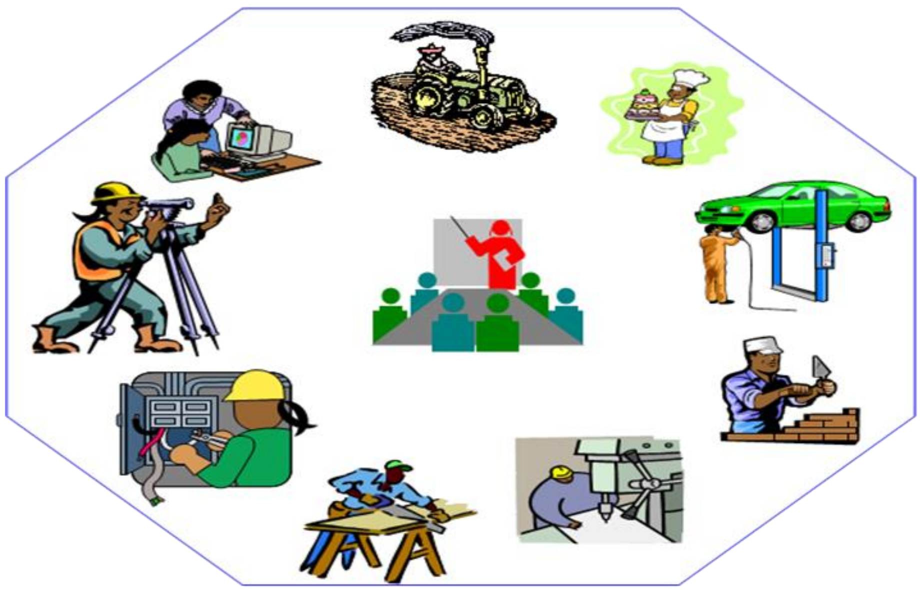
Crop Production
Level-III

Based on March 2018, Version 3 Occupational standards



Module Title: - Sampling soils and analyzing results
LG Code: AGRCRP3 M04 LO (1-3) LG (20-22)
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East Africa Skills for Transformation and Regional Integration Project (EASTRIP)

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LG #20	LO #1- Prepare for soil sampling

Instruction sheet

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

- Identifying the soils to be surveyed, surveying activity and contractors
- Selecting tools, equipment and machinery
- Carrying out pre-operational and safety checks
- Identifying areas of homogeneous soil types
- Locating services site plans
- Identifying OHS hazards
- Selecting, using and maintaining personal protective equipment (PPE)
- Maintaining a clean and safe work area

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify the soils to be surveyed, surveying activity and contractors
- Select tools, equipment and machinery
- Carry out pre-operational and safety checks
- Identify areas of homogeneous soil types
- Locate services site plans
- Identify OHS hazards
- Select, using and maintaining personal protective equipment (PPE)
- Maintaining a clean and safe work area .

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the "Self-checks" which are placed following all information sheets
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks)

Information Sheet 1- Identifying the soils to be surveyed, surveying activity and contractors

1.1. Introduction to soil

Soil can be defined in either the following three ways as

(a) “The natural medium for the growth of land plants.

(b) A dynamic natural body on the surface of the earth, in which plants grow, composed of mineral and organic materials and living forms.

(c)The collections of natural bodies occupying parts of the earth’s surface that support plants and that have properties due to the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.” Or in general. We build on soil, as well as in it and with it. Soil is the major support systems of human life and welfare.

They provide anchorage for roots, hold water long enough for plants to make use of it, and hold nutrients that sustain life. Soils are home to myriad micro-organisms that accomplish a suite of biochemical transformations from fixing atmospheric nitrogen to the decomposition of organic matter and to armies of microscopic animals as well as the familiar earthworms, ants and termites. In fact, most of the land’s biodiversity lives in the soil, not above ground.

Soil is initially formed by three principle actions

- Weathering and erosion of bed rock (the action of wind, water, and temperature)
- Sedimentation, the importation of material from other areas e.g. by ice, wind orwater (flooding)
- Colonization by plants and animals which adds organic matter.

Soil is the unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants.

Soil is the unconsolidated mineral or organic matter on the surface of the Earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and micro-organisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics.

Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment. parts of the earth surfaces.

The soils are three-phase systems, which consist of **solids**, **liquid**s and **gases.** Soil is made up of organic matter, inorganic matter, water and air in various proportions. These soil constituents greatly impact the soil plant water relationship which is highly important in plant productions. Therefore we have to manipulate the soil in order obtain the best soil, water and plant relationships and the nutrient status as a result of which we can get higher horticultural crop yield.

To manipulate the soil we first have to study the soil profile the physical and chemical properties of the soil, however we can't study the whole soil on the surface of the land, but we have to take a representative soil lot/ sample from a plot of land. The soil sample should be representative of the area; once we take the sample we test the samples and conclude about the whole soil in that area, the conclusion can help in measure we need to take in ameliorating the soil in which it .

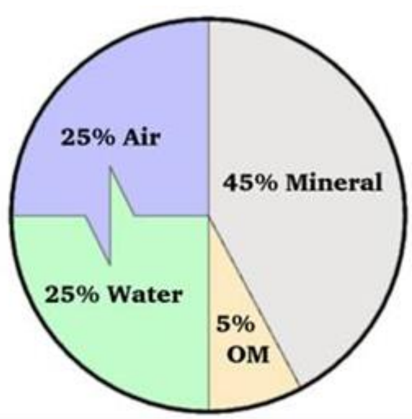


Figure 1.1 The four components of soil

Type of Soils in Ethiopia

In Ethiopia there are five primary types of soil, three of which have medium to good agricultural potential. The soils with Agricultural potential are:

a**. Euritic Nitrosols and Androsols**, formed from volcanic rock, found in the Western and Eastern Highlands, and having medium to high agricultural potential

b. **Eutric Cambisols and Ferric & Orthic Luvisols**, found in the Simien plateau in Western Ethiopia. These soils are heavily weathered with sub surface clay, have low nutrient retention and are prone to surface crusting and erosion but have medium agricultural potential

c. **Vertisols,** found in the Western lowlands and foot hills of the western highlands, are dark clay soils which have medium to high agricultural potential but need careful management as they set hard when dry, are sticky when wet and prone to cracking.

Typical profiles of these soils are shown below

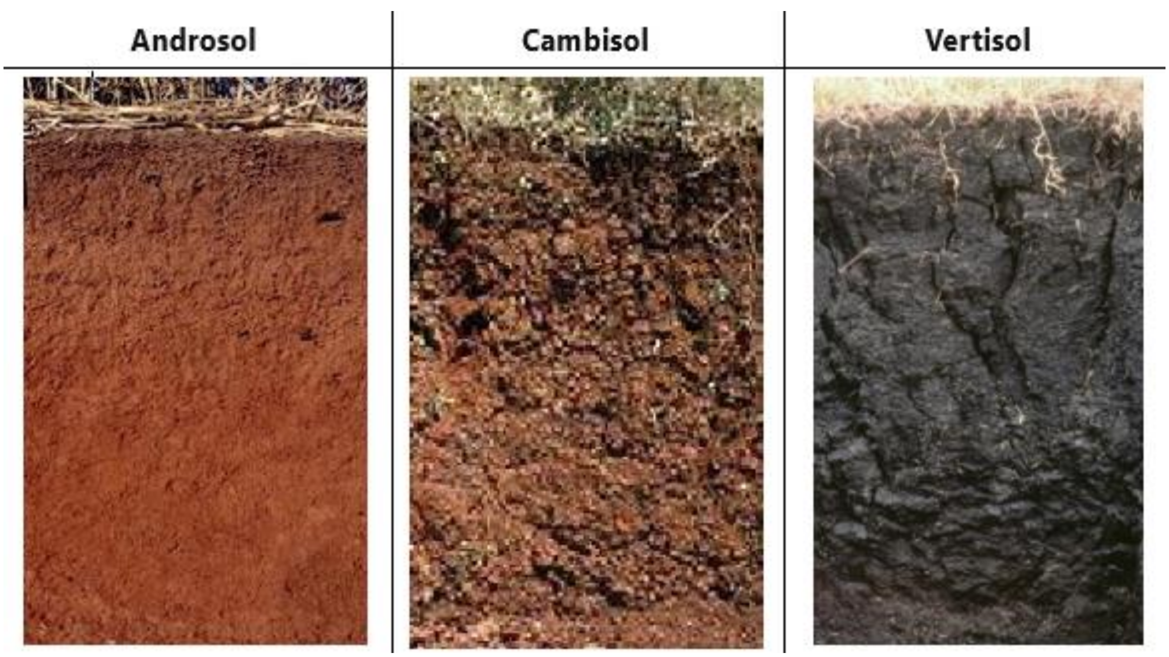


Fig 1.type of soil in ethiopia

1.2.1. The purpose of the soil survey

The purpose of making a soil survey is to obtain a representative image of the various types of soils and of the soil horizons present on the site.

The first part is a short, quick survey to get a general idea of the soil varieties present and where they are found on the site. This is called a reconnaissance survey. A reconnaissance survey is usually conducted by digging a number of open pits and examining the exposed soil profiles. Selected samples are then taken for field or laboratory testing. The results of this quick survey should enable you to determine which parts of the site may be suitable for pond construction, such as those with good impermeable soil, and which parts of the site are unsuitable, such as those with gravel beds or thick layers of organic soil.

The second part is a more complete survey of the parts of the site which you found to be suitable in the reconnaissance survey. This is called a detailed survey. A detailed survey is usually conducted by drilling a number of holes using the auger boring method. The auger samples you take will allow you to determine in greater detail the existing soil conditions and the suitability of the soils present. If necessary, you can take undisturbed soil samples to a laboratory for additional testing.

The number of samples you will have to take on a site will depend on the variety of soil conditions present. The greater the variety, the greater the number of samples you will have to take and examine to get a clear picture of possible site suitability. when making a soil survey in a valley, plan your survey to obtain samples across the valley and along the slope where most of the soil variation occurs. when you have different kinds of vegetation such as cultivated land, pasture, open savannah, forested savannah, and light and thick forest area, plan your reconnaissance survey so that you obtain soil samples from each of the different vegetations.

You can eliminate areas from your plan with large surface stones, gravel beds or rock outcroppings which are unsuitable for earth-pond construction.

Most thickly forested areas can also be considered unsuitable. Soils to be surveyed may include: field soil sites and specialist growing media.

Surveying activity include: collecting, preparing, packaging and labelling soil samples for off-site testing and/or on-site testing and analysis.

Contractors; include: off-site testing agencies such as government, commercial or private consultants, and contractors engaged for the mechanical extraction of soil samples by the use of machinery such as an auger or backhoe

1.2.2. General information considered while surveying the soil

- Land use: arable/fallow/ pasture (hay) /other:
- Vegetation: (detail species present)
- Catchments topography: flat/gentle/rolling/steep
- Slope of the site: ◭º/◭%
- Surface hindrance: stones/boulders/rock outcrops/other:
- Extent of hindrance: none/little/moderate/ extensive
- Evidence of erosion: runoff/surface crust/siltation/surface channels
- Extent of erosion: none/little/moderate/extensive
- Water table: yes/no; if yes, depth of water table:
- Drainage: free/impeded
- Drains: none/few/many Period of water logging

Self-check 1	Written test

Name…………………………………………… ID………………………… Date…….

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

Test I: Short Answer Questions

1. Define soil?(2pts)
2. List the three soil-phase systems?(2pts)

Test II: Write true if the statement is correct and false if statement is incorrect

1. Soil is the basis for life as it is the foothold for plants on which other lives are dependent. (2pts)
2. Soil constituents greatly impact the soil plant water relationship which is highly important in plant productions.?(2pts)

Note: **Satisfactory rating - 8 points Unsatisfactory - below 8 points**

You can ask you teacher for the copy of the correct

Information Sheet 2- Selecting tools, equipment and machinery

2.1. Tools and equipment's for soil testing

Equipment's for testing include those used to test the physical and chemical properties of the soil

Physical property: - The soil texture, bulk density, and particle density

- Equipment's used for soil texture measurements are: Hygrometer, 1000ml measuring cylinder, agitator. Using feel method the procedure guide can be used
- Equipment's used for bulk density are the core sampler and oven dry and to measure the particle density measuring cylinder and distilled water

Chemical property: - Soil pH, EC, Nutrients: N, P, K

pH - pH meter (Potentiometric analysis)

EC: -Conductivity meter (EC meter) (Conductometric analysis)

N: - kejeldal apparatus

P: - Olsen apparatus

K: - Spectrophotometer

2.2. Types and uses of tools and equipment's

- Shovels and spade are tools used to take an individual sample from the top surface of soil. To make a composite sample shovel and spade should be avoided because to make a composite/average mixture equal volume of different soil samples should be used for mix up, then to get this equal volume of soil an auger is best used as it can take similar volume of soil sample from same depth.
- A clean bucket is used to mix the samples to make it composite
- Paper bag is used to hold each sample separately and take to laboratory
- Mortar and pistil or soil grinder is used to break the soil clods in to pieces, to suit the soil for the different tests.

- Sieves are used to separate the desired size of soil particles according to the test for example to test soil texture a sieve with 2mm diameter is needed, and different diameter sieves for nutrient tests.
- Ruler, pencil and not pad is use to label the soil sample after preparation and documentations.
- A hand or powered auger, backhoe, pH test kit or electronic pH testing device, hand held salinity or EC meter, tape measure, sample bags, plastic overlays, aerial photographs, charts and tables of soil characteristics and plant soil parameters

Tools and equipment's for soil sampling includes the following, you need to know these tools and equipment by their name and should identify those tools and equipments physically.

Tools and equipment for soil sampling include the following: -

- soil probe
- shovel/spade
- plastic bucket
- sample bags
- waterproof marker
- gloves
- measuring tape
- soil augers
- pH field test kit
- Munsell soil colour charts
- interpreting charts
- String
- Filed note book
- Litmus paper
- Balance
- spatula/knife
- distilled water
- water
- bottle water

Figure: 1:2 Tools and equipment needed for soil sampling and testing

Self-Check – 2	Written test

Name…………………………………………… ID……………………….. Date…….

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

Short Answer Questions

1. List tools and equipment use of soil samplings? (5 pts.)
2. Can you differentiate between tools for sampling and equipment's for testing? (2pts)
3. What are the equipment's used to test nutrients like N, P and K? (3 pts)

***Note:* Satisfactory rating - 10 points Unsatisfactory - below 10 points**

Information Sheet 3- Carrying out pre-operational and safety checks

3.1. Pre-operational and safety check up of tools and equipments

Check all the tools and equipment before use, are all functional and sufficient in number Are all clean of any soil contaminants. During sampling any contaminant soil remaining on the sampling tools can affect the test of the new sample.

- Guideline's while check tools and materials
  - ✓ Checked tools and materials properly.
  - ✓ Done effective and efficient inspections
  - ✓ Properly maintained soil auger, bucket, shovel
  - ✓ Safe physical conditions with effectively controlled components,
  - ✓ Process equipment and materials.
  - ✓ Safe work steps to check set up machines, start, and finish job or task.

- If any faulty tool and equipment is found, maintain it:
  - ✓ Shovel and spade- stiffen the handle and the head together and clean from soil remains
  - ✓ Prepare the appropriate number and desired size of the paper bag
  - ✓ Prepare the appropriate sieve size in diameter.
  - ✓ Auger- put together tightly the head and the handle and clean from soil remains
  - ✓ Prepare the appropriate number and desired size of the paper bag
  - ✓ Prepare the appropriate sieve size in diameter

If there is any material totally none functional and cannot be maintained purchase it before starting the job.

Self-Check – 3	Written test

Name…………………………………………… ID……………………….. Date………….

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

Test I: Short Answer Questions

1. List the Guideline's while check tools and materials?(3pts)
2. List the importance of check all the tools and equipment before use?(2pts)

Test II: Choose (2pts)

Select the one not included as part of pre-operational checkup of tools and equipments

A. Identifying/ knowing C. checking (clean, functional, sufficient in number),

B. Maintaining D. Purchasing. F. none

Note: **Satisfactory rating - 7 points Unsatisfactory - below 7 points**

Information Sheet 4- Identifying areas of homogeneous soil types

4.1. Identify areas of homogeneous

Larger area may be divided in to appropriate number of smaller homogeneous units for better representations of the field.

- **Sample variation**

Soil variability may be classified in either a vertical or horizontal direction and as to whether the variability is natural or human caused. Soil differences between points on the landscape present the basic challenge in designing an effective soil-sampling procedure. Soil-forming processes may cause sharply contrasting differences in the soil profile, particularly the A, E, and B horizons. These differences relate to organic matter, pH, texture, cation exchange capacity, and, ultimately, plant nutrient Availability. Soils tend to be shallower on the crests of hills and deeper on lower slopes. Avoid sampling in landslides, soil slumps, and from around the roots of overturned trees because a large amount of soil mixing will have taken place. Selection of representative soils is a key to successful sampling and analysis. Therefore, awareness of site variability is essential before planning a soil sampling scheme.

- **Uniform Sites:** The first problem is defining a uniform site. This means that on the meso- (variation in points separated by 0.05-2 m) and macro- (variation in points separated by greater than 2 m) scales, variability is nonsignificant. Sampling procedures that fully satisfy these conditions involve collection of randomly selected soil cores (of known volume) that are mixed together into one (or more) composite soil samples. More than one composite will give an estimate of soil variability. In practice, it is common to collect cores following a zigzag path where a conscious effort is made to force the path into corners and along edges as well as the central parts of the site being sampled. When the site history is well known, this type of sampling is usually adequate for determining both physical and chemical characteristics.

- **No uniform Sites:** Where macro-variation is large, a nonrandom soil sampling procedure is recommended. The major objective of nonrandom sampling is to understand the average field conditions, the highs and lows, and the specific locations of site extremes. By its nature, nonrandom sampling requires numerous point soil samples. To do this, a customized grid system is established prior to sampling and soil is collected at each point. Spacing between grid points will vary depending on the degree of detail needed to satisfy sampling objectives. Each point sample is analyzed and results are plotted on a site map in relation to their grid point. If a site contains a smaller area that is of a different land type, soil classification, or habitat type, then those areas should be sampled separately. This is called a stratified random sample.

Self-Check – 4	Written test

Name: ___________________________ Date: ________________

Directions: Answer all the questions listed below. Illustrations may be necessary to aid

Short Answer Questions

1. What is the important of divided larger area in to appropriate number of smaller homogeneous units?(3pts)
2. Differentiate soil variation and homogeneous soil sampling?(3pts)

Note: **Satisfactory rating - 6 points** **Unsatisfactory - below 6 points**

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

Information Sheet 5- Locating services site plans

5.1. Locating services using site plans

The sites use for sampling should have the following accessibility of services and locate on the appropriate place:

- If we are establishing a site for sampling especially, the site selected should be near the water supply.
- These should have transport facilities, electricity supply and housing facilities for the workers near the sampling area (if possible).
- These should have telecommunication, gas and irrigation for the workers near the sampling area (if possible). These should have storm water and drainage for the workers near the sampling area.

Self-Check – 3	Written test

Name……………………………………………ID………………………… Date…….

Directions:

Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Short Answer Questions

1. What is the importance locating service using site plan? (5pts)

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

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

Information Sheet 6- Identifying OHS hazards

6.1. Identifying and controlling OHS hazards

Several hazards can be encountered in the field during sample collection due to different production chain as a result of bad agricultural practices. Hazards associated with production flow that could be harmful to the worker

There are three main types of hazards associated with workplace:

- Biological
- Chemical
- Physical

Biological hazards

Biological hazards pose risks for many workers in a wide variety of ways. For example, workers in exposure to biological hazards in the work environment can also occur when people are in contact with laboratory cell cultures, soil, clay and plant materials, organic dusts.

- Micro-organisms able to cause human disease may be found on raw produce. Sometimes they are part of the fruit or vegetable micro flora as incidental contaminants from the soil, dust and surroundings. In other instances they get introduced onto the produce through poor production and handling practices, such as the use of untreated manure, the use of contaminated irrigation water or unsanitary handling practices.

Chemical hazards

Chemical contaminants in raw materials, chemicals compounds (pesticides, fertilizers), Heavy metals, powders, dusts and vapours that have the potential to impair health, have adverse effects on human reproduction, cause disease or have explosive, flammable, toxic or corrosive properties.

Harmful chemicals at high levels have been associated with acute toxic responses and with chronic illnesses.

Physical hazards:

- Phyical hazards including: plant, stone, falling objects, nois disturbance, machinery, uneven places, unproper handling, jewlery, equipment and items (and parts of them) that have the glass and sharp objects potential to cut, rip, tear, abrade, crush, penetrate, produce projectiles or cause sudden impact.
- Basic understanding of risk assessment including:
  - ✓ Identify hazards
  - ✓ Assess associated risks
  - ✓ Strategies to control/eliminate risks.

Steps in controlling OHS hazards and risks

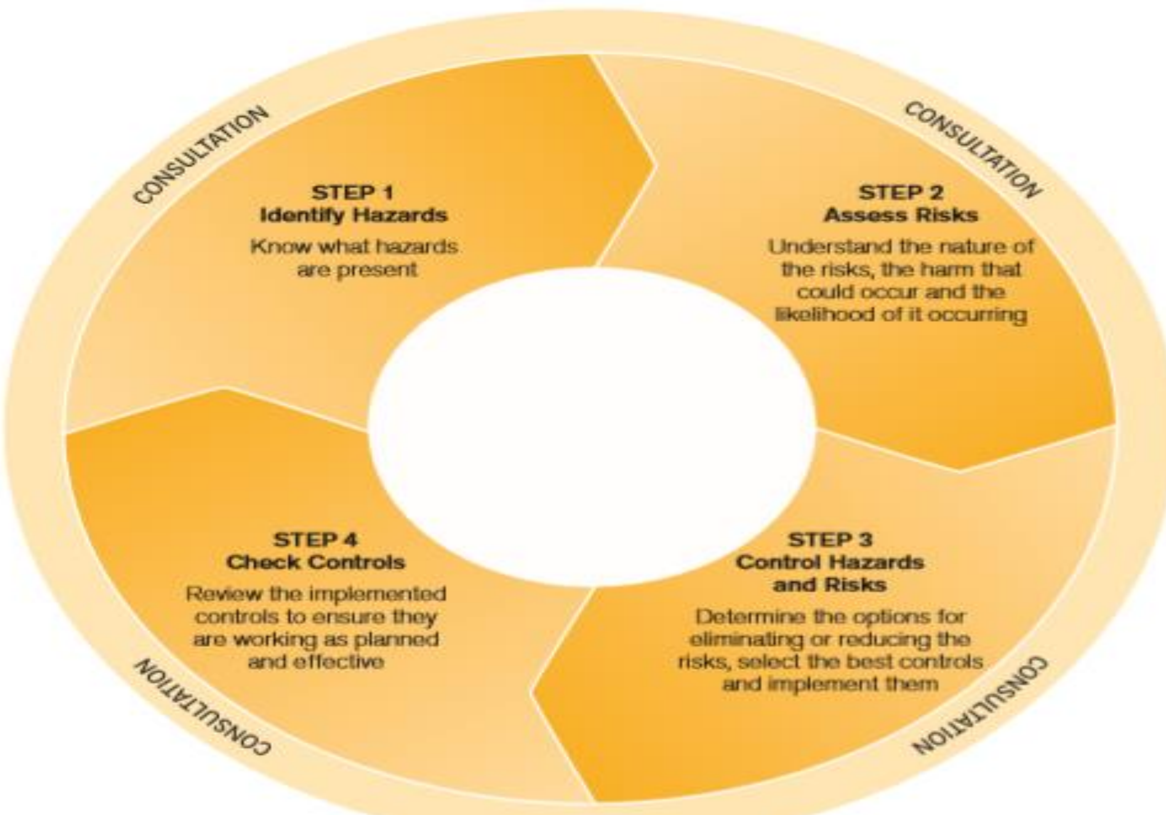


Figure.7.1. controlling OHS hazards and risks

An awareness of appropriate OHS strategies including

- ✓ Select, use and maintain appropriate personal protective equipment (PPE)
- ✓ Sufficient drinking water
- ✓ Basic first aid training
- ✓ Access to first aid kit
- ✓ Safe work practice and procedure
- ✓ Access to appropriate communication device
- ✓ Emergency plan
- ✓ Safety sign
- ✓ Environmental polices
- ✓ Cleaning and disinfecting procedure

Self- check -6	Written test

Name………………………………………… ID……………………….. Date…….

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

Short Answer Questions

1. What is occupational health and safety? (3pts)
2. List the aims of occupational health? (2pts)
3. Identify physical, chemical and biological hazards? (5)

Note: **Satisfactory rating - 10 points Unsatisfactory - below 10 points**

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

Information Sheet 7- Selecting, using and maintaining personal protective equipment (PPE)

7.1. Definition of Personal protective equipment

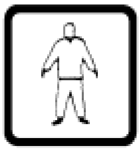
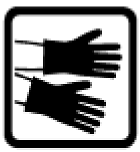
Personal protective equipment is to include that prescribed under legislation, regulations and enterprise policies and practices. Face masks are available for rubbing back and painting.

7.2. Selecting personal protective clothing and equipment

Suitable personal protective clothing and equipment is selected, used, maintained and stored in accordance with Occupational Health and Safety requirements.

- Consider these factors when selecting PPE:
  - ✓ Type of hazardous materials, processes, and equipment involved
  - ✓ Routes of potential exposure (ingestion, inhalation, injection, or dermal contact)
  - ✓ Correct size for maximum protection
  - ✓ Minimal interference with movement
- Personal protective clothing and equipment may include:
  - ✓ Foot Protection- Boot/Footwear
  - ✓ Head protection -hard hat, sun hat and helmet
  - ✓ Body Protection- Overalls, Apron
  - ✓ Hand Protection - Gloves
  - ✓ Respirator
  - ✓ Face Protection; face mask

Different types of PPE are described below:

Equipment Pictogram		Principle	Comments
Clothing (overall)		Cover as much of the body as possible, especially the neck, chest and forearms. Use washable fabric overalls.	Under hot conditions beware of perspiration –this can increase the rate of entry into the body
Gloves		Never use leather or cloth materials because they provide a constant source of contamination. Gloves should be unlined for this reason.	
Boots		Never use leather or cloth materials because they provide a constant source of contamination	Wear the trouser leg outside the boots
Head, face and eye protection		Hard hats, washable hats Goggles shields Spray helmets	Important when handling concentrates. Avoid splashes
Respirators	 	Dust mask for particles and larger droplets. Types of filtration available include mechanical, electrostatic and chemical. Choose the correct type and have the correct cartridge fitted.	Use a mask that matches the job to be done. Replace cartridges regularly and write the date on each cartridge. Ensure there is an adequate fit on the face.

- Maintenance of PPE including:
  - ✓ Cleaning and decontamination
  - ✓ Correct storage
  - ✓ Regular checks for damage
  - ✓ Repair/replacement of worn, malfunctioning or damaged equipment/parts
  - ✓ Disposal of single-use equipment.
- Checking the PPEs for effective operation
  - ✓ Inspect PPE prior to use
  - ✓ Regularly check respiratory devices (every time before and after use)
  - ✓ Clean/decontaminate all re-useable PPE in detergent and warm water using a soft cloth, then rinsed and dried.
  - ✓ Avoid using any cleaning agents that are likely to scratch surfaces, Kept clean PPE.
  - ✓ Remove damaged PPE from use

Self- check -7	Written test

Name…………………………………………… ID………………………… Date…….

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

Short Answer Questions

1. List the factors considering when selecting PPE?(3)
2. List different types of PPE? (3pts)

Note: Satisfactory rating - 6 points Unsatisfactory - below 6 points

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

Information Sheet 8- Maintaining a clean and safe work area

8.1. Maintaining a clean and safe work area

Assessing the cleaning workplace and implementing safety measures are an excellent first step, but efforts must be maintained to keep workers safe and healthy. One of the best ways to maintain a safe facility and promote a safe culture is through visual communication. Training is an excellent strategy for maintaining safety in the workplace. Periodic training sessions should be held annually or throughout the year to keep workers up-to-date and refreshed on safety practices and procedures.

Another way to ensure your cleaning work areas safety is a priority is to establish a safety committee. Workers from different levels and different departments should be brought together to form a committee dedicated to safety. The committee can meet on a monthly-basis to review safety practices, evaluate safety procedures, assess issues, and to brainstorm safety solutions. During monthly company meetings, the safety committee prepare to share any safety related news and any employee feedback. So the cleaning area should maintain based on housekeeping standards.

The workplace environment influences employees' productivity, performance and well-being. Maintaining a clean workplace for soil sampling and result interpretation/result analysis is vital for employers to reduce their workers compensation claims and keep efficiency high. A clean workplace is essential to safety**;** when employees work in a messy environment, they may not notice all hazards, which increase the risk of an accident. According to the Occupational Safety and Health Administration (OSHA), an occupational hazard is anything in the workplace that may cause harm.

An occupational hazard is commonly caused by neglect on the part of the employer or a lack of awareness by workers. Clean workplace is also crucial to health: Fllu season is rapidly approaching and workplaces may see an increase in the number of employees using sick days if they become ill. Germs can spread quickly through the workplace if supervisors and employees don’t adequately sanitize their hands and their workspaces. Another common health hazard of unclean workplaces is the germination of mold.

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Self- check -8	Written test

Name………………………………………… ID……………………… Date…….

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

Short Answer Questions

1. Mention the responsibilities of safety committee?(3pts).
2. Write the importance of a clean work area in processing industries?(2pts)

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

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

LG #21	LO #2 Determine soil characteristics by performing soil sampling

Instruction sheet

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

- Determining the density and depth
- Identifying holes dig out at sampling sites
- Collecting, preparing, packaging, labelling and dispatching samples for off-site testing.
- Determining the physical and chemical characteristics of the soil
- Cleaning sampling and testing tools and equipment
- Recording results in an established format

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, **you will be able to**:

- Determine the density and depth
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- Collect , preparing, packaging, labelling and dispatching samples for off-site testing.
- Determine the physical and chemical characteristics of the soil
- Clean sampling and testing tools and equipment
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5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets
7. Perform "the Learning activity performance test" which is placed following "Operation sheets" ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to "Operation sheets".

Information Sheet 1- Determining the density and depth

1.1. Density of soil sampling

There is significant small scale variation in the nutrient content of soil, so a relatively large number of sub-samples must be collected to provide an accurate average value. In small fields (less than 5 hectares, 12.5 acres) collect a minimum of twenty sub-samples (about 50 - 75 cm^3 each), and mix them together thoroughly to produce the composite sample that is to be submitted for analysis. In larger fields (more than 5 hectares, 12.5 acres), at least two additional cores must be taken for each additional hectare (2.5 acres). Density of a material is the mass per unit volume of that material. This holds true for soils as well. However, the density of mineral soil is expressed in two different forms.

- *Particle density* is defined as *the mass per unit volume of **soil solids**.*
- Particle Density depends on the type of the mineral that constitutes the soil and the organic matter content of the soil.
- Usually its value for mineral soils falls in the range between 2.6 and 2.75 g/cm^3
- Bulk density is defined as *the mass per unit volume of dry soil.*
- The volume in this case is the sum of the volume of the soil solids and the volume of the pore spaces. Bulk density of a soil depends on the Porosity and organic matter content.
- All other factors that affect the porosity of the soil do affect the bulk density of the soil.
- The higher the porosity, the lower is the bulk density.

Pore Space of Mineral Soils

- Pore space is that portion of a soil occupied by air and water.
- It is determined by the arrangement of the solid particles.
- Its volume is the difference between the total volume and the volume of soil solids.

% Solid space = <u>bulk density</u> * 100

Particle density

% Pore space = 100 - %solid space = 100- bulk density *100

Particle density

1.2. Depth of sampling

Type's crop in relation to their root depth must be checked before sampling the soil of that farm i.e. sampling depth depend on root depth of a given crops as.

The depth of penetration by plant roots is the guiding principle in deciding the depth of sampling. The depth of the sampling is important because the mobility of the nutrients varies with the nutrient content in the different soil zones.

The mobility of each nutrient in the soil is also varying from each other.

The recommended depth for sampling is the following:

- 0-15 cm To measure pH, P, K, Cl, S, Ca, Mg, Zn, NH4 + -N, Fe, Mn, Cu, soluble salts
- 15-60 cm To measure soluble salts, NO3-N, S, Cl (in addition to 0-15 cm depth)\
- 60-120 cm To measure NO3-N (in addition to 0-15 cm and 15-60 cm depth)
- The depth of the sampling also varies according to the crop in use:
- Annual Flowers: Sample the top 15 to 20 cm of soil.
- Perennial Flowers: Sample the top 15 to 30 cm of soil.
- Commercial Production of Field-Grown Flowers: Sample the top 20 or 30 cm of soil.
- Home Landscape Trees, Shrubs, & Field-Grown Nursery Stock: Sample the top 15 to 30 cm of soil. Take sample from under the established trees (under tips of the longest branches all the way around the tree), or just outside root ball or planting area for newly planted trees.
- Home Vegetable Gardens: Sample the top 15 to 30 cm of soil

- Commercial Vegetable Fields: Sample the top 20 or 30 cm of soil.
- Fruit Trees: Sample the top 30 to 45 cm of soil. Take samples from area under branch tips (or closer to trunk for newly planted trees).
- Bush and Vine Fruits: Sample the top 20 or 30 cm inches of soil.

1.3. Definition of soil profile

Soil profile: is a vertical cross section through the soil in the field.

Soil horizon: is the layer of soil and process of forming first kind of soil profile.

A vertical section exposing a set of horizons in the wall of soil pit is termed as soil profile. Road cuts and other ready-made excavation can expose soil profile and several windows to the soil. In an excavation open for some time, horizons are often covered by soil material that has been washed by rain from upper horizons to cover the exposed face of lower horizons. To represent an individual soil, profile, the pit has to be wide enough to show lateral variation and deep enough the underlining the unconsolidated or consolidate layers that influence the behavior of the soil. Soil profile shows layers approximately parallel to the soil surfaces, soil horizons. The subdivision of layers of soil develop due to soil forming processes (weathering) are called soil horizons (it is designated as O, A, E, B, and C system i.e. the five master soil horizons).

1.4. Soil profile description

The soil profile description/sampling point should be located as close as possible to the station.

- The purpose of the soil profile description is to:
  - ✓ Characterize the properties of each soil horizon classify the soil profile
  - ✓ Group classification for later analysis of soil type
  - ✓ Collect data required for soil structure and erode ability assessments
  - ✓ Collect samples for laboratory analyses to determine other soil parameters
  - ✓ Comply with soil survey sampling standards.

Horizon-O (Humus or Organic): It appears as a thin layer, mainly comprised of dead organic matter (predominantly decomposed leaves).

Horizon-A (Topsoil): It primarily has a combination of plant's organic material and minerals.

Horizon-E (Eluviated): Only older or forest soils have eluviated layer and contain perlocated clay, inorganic minerals and organic matter.

Horizon-B (Subsoil): It is rich in minerals and containing a residual concentration of sesquioxides.

Horizon-C (Substratum): It serves as the parent material that contains weathered mineral nutrients. Horizon-C forms the overlying soil horizons.

Horizon-R (Bedrock): It provides the unweathered parent material, which contains granite, basalt, quartz, and limestone etc. Horizon-R is present underneath the substratum.

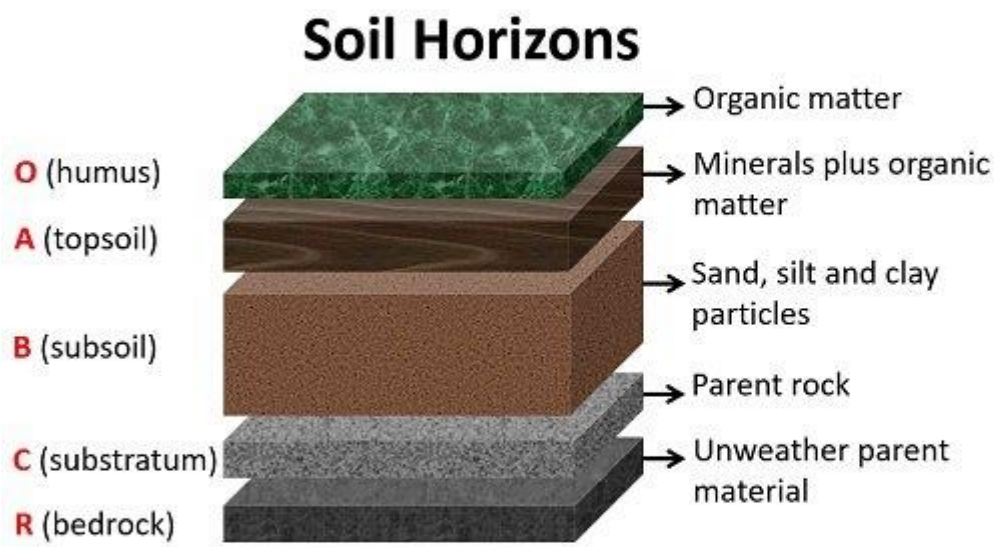


Figure 1.1 showing soil profile/horizons

Self-Check – 1	Written test

Name…………………………………………… ID……………………….. Date……

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

1. What is soil profile?(3)
2. List the five master of soil horizons?(5)
3. What is particle density and bulk density

Part II Choose the best Answers

1. Which horizon is a good material for plants?

A. A-horizon B.B- Horizon C. C- horizon D.. O-horizon

2. Which one of the following is true about C- horizon?

A. It has organic matter C. It contains cemented sediments

B .It contains broken bed rock D. All

Note: Satisfactory rating - 8 points Unsatisfactory - below 8 points

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

Information Sheet 2- Identifying holes dig out at sampling sites

2.1 Identify sampling holes

Excavation soil holes generally means work involving the removal of soil or rock from a site to form an open face, hole or cavity, using tools, machinery or explosives.

Stable rock is natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed. It is usually identified by a rock name such as granite or sandstone. Determining whether a deposit is of this type may be difficult unless it is known whether cracks exist and whether or not the cracks run into or away from the excavation.

Type A Soils are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) (144 kPa) or greater. Examples of Type A cohesive soils are often: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. (No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, is part of a sloped, layered system where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical (4H:1V) or greater, or has seeping water.

Type B Soils are cohesive soils with an unconfined compressive strength. Examples of other Type B soils are: angular gravel; silt; silt loam; previously disturbed soils unless otherwise classified as Type C; soils that meet the unconfined compressive strength or cementation requirements of Type A soils but are fissured or subject to vibration; dry unstable rock; and layered systems sloping into the trench at a slope less than 4H:1V (only if the material would be classified as a Type B soil).

Type C Soils are cohesive soils with an unconfined compressive strength of 0.5 tsf (48 kPa) or less. Other Type C soils include granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable.

Types soil sampling

Soil sample may take in two ways, according to the kinds of test to be performed, these are:

- **Disturbed sample** which do not represent exactly how the soil was in its natural state before sampling.

  ✓ Are used for the more simple tests that will be performed and particularly for those tests which you will perform you in the field.

- **Undisturbed** sample which represent exactly how the soil was in its natural state before sampling.

  ✓ Undisturbed samples are necessary for the more sophisticated tests which must be performed in laboratory for more detailed physical and chemical analyses.

Soil sampling techniques

There are so many different Sampling Strategies to take soil sample from different fields in order to test soils for different purposes. From those strategies the commons are using random sampling, diagonal or zigzag, W or X sampling methods are usual.

Composite random sampling: Soil sampling as a basis for fertilization recommendations has traditionally used composite random. This strategy is the random collection of representative samples throughout the field, with areas of variability within the field avoided or sampled separately for other specific project objectives. In composite sampling, surface litter is removed, and subsamples collected and placed in a clean container and thoroughly mixed into one uniform (composite) sample.

Diagonal and zigzag sampling: While composite random sampling is considered the ideal strategy. Other strategies for uniform fields include the collection of eight subsamples per hectare in a diagonal pattern for one composite sample. Additional schemes range from 5 to 25 subsamples per composite sample, with sample units varying from 2 to 8 ha.

Grid point sampling

To better characterize the field for site-specific management and variable-rate application, point samples can be used to measure the variability across the field.

Dividing the field into 2 ½ acre grids and collecting a sample for each cell, the grid lines help ensure a good spatial representation of the field that can be used to develop a nutrient map. Again, 5 cores should be collected, but they should be within a 10-foot radius of the center point for the sample. This provides nutrient information for the point, and the collection of data for all points in the field provides the basis of nutrient variability maps. Several different interpolation schemes are used to estimate the nutrient levels across the field based upon the sample points.

It follows that uniform interval is used to locate the sampling points; Distance between sampling locations can be greater on homogenous fields than on variable fields. Separate soil samples should be collected from areas or fields that have had different crop history, yield, and fertilizer treatments, or that vary substantially in slope, texture, depth, or soil color.

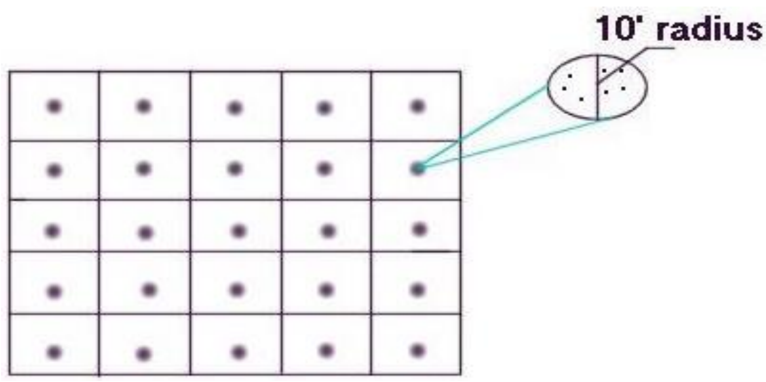


Figure 2.1. Grid point sampling technique

Stratified systematic sampling

To avoid sampling bias caused by patterns in the field due to tillage, crop residue, fertilizer application, and other patterns associated with crop production, a staggered pattern can be used. It helps avoid the pattern bias, yet provides an organized sampling scheme to represent the entire field. This pattern can be set up by counting rows, using a measuring wheel or using a global positioning satellite (GPS) navigation system.

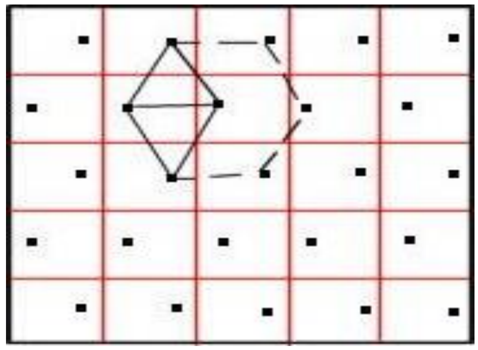


Figure 2.2: Stratified Systematic Sampling (Triangle, Diamond, or Hexagon)

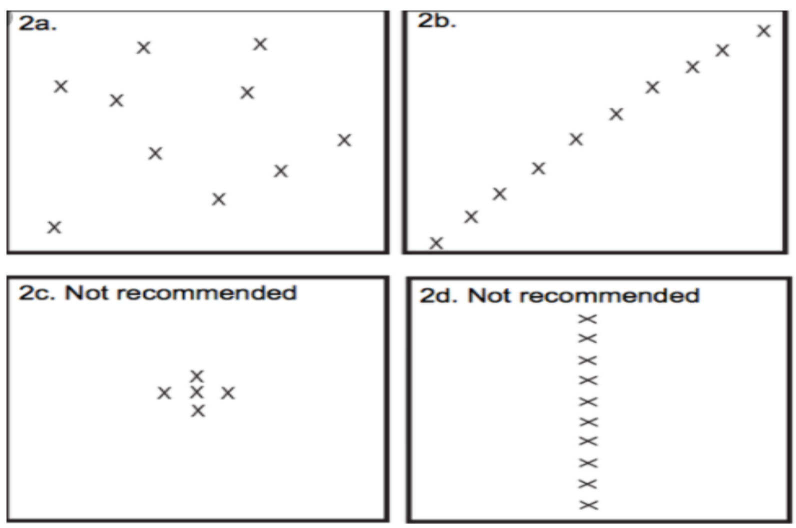


Figure.2.3 sampling method

Considerations included in soil sampling:

- Before sampling, study the history of the area,
- The sample must truly represent the field it belongs to.
- Afield can be treated as a single sampling unit if the area is less than 0.5 ha

  Collect soil samples (15-20) from each transect at least every 2-3 years.

- Collect separate samples from fields that differ in colour, slope, drainage, past management practices like liming, gypsum application, fertilization, cropping system *etc*.
- Soil samples should be randomly selected avoiding fence lines, waterlines and animal matter.
- Collecting the soil sample for each distinct soil area you are sampling, take 5 to 10 subsamples and mix them together to obtain the final sample.
- Take the subsamples by selecting spots in a pattern that ensures a balanced representation of the whole area sampled.
- Use clean tools to sample soil, a clean container to mix it, and clean bags to store it. Small amounts of contaminants, especially fertilizer or lime, can distort the analysis results.

Do not sample from: -

- Back furrows or dead furrows
- Old fence rows
- Areas used for manure or hay storage and livestock feeding, and
- Areas where lime has been piled in the past.
- Within 2-3 months following fertilizer application.
- Recently fertilized plots or fields must be avoided carefully
- Don't sample spots that look atypical of the area being sampled.

Sample timing

The most convenient time to collect soil samples is when there is no standing crop in the field (i.e. in the spring prior to planting or in the fall after harvest). Both sample collection times can be useful for a given management program. When selecting a sample collection time consider the following points:

- Schedule soil sampling and testing prior to application of fertilizers or lime
- Collect samples early enough to provide the laboratory sufficient time to return the data
- Keep sample collection timing consistent to avoid year-to-year variability. For example, if implementing a spring sampling one year, do not adopt fall sampling for the next year of sampling. In most soils, try to sample fields once every four years. This should provide sufficient data on changes in soil fertility

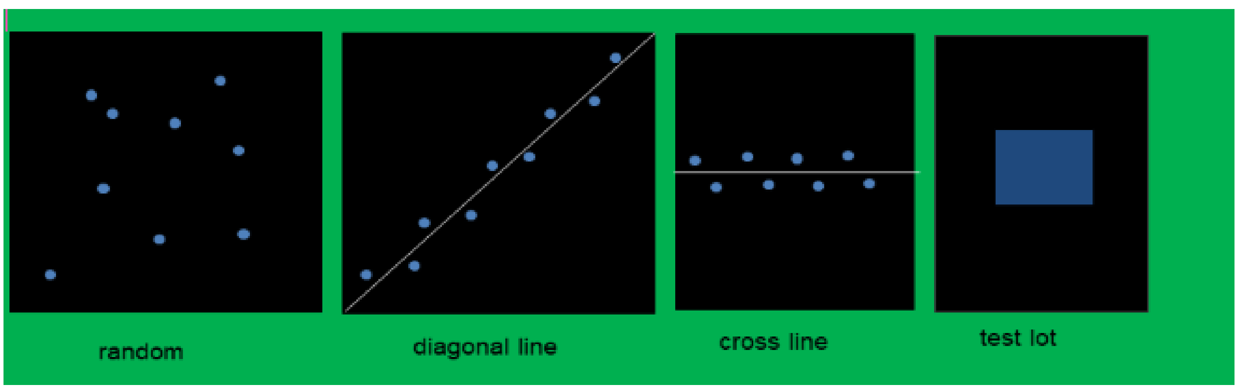


Fig 2.5 Soil sample method

Self-Check – 2	Written test

Name…………………………………………… ID………………………… Date…….

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

Test I: Short Answer Questions

2. Define excavation soil holes?(3)

Note: Satisfactory rating - 3 points Unsatisfactory – below 3 points

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

Information Sheet 3- Collect, preparing, packaging, labelling and dispatching samples

3.1 Sample Preparation from the Field to off-site testing

Drying: Except under special conditions (for example, saturated soils), oven drying is unnecessary. Air drying is preferable (4 to 8 days). Crumble samples into small clods or peds by hand and spread on a nonmetallic tray in a well-ventilated room. Andisols and peaty soils should not be dried.

Storing: Once dry, each soil sample should be placed in a zip-loc type bag, permanently labeled and stored in a cool, dry location. Andisols can be stored the same way, but should be undried. These samples should be processed as soon as possible to avoid mold and mildew interference problems.

a. Labeling information

Why label samples?

When taking soil samples it is important to keep clear records of what you do for a number of reasons:

- You may be carrying out tests on a number of different soil samples in an area.
- You may be carrying out some tests in the field while further tests will require special equipment and need to be carried out off-site under laboratory conditions.

Soil samples may be stored over long periods as part of a monitoring program for your land. In each of these cases there may be more than one person handling the soil samples. To avoid confusion it is important to make sure that the correct information is attached to each sample. It is also a good idea to standardize your recording technique so that it is easier to compare results from different samples.

After the samples have been collected in the field, the samples should be emptied out on to a clean sheet and mixed thoroughly. Remove stones and pebbles and large bits of organic material

If the soil is fairly dry, the sample for analysis can be take and bagged immediately. However, if the soil is very wet, the whole sample should be air dries for 12 hours before bagging. Samples for off-Site analysis by a contracted laboratory service provided

The size of sample required by most laboratories for analysis is 500g (500ml)

Soil samples are usually transported in plastic bags or paper sacks. It is easier to label the bag or sack before filling. Remember to use a waterproof pan and to write legibly.

Information required on the bag or sack label is:

- Name of farm
- Name of field or block where the sample was collected
- Date of collection

Place the soil sample into the bag or sack and close the top to prevent the soil escaping Samples should be transported to the laboratory for analysis promptly to prevent Deterioration of the sample.

Laboratories will also ask the farmer to complete an analysis request form.

Details requested will include:

- Name of farm
- Name of field or block where the sample was collected
- Date of collection
- Reason for analysis: Problem solving / Routine monitoring / Fertilizer recommendation plus Relevant details

b. Dispatching sample for off-site testing

After collecting a composite sample, it is important to properly store samples to prevent contamination. Typically, most laboratories prefer to prepare samples in their lab. This means that you can often send samples directly to the laboratory without doing any processing yourself. Some laboratories require samples to be submitted in specific sample bags or containers. Check with your chosen laboratory for specific information on its requirements for handling and packaging samples.

If you are not sending samples directly to the laboratory, consider storing samples in the refrigerator or freezer to minimize the chance of mold forming in the sample bag. If the soil is excessively wet or you cannot store samples in a refrigerator/freezer, allow the samples to air dry slightly by spreading the soil in a thin layer on a flat surface like a table. You can put down some paper such as used newspaper to protect the surface from getting dirty. Never dry a sample in an oven or microwave; excessive heat can damage the sample and alter laboratory results.

Self-Check – 2	Written test

Name………………………………………… ID………………………… Date…….

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

Test I: Short Answer Questions

1. Why label samples?(3pts)

Test II: Write true if the statement is correct and false if the statement is incorrect

1. If you are not sending samples directly to the laboratory, consider storing samples in the refrigerator or freezer to minimize the chance of mold forming in the sample bag.(1pts)
2. After collecting a composite sample, it is important to properly store samples to prevent contamination. (1pts)

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

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

Information sheet 4-Determining the physical and chemical characteristics of the soil

4.1. Physical characteristics of the soil

Physical property of the soil refers to the function and management of soil in an ecosystem in determining the successes or failure of agriculture crop production based on the soil texture, structure, consistence & color. Soils are porous and open bodies, yet they retain water. They contain mineral particles of many shapes and sizes and organic material which is colloidal (particles so small they remain suspended in water) in character. The solid particles lay in contact one with the other, but they are seldom packed as closely together as possible. Permeability (the rate at which water moves through the soil) and Water-Holding Capacity (WHC; the ability of a soils micro pores to hold water for plant use) of the soil is affected by

- The amount, size and arrangement of pores
- Macro pores control a soil's permeability and aeration
- Micro pores are responsible for a soil's WHC Porosity is in turn affected by
  - ✓ Soil texture
  - ✓ Soil structure
  - ✓ Compaction
  - ✓ Organic matter

A. Soil texture:

Soil texture refers to the proportion of the soil "separates" that make up the mineral component of soil. These separates are called sand, silt, and clay. It is important in determining the water-holding capacity of soil:

- Fine-textured soils hold more water than coarse-textured soils but may not be ideal.
- Medium-textured soils (loam family) are most suitable for plant growth.

Three primary soil separates are widely recognized: ***sand, silt*** and ***clay.***

A number of different classifications have been devised by different institutions.

i) **International Society of Soil Science (ISSS) made the following classification for soil separates**

- < 0.002mm=Clay,
- 0.002-0.02mm= Silt,
- 0.02-0.2mm=fine sand
- 0.2-2mm=coarse

ii). United States Department of Agriculture (USDA) made more classes in the following size ranges:

- < 0.002mm=Clay,
- 0.002-0.05mm=silt,
- 0.05-0.10mm=Very Fine Sand,
- 0.10-0.25mm=Fine Sand,
- 0.25-0.5mm=medium sand,
- 0.5-1.0mm=coarse sand,
- 1.0-2.0mm=very coarse sand

Analytical Procedure

- Soil particles of various sizes are separated by a procedure known as ***mechanical analysis***.
- A sample of soil is broken up and the very fine and larger sand fractions are separated by *sieving.*
- The silt and clay fraction are then determined by methods that depend upon the rate of settling of these two separates from suspension.
- The principle is that when soil particles are suspended in water they tend to sink, and the rapidity of settling is roughly proportional to their size.
- Organic matter is also removed by oxidation before the mechanical separation.
- It is only the particles whose diameter is less than 2mm that is considered as ***fine earth*** or ***"soil."***

Soil textural class

- Individual soil separates do not constitute a soil in the field.
- It is rather their mixture that constitutes a soil.

- Soil textural class names have become standardized to express the variation of soils in composition of the different sized particles (sand, silt and clay).
- There are three basic soil textural names **(Sand clay and Loam)** whose combination gave a total of twelve soil textural classes:

A. ***SAND***

- Contains >70% sand by weight. It is not sticky and not heavy when ploughed.
- Textural classes of such soils are ***Sand*** and ***Loamy Sand***.

B. ***CLAY***

- Contains >35 or 40 % clay separate by weight. It feels sticky and heavy when ploughed.
- Textural classes: ***Clay, Silty Clay,*** and ***Sandy Clay***.

C. ***LOAM***:

- Exhibits heavy and light properties in about equal proportions.
- It is agriculturally important soil. Textural classes: ***Loam, Sandy Loam, Silt Loam, Silty Clay Loam, Clay Loam, Sandy Clay Loam.***

Textural class name is normally given after the proportion of the different soil separates is known. For easy representation, soil textural triangle has been devised. Sand, Silt and Clay take each of the sides of the triangle.

C. Soil structure

Soil structure is a field term descriptive of the gross, overall aggregation, or arrangement of the primary soil separates. It influences water movement, heat transfer, aeration, bulk density and porosity. Soil structure can be classified based on three parameters.

- ***Type*** (***or Shape***) describes the shape of the soil aggregates;
- ***Class*** describes the size of the peds; and,
- ***Grade*** *(or distinctness)* refers to how distinct and strong the peds are.

There are four primary *types* of soil structure:

A. ***Platy***-

- Aggregates are arranged in a relatively thin horizontal plates, leaflets, or lenses.
- It may occur in any part of the soil but mainly at the surface.

B. ***Prism-like-***

- Vertically oriented aggregates or pillars varying in length.
- Most commonly, it occurs in the B-horizons of arid and Semi-arid Soils.
- They can be grouped in to two: ***Columnar***- and ***Prismatic-***

C. ***Block-like***

- Blocky peds are irregular, roughly cube like.
- The shape is dependent by the surrounding blocks.

These can also be classified in to two:

- ***Blocky -*** edges are sharp and the faces distinct.
- ***Sub-angular blocky*** - When sub-rounding has occurred.

D. **Spheroidal**

- Consists of spheroidal peds that are usually separated from each other in a loosely packed arrangement. They are common in A-horizons that are high in organic matter content.
- Practical soil management like manuring can influence them.

The different classes are:

Granular - Ordinary aggregates, and ***Crumb*** - When the aggregates are especially crumb

Soil structure is generally classified based on the following factors:

Based on the Ped Structure and Arrangement

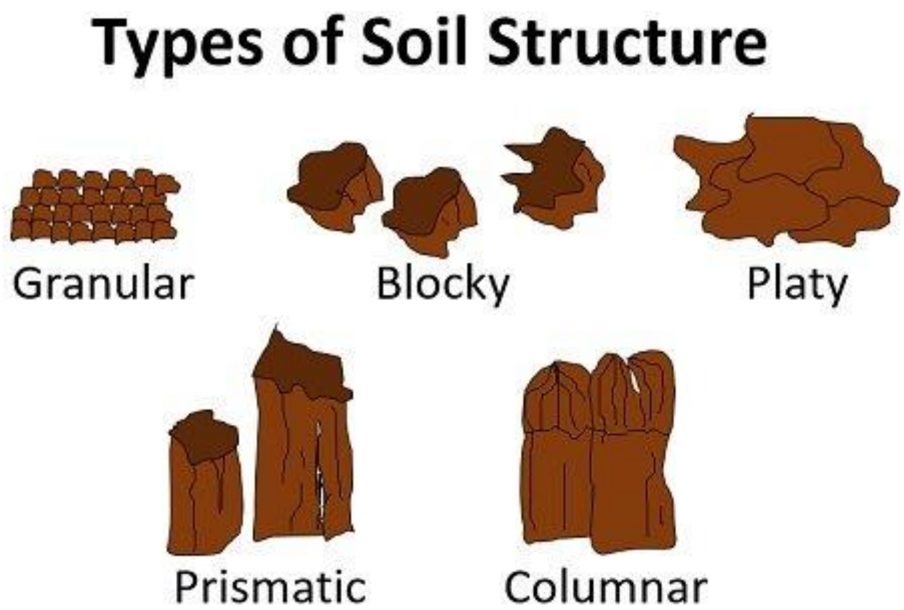


Figure 4.1 Soil structure

Table 4.1. Properties of soil particle size.

Characteristics	Sand	Silt	Clay
Porosity	Mostly large pores	Small pores predominate	Small pores predominate
Permeability	Rapid	low to moderate	Slow
Water holding capacity	Limited	Medium	very large
Soil particle surface	Small	Medium	very large

C. Bulk density

Bulk density is the proportion of the weight of a soil relative to its volume. It is expressed as a unit of weight per volume, and is commonly measured in units of grams per cubic centimeters (g/cc).

Bulk density is an indicator of the amount of pore space available within individual soil horizons, as it is inversely proportional to pore space:

Pore space = 1 – bulk density/particle density

Pore Space of Mineral Soils

- Pore space is that portion of a soil occupied by air and water.
- It is determined by the arrangement of the solid particles.
- Its volume is the difference between the total volume and the volume of soil solids.

$$\% \text{ Solid space} = \frac{\text{bulk density}}{\text{Particle density}} * 100$$

% Pore space = 100 - %solid space = 100- bulk density *100

Particle density

- Porosity of a soil depends upon particle size, depth, organic matter content and management. Generally, sandy soils are less porous than clay soils.
- The higher the organic matter content of the soil, the higher its porosity.

D. Consistence

Consistence is a description of a soil's physical condition at various moisture contents as evidenced by the behavior of the soil to mechanical stress or manipulation. Descriptive adjectives such as hard, loose, friable, firm, plastic, and sticky are used for consistence. Soil consistence is of fundamental importance to the engineer who must move the material or compact it efficiently.

The consistence of a soil is determined to a large extent by the texture of the soil but is related also to other properties such as content of organic matter and type of clay minerals.

Soil consistence is *the resistance of the soil to deformation or rupture*. It is determined by the cohesive and adhesive properties of the entire soil. It is basically described at three moisture levels: wet, moist and dry.

- ***Wet:*** two parameters are used here, the *stickiness* (non-sticky, slightly sticky, sticky and very sticky) and the *plasticity* (non-plastic, slightly plastic, plastic and very plastic).

- ***Moist:*** is important since it best describes the condition of soils when they are tilled in the field.
- It is the measure of the resistance of the soil to crushing between the thumb and the forefinger. Terms used are: Loose, Very friable, Friable, Firm, Very firm, and Extremely firm

- Texturally speaking course sands would be expected to have loose consistence.

- Well-granulated loam and silt loam soils would be very friable, friable or perhaps firm.
- Clay, silty clay, and silty clay loam soils are more likely to be firm or very firm,

Dry Consistence: the degree of the resistance of dry soils to crushing or other manipulations

- It is related to the attraction of the particles to each other.

The following terms are used: Loose, Soft, Slightly hard, Hard, Very hard and Extremely hard

E. Color

The color of soils can be determined by minor components. Generally, moist soils are darker than dry ones and the organic component also makes soils darker. Thus, surface soils tend to be darker than sub-soils. Red and yellow hues are indicative of good drainage and aeration, critical for activity of aerobic organisms in soils. Gray hues indicate poor aeration. Soil color charts have been developed for the quantitative evaluation of colors.

The first test that we have to make is to register the color of the soil. This process does not require any sophisticated technique. It is usually described from the Munsell color chart.

Soil color is an indirect measure of other important characteristics such as water drainage, aeration, and the organic matter content. The following are some of the possible judgments that could be inferred looking at the soil color.

- ***Brown to black color***: results from organic matter or dark parent material.
- High level of organic matter in a waterlogged area has a sour, oily smell.
- In a well-drained area it has earthy smell. A dark parent material gives a faint chalky smell.

- ***White to light gray:*** results when organic matter has been leached down of sandy soils and E-horizons. Can also be caused by the accumulation of lime, gypsum and other light materials.
- ***Yellow to Red:*** Is due to iron oxides most commonly in warm areas.
- Red color is from iron (Fe^{+3}) oxides where there is good drainage for the aeration (oxygen supply).
- ***Bluish gray:*** results from unoxidized iron, indicates lack of oxygen

- **Determination of soil color:** Soil color is determined by matching the color of the soil sample with color chips in a Munsell soil color book.
- In most book, hue, value and chroma, are the three variables that combine to give colors.
- Hue refers to the dominant wavelength, or color of the light.
- Value, sometimes color brilliance, refers to the quality of the light. It increases from dark to light colors. Chroma is the relative purity of the dominant wavelength of the light.

- The three properties are always given in the order of hue, value and chroma
- E.g. 10YR 6/4,10YR is the hue, 6 is the value, and 4 is the chroma.
- This color is a light-yellowish brown.

Fig 4.2 soil color

F. Permeability- refers to the movement of air and water within the soil

- Permeability is the rate at which water moves through the soil) and Water-Holding Capacity (WHC; the ability of a soils micro pores to hold water for plant use)

G. Soil compaction: - Soil compaction restricts rooting depth, which reduces the uptake of water and nutrients by plants.

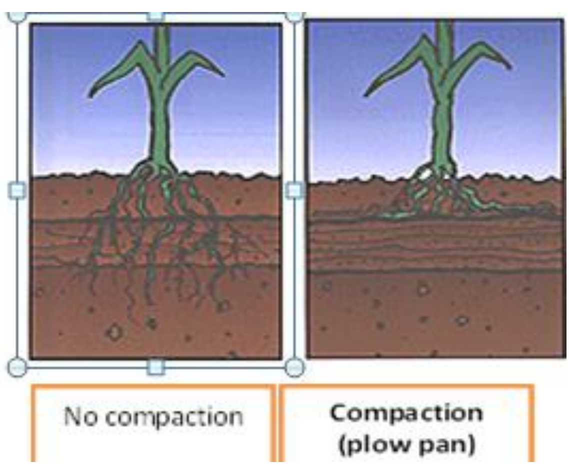


Figure 4.3 Soil compaction

H. Porosity: is the percentage of soil volume occupied by pore space.

Pore space of a soil is the space occupied by air and water between particles in a given volume of soil responsible for better plant growth

- Sandy soil -low pore space
- Clay soil - high pore space
- Organic matter- increases the pore space

Porosity depends up on

- Texture
- Structure
- Compactness
- Organic content of the soil.

The Soil Moisture holding capacity

The water holding capacity of a specific soil type is very important to calculate the necessary volume and frequency for irrigation during production.

Equations: Calculate the water holding capacity as follows

Weight of the dry soil = Weight of dry soil and pot – Weight of the pot (g)

Weight of wet soil = Weight of wet soil and pot – Weight of the pot (g)

Weight of water = Weight of wet soil – Weight of dry soil

Water holding capacity by mass = (Weight of water / Weight of the wet soil) x 100 (%)

Volume of water = Weight of water / Density of water (1g/cm3 or ml)

Water holding capacity by volume = (Volume of water / Volume of Gooch Crucible) x 100 (%)

Measuring the soil moisture contents

Volumetric method

Draw a sample of soil with a core sampler or whose volume is known.

Weigh the sample in a moisture box (Y).

Dry it in an oven dry to a constant weigh at 105^{O}C and again measure the weight of oven dry soil.

Calculate the moisture percentage by relationship given as follows.

Equation: Calculate the moisture content using the following formula

Volumetric moisture % (MW) = $\frac{Y-Z}{Dw \ x \ V}$ X 100

Volume of core (cylinder) = $\pi r^2 h$

Where DW = Density of water (1gm/cm^3)

r = radius

h = height

Note: Sample volume of greater than 50 cm3 in size and more than 200 g in weight yield more accurate estimates of soil moisture content than do smaller samples.

Gravimetric method

- Weigh the empty moisture cans
- Take soil sample of about 100 g from the required depth with the help of auger.
- Put soil sample immediately in the moisture can and close it to prevent loss of moisture by evaporation.
- Bring the cans containing the moist soil to the laboratory and weigh immediately.
- Remove the lids and place moisture cans in oven dry to a constant weigh at 105 degree Celsius. This takes approximately 46 hours.

Allow the sample to cool for some time in oven dry. Then close the cans and put them in a desiccators or further cooling. Now weigh the closed cans with the oven dry soils.

Observation

Weigh of empty moisture cans = X

Weigh of moisture cans + moist soil = Y

Weigh of moisture can + oven dry soil = Z

Equation: Calculate the moisture content as follows

Moisture content in soil = Y – Z

Weigh of oven dry soil = Z – X

Percentage of moisture in the soil = $\frac{Y-Z}{Z-X}$ X 100

4.2. Chemical property of soil

Chemical property of soil deals with the nature of colloids (organic and inorganic). It mainly focuses on the mineral and chemical composition, charges, and exchange of ions, salinity, and alkalinity and acidity of soil (PH). It is important from the point of view of nutrient availability for agricultural crops or plants.

The most important chemical characteristics of a soil are:

- Its content of essential nutrients and their availability to plants;
- The cation exchange capacity;
- The buffering capacity(the ability of a soil to resist change in ph of the soil solution if acid or base is added)
- Acidity or alkalinity; and salinity
- Content of inorganic and organic colloids (humus).

Perhaps the state of oxidation or reduction of the soil should be mentioned; this is ordinarily not of major importance but may be if a waterlogged or poorly drained soil is under consideration.

Soil Reaction (pH): by definition, "pH" is a measure of the active hydrogen ion (H+) concentration. It is an indication of the acidity or alkalinity of a soil, and also known as "soil reaction".

The pH scale ranges from 0 to 14, with values below 7.0 acidic, and values above 7.0 alkaline. A pH value of 7 is considered neutral, where H+ and OH- are equal, both at a concentration of 10-7 moles/liter. A pH of 4.0 is ten times more acidic than a pH of 5.0.

The most important effect of pH in the soil is on ion solubility, which in turn affects microbial and plant growth. A pH range of 6.0 to 6.8 is ideal for most crops because it coincides with optimum solubility of the most important plant nutrients. Some minor elements (e.g., iron) and most heavy metals are more soluble at lower pH. This makes pH management important in controlling movement of heavy metals (and potential groundwater contamination) in soil.

In acid soils, hydrogen and aluminum are the dominant exchangeable cations. The latter is soluble under acid conditions, and its reactivity with water (hydrolysis) produces hydrogen ions. Calcium and magnesium are basic cations; as their amounts increase, the relative amount of acidic cations will decrease.

Soil pH and plant growth - Most plants grow well from 5.5 to 8.5

- Strongly acidic soils undesirable – develop toxic levels of Al & Mn, microbe activity greatly reduce
- Strongly alkaline soils have low micronutrient availability, P may be deficient
- Affects the activity of soil microorganisms, thus affecting nutrient cycling and disease risk.

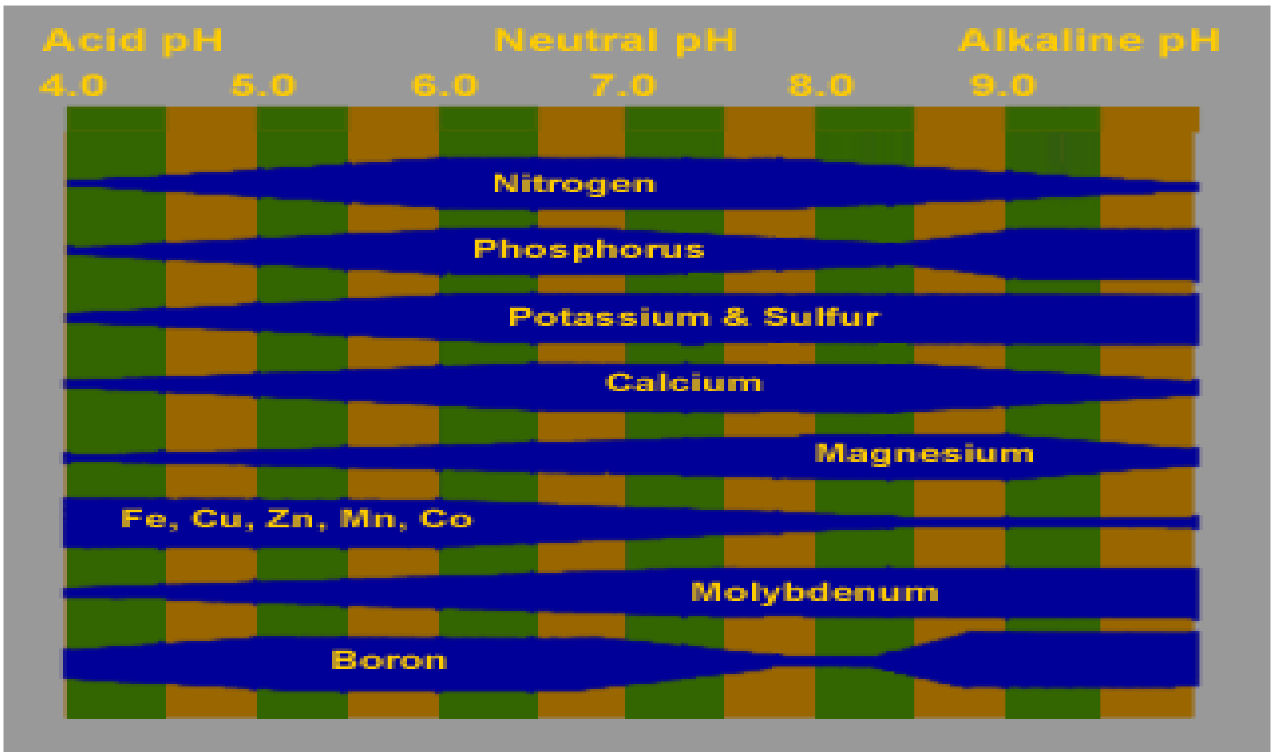


Figure 4.4. Soil pH with relation to plant growth

Soil pH Test

Method 1: pH Test

Soil pH analysis test uses the pH scale numerical system to measure the acidity or alkalinity of the soil.

- After filling the test tube with an indicator solution,
- Add some soil sample to the indicator.
- Cap the tube and gently mix the soil and indicator solution for 1 minute.

* After 10 minutes of waiting, match the colour of the solution with pH Colour Chart.

Data analysis

The color chart indicates the pH numeric value of the sample. It is not indicated by decimal values. According to obtained color, the soil sample belongs to one of the three main groups: alkaline, neutral or acidic. The Neutral point is 7.0 and the neutral range is between 6.0 and 8.0 (With other pH test methods, which are able to indicate decimal values, this range would be considerably less). pH value less than 7.0 are considered acidic and values higher than 7.0 are considered to be an alkaline.

Method 2: pH in soil-water suspension (pH meter method)

The pH may be determined in soil water suspension of varying ratios but the results should be expressed along with the ratio adopted. Conveniently, the suspension is prepared in 1:2 or 1:2.5 ratio.

1. Take 10 g of soil sample in 50 or 100 ml beaker.
2. Add 20 or 25 ml of distilled water, stir well for about five minutes and keep for half an hour.
3. Again stir just before immersing the electrodes and take the pH meter reading.

Soil salinity- is a Potential problem in irrigated soils due to high evaporation rates and low annual rainfall leaving salts to accumulate.

* Come from irrigation water, fertilizers, composts, and manure.
* Leached by slowly applying excess water.

Soil Salinity and Interpretation

a. Conductivity 4 or above; Severe accumulation of salts. May restrict growth of many vegetables and ornamentals.
b. Conductivity 2 or 4; Moderate accumulation of salts. Will not restrict plant growth, but may require more frequent irrigation.
c. Conductivity less than 2: Low salt accumulation. Will not affect plants.

Cation-Exchange Capacity- is a measure of the ability of a soil to hold and exchange cations.

Cation Exchange Capacity;

- Is the ability of a soil to absorb and release cations
- Closely related to soil fertility
- Is part of plant nutrient cations are part of CEC include Ca, Mg, K, NH_3
- Is positively charged Ion.: Ca^{2+}, Mg^{2+}, K^+, NH_4^+, Zn^{2+}, Cu^{2+}, and Mn^{2+}.
- Nutrients adsorb in the soil solution on the surface of clay and organic matter.
- Is a measure of the quantity of cations that can be adsorbed and held by a soil?

CEC depend up on amount of;-

- Organic matter
- Clay in soils and
- Types of clay.

In general, the higher OM and clay content, the higher the CEC

Soil Organic Matter - Beneficial impacts of SOM on soil properties:

- Physical - stabilizes soil structure, improves water holding characteristics, lowers bulk density, dark color may alter thermal properties
- Chemical - higher CEC, acts as a pH buffer, ties up metals, interacts with xenobiotic
- Biological - supplies energy and body-building constituents for soil organisms, increases microbial populations and their activities, source and sink for nutrients, ecosystem resilience, affects soil enzymes. Microorganisms are the driving force for nutrient release to plants.

C: N (carbon to nitrogen) ratios

- Low C:N ratios (<25:1) are indicative of mineralization and rapid rates of decomposition
- High C:N ratios (>25:1) indicate immobilization and slower decomposition rates
- Low C:N material (high nitrogen value)- Undiluted manure and blood meal, grass clippings (can get high), vegetable wastes
- Intermediate C:N materials- Most composts, leaf mulches, cover crop residues
- High C:N materials- saw, bark, wood chip, sawdust, paper, cornstalk, foliage

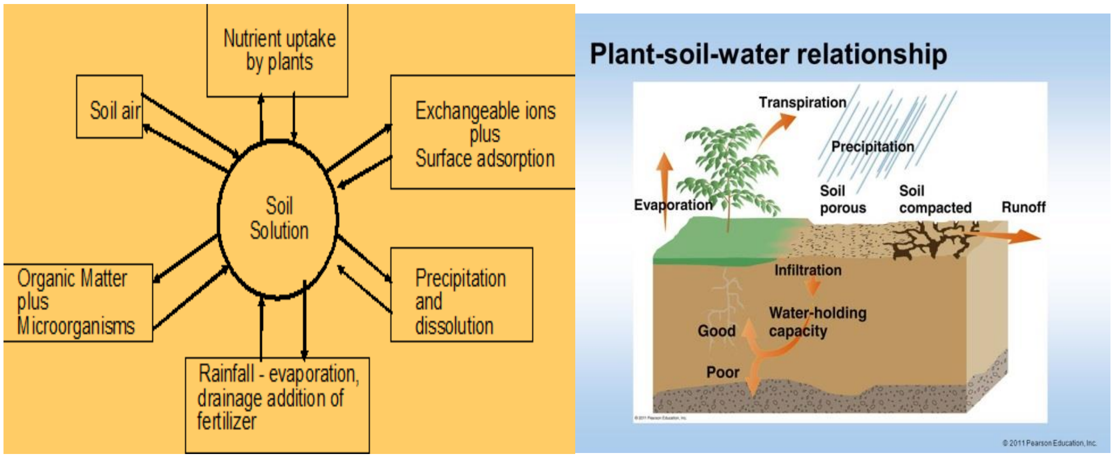


Figure.4.5 shows soil plant relationship

Self-Check – 4	Written Test

Name………… ………………………………… ID……………………….. Date…….

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

Part II Choose the best answer

1. Which one of the following odd

A. Soil bulk density B. soil texture C. soil structure D. None

2 .Which combination is true

A. Fine sand: 0.002-0.05 mm C. Silt: 0.05-0.1 mm

B. Medium sand: 0.1- 0.05 mm D. All

3. One is wrong about blocky soil structure

A. It is smooth faced B. common in sub soil

C. 1-10 mm ranged in size D. It has high clay content

Part I: Matching Instructions. Match the term with the correct response. Write the letter of the term by the definition.

a. water-holding capacity c. peds e. soil texture
b. soil structure d. permeability f. textural triangle

________ 1. The fineness or coarseness of soil particles.

________ 2. The ease with which air and water may pass through the soil.

________ 3. The ability of soil to retain moisture for plants.\

________ 4. The arrangement of soil particles into clusters or aggregates.

________ 5. A chart used to classify soil according to its coarseness or fineness.

________ 6. Aggregates that occur naturally in the soil.

Note: Satisfactory rating - 6 points Unsatisfactory - below 6 points

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

Information sheet 5- Cleaning sampling and testing tools and equipment

5.1 Cleaning equipment and tools

The major steps in cleaning are

- ✓ Washing
- ✓ Rinsing and
- ✓ Drying and
- ✓ Finally storing

- Many precipitates can be removed from the filter surface simply by rinsing from the reverse side with water
- Drawing water through the filter from the reverse side with a vacuum pump is also effective. Some precipitates tend to clog the pores of a fritted filter and may require special cleaning solutions
- Before commencing sampling operations for a project, those parts of the drilling or excavation equipment that will come in contact with the sampled media, shall be screened for radiological contamination and volatile organics.
- If soil adhering to the equipment is found to be contaminated during the field screening, perform dry contamination.
- If hazardous chemicals or residual radioactive contaminants are potentially present, follow dry contamination with wet decontamination.
- Perform a visual inspection of the entire piece of equipment.
- Remove gross residuals (i.e., dirt from previous operations) if it could affect the objectives of the sampling operation or has the potential of falling from the equipment and contaminating the site.
- If contamination is suspected or found on the surface of the equipment, or in the soil on the equipment, decontaminate the piece of equipment in the dry decontamination area.
- Gently remove the coarse contaminated material using a steel brush.

- Remove the more cohesive material with a flat scraper such as a wooden spatula or paint stirring stick.
- Use a water spray bottle to lightly moisten dry soil being removed from the equipment to control dust.
- After the coarse contaminated material has been removed, remove the remaining contamination by washing with Fantastik™ (an alkaline, waxless household cleaner) and/or Radiac™ (a commercial cleaner for removing radioactive particles), or similar product, followed by air drying or other appropriate methods.
- If radioactive contaminants are present, periodically survey the equipment with hand-held radiation detectors during the course of decontamination to determine where contaminated areas are located.
- Upon completing the decontamination process, collect swipe and/or smear samples from the equipment.
- Submit swipe and/or smear samples to a laboratory for radiological analysis or count on-site if appropriate portable equipment is available.
- If hazardous and/or residual radioactive contamination is still present after dry decontamination, use the wet decontamination process.

Self-Check – 5	Written Test

Name…………………………………………… ID………………………… Date…….

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

Short answer

1. What is cleaning equipment's? (3 point)
2. Mention the major steps in cleaning of equipment's? (3 point

Note: Satisfactory rating - 6 points Unsatisfactory - below 6 points

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

Information sheet 6- Recording results in an established format

Recording soil/media testing results including:

- Sampling location and details
- Soil profile description
- Physical analysis results
- Chemical test results
- Test results from off-site soil analysis
- Test analysis interpretation
- Management history

Records that need to be taken during sampling

• Sampling Date	• Sample Depth
• Sampler • Name • Address • City • Phone number • Email address	• Last season/year crop • Organic amendments ✓ Liquid ✓ Solid • Irrigation system ✓ Drip ✓ flood ✓ sprinkler • Depth to ground water
• Sample location ✓ Farm ✓ Home ✓ Orchard	• Water Nitrate-N credit
• Field ID	
• Geographic location	

Self-Check – 6	Written Test

Name…………………………………………… ID……………………….. Date…….

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

1. List the points including in recording?. (5pts)

Note: Satisfactory rating – 5 points Unsatisfactory - below 5 points

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

Operation Sheet 1– Soil sampling

Objective:	To take sample and prepare for test to determine soil fertility status
Materials required	✓ Sampling auger, spade or shovel ✓ Clean bucket ✓ Sample bags ✓ Strings ✓ Labels ✓ Field note
Procedure	✓ Site selection ✓ observe field for variations in soil color, texture, topography, drainage ✓ lay outing the field ✓ decide the sampling depth depends on the crop to be grown ✓ Prepare a sketch map of the field showing different sampling unit ✓ clean litter from the surface and expose the soil ✓ Push and take the soil from the sampling unit using auger or spade ✓ Place the soil in a clean bucket ✓ Remove roots and stones, which will not be part of the analysis ✓ Mix well the samples with hand to set the composite sample ✓ Weigh and labelling the composite soil for required KG
Precautions:	Do not take the top 5 cm soil Do not use galvanized or rubber buckets, as they will contaminate the samples
Quality criteria	Samples should be labeled in a clean plastic bag

Operation Sheet 2– Soil sample preparation

Objective:	To know how to prepare soil sample for test or analysis
Materials required	• Sampling auger, spade or shovel • Clean plastic sheet/sacks • Sample bags/ buckets • Labels • Field note
Procedure	○ Placed sample in the bucket ○ Dry the sample ○ Crush the soil material ○ Discard any plant residues and other materials if present ○ Sieve with 2mm diameter sieve and mix the sample thoroughly. ○ For certain types of analysis grind the soil further so as to pass through 0.2 -0.5mm sieves. ○ Remix the sieved sample before analysis. ○ Allow the sample to air dry in an open space free from contamination. ○ When dry, fill the sample container with the soil.
Precautions:	Do not dry the sample in an oven or at an abnormally high temperature.
Quality criteria	Samples should be dry in a clean area.

Operation Sheet 3– Conducting soil sampling using soil auger

Objectives;. To take sample and prepare for test to determine soil fertility status

Materials required,

- ✓ Sampling auger, spade or shovel
- ✓ Clean bucket
- ✓ Sample bags
- ✓ Strings
- ✓ Labels
- ✓ Field note

Procedure of soil sampling

Step 1 Site selection

Step 2 observe field for variations in soil color, texture, topography, drainage

Step 3 lay outing the field

Step 4 decide the sampling depth depends on the crop to be grown

Step 5 Prepare a sketch map of the field showing different sampling unit

Step 6 clean litter from the surface and expose the soil

Step 7 Push and take the soil from the sampling unit using auger or spade

Step 8 Place the soil in a clean bucket

Step 9 Remove roots and stones, which will not be part of the analysis

Step 10 Mix well the samples with hand to set the composite sample

Step 11 Weigh and labelling the composite soil for required KG

Operation Sheet 4– Soil color identification

Objectives; to identification of the main color of the soil

She simple identification of the main color of the soil is sufficient notice that wet soil looks darker than when it is dry.

Soil color identification procedures

Step 1: Take some soil ped from each soil horizon

Step 2: Break the ped

Step 3: Mix with tap water in baker

Step 4: Check the color of the ped according to the Munsell color chart.

If the ped shows more than one type of color, indicate the dominant and the sub-dominant color.

Key to use the Munsell

Colors indication

- ✓ Brown to black color: Result of organic matter or dark parent material. It gives faint chalky smell.
- ✓ White to light grey*:* results when organic matter leached down of sandy soils and E-horizons. It caused by accumulation of lime, gypsum and other light materials.
- ✓ Yellow to Red: results from an iron oxide that includes some water (limonite), i.e. slightly less well drained
- ✓ Bluish grey*:* results from autoxidized iron, indicates lack of oxygen

Operation Sheet 5– Testing soil Ph

Objectives; to identification of the main color of the soil

Procedure of soil pH determination using pH in soil-water suspension (pH meter method)

Step 1. Take 10 g of soil sample in 50 or 100 ml beaker.

Step 2. Add 20 or 25 ml of distilled water, stir well for about five minutes and keep for half an hour.

Step 3. Again stir just before immersing the electrodes and take the pH meter reading.

The color chart indicates the pH numeric value of the sample .According to obtained color, the soil sample belongs to one of the three main groups: alkaline, neutral or acidic. The Neutral point is 7.0 and the neutral range is between 6.0 and 8.0 (With other pH test methods, which are able to indicate decimal values, this range would be considerably less). pH value less than 7.0 are considered acidic and values higher than 7.0 are considered to be an alkaline.

LAP TEST	Performance Test

Name……………………………… ID………….. Date………………………………

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **6** hour. The project is expected from each student to do it.

Task 1: Perform soil sampling

Task 2: Perform soil sample preparation

Task 3: Conduct soil sampling using auger

Task 4: Perform soil color identification

Task 5: Perform soil pH measurement

Task 6: Perform clean and dispose materials

LG #22	LO # 3 - Interpret results of soil analysis

Instruction sheet

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

- Classifying the soil types of the sample area
- Determining the acceptable soil physical and chemical parameters
- Comparing collected analytical results
- Evaluating soil characteristics
- Determining the Readily Available Water (RAW)

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, **upon completion of this learning guide, you will be able to**:

- Classify the soil types of the sample area
- Determine the acceptable soil physical and chemical parameters
- Compare collected analytical results
- Evaluate soil characteristics
- Determining the Readily Available Water (RAW)

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the "Self-checks" which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

".

Information Sheet 1- Classifying the soil types of the sample area

1.1. Classifying the soil type

Soil classification is a dynamic subject, from the structure of the system itself, to the definitions of classes, and finally in the application in the field. Soil classification can be approached from the perspective of soil as a material and soil as a resource. The most common engineering classification system for soils in North America is the Unified Soil Classification System (USCS). The USCS has three major classification groups: (1) coarse-grained soils (e.g. sands and gravels); (2) fine-grained soils (e.g. silts and clays); and (3) highly organic soils (referred to as "peat"). The USCS further subdivides the three major soil classes for clarification. It distinguishes sands from gravels by grain size, and further classifying some as "well-graded" and the rest as "poorly-graded". Silts and clays are distinguished by the soils' Atterberg limits, and separates "high-plasticity" from "low-plasticity" soils as well. Moderately organic soils are considered subdivisions of silts and clays, and are distinguished from inorganic soils by changes in their plasticity properties (and Atterberg limits) on drying. The European soil classification system (ISO 14688) is very similar, differing primarily in coding and in adding an "intermediate-plasticity" classification for silts and clays, and in minor details.

These soil separates have the following size ranges:

- Sand = <2 to 0.05 mm
- Silt = 0.05 to 0.002 mm
- Clay = <0.002 mm

Therefore, the texture of soils is usually expressed in terms of the percentages of sand, silt, and clay.

Sand and silt are the “inactive” part of the soil matrix, because they do not contribute to a soil’s ability to retain soil water or nutrients. These separates are commonly comprised of quartz or some other inactive mineral.

Because of its small size and sheet-like structure, clay has a large amount of surface area per unit mass, and its surface charge attracts ions and water. Because of this, clay is the “active” portion of the soil matrix.

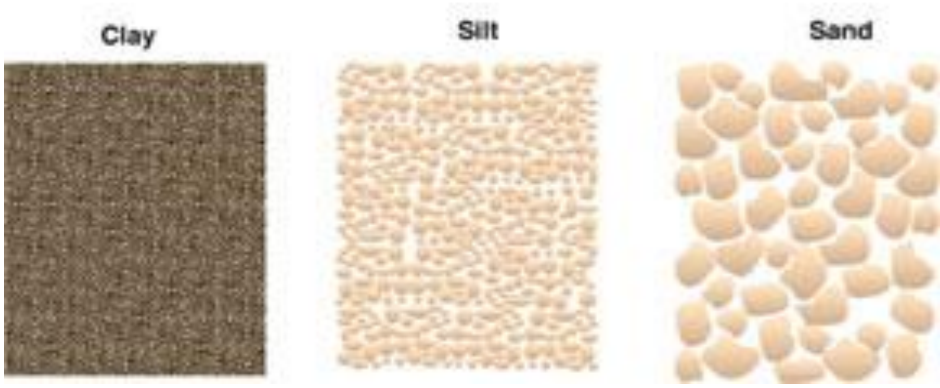


Figure 2.1. Soil textural class

- Some characteristics soil texture

Sands are:

- the largest particles and feel gritty
- rapid permeability ana large pores
- high infiltration rate and low WHC
- poor store house of plant nutrients
- contain low organic matter.

Silts are:

- medium-sized and feel soft
- Medium permeability & WHC
- Silky and Floury- powder fell when dry and is only moderately plastic and sticky when wet

Clays are:

- the smallest sized particles
- feel sticky and are hard to squeeze.
- High water holding capacity and Low infiltration and Porosity

Relative size perspective: Sand > Silt > Clay

For all mineral soils, the proportion of sand, silt, and clay always adds up to 100 percent. These percentages are grouped into soil texture “classes”, which have been organized into a “textural triangle”.

Use of the Soil Texture Triangle shown below to identify the type of soil

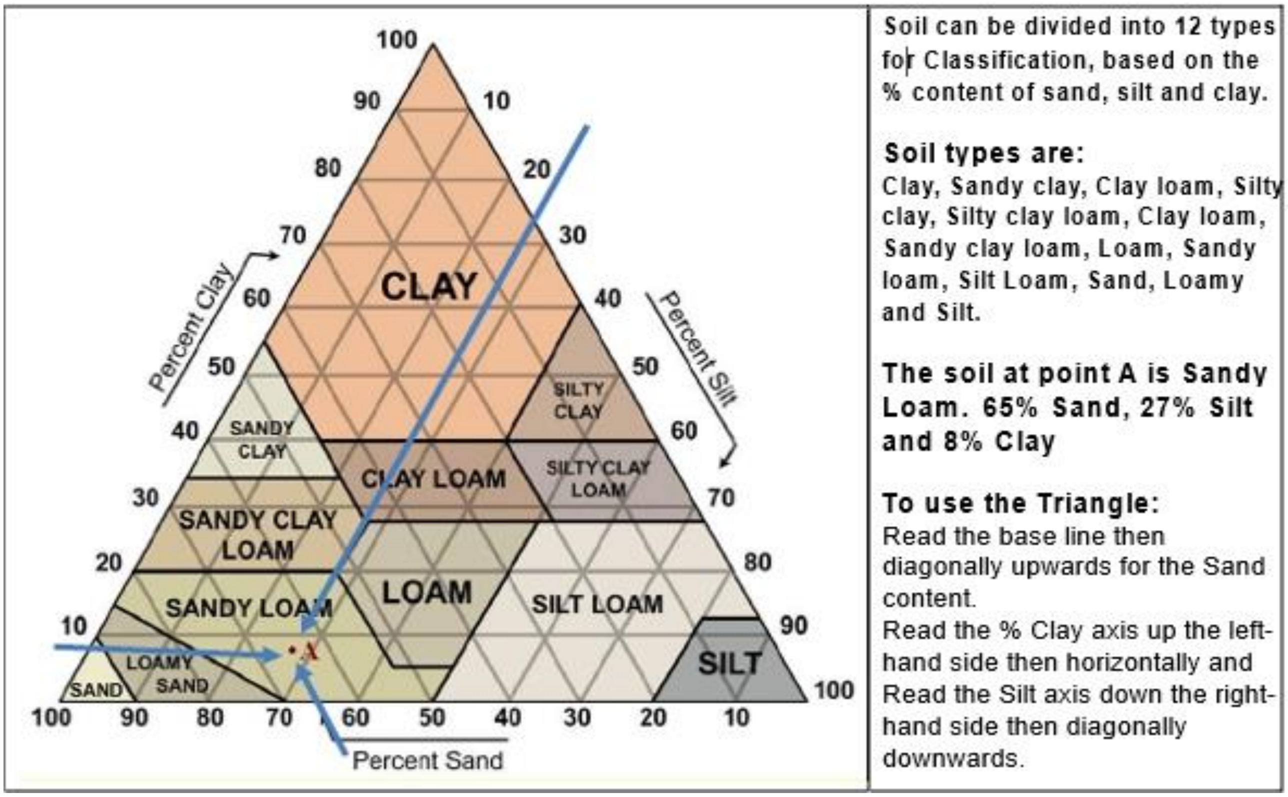


Figure.2.2 Soil textural triangle

NB: - Soil containing equal amount of sand, silt and clay is called “loam”. sand + clay +silt = Loam 33% 33% 33% For ex. 15 % clay, 20% silt and 65% sand is called “sandy loam

- There are different methods to determine the soil sample’s textural class:

Method 1: Rapid Feel method

- **Graininess test:** Rub the soil between your fingers. If sand is present, it feels “grainy”. Determine if the sand constitutes more or less than 50%.
- **Moist cast test**: Compress some moist soil by clenching it in your hand. If the soil holds together, toss it from hand to hand. The more durable it is, the more clay is present.

- **Stickiness test:** Moisten the soil thoroughly and compress it between thumb and forefinger. Determine degree of stickiness by noting how strongly the soil adheres to the thumb and forefinger when pressure is released, and how much it stretches. Stickiness increases with clay content.
- **Worm test**: Roll some moist soil between the palms of your hand to form the longest and thinnest worm possible. The longer, thinner and more durable worm contains more clay.
- **Taste test**: Work a small amount of moist soil between your front teeth. Silt particles are distinguished as fine grittiness, sand is distinguished as individual grains and clay has no grittiness.
- **Soapiness test**: Work a small amount of wet soil between your thumb and fingers. Silt feels slick and not too sticky (=clay) or grainy (=sand). The slicker it feels, the higher the silt content. Generally, we can say that sand feels gritty, silt feels smooth and silky and clay feels sticky.

Method 2: On Field Test

A field test is carried out in the following way:

- a small soil sample is taken and water is added to the sample.
- Place the soil in your palm and knead it to break up aggregates
- Place a ball of soil between your thumb and forefinger.
- Push the ball with your thumb, squeezing it upwards into a ribbon.
- Allow the ribbon to emerge and extend over the forefinger. It should break from its own weight.
- saturate a small pinch of soil in palm and rub with forefinger.

Self-Check – 1	Written test

Name…………………………………………… ID……………………… Date…….

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

Short Answer Questions

1. Define soil classification?(3pts)

2. There are different methods to determine the soil sample's textural class? (2pts)

Note: Satisfactory rating – 5 points Unsatisfactory - below 5 points

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

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

Information Sheet 2- Determining the acceptable soil physical and chemical parameters

2.1 Determining the acceptable soil physical and chemical parameters

The way a soil "feels" is called soil texture and represents the percentage or relative proportion of sand, silt and clay present in a soil (FAO, 2006). Sand, silt, and clay are names that describe the size of individual particles in the soil. Soil texture is fundamental to soil properties and their impact on plant growth and overall farm productivity. Texture is a parameter that influences soil behavior in many ways, being an important factor in water retention and availability, soil structure, aeration, drainage, soil workability and trafficability, soil biodiversity, and the supply and retention of nutrients. It is for this reason that measuring soil texture is of great importance in agricultural production. You can also visit annex I for a visual assessment of soil texture in the field.

2.2. Determining the acceptable soil chemical parameters

Soil test results Interpretation based on soil pH level

Depth of Topsoil; 60 – 90 cm is desirable

Texture Loams are particularly desirable, but production is possible in most soil texture types provided that there is adequate drainage. Freedom from a large number of stones is desirable for production of root crops. Very heavy Clay soils and very free draining sandy soils should be avoided

• pH in the range 6.0 – 6.5 is ideal but pH 5.5 – 7.0 is manageable with suitable use of lime, fertilizer, and organic matter.

• EC Low EC is most desirable (<2dS/m measured in a 1:2 Extract is ideal but up to 4dS/m is Ok for some crops) Note: 1dS/m = 1mS/cm

• Freedom from high levels of toxic ions, e.g. Sodium (ESP less than 15)

• Bulk density of < 160 g / 100ml soil (This will give a reasonable balance between Water holding capacity and Air-filled porosity and allow good root penetration)

1. Soil pH is a measure of soil acidity and most horticultural crops grow best if the soil pH is between 6.00 and 7.5
   - Below 5.1 it is strongly acid
   - 5.2-6.0 it is moderately acid
   - 6.1-6.5 it is slightly acid
   - 6.6-7.3 it is neutra7.4-8.4 it is moderately alkaline
   - Above 8.5 it is strongly alkaline

Soil pH can be increased by liming; the soil pH test indicates if lime is needed, but the lime requirement test is needed to determine how much lime is required. If the pH is high value sulfur may be needed to acidify the soil

2. Potassium (K)

Potassium or K is expressed in parts per million (PPM) of the actual element on the analysis report but fertilizers measure potassium as potash (K_2O) and application rates are usually expressed in pounds per acre (PPA). To convert K expressed in ppm to K_2O expressed in PPA, multiply the PPM value by 2.4. To convert the value expressed in PPA to PPTSF divide PPA by 43.56. Once you have determined the amount of potash per acre or per thousand square feet, you'll need to decide what product you're going to use to supply the needed potash. North Country Organics has four products that supply potash. To calculate the amount of material needed, divide the PPA needed by the percent value in the right column of the table below.

Table 2.1. source of Potassium

Product	Percent soluble potash
Natural sulfate of potash	51
Natural sulfate of potash, magnesia	22
Greensand Plus	17
Greensand	0 soluble, 6 insoluble
Example Greensand will slowly build reserves of potash but will not satisfy an immediate need. Natural sulfate of potash, magnesia also contains 11 percent magnesium and should not be used unless the analysis report indicates a deficiency in Mg.	

3. Magnesium

Magnesium is also express in PPM on the analysis report. To convert Mg expressed in PPM to PPA, multiply by 2. To convert PPA to PPTSF, divide by 43.56. Mg can be supplied by dolomite lime but if the pH is in the desired range, lime should not be used. To calculate the amount of material needed, divide the PPA or PPTSF needed by the percent value in the right column of the table below.

Table 2.2. Source of Magnesium

Product	Percent magnesium
Epsom salts (magnesium sulfate)	10
Natural sulfate of potash, magnesia	11
Magnesium oxide	60
Example Magnesium oxide is not allowed on certified organic farms.	

4. Calcium

Like Mg and K, Ca is also expressed in PPM on the analysis report. To convert Ca expressed in PPM to PPA, multiply by 2. To convert PPA to PPTSF, divide by 43.56. Ca can be supplied by both dolomite and calcium lime but if the pH is in the desired range, lime should not be used. To calculate the amount of material needed, divide the PPA needed by the percent value in the right column of the table below.

Table 2.3. Source of Calcium

Product	**Percent calcium**
Aragonite	38
Calcium limestone	38
Gypsum	23
Bone char	33
Soft rock phosphate	20
Example Aragonite, Calcium limestone, and even Phosphate rock (to a certain extent) will raise the pH of the soil. Gypsum is the only product that will add calcium to the soil without affecting the pH. Phosphate rock should only be used if the analysis report also indicates a need for phosphorus.	

5. Phosphorus

Phosphorus is calculated differently than K, Mg, and Ca because it has opposite ionic properties and is not related to the CEC. Adequate levels of available phosphorus are between 22 and 33 PPM. Reserve levels should be between 34 and 51 PPM. If the results indicated on your analysis report are below these ranges, then applications of phosphorus should be considered. Phosphorus is applied as phosphate in fertilizers (expressed as P_2O_5). To convert phosphorus expressed in PPM to phosphates in PPA, multiply by 4.6. For example, if you need 20 PPM phosphorus, 20 X 4.6 = 92 PPA of phosphate. North Country Organics has three products that supply phosphate.

To calculate the amount of material needed, divide the PPA needed by the percent value in the right column of the table below.

Table 2.3. Source of phosphorus

Product	Percent available phosphate
Soft rock phosphate	2-5 available, 20 total
Bone char	16
Steamed bone meal	11-13
The total amount of phosphate in phosphate rock is eventually released in 4-6 years depending on the climate, pH, and the overall health of the soil. Precipitated bone meal has the most available phosphate but the product's consistency is very fine and can be difficult to work with. Steamed bone meal has a better consistency and has 5 percent nitrogen but is expensive to use on a large scale.	

6. Organic Matter(OM)

As the level of OM is reduced below 5 percent, many of the soil's natural and beneficial functions begin to diminish. Soils with OM below 3 percent may perform fine in ideal conditions; however, they have a more difficult time holding nutrients and water. Soils with very low OM cannot support the populations of beneficial organisms needed for very important functions that both feed and protect plants. OM levels are not easy to change. Each percent of OM in the top six inches of soil is about 20,000 pounds of stable humus. Creating, let alone replacing, stable humus is a monumental task. Compost can be added before and after the growing season, but if it isn't incorporated into the soil, no more than ½ inch should be applied at a time. ½ inch of compost on an acre of soil is equivalent to 69 yards so it may not be a practical solution. There are steps that one can take to increase the production and reduce the depletion of OM.

- Reduce the amount and the depth of tillage. Tillage fractures OM and introduces excessive oxygen, which hastens the decomposition of OM.
- Rotate crops. Row crops should be rotated with sod crops periodically.
- Grow cover crops or green manure. Levels of OM above 15 percent are extremely rare in the Northeast. The major problem associated with very high OM is drainage.

Self-Check – 2	Written test

Name………………………………………… ID……………………… Date…….

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

Short Answer Questions

1. What is soil test interpretation; what do you understand from the information given in the information sheet? (3 point)
2. How do you reach on recommendation of lime addition based on pH test result? (4 point)

Note: Satisfactory rating - 7 points Unsatisfactory - below 7 points

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

Information Sheet 3- Comparing collected analytical results

3.1. Comparing collected analytical results

Interpretation of results: It is difficult to interpret analytical results for a single sample. Every measurement must be compared to others. It is particularly useful, for example, to calculate the ratio of total potassium/clay, or estimate the cation exchange capacity of the clay fractions. For individual horizons the overall results (results of analyses plus morphological description plus other information such as physical, hydrological data, or mineralogical determinations) should be taken into account. In addition, every horizon should be considered in relation to the horizons above or below (vertical relationships) while not forgetting relationships to other soil volumes up or downslope (lateral relationships).

3.1.1. Soil physical analysis

- If the soil does not remain in a ball when squeezed the soil is sand
- If the soil remains in ball when squeezed continue with the formation of ribbon. If the soil does not form a ribbon the soil has Loamy – Sand texture
- If the ribbon is less than 2.5 cm long before breaking and feels gritty, the texture class is

✓ Sandy – Loam

- If the ribbon is less than 2.5 cm long before breaking and feels smooth, the soil is

✓ Silt – Loam

- if the ribbon is less than 2.5 cm long before breaking and does not feel gritty and smooth, the texture is a Loam
- If the ribbon is 2.5-5.0 cm long before breaking and feels very gritty the texture class is Sandy – Clay – Loam
- If the ribbon is 2.5-5.0 cm long before breaking and feels smooth the soil is a Silty

✓ Clay – Loam

- If the ribbon is 2.5-5.0 cm long before breaking and does not feel gritty and smooth, the texture is a Clay - Loam
- If the ribbon is strong, equal or more than 5.0 cm long before breaking and feels gritty, the texture class is Sandy – Clay
- If the ribbon is strong, equal or more than 5.0 cm long before breaking and feels smooth, the soil is a Silty – Clay
- If the ribbon is strong, equal or more than 5.0 cm long before breaking and does not feel gritty and smooth, the texture is a Clay.

3.1.2 Soil chemical analysis

According to requirements and financial constraints many different chemical analyses can be requested. Generally, the six most important elements are: N, K, Mg, Ca, Na, and P. The S and Mn may also be requested. All other chemical elements occur in small amounts and their determination is outside the scope of routine analysis and are expensive to obtain.

Nitrogen analyses - including ammonium (NH4+), nitrate (NO3-), and total N - are usually the most important and can be used, for instance, to determine the C/N ratio. Nitrogen in most forested ecosystems is the most limiting element and therefore of great concern to managers.

The inorganic combined N in soils is predominately NH4+ and NO3. Inorganic N may represent more than a small fraction of soil total N. Exchangeable NH4+ is extractable at room temperature in a 2 N KCl solution. Determination of NH4+ and NO3- in soils is complicated by rapid biological transformations that may occur, changing the amounts and forms of inorganic N in the sample. Ideally, soil samples taken to determine inorganic forms of N should be refrigerated and analyzed as soon as possible for valid results. However, some delay is nearly impossible to avoid, because samples must be transported to the laboratory, sieved, and perhaps subsampled before analysis. If the samples cannot be run within 3 weeks, the soil should be either frozen at 0 degrees C or dried at laboratory temperatures. Air-drying can lead to small but significant increases in exchangeable NH_4^+-N and NO_3^--N. Suitable precautions for air-drying of soil samples include drying at low temperatures (elevated temperatures such as greater than 55 degrees C can lead to marked increases in exchangeable NH_4^+-N) and storing in closed plastic or glass containers. Drying in paper bags also results in significant increases in exchangeable NH_4^+ N. Nitrogen mineralization (the potential of a soil to supply N to plant when conditions are ideal for mineralization) may be the most diagnostic analysis when trying to relate N to tree growth.

Total N is obtained by a medium-temperature resistance furnace. Total N analysis is complicated by the lack of knowledge concerning N forms present and by the low N content of the material under analysis. Total soil N content ranges from less than 0.02 percent in subsoils and greater than 2.5 percent in peats.

Exchangeable K is another important soil analysis that can be used to relate soil K to tree growth. The Intermountain Forest Tree Nutrition Cooperative suggests that when the ratio of exchangeable K/mineralizable N is less than 6 to 10 then K is in short supply or there is too much mineralizable N.

Results from a laboratory are expressed either as elements or oxides. Check this point carefully. They are also frequently expressed as percentages or parts per million (or thousands). The sum of the oxide form and the loss-on-ignition organic matter value should be approximately 100 percent, provided that these values have been expressed in the same way and loss-on-ignition was determined on the same sample.

Chemical analysis of one or more elements allows samples to be compared, thus allowing one to trace the pedological differences within a solum or changes across the landscape.

Examples:

- Potassium analysis: A high K concentration can indicate abundant micas or potassium feldspars (orthoclase) in the sand and silt fractions.
- Magnesium analysis: In limestone country a relative abundance of this element can indicate the presence of dolomite.
- Calcium analysis: In soils without carbonate or dolomite, low concentrations of Ca can be attributed to feldspars.

Self-Check – 2	Written test

Name…………………………………………… ID……………………….. Date……

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

Write true if the statement is correct and false if statement is wrong

1. If the soil does not remain in a ball when squeezed the soil is sand.(2pts)

2. If the soil does not form a ribbon the soil has Loamy – Sand texture. (2pts)

Note: Satisfactory rating - 4 points Unsatisfactory - below 4 points

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

Information Sheet 4- Evaluating soil characteristics

4.1 Evaluating soil characteristics

Properties used to evaluate soil chemical properties typically include soil pH, plant available nutrients, soil nitrate, reactive carbon, soil organic matter, and electrical conductivity.

Some soil characteristics, depending on the nature and severity of the problem, can be

Improved by on-farm treatment and or the use of Good Agricultural Practices,

For example:

• Soil compaction and plough pans can be broken using a ripping or sub-soiling tine Plough using this tine at the appropriate depth in one direction and then at right angles to the first ploughing

Soil tilth for planting can be improved if large clods are broken up by hand tools or a Rotovator when the soil is at the correct stage of moisture content pre-planting.

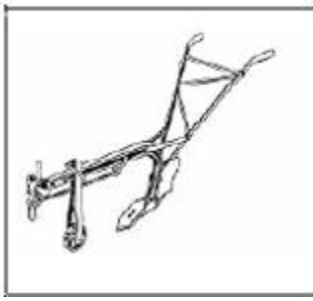
This will improve water holding capacity in the root zone and aid establishment

• Addition of organic matter will stabilize a soil structure and also improve the water Holding capacity

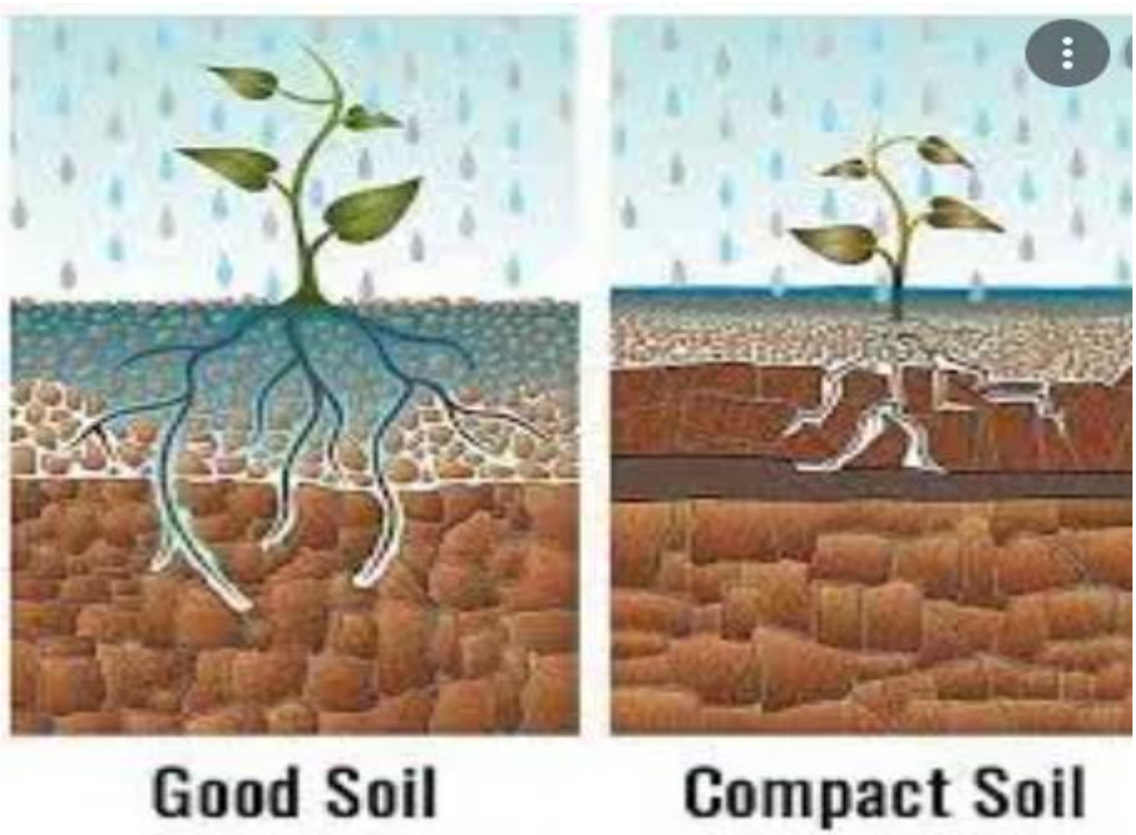
• Use of Lime will raise the soil ph. Remember that the lime should be applied and Incorporated at least one month before the crop is planted and that annual application Will be necessary on some types of soil.

• Use of organic or inorganic fertilizers, according to identified needs and Recommendations, to increase the fertility of the soil and or to adjust the balance between the different nutrients to control the type of plant growth and or to correct a nutrient deficiency.

Soil compaction and plough pans can be broken using a ripping or sub-soiling tinePlough using this tine at the appropriate depth in one direction and then at right angles to the first ploughing




Cultivator
Disk
Plow
Plow Pan


Good Soil
Compact Soil

Self-Check – 4	Written Test

Name…………………………………………… ID……………………….. Date…….

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

Write true if the statement is correct and false if statement is wrong

1 To apply of Lime will drecesse the soil pH.(2pts)

2 What is Soil compaction? (3 point)

3 What are conditions that should be considered during soil pH? (3 point)

4 What is pre planting fertilizer application? (3 point)

5 How do you ameliorate a soil with high salinity? (3 points)

6 If the soil does not form a ribbon the soil has Loamy – Sand texture. (2pts)

Note: Satisfactory rating - 4 points Unsatisfactory - below 4 points

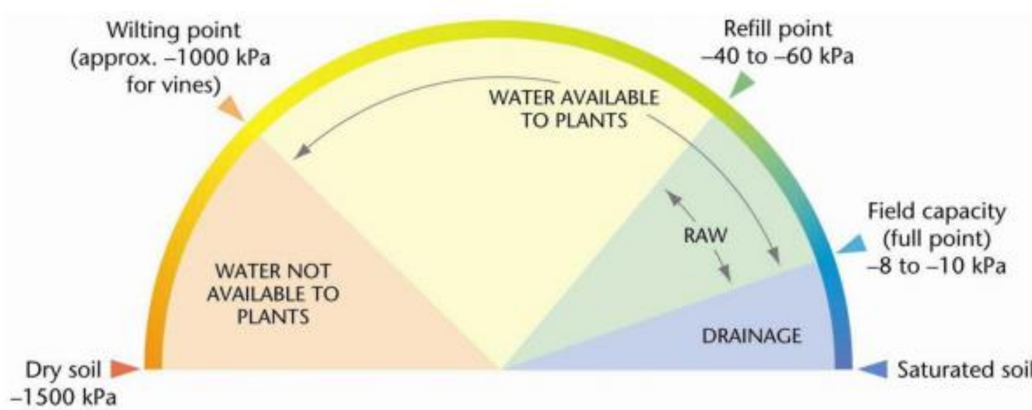
You can ask you teacher for the copy of the correct answers.

Information Sheet -5 Determining the Readily Available Water (RAW) for Irrigation

Readily available water (RAW) is the water that a plant can easily extract from the soil. RAW is the soil moisture held between field capacity and a nominated refill point for unrestricted growth.

In this range of soil moisture, plants are neither waterlogged nor water-stressed.

Soil water content. Depending on the type of crop, RAW for horticultural crops is usually the amount of water held between field capacity (–8 to –10 kPa) and –20 to –60 kPa



Plant roots will continue to take water from the soil after the refill point is reached. However, this water is not as readily available to plants and the crop finds it difficult to extract. If the soil dries to the permanent wilting point, the plant can no longer remove any water from it: some water may still be present but is completely unavailable.

The drier the soil, as shown by high tensi meter values, the more water needs to be added to bring the soil back to field capacity. These values are presented in Table 1 as millimeters of moisture available per centimeter of soil depth. The figures in kPa across the top of this table correspond to the figures that you would find on a tensiometer gauge.

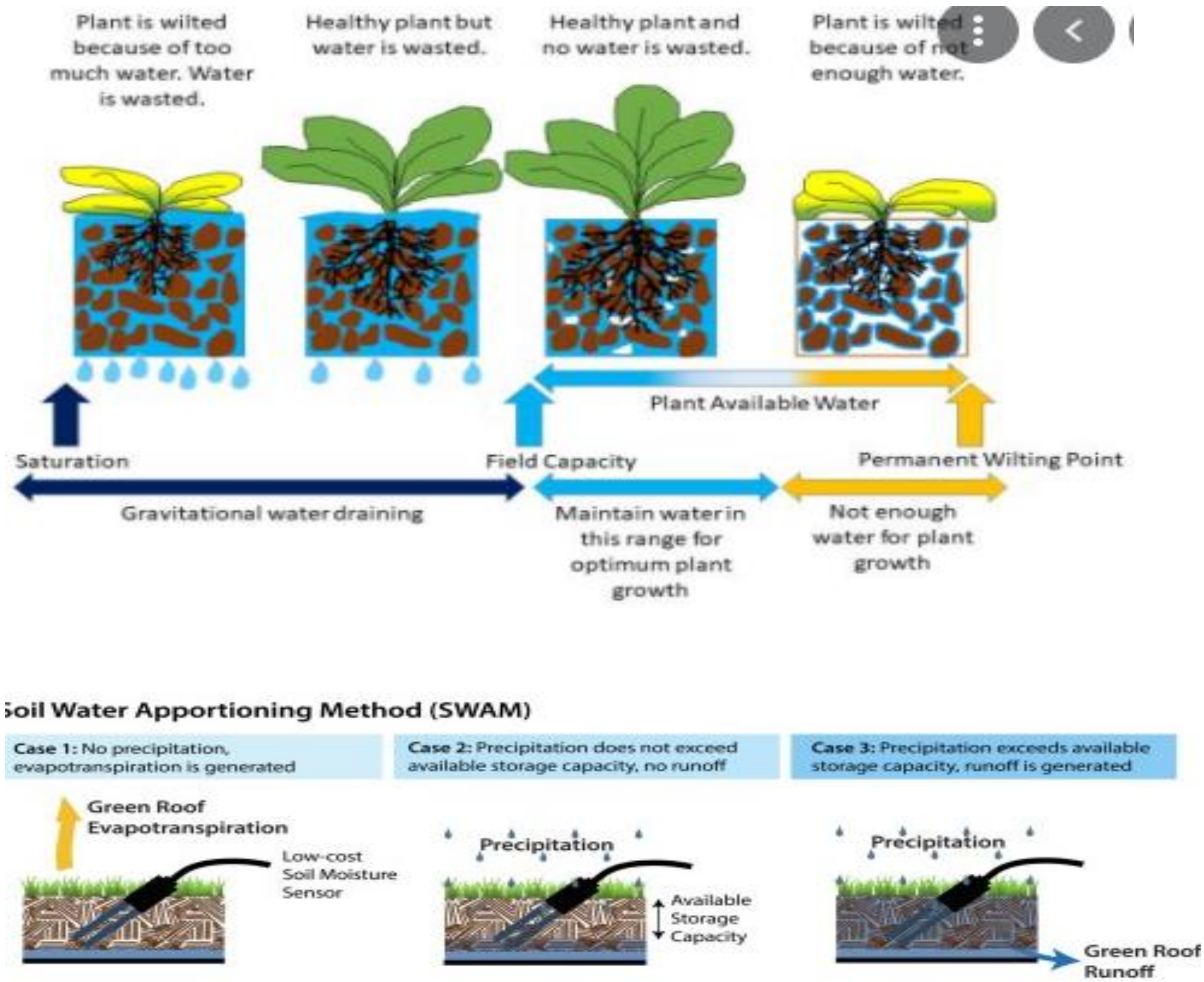


Fig 5.1 water available for root zone

Available Water is the water held in the soil in the between Field Capacity and Permant Wilting Point, i.e.

AW = FC - PWP   where **Field Capacity (FC),** is the water content of the soil when the soil has been fully saturated and then allowed to drain

Permanent Wilting Point (PWP) is the water content of the soil where the plant is not able to extract water and will die.

Readily available water (RAW) is water that can be easily extracted from the soil by the Crop (before wilting occurs).

The amount of RAW is affected by a number on factors, as shown in the Table below

Factors that increase RAW	Factors that reduce RAW
• High levels of soil moisture • Organic matter in the soil • Good soil structure that provides hig h water • holding pore space • Low soil EC	• Dry soil • Low Organic matter content • Poor soil structure: very dense with low pore space or very open with wide air-filled pores

The amount of Readily available water affects a crop need for irrigation and in practice farmers can judge the need for irrigation by:

- Feeling the soil to assess the wetness *Common in the small farmer sector*
- Observing the crop appearance Wilting, stunting, etc.
- Use of soil tensiometers or neutron probes
  Used in experimentation but not widely

used on farms

Self-Check – 5	Written Test

Name…………………………………………… ID………………………… Date…….

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

Write true if the statement is correct and false if statement is wrong

1. Feeling the soil to assess the wetness *Common in the small farmer sector*
2. Observing the crop appearance Wilting, stunting
3. Soil is the water held in the soil in the between Field Capacity and Pe

Part 2 Short answers

1. List down Factors that increase RAW
2. List down and mention of Factors that reduce RAW

Note: Satisfactory rating - 4 points Unsatisfactory - below 4 points

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

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