf burn or deep blue green color, delayed and retarded germination and so on.

**Water logging conditions**: - accumulation of water at the surface of irrigated field. This is a result of excess water application. If this condition occurs it indicates ineffectiveness of irrigation practice. It can be detected by observing accumulation of water in to depressions and pits inside the field.

### 4.4. Recording water orders and water usages

There should be a detail records on water supply for irrigation and the actual water usage (ML) and associated type and area (ha) of crops irrigated per irrigator per month. Record all water taken against each irrigator' irrigation right (a spread sheet and graph may assist in showing this).because any data can be recorded either by text, graph, symbol or drawings.

Record total water allocation against actual delivery, link to restriction % (a graph may assist in showing this).Show how total water taken for irrigation purposes was consistent with the allocations on the water entity and water license.

| Self-Check 1 | Written Test |
|---|---|

Name: ________________________ Date: _______________

*Directions:* Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. What is the objective of recording irrigation and rainfall? (5pts)
2. What are the positive and negative changes/effects of recording irrigation agriculture?(5pts)
3. List the ways that we uses during recording system performance data?(5pts)
4. Which plant and crop environment datas are required to be recorded?(5pts)

**Note:Satisfactory rating – 10 points and above Unsatisfactory - below 10 points**

you can ask you teacher for the copy of the correct answers

| Information Sheet-5 | Plan for extremes of weather |
|---|---|

### 5.1. Modifying extreme deficits and saturation

Deficits of water means the scarcity of water in the soil system and saturatation of water means the filling of all pore spaces only with water. Both the deficit and saturation of water in the soli pore space near to the plant root zone have great influence in the development of the crop. The reduction of moisture (extreme deficit) in the soil results in reduction of plant growth through large number of physic-chemical activities. Plants subjected to water stress not only show a general reduction in size but also exhibit characteristic conditions in structure, particularly, of leaves. Leaf area, cell size and volume and division are reduced.

Stomata close early and gaseous exchange between plant and atmosphere stops. Photosynthesis decreases earlier than the soil moisture potential reaches permanent wilting point. Reduction in photosynthesis accompanied by increased respiration reduces assimilates in the plants and reduces crop yield. Chemical composition and quality of the crop also affected.

Depending on stage of crop growth, moisture stress has variable effect on protein content in vegetative and /or reproductive parts. In cereals like rice and wheat, moisture stress during ripening reduces grain yield but increases protein content in grains. Levels of rubber, essential oils and fats increase due to moisture stress.

**5.2. Altering shift areas and application rates**

As we know that every condition in nature is dynamic /not stable, i.e.it will change from time to time. Likewise the design parameters or factors which influence these parameters like soil and environmental conditions will be changed from time to time or there may be UN usual change on these factors that may cause a failure in our project efficiency or goals.

Irrigation scheduling/ determining irrigation time is an important activity that should be carried out for success of any irrigation project, but at designing stage it is determined by using some meteorological and soil data of crop environment that is taken from the past records or observations, but these conditions may be changed from time to time or there may occur un even change on these conditions, the condition may be;

- Rise in temperature
- Increase in wind speed
- Increase in sun shine intensity
- Increase in day time duration
- Fall in temperature
- Increase in humidity
- Un usual rain fall etc

Based on the above conditions and stage of crop growth crop water requirements will be changed and we have to recommend irrigation shifts according to environmental conditions and crop water requirements and the conditions should be interpreted according to the project goals. For example our aim is rubber production from a given crop, moisture stress at ripening stage is recommended and we should reduce our irrigation frequency.

Plants are finely tuned to the seasonality of their environment, and shifts in the timing of plant activity (i.e. phenology) provide some of the most compelling evidence that species and ecosystems are being influenced by global environmental change. Researchers across disciplines have observed shifting phenology at multiple scales, including earlier spring flowering in individual plants and an earlier spring green-up' of the land surface revealed in satellite images. Experimental and modeling approaches have sought to identify the mechanisms causing these shifts, as well as to make predictions regarding the consequences. Here, we discuss recent advances in several fields that have enabled scaling between species responses to recent climatic changes and shifts in ecosystem productivity, with implications for global carbon cycling.

| **Self-Check 4** | **Written Test** |
|---|---|

**Name:** ________________________ **Date:** ______________

***Directions:*** **Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers**

1. How can we modify extreme deficit and saturation? 5pts
2. How can we modify extreme deficit and saturation? 5pts

***Note:*** **Satisfactory rating –5 points and above** **Unsatisfactory - below 5 points**

You can ask your teacher for the copy of the correct answer.

| **Operation sheet-1** | **Investigate surveying tools, material and equipment** |
|---|---|

**Objectives:** The main objective of irrigation scheduling is management of water so that it is applied at right time and in the amount needed

**Procedure:**

1. Close the PPE
2. To calculate the WHC of soil in the root zone depth the m/c at PWP is subtracted from m/c at FC then multiplied by root zone depth

$$\frac{Fc \quad Pwp\,(As \quad RD)}{100}$$

3. This available water is multiplied by an allowable depletion factor to determine the allowable depletion.

4. To calculate the current depletion (CD) the actual evapotranspiration and previous depletion is added and actual rainfall & irrigation (if any applied in the previous week) is subtracted from the previous sum. Page | 35 CD = (ETa + previous depletion)-(actual rainfall + irrigation)
5. To calculate the predicted evapotranspiration Kc is multiplied by reference crop evapotranspiration.
6. The predicted depletion is calculated by adding the predicted evapotranspiration and current depletion and then subtract the rainfall from it. This predicted depletion is the amount for irrigation.
7. The irrigation frequency is calculated by using the following expression Irrigation frequency = 7*(Allowable depletion-CD+R)/Etc

| **LAP Test1** | **Practical Demonstration** |
|---|---|

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

***Instructions:***

1. You are required to perform any of the following:

1.1 Request your teacher to arrange for you to visit the nearby irrigation scheduling. You should have to observe and identify the type of crop would be planted.

1.2 Request a set of irrigation scheduling parameters, then perform the following tasks in front of your teacher

1. determine Field Capacity (FC) , permanent wilting point, Gravitational Water, Available Water, Total Available Water (TAW), Management Allowable Depletion (MAD), Reference Crop Evapotranspiration (ETo), Crop Evapotranspiration (ETc), Crop Coefficient (Kc), Effective Rainfall ( Effective Rainfall (Re) =Total rainfall(R)-Runoff (R0)-Evaporation (E)-Deep percolation)

2. prepare irrigation schedule depending on the type of crop planting in your field
3. Request your teacher for evaluation and feedback

## REFERENCES


1. Garg, 2006, 19th revised edition. Irrigation engineering and Hydraulic structure
2. 2nd Editions by a.m Michael. Irrigation principle and practice
3. 2nd Editions FAO by w.r. walker. Irrigation and drainage management
4. Garg 2005 revised edition. Drainage engineering
5. 2nd Editions by George's. Technical irrigation information