RWANDA POLYTECHNIC

TVET LEVEL II

AGRICULTURE

Growing Medium

TRAINEE MANUAL

RWANDA POLYTECHNIC

Approved by: Workforce Development Authority

USAID FROM THE AMERICAN PEOPLE

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GROWING MEDIUM

Unit 1: Collection of soil samples for laboratory testing

Unit 2: Preparation of soil samples for laboratory testing

Unit 3: Soil tillage for planting

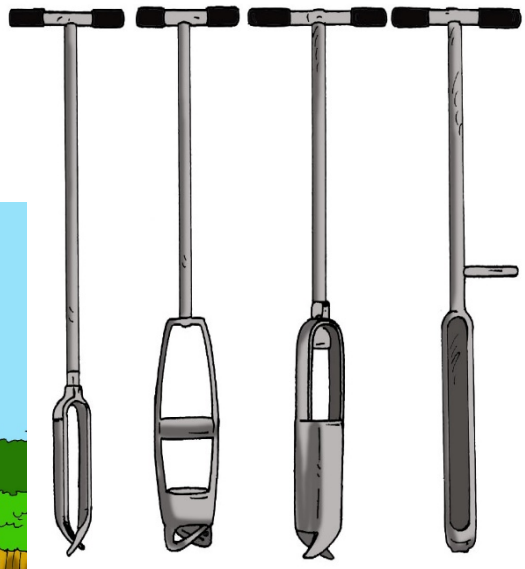
Unit 4: Soil maintenance

Unit 5: Sterilization of soil for organic growing medium

Unit 6: Setting up growing medium for planting

Unit 7: Setting up water delivery systems for growing medium

Unit 1: Collection of soil samples for laboratory testing



Topics

1.1 Identification of tools, materials and equipment for soil sampling

1.2 Cleaning of tools and equipment for sampling

1.3 Adjustment of tools and equipment for sampling

1.4 Collection of soil samples for laboratory testing

1.5 Handling of soil samples

Unit Summary:

This unit describes the knowledge, skills, and attitudes required to identify equipment, tools and materials for soil sampling; clean tools and equipment for sampling; adjust tools and equipment for sampling; collect soil samples for laboratory testing and handle soil samples.

Self-Assessment: Unit 1

1. Look at the unit illustration. What do you see? What do you think this unit will be about? What topics might be covered?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this assessment. It is for your own use during this course. The trainer will read a skill that is listed in the left column. Think about yourself: Do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, we'll take this survey again.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Explain the importance of soil sampling					
State the general requirements for equipment, tools, and material for reliable soil sampling					
Choose appropriate soil sampling equipment, tools, and material					
Describe decontamination methods for equipment and tools					
Disinfect and sterilize equipment, tools, and materials for soil sampling					
Identify causes of malfunctioning of tools and equipment					
Follow adjustment guidelines to perform minor adjustments on tools and equipment					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Describe soil sampling methods					
Collect soil for laboratory testing					
Handle moist soil samples following the requirements					
Explain soil shipping requirements					

Topic 1.1: Identification of tools, materials and equipment for soil sampling

Key Competencies:

Knowledge	Skills	Attitudes
1. Describe the importance of soil sampling	**1.** Provide information to others on how soil sampling is necessary to identify nutrients in the soil	**1.** Self confidence
2. State the general requirements of equipment, tools and materials for reliable soil sampling	**2.** Choose equipment, tools and materials for soil sampling that meet quality standards	**2.** Attention to detail and quality standards
3. Identify key factors related to soil, weather and terrain to consider when selecting equipment, tools and materials for soil sampling	**3.** Select equipment, tools and materials based on factors related to soil, weather and terrain	**3.** Analytical

Getting Started: What do we know and where are we going?

Topic 1.1 Task 1:

1. Reflect on:
   a. The pictures at the beginning of the unit again. What is soil sampling? How would you describe it to someone?

   b. Past experiences you have had in soil sampling. Where did you do it? How? Why?

   c. Why soil sampling is important in crop production. How might taking care of the soil be similar to taking care of one's body? What purpose does soil testing serve?

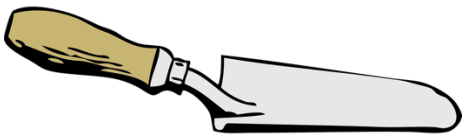
Problem Solving Activity

Topic 1.1 Task 2:

1. Complete the following tasks and be ready to share your responses with the large group:
   a. Circle the pictures you think are related to the tools, equipment and material used in soil sampling.

   b. Name the items you circle and discuss how they might be used in soil sampling.

   c. List features of a good soil sampling tool.

a) 	 **b)**

c) 	**d)** 
e) 	**f)** 
g) 	**h)**  [1]
i) 	**j)** 

[1] User: Suricata. (2005, November 21). *Messrad Suricata* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:MessradSuricata.jpg
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1.1 Key Facts

- **Soil sampling:**
  - Shows the nutrients in the soil that are available to the plants.
  - Plants need nutrients to grow well. They need nitrogen (N), phosphorus (P) and potassium (K) as well as small amounts of boron (B) and zinc (Zn).
  - Farmers can add compost and fertilizers to the soil to make it richer in nutrients.

- **Commonly used sampling tools, equipment and materials:**
  - **Blades:** trowel, spade, shovel, spoon, knife, cutlass
  - **Tubes:** open-sided and plain cylinder soils samplers
  - **Augers:** screw, post-hole, sheathed, clay/sand/mud
  - **Containers and bags:** plastic and paper bags, cardboard boxes

- **General requirements of high-quality sampling tools:**
  - Be robust enough to withstand handling operations;
  - Be clean (free of dirt and rust) – check before use!
  - Be easy to clean – clean according to instructions after each use!
  - Conform to safety requirements;
  - Be uncontaminated (stainless steel or chrome-plated tools to avoid contaminating sample with traces of chemicals; avoid brass, bronze or galvanized tools);
  - All parts must be made of materials resistant to:
    - the effects of the goods being sampled (e.g. fruit acid or chemicals);
    - the cleaning agents (e.g. bleach or surfactants);
  - Be approximately uniform in cross section to the desired depth
  - Provide reproducible sampling units

[2] All images, except those otherwise cited, are from Pixabay.com; License: https://pixabay.com/service/license/

Guided Practice Activity

Topic 1.1 Task 3:

1. A school neighbour wants to collect soil samples but needs advice on the types of equipment/tools/materials to use and how to select them. Before giving the neighbour advice, go to the school workshop to become more familiar with the tools. Perform the following tasks and/or answer the questions:

a. Gather the equipment/tools/materials used in soil sampling. List the items.

b. Observe the soil probes and augers in the workshop. Write down 3 observations. For example - What materials are the tools made up of? What are the main parts of the tools?

c. Determine whether or not the equipment/tools/materials are in good condition to be used for soil sampling. If not, identify what actions need to be taken to improve the quality.

d. List the factors to consider when identifying tools and equipment for soil sampling.

1.2 Key Facts

- **Factors to consider when identifying soils sampling equipment, tools, and materials:**
  - Background of the field (type of crop grown previously, deep rooting crop or not, etc.)
  - Field accessibility (near the road for example)
  - Climatic conditions (rainy or dry season)
  - Soil condition (soil texture and structure types – sandy, clay, gravel, etc.)
  - Availability of equipment, tools and materials (that will not contaminate the sample)

- **Soil Auger Features:** A soil auger is an essential piece of soil sampling equipment for general testing. In order to do its job well and last a long time:
  - It needs to be made of sturdy, high-quality materials like stainless or carbon steel. Carbon steel is the best material for a wide range of soil types.
  - The blades are fully welded to prevent bending and separation from the auger head.

- It should be able to reach a variety of depths to give you a comprehensive soil profile.

- **Soil probe features**
  - Because soil probes generally require manual turning to dig their way into the ground, they should have comfortable handle grips (padded is ideal).
  - To minimize sample loss, soil sampling tools like probes should use core catchers or another form of retention system to make sure loose materials are not lost when pulling up the probe.

- **Soil sampling kit features:** Having a good kit of soil testing equipment on your side will make the sample collection process easier, faster, and more accurate. A quality kit should generally consist of:
  - Essential tools like a probe and auger
  - A soil ejector scoop
  - Multiple probe tips to accommodate varying soil consistencies
  - A cleaning brush to help limit sample contamination while in the field[3]

- **Further information on augers, from Gilson Company, Inc.:**

Tool	Uses	Characteristics
Standard Auger	for sampling most soil types	has an open bit design available in 76mm and 102mm
Clay Auger	works well in cohesive (sticks together) soils	has an open bit design available in 76mm and 102mm
Sand Auger	looser, granular soils	closed bits to retain cuttings available in 76mm and 102mm
Mud (Dutch) Auger	muck-like, boggy and root-bound soils	open design available only in 76mm[4]

[3] Certified Material Testing Products. (2019, March 18). *Features of the best soil sampling tools*. https://www.certifiedmtp.com/blog/best-soil-sampling-tools/

[4] Global Gilson Company Inc. (n.d.). *Soil sampling equipment*. https://www.globalgilson.com/soil-sampling-equipment

Application Activity

Topic 1.1 Task 4:

1. A cooperative in Nyamagabe District grows Irish potatoes, and the yield is decreasing day by day. The agronomist advised the cooperative to send a soil sample to the laboratory to see if the problem relates to the soil properties (chemical properties). The soil is sandy, and the field used to be a site where factories would dump their waste.

You are going to assist the cooperative in identifying the equipment, tools, and materials needed to collect the soil sample. These are available in the cooperative's workshop. The condition of the equipment, tools and materials varies, however. Some do not meet the standards needed to collect reliable soil sample.

a. List the criteria for good soil sampling equipment, tools and materials.

b. Based on the criteria in **question a**, sort the equipment, tools, and materials that are good for soil sampling and that are not good. Give the cooperative a list of those you recommend they use.

c. Explain to the cooperative the other factors they should consider when choosing their equipment, tools, and materials. Write these down on paper.

d. Given the information provided about the field, what type of auger do you think should be used? What materials should be used to ensure safety requirements are met?

Points to Remember

- Just like humans, plants need nutrients to grow! These nutrients are found in the soil.
- Soil sampling tells us what nutrients are needed in the soil for plants to grow better.
- Tools, equipment and materials must conform to safety requirements, be well-made, clean and easy to clean and resistant to reacting with whatever is being used in the testing.
- Always clean tools and equipment after use.
- When choosing equipment/tools/materials for soil sample, also consider the background, accessibility and condition of the field, type of soil and the physical/chemical makeup of the tools, materials and equipment.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Answer by identifying each statement as **true** or **false**.

a. Soil sampling helps determine when to plant.

b. It is necessary to consider the physical and chemical makeup of materials, tools, and equipment when selecting such items for soil sampling.

c. Soil sample tools can be used several times in different fields before cleaning.

d. Soil type should be taken into consideration when identifying soil sampling tools, material, and equipment.

2. The school workshop has different soil sampling tools and equipment.

a. Identify the ones which meet the requirements for soil sampling.

b. Explain why you chose the selected tools, materials and equipment.

Topic 1.2: Cleaning of tools and equipment for sampling

Key Competencies:

Knowledge	Skills	Attitudes
1. List cleaning and sanitization steps	**1.** Apply appropriate decontamination methods based on tools and equipment being used	**1.** Hardworking
2. Identify decontamination methods	**2.** Select appropriate cleaning and sanitizing products	**2.** Reliable
3. Identify appropriate cleaning and sanitizing products	**3.** Disinfect/sterilize tools, materials and equipment for soil sampling	**3.** Realistic

Getting Started: What do we know and where are we going?

Topic 1.2 Task 1:

1. Discuss:

What is the difference between washing your hands with water and washing your hands with soap and water?

2. With a partner, discuss the terms**:** disinfect, decontaminate, and sterilise. What do you think it means to disinfect, decontaminate, or sterilize something?

3. Continue discussing: What are some examples of things that you regularly disinfect, decontaminate, and/or sterilise before using?

4. Discuss these terms and examples as a class.

5. Read the Key Competencies table above to learn about the knowledge, skills, and attitudes you will gain through this topic.

Problem Solving Activity

Topic 1.2 Task 2:

1. With your group, read the following scenario and discuss the questions:
Alice recently started working for an organisation that supports farmers. To determine what type of fertilisers to use in a farming area, the organisation is going to collect soil samples. Alice's supervisor has asked her to prepare the necessary tools and equipment to take samples.

Give Alice some guidance by answering the following questions:

a. Why do you think Alice needs to be careful about contaminating soil samples? How could she prevent possible contamination?

b. If you were Alice, what are the steps you would take to clean and sanitise the tools and equipment?

2. Now, with your class, brainstorm the different type of cleaning products you are familiar with. For what purposes/activities are they used?

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1.3 Key Facts

- **Decontamination**
  - The process of decreasing antimicrobial presence in an area or on a surface.
  - Sterilization, disinfection, and antisepsis are types of decontamination.
  - Makes a medical device, instrument, or environmental surface safe to handle.
  - All infectious materials and all contaminated equipment should be decontaminated before being used, washed, stored, or discarded.[5]

[5] UC San Diego Blink. (2019, January 29). *Biosafety: Decontamination methods for laboratory use*. https://blink.ucsd.edu/safety/research-lab/biosafety/decontamination/index.html

- **Examples of common things that can be contaminated are:**
  - Food, water, air, land, surfaces used for cooking and cleaning, etc.
  - People and animals can become sick and even die from contaminated food, land, water, and air.

- **Types of decontamination:**
  - The effectiveness of decontamination ranges from high-level sterilization to simple cleaning with soap and water. Levels of decontamination include:
  - **Cleaning**
    - Uses water, detergent, and some mechanical action such as scrubbing with a gloved hand or brush.
    - Often required *before* sterilization or disinfection of objects because it removes all material, such as soil or organic material, and reduces the number of microorganisms on an object.

  - **Sterilization**
    - Uses a physical or chemical procedure to destroy all microbial life, including highly resistant bacterial endospores.
    - "Microbe" is a general term that encompasses almost any microscopic organism, including bacteria.

  - **Disinfection**
    - Uses a liquid chemical to eliminate all pathogenic microorganisms on work surfaces and equipment.
    - Reduces the amount of contamination but does not remove all contaminants.
    - Effectiveness is influenced by the kinds and numbers of organisms, the amount of organic matter, and the object to be disinfected and chemical exposure time, temperature, and concentration.
    - Certain surfaces cannot handle harsh cleaning over and over again, so disinfection suffices.
    - Everyday surfaces are usually disinfected, which kills some bacteria and fungi while inactivating viruses.[6]

  - **Antiseptics**

[6] UC San Diego Blink. (2019, January 29). *Biosafety: Decontamination methods for laboratory use*. https://blink.ucsd.edu/safety/research-lab/biosafety/decontamination/index.html

- Uses antiseptics (anything that prevents the growth of disease-causing microbes) to eliminate the microorganisms that cause disease.
- Examples include hand washing with soap and hot water and the use of sterile equipment - gowns, masks, and gloves.
- An antimicrobial liquid is applied to skin or incision sites that are contaminated.
- Common antiseptics include alcohols (e.g., ethyl or isopropyl alcohol), and hydrogen peroxide.

- **Methods of decontamination:**
  - **Wet heat sterilization**
    - Most dependable method of sterilization.
    - Autoclaving (steam or pressure sterilization) is the most convenient method of rapidly killing all forms of microbial life.

  - **Dry heat sterilization**
    - Dry heat is less efficient than wet heat and requires longer times and/or higher temperatures to achieve sterilization.
    - Kills bacteria and spores through very high temperatures.
    - Main source of dry heat decontamination is an oven.

  - **Liquid disinfection**
    - Liquid disinfectants can be generally classified as halogens, acids, alkalis, heavy metal salts, quaternary ammonium compounds, phenolic compounds, aldehydes, ketones, alcohols, and amines.
    - Most common types of liquid disinfectants are bleach and hydrogen peroxide.
    - Bleach is commonly used to clean and disinfect kitchens and bathroom and hydrogen peroxide is used to clean cuts and sores on skins.

  - **Vapours and gases**
    - Provide excellent disinfection when used in closed systems and under controlled conditions of temperature and humidity
    - Agents include the aerosol, vapour, or gas phase of chlorine dioxide, glutaraldehyde, paraformaldehyde, ethylene oxide, peracetic acid, and hydrogen peroxide.
    - Primarily used to decontaminate biosafety cabinets, animal rooms, and their associated systems, bulky or stationary equipment not suited to liquid disinfectants, instruments or optics that might be damaged by other

decontamination methods, and rooms, buildings, and associated air-handling systems.[7]

- **Cleaning your tools after every use**
  - Essential for keeping your tools in good shape.
  - If you regularly clean and take care of your equipment, you will save yourself a lot of time and money in the future by not having to repair or spend money to replace equipment.

- **Products to clean and sanitize**
  - To sanitize means to make clean and hygienic, and to disinfect something.
  - Always make sure that the products you are using to sanitize are suitable for the surface being cleaned.
  - The best source for product use information is the manufacturer's label, but some general guidelines are:

Adapted from the Government of British Columbia's Farming, Natural Resources & Industry Webpage:[8]

Surface Material	Precautions
Stainless steel	• Use mild, non-abrasive cleaners. • Will corrode when exposed to strong alkalis, acids, or chlorine.
Galvanized metal	• Will corrode when exposed to alkaline or acidic detergents.
Nickel alloys	• Any alkali may be used.
Plastics	• In general, plastic is more corrosion-resistant than stainless steel but will deteriorate when exposed to organic solvents. • Ask for advice from the manufacturer.
Rubber	• Strong alkalis may be used. • May be damaged when exposed to acidic detergents or detergents containing organic solvents.

[7] UC San Diego Blink. (2019, January 29). *Biosafety: Decontamination methods for laboratory use*. https://blink.ucsd.edu/safety/research-lab/biosafety/decontamination/index.html

[8] Province of British Columbia. (n.d.). *Cleaning & sanitizing - 5.1 cleaning & sanitizing*. https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/food-safety/good-agricultural-practices/5-1-cleaning-sanitizing

Tin, copper	• Some alkalis can cause corrosion. • Recommended to use slightly alkaline detergents containing silicates to minimize the corrosive effect. • Exposure to chlorine will cause some corrosion.
Aluminium	• Some alkalis and acids attack aluminium. • If alkalis are used, they should have low alkalinity levels and incorporate silicates. • Do not use chlorine.
Wood	• Very porous and difficult to clean. • Clean with detergents and rinse thoroughly. • Avoid strong acids and alkalis.
Iron drains	• Use moderately alkaline cleaners because acidic ones are corrosive.
Painted surfaces	• Strong alkaline detergents will deteriorate painted surfaces.
Concrete	• Rough, porous surfaces should be given a smooth, impervious coating approved by CFIA to make them cleanable. • Use alkaline cleaners, as acid cleaners will corrode concrete floors.

- **Detergents**
  - Most common type of cleaning agent.
  - Used to break up dirt or soil, making it easy to wash it away.

- **Degreasers**
  - Sometimes known as solvent cleaners
  - Used to remove grease from surfaces, such as oven tops, counters, and grill backsplashes. Methylated spirits or white spirit were commonly used as degreasers in the past. Most businesses now try to use non-toxic, non-fuming degreasers in their operations to prevent chemical contamination.

- **Abrasives**
  - Substances or chemicals that depend on rubbing or scrubbing action to clean dirt from hard surfaces.
  - Should be used with care as they may scratch certain types of materials such as plastic or stainless steel.

- **Acids**
  - The most powerful type of cleaning agent and should be used with care.
  - If not diluted correctly, can be very poisonous and corrosive.[9]

- **Basic steps to cleaning and sanitizing:**
  1. Flush or sweep surfaces to remove soil and debris.
  2. Wash the surface with the appropriate cleaning /product.
  3. Flush the cleaner from the surface.
  4. Apply a sanitizer.
  5. Flush the sanitizer.
  6. Dry the surface or equipment.[10]

- **Care and maintenance of tools and equipment used in soil sampling:**
  - Rust is very harmful to tools. To avoid rust when storing your tools:
    - Always keep your tools in a dry place.
    - Hang your tools - If possible, build a hinged pegboard storage system for your workshop. This helps you stay organized and clean. (See image below)
    - Store power tools in their original cases.[11]

Guided Practice Activity

Topic 1.2 Task 3:

1. Read through **1.3 Key Facts** and make sure you understand the terminology used.

2. Return to **Topic 1.2 Task 2** and revise your answers according to the information provided in **1.3 Key Facts.** Share some of the changes you made.

3. With your group, read and discuss the following scenario and answer the questions:

[9] Canadian Institute of Food Safety. (2017, June 12). *4 types of cleaning agents and when to use them*. https://www.foodsafety.ca/blog/4-types-cleaning-agents-and-when-use-them
[10] Parker, A. (2007). *JIFSAN good aquacultural practices program: Effective cleaning and sanitizing procedures*. Joint Institute for Food Safety and Applied Nutrition. https://jifsan.umd.edu/files/pdf/GAqP%20Manuals/09%20GAqPs%20Manual%20CleaningSanitation.pdf
[11] Glenn, W. (2014, March 13). *How to take care of your tools*. Lifehacker. https://lifehacker.com/how-to-take-care-of-your-tools-1543310658

Claude is a new employee at Farm Tech, a company that helps farmers in rural areas. One of his first assignments is clean and organize a workshop containing soil sampling equipment he and his team will be using in the field.

a. Provide Claude some tips for how and why he should always keep the workshop organized.

b. Explain to Claude what the steps are to properly clean and sanitize equipment.

c. Claude is considering using an acid to clean the stainless-steel soil probe and hand shovels. Is this a good idea, why or why not?

4. After discussing with your group, share your responses with the rest of the class.

Application Activity

Topic 1.2 Task 4:

1. Go to the school workshop to apply what you have learned and discussed in the classroom. With your group, perform the following tasks:

a. Separate the equipment that needs to be cleaned with the equipment that does not need to be cleaned.

b. With your group, clean the dirty tools and equipment using the appropriate and available cleaning product. First discuss with your group which cleaning compounds you will use for the different equipment and then receive approval from your trainer before beginning.

c. Write a short report describing the tools and equipment your group inspected and cleaned, the cleaning products used, and the steps used in cleaning.

2. After your groups has finished, be sure to clean and organise the space appropriately before leaving. One person from each group presents your report from **part c.** Ask questions and provide feedback to other groups.

3. Listen to the trainer's observations and feedback.

Points to Remember

- Decontamination includes, cleaning, disinfecting, sterilizing, and using antiseptics.
- Clean your tools before and after every use.
- Store and organize your tools properly.
- Always use the appropriate cleaning products for the equipment material/surface.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Explain what kind of cleaners should be used for stainless steel equipment. Why?

2. Complete the following sentence:
If I clean my tools and equipment after every use, then _____.

3. Explain the importance of decontamination.

4. Answer by identifying each statement as **true** or **false**.

a. Sterilization is not a form of decontamination.

b. Methods of decontamination include, wet heat, dry heat, liquid disinfection, and vapors and gases.

c. Rust can be good for your tools.

d. Hanging your tools is not a good strategy for staying organized.

Topic 1.3: Adjustment of tools and equipment for sampling

Key Competencies:

Knowledge	Skills	Attitudes
1. List the causes of malfunctioning tools and equipment	**1.** Separate tools and equipment in good working condition from those in bad working condition	**1.** Team spirit
2. Identify causes of malfunctioning tools and equipment	**2.** Take care of tools and equipment used in soil sampling	**2.** Analytical
3. List the adjustment guidelines for tools and equipment	**3.** Perform minor adjustments of tools and equipment used in soil sampling	**3.** Careful

Getting Started: What do we know and where are we going?

Topic 1.3 Task 1:

1. Brainstorm and discuss responses with your partner about the following questions:
   a. What does it mean to **adjust** something?

   b. How do you know if it is ok to use a piece of equipment or not? What should you look for?

2. Discuss your responses with the rest of the class. Share your ideas.

3. Look at the Key Competencies table and identify the knowledge, skills, and attitudes you will gain by the end of this topic.

Problem Solving Activity

Topic 1.3 Task 2:

1. Read the following scenario and questions. Based on what you know at this time, brainstorm and write your answers to the following questions.

Ganza wants to collect a soil sample using sampling tools and equipment. In the workshop, however, he realized that among the available tools and equipment, there are some that are in good working condition and others that are in bad condition. He decides to sort the tools into two sections: **ready to use** and **need adjustments before using**.

a. With your groups, discuss and write what Ganza should be looking for when sorting the tools and equipment.

b. Discuss and explain: What could cause different tools and equipment to need servicing, cleaning, and adjusting before using?

2. Volunteer to share and discuss your ideas with the rest of the class.

3. Note that after discussing **1.4 Key Facts**, you will return to this activity to revise your responses.

1.4 Key Facts

- **Causes of malfunctioning or problems with tools, material, and equipment:**
  - Loose connections/bolts/screws/gears/joints
  - Dust
  - Moisture or high humidity
  - Supply line surges (electrical problems)
  - Insulation deterioration
  - Overload conditions
  - Cracked or splintered handles
  - Corroded tools/equipment (rust)
  - Over-seizing: connections lock up and become stiff

- Natural aging (wear and tear) of tools /equipment from frequent use
- Cracked or damaged housing on power tools

- **Possible handling practices on faults:**
  - Sharpening blades
  - Removing rust
  - Fixing broken or splintered handles

- **Adjustment techniques and procedures:**
  - **Inspect your tools every time you use them**
    - One of the most important things you can do to ensure your safety and the longevity of your tools
    - Overtime, this helps you save money by not having to replace your equipment.
  - **Loose, cracked, or splintered handles**
    - If a wooden handle is damaged, it is likely to breaking during use, which can cause injury to you or others.
    - If a handle is not splintered too badly, you can probably sand it down using rough/coarse sandpaper. Sand against the grain first if the handle is rough and then sand with the grain until it's smooth enough for you to move your hand along it without feeling any chips or splinters. Finish off with a coating of linseed oil.
    - If the handle is cracked or heavily splintered, you need to replace it.
  - **Keeping your tools sharpened**
    - Sharpen blades whenever you notice they are becoming dull (not sharp).
    - Also, plan to sharpen them every six months as a habit to prevent them from losing their edge (becoming dull/not sharp).
  - **Corrosion and rust**
    - Depending on the level of corrosion or rust, the tool may be unsafe to use.
    - Try removing the rust yourself or just replacing the tool.
    - To remove rust from small items like knives and hand tools, soak them in a bowl of vinegar. Let them sit overnight. Remove the item and scrub with a metal brush or steel wool. Rinse with clean water and dry with a towel. You can also purchase specific cleaners to remove rust.[12]

[12] HGTV. (n.d.). *How to clean rust*. https://www.hgtv.com/lifestyle/clean-and-organize/how-to-clean-rust

- **Cracked housing on power tools**
  - If a power/electric tool has anything more than a simple hairline (very thin) crack on the housing, don't use it.
  - Get it repaired by a professional.[13]

Guided Practice Activity

Topic 1.3 Task 3:

1. Read through all of **1.4 Key Facts** with the trainees. Ask questions and discuss the content in **1.4 Key Facts**.

2. After reading and discussing **1.4 Key Facts**, check your answers from the first two activities **(Topic 1.3 Tasks 1 and 2)** with the information provided in the **1.4 Key Facts**.

3. Share the correct answers the questions from **Topic 1.3 Task 2** according to the information in **1.4 Key Facts:**
   a. With your groups, discuss and write what Ganza should be looking for when sorting the tools and equipment.

   b. Discuss and explain what could cause different tools and equipment to need servicing, cleaning, and adjusting before using.

4. Now, form groups of three and take a square of sandpaper, a wooden handle/pole/small board of wood, and some linseed oil for polishing the wood after repairing.

5. Observe the trainer model how to properly inspect a tool, adjust/fix it, and polish it.

6. Inspect your given piece of wood/wood handle and ensure that it has no harmful cracks or splinters for anyone who will be touching it.

7. In your own words, write an explanation of this process. What specifically are you doing and why?

[13] SoilWorx. (n.d.). *Basic tool maintenance*. https://www.soilworx.com.au/blog/inspiration/basic-tool-maintenance

8. Come together to discuss the process and share your written explanations of the process in your own words. Listen to the trainer's observations and feedback.

Application Activity

Topic 1.3 Task 4:

1. Visit the school workshop or observe the tools and equipment in the classroom.

2. Take an inventory of the equipment and tools to be serviced and adjusted before use in the field. Carefully observe surroundings and fill out the following table.

Adjustment Inventory Checklist:			
Type of tool/equipment	**Adjustment/ repair needed before use**	**Reason for adjustment/ repair?**	**Technique or procedure to be done**
***Example**: Machete*	*Remove rust and sharpen blade*	*Corrosion/Rust and dull blade (not sharp)*	*Soak blade overnight in compound to remove rust and then scrub with a metal brush or pad. Dry and store blade in an area with no moisture/humidity. Sharpen blade.*

Points to Remember

- Causes of malfunctioning of tools material and equipment include loose connections, dust, moisture or high humidity, overloaded conditions, cracked housing, and corrosion and rust.

- Inspect and repair your tools every time you use them.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. What are five causes of malfunctioning equipment?
   1.
   2.
   3.
   4.
   5.

2. Why is it important to inspect equipment before using it?

Complete the following sentences:

3. If a wooden handle is damaged, you should _____ .

4. If your power tools are damaged, you should _____ .

5. Answer by identifying each statement as **true** or **false**:
   a. A dull blade is perfectly safe to use.

   b. Rust can be scrubbed off with the correct cleaning compound.

   c. Overtime, tools and equipment will naturally break down and fall apart.

Topic 1.4: Collection of soil samples for laboratory testing

Key Competencies:

Knowledge	Skills	Attitudes
1. Describe soil sampling methods	**1.** Apply soil sampling methods	**1.** Team spirit
2. List sampling strategies	**2.** Apply soil sampling procedures	**2.** Analytical
3. Explain soil sampling guidelines	**3.** Collect soil samples	**3.** Careful

Getting Started: What do we know and where are we going?

Topic 1.4 Task 1:

1. Brainstorm responses to the following questions with your class:

a. What do you think the importance is of soil sampling?

b. Under what circumstances would you need to test the soil of a location?

2. Look at the Key Competencies table above and consider the knowledge, skills, and attitudes you will gain from this topic.

Problem Solving Activity

Topic 1.4 Task 2:

1. Read the scenario with a partner:

Agricultural production takes place on many different types of soil. When cultivating season after season, the soil begins to lose some of its fertility and crop production decreases. As a result, it is advised to analyse the soil in order to see what is in the soil and what to incorporate so that production can be increased.

a. What do you think are the factors that cause a soil to lose its fertility and cause crop production to decrease overtime?

b. Based on what you know, how do you think you can prevent or save the soil from losing its productivity?

2. Even though you may not know all of the answers, share your ideas with your partner. Offer to present some of your responses to the class.

3. You will return to this activity after discussing **1.5 Key Facts** to revise your answers.

1.6 Key Facts

- **Soil sampling and testing:**
  - Provides an estimate of the capacity of the soil to supply enough nutrients to meet the needs of growing crops.
  - Test results are compared to standard response data to estimate the need to supply more nutrients for the best crop production.

- **Soil sampling procedure:**
  - Collect samples using specified tools and equipment that follow sampling requirements.
  - Avoid taking samples from areas such as lime piles, fertilizer spills, ant hills, gate areas, livestock congregation areas, poorly drained areas, dead furrows, fertilizer bands, old fence rows, or any other unusual areas. Sampling from these areas will not produce accurate results because of a possible concentration of components previously used at that site (fertilizer, animal waste, sewage, drainage, etc.).
  - Place the soil cores in a bucket and mix thoroughly. A soil core is an individual sample collected at one spot in a field.
  - Label the sample bag carefully with your company name, farm name, field name, sample depth and date, and what crop is to be grown there.[14]

- **Sampling guidelines for any soil sampling method:**
  1. Take 15 to 20 cores (small samples) for each representative bulk sample.

[14] Crop Nutrition Laboratory Services Ltd. (n.d.). *How to take a soil sample for field crops*. https://cropnuts.helpscoutdocs.com/article/879-soil-sampling-for-nutrient-analysis-of-field-crops

2. Segment each core into lengths that represent depths of 0 to 15 cm, 15 to 30 cm, and 30 to 60 cm.
3. Separate the segmented cores by depth into clean, labelled plastic pails. Thoroughly mix the content of each pail and crush any lumps. Avoid using metal pails to collect samples because they can alter the results of micronutrient tests.
4. Take a single sub-sample (0.5 kg) for each sampling depth and submit for analysis.[15]

- **Sampling tips**
  - For hilly fields with knolls, slopes, or depressions, take samples from mid-slope positions to get a representative sample of the field average.
  - Avoid sampling saline areas, eroded knolls, old manure piles, burn piles, haystacks, corrals, fence rows, old farmsteads, or any other unusual areas.
  - Soils within 15 m of field borders or shelterbelts and within 50 m of built-up roads should be avoided or sampled separately.
  - Always sample before manure or fertilizer application.[16]

- **Soil sampling methods:**
  - **Random:**
    - Avoid unusual areas or sample these areas separately.
    - Does not determine what nutrient variability exists in the field.
    - Suitable for uniform fields.
    - One sample is produced by 20 cores composited.
    - Collect in a zig-zag pattern across the field.

  - **Benchmark Sampling:**
    - Involves sampling a one to two-acre area representative of the majority of the field or zone.
    - Sample the same area each year.
    - When a field is has different types soil or topography, three or more benchmark locations may be needed to represent the different field areas.
    - Use your personal field knowledge and observations of crop growth differences (crop establishment, vigour, colour and growth) and topography of each field to identify where different soil types occur.

[15] Government of Alberta. (n.d.). *Chapter 3.3: Soil sampling*. https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw11920/$file/3-3.pdf
[16] Government of Alberta. (n.d.). *Chapter 3.3: Soil sampling*. https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw11920/$file/3-3.pdf

- **Grid Sampling:**
  - Involves taking a single soil sample at each point of a grid (or other pattern) across a field and creating one composite soil sample.
  - A single fertilizer recommendation per nutrient is made for the whole field.[17]

- **Sampling depth:**
  - It is recommended that samples be taken from the following depths to get the best estimate of soil nutrient levels to optimize nutrient management:
    - 0 to 15 cm
    - 15 to 30 cm
    - 30 to 60 cm

- **Soil fertility:**
  - Soils lose fertility when the qualities that support plant growth and soil health are decreased:
  - **Loss of plant nutrients**
    - Nutrients are naturally lost when plants are harvested and removed.
    - They are also lost when soil erodes or when water leaches nutrients through the soil.
    - To minimize nutrient loss, use effective erosion control practices, and capture nutrients with the use of cover crops before and after the main crop.
  - **Loss of organic matter**
    - Organic matter gives many benefits to topsoil, including increasing water-holding capacity, maintaining soil structure, holding nutrients until needed by plants, and increasing permeability to rainfall.
    - Return crop residues to the soil and use cover crops to generate additional plant matter.
  - **Loss of soil structure**
    - To maintain soil structure, keep adequate levels of organic matter in the topsoil and take measures to prevent soil compaction by farm or construction equipment.

[17] McKenzie, R. (2015, October 6). *Soil sampling and soil testing*. Grain news. https://www.grainews.ca/columns/soil-sampling-and-soil-testing/?utm_source=FBC%20Publications&utm_campaign=a7441e9701-Grainews%20daily%20enews%20Oct%2007%2C%202015&utm_medium=email&utm_term=0_2da8244677-a7441e9701-88089737

Guided Practice Activity

Topic 1.4 Task 3:

1. First, read through **1.5 Key Facts**, pausing after each one to make sure you understand the terminology.

2. Return to your answers from **Topic 1.4 Task 2** and revise your answers based on the information provided in **1.5 Key Facts.**

   a. What do you think are the factors that cause a soil to lose its fertility and cause crop production to decrease overtime?

   b. Based on what you know, how do you think you can prevent or save the soil from losing its productivity?

3. Share your revised answers with the class.

4. Now, form groups of 4-5 people and read the scenario and questions:

   Imogene is a new farmer in Rulindo. She was advised by the Rwandan Agricultural Board take several samples of her soil and have it analysed. Imogene walks outside with a hand shovel and three plastic cups. In one cup, she takes a scoop of topsoil off the surface by her goat shelter. In the second cup, she takes another sample from the middle of her crop field. Her last sample is taken right outside of her door by her wash basin.

   a. What errors did Imogene make in collecting her soil samples?

   b. Which method did she use for collecting soil samples? How do you know?

   c. Provide Imogene with one piece of advice for next time.

5. When all groups are finished discussing and recording their answers, volunteer to share your group's answers. Ask questions and listen to the trainer's feedback.

Application Activity

Topic 1.4 Task 4:

1. The school, in collaboration with the farmers in the surrounding area, wants to test the soil in a nearby field in order to begin cultivating soon.

2. Visit a nearby field outside of the school. Separate into groups of five and take the tools and equipment needed to collect soil samples from the field.

3. Choose a sampling method and justify why your group chose that method.

4. Using the process and guidelines from **1.5 Key Facts** on hand for reference, practice collecting soil samples.

5. At the end of the activity, come together and share your group's method and any challenges you encountered during the activity.

Points to Remember

- Proper depths for collecting soil samples:
  - 0 to 15 cm
  - 15 to 30 cm
  - 30 to 60 cm

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Why should you avoid taking samples from areas such as lime piles, fertilizer spills, ant hills, gate areas, livestock congregation areas, poorly drained areas, dead furrows, fertilizer bands, old fence rows, or any other unusual areas?

2. What is one way that soil loses its' fertility overtime?

3. Answer by identifying each statement as either **true** or **false:**
   - **a.** The first sample should be taken from the surface of the soil.
   - **b.** When a field has different types of soil or topography, more benchmark locations may be needed for sampling.
   - **c.** Random sampling is not suitable for uniform fields.

4. What is a soil core?

5. Circle the correct answer.
   Before collecting a soil sample, you should:
   - **a.** apply fertilizer
   - **b.** compact the soil
   - **c.** plant crops
   - **d.** none of the above

Topic 1.5: Handling soil samples

Key Competencies:

Knowledge	Skills	Attitudes
1. Describe moist soil sample handling procedures	**1.** Handle moist soil samples.	**1.** Analytical
2. List soil packaging requirements	**2.** Pack soil samples	**2.** Careful
3. Explain soil shipping requirements	**3.** Ship/transport soil samples	**3.** Team spirit

Getting Started: What do we know and where are we going?

Topic 1.5 Task 1:

1. On opposite sides of your classroom, there are two signs: AGREE and DISAGREE. When your trainer reads the following statements out loud, discuss with your colleagues whether you agree or disagree with the statement and then walk to one side of the classroom. Use the information you know to make an educated guess.

a. Soil samples should be sent to a laboratory within 4 hours of collecting it.

b. If soil cannot be sent to the lab within 48 hours, dry the soil in an oven at a high temperature to kill any microbes.

c. Labelling the box or bag of the soil sample is part of the process.

2. Look at the Key Competencies table and note the knowledge, skills, and attitudes you will gain during this topic.

Problem Solving Activity

Topic 1.5 Task 2:

1. Observe the three signs in different areas of the classroom: Handling, Drying, and Shipping.

2. Form small groups of five people.

3. You will receive a card that has a key fact written on it. The card corresponds to one of the three main categories on the signs around the room. Your task is to put each card under the appropriate category.

4. Spend five minutes in your group sharing, reading, and discussing your fact cards to determine the category they belong to.

5. Then, walk around the room and place your card where you think it should go. Once your card is placed, stand near it in that area of the room.

6. When everyone has placed their cards in the right place, explain why you placed that fact with that category.

7. After the class discusses **1.6 Key Facts**, you will have a chance to revise your knowledge from this activity.

1.6 Key Facts

- **Handling moist samples**
  - Must properly handle soil samples before analysis to ensure reliable test results.
  - If possible, moist (wet) samples should be delivered to the laboratory on the day they are collected.
  - If this is not possible, samples can be refrigerated for a couple of days or frozen for a longer period.
    - Refrigerating or freezing the samples stops microbial activity.
    - Microbial activity could result in nutrient transformations and affects the results of the analysis.
  - Ensure moist samples spend no more than two days in transit.

- **Drying samples prior to shipping**
  - Air dry samples if they cannot be sent to the laboratory immediately.
  - Spread out each soil sample on a clean surface (aluminium pans, plastic trays).
  - Allow the sample to completely air dry at a temperature no more than 30°C.
    - If desired, a fan may be used to ensure constant airflow over samples to enhance drying.
    - Do not dry in an oven, microwave or at a high temperature. This can change the levels of some nutrients, invalidating test results, and fertilizer recommendations.

- **Shipping samples**
  - Fill the soil sample bags or cartons with 0.5 kg of soil.
  - Label each container with the information specified by the testing facility including the date of sampling, field number, contact name, and sample depth.
  - Complete an information sheet on cropping and fertilizer history. Note in detail where unusual problems exist.
  - Ensure that samples do not become contaminated with anything that might invalidate test results (such as fertilizers).[18]

- **Submitting information with samples**
  - **Importance:** Puts soil analysis results in context and leads to relevant fertility recommendations.
  - **Legal land description or location:**
    - Used to make assumptions about precipitation (rain), soil zone, organic matter content, and length of the growing season.
    - Used to identify samples sent for analysis and for field records.
  - **Planned crop rotation:**
    - Used to determine fertility and nutrient requirements, which should be based on provincial yield response curves.
    - Will have implications for nutrient management due to differences in crop nutrient demand.
    - Fertility recommendations based on test results can be developed for several different crops.

[18] Government of Alberta. (n.d.). *Chapter 3.3: Soil sampling*. https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw11920/$file/3-3.pdf

- Economics can then be factored into decision making based on recommendations.[19]

Guided Practice Activity

Topic 1.5 Task 3:

1. Before the next activity, separate into three groups. Your group will be assigned a section of **1.6 Key Facts** to read aloud (handling, drying, or shipping).

2. After each section, pause make sure you understand the terminology used.

3. Walk around the room and check that the appropriate fact cards are with the correct category signs from **Topic 1.5 Task 2**. Use the information provided to them in **1.6 Key Facts** to verify your answers.

4. After five to ten minutes of revising your knowledge from the last task, someone from the **handling** group reads a key fact card placed there. Then, someone from the **shipping** group reads a key fact from the shipping category. Repeat this for once more for the **drying** category and verify that all cards are placed in the correct category.

5. For the next part, form groups of three people. Discuss, and answer the following scenario and questions with your group:

Egide is a farmer in Huye. He is collecting soil samples to send for analysis. He properly collected a moist soil sample on Monday using the benchmark method of collection and stored it on a table inside of his home. On Thursday, he sent his sample to Kigali for analysis. Before he sent it, he labelled each container with the information specified by the testing facility including the date of sampling, field number, contact name and sample depth.

a. What mistakes did Egide make?

b. What did Egide do correctly?

[19] Government of Alberta. (n.d.). *Chapter 3.3: Soil sampling*. https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw11920/$file/3-3.pdf

c. What advice can you offer Egide about this process for next time?

6. Afterwards, share your responses.

Application Activity

Topic 1.5 Task 4:

1. Work with the person sitting next to you.

2. Analyse some packed soil samples before transportation using the information below:

Sample 1:

- Collected more than two days ago
- Not refrigerated
- Dried in oven
- Carton is labelled with the date, contact, location, depth of soil

Sample 2:

- Collected three days ago
- Dried in room at 35 degrees Celsius
- Carton contains residue from a previous soil sample
- Carton is labelled with the date

3. For each sample, answer the following questions:

a. Are the soil samples ready for transporting? Why or why not?

b. Explain to the sample collector why it is essential for him/her to carefully and correctly follow each step of the soil collecting and handling process.

4. At the end of the activity, share your answers with the class and provide observations and feedback to others.

Points to Remember

- To dry samples prior to shipping, spread out each soil sample on a clean surface and allow the sample to completely air dry at a temperature no more than 30°C. Do not dry in an oven, microwave, or at a high temperature.
- When shipping samples, be sure to fill the soil sample bags or cartons with 0.5 kg of soil and label each container with the information specified by the testing facility including the date, soil depth, contact and location.
- Remember to note in detail where unusual problems exist.
- Ensure that samples do not become contaminated with anything that might invalidate test results (e.g., fertilizer).

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Answer by identifying each statement as either **true** or **false:**

a. Soil samples should always be accompanied by information about the site, cropping expectations, and management.

b. Moist samples should not spend more than two days in transit.

c. Crop rotation does not have an effect on soil nutrients.

2. Why shouldn't you dry soil samples in an oven or a microwave?

3. Explain what the freezing or refrigeration process does to a soil sample.

4. Complete the following sentences:

a. Fill the soil sample bags or cartons with _____ of soil.

b. Proper handling of soil samples before analysis will _____.

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the Knowledge, Skill or Attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Explain the importance of soil sampling					
State the general requirements for equipment, tools, and material for reliable soil sampling					
Choose appropriate soil sampling equipment, tools, and material					
Describe decontamination methods for equipment and tools					
Disinfect and sterilize equipment, tools, and materials for soil sampling					
Identify causes of malfunctioning of tools and equipment					
Follow adjustment guidelines to perform minor adjustments on tools and equipment					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Describe soil sampling methods					
Collect soil for laboratory testing					
Handle moist soil samples following the requirements					
Explain soil shipping requirements					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace.

Areas of strength	Areas for improvement	Actions to be taken to improve
1. **2.**	**1.** **2.**	**1.** **2.**

Unit 2: Assistance in preparing soil samples for laboratory testing


LABORATORY

Topics

2.1 Selection of laboratory soil protocols and procedures

2.2 Preparation of soil samples

2.3 Application of laboratory analyser recommendations

Unit Summary:

This unit describes the knowledge, skills, and attitudes that will help trainees select laboratory soil protocols and procedures, prepare soil samples, and apply laboratory analyser recommendations**.**

Self-Assessment: Unit 2

1. Look at the illustration. What do you see? What do you think this unit will be about? What topics might be covered?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this survey. It is for your own use during this course. The trainer will read a skill that is listed in the left column. Think about yourself: Do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, we'll take this survey again.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Identify soil sample preparation procedures					
Follow soil sample preparation protocol					
Follow soil sample preparation procedures					
Follow soil sample drying, crushing, mortaring, weighing, and sieving guidelines					
Perform drying, crushing, mortaring, weighing, and sieving processes to soil samples					
Explain soil sample packing requirements					
Read information in soil analysis report					
State normal range of soil parameters					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Follow guidelines in soil analyser recommendations					

Topic 2.1: Selection of laboratory soil protocols and procedures

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain soil sample preparation protocols	**1.** Select soil sample preparation procedures	**1.** Team spirit
2. State soil sample preparation procedures	**2.** Follow soil laboratory protocols	**2.** Analytical
3. Explain soil sample preparation practices	**3.** Follow soil sample preparation protocol	**3.** Honest

Getting Started: What do we know and where are we going?

Topic 2.1 Task 1:

1. Give examples of when you have had to follow a protocol or procedure.

2. Next, define the following terms:

a. Protocol

b. Procedure

3. Read the Key Competencies table to review what knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 2.1 Task 2:

1. Form groups of five people.

2. Read the following instructions and questions:

   Based on what you learned from Unit 1, what are some of the essential ways to collect and prepare soil samples for transport before you send them to a laboratory? Make a list of facts that will help the class review together.

3. Try to brainstorm at least five things to review from Learning Unit 1 that relates to this topic.

4. Share what your group discussed and wrote down. The trainer will write your ideas on the board/flipchart for the class to see.

2.1 Key Facts

- **Terms and definitions:**
  - **Procedure**: A set of written directions that explain how to apply a method to a particular sample, including information on obtaining samples, handling interferents, and validating results.
    - An interferent is any substance whose presence interferes with an analytical procedure and generates incorrect results.
  - **Method:** May have several procedures as each analyst or agency adapts it to a specific need.
  - **Protocol**: A set of strict guidelines specifying a procedure that must be followed if an agency is to accept the results. Protocols are rules and regulations.

- **Sampling procedures:**
  - Collect sample using specified tools and equipment that meet sampling requirements.
  - Avoid taking samples from areas such as lime piles, fertilizer spills, ant hills, gate areas, livestock congregation areas, poorly drained areas, dead furrows, fertilizer bands, old fence rows, or any other unusual areas. These substances and materials can act as interferents and mess up the results of the soils analysis.

- Put the soil cores in a bucket and mix thoroughly.
- Label the sample bag carefully with your company name, farm name, field name, sample depth and date, and crop to be grown.[20]

- **Drying samples prior to shipping:**
  - Spread out each soil sample on a clean surface (such as aluminium pans or plastic trays).
  - Allow the sample to completely air dry at a temperature no more than 30°C.
  - Do not dry in an oven, microwave or at a high temperature.

- **Shipping samples:**
  - Fill the soil sample bags or cartons with 0.5 kg of soil.
  - Label each container with the information specified by the testing facility including the date, soil depth, contact and location.
  - Complete an information sheet on cropping and fertilizer history as required.
  - Note in detail where unusual problems exist.
  - Ensure that samples do not become contaminated with anything that might invalidate test results (e.g., fertilizer).[21]

- **Information to submit with samples**
  - The site, cropping expectations, and management.
  - Puts soil analysis results in context and lead to relevant fertility recommendations.
  - Included information:
    - **Legal land description or location**: Used to make assumptions about precipitation (rain), soil zone, organic matter content (manure, compost, etc.), and length of the growing season; used to identify samples sent for analysis and for field records.
    - **Planned crop rotation**: Used to determine fertility and nutrient requirements, which should be based on provincial yield response curves.[22]

[20] Crop Nutrition Laboratory Services Ltd. (n.d.). *How to take a soil sample for field crops*. https://cropnuts.helpscoutdocs.com/article/879-soil-sampling-for-nutrient-analysis-of-field-crops
[21] Government of Alberta. (n.d.). *Chapter 3.3: Soil sampling*. https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw11920/$file/3-3.pdf
[22] Government of Alberta. (n.d.). *Chapter 3.3: Soil sampling*. https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw11920/$file/3-3.pdf

- **Other points:**
  - Be sure to take the sample when the soil is dry.
  - Wet soil can give a false test reading. You may want to check your soil more than once to verify your results.

- **Example of soil sampling protocol for soil organic matter analysis**
  - **What do I need?** Be sure to bring materials with you when heading to the field for soil sampling.
    1. Clean plastic buckets (one for soil sample and one for supplies)
    2. Soil sample bags: one-gallon freezer storage bags (or soil sample bags); one bag per sample
    3. One clipboard and papers for recording
    4. Permanent marker and/or pen
    5. A straight shovel (sharpshooter or drain spade style) or a soil probe

  - **When do I take samples?** Do not take samples immediately after heavy rainfall or irrigation events, or after applications of manure or compost.

  - **Where do I sample?** All soil samples should come from the same uniform soil, as well as uniform management history and yields as determined by the producer.[23]

Guided Practice Activity

Topic 2.1 Task 3:

1. Read through **2.1 Key Facts** and make sure you understand the terminology used.

2. Separate into groups of four and watch the following video that presents a farmer demonstrating some of the procedures and best practices of soil sampling:
   a. https://www.youtube.com/watch?v=--fdaGmYwEw (Search YouTube: Soil Sample Guidelines)

[23] California Department of Food and Agriculture. (n.d.). *Soil sampling protocol for soil organic matter analysis*. https://www.cdfa.ca.gov/oefi/healthysoils/docs/2018-HSPIncentives_SoilSampling.pdf

3. You will watch the video three times. For the first time, just watch and listen (no writing). On the second viewing, watch and listen to answer the questions below. The third viewing will be a chance to get any other information that you missed.

4. With your group, answer the following questions:
   a. According to the Soil Sampling Guidelines video, what is the first thing you need to decide before sampling?

   b. How many soil cores does the farmer in the Soil Sampling Guidelines video recommend taking?

   c. What are two essential pieces of information that were not in the video?

   d. What the most important piece of information presented in the video? Explain why.

5. Present an answer to one of the four questions from the task. Ask questions and give feedback to other groups.

Application Activity

Topic 2.1 Task 4:

1. Visit a nearby field to practice collecting soil samples and take the proper tools and materials.

2. Form groups of 4-5 people.

3. Prepare soil samples using the information provided in **2.1 Key Facts.** The trainer will walk around and observe as you collect samples. You are expected to explain the process as you conduct it.

   Note: You could demonstrate to the class how to collect soil samples first if they are not able to do it easily.

4. Now, collect samples as practice using the information from **2.1 Key Facts** - **sampling procedures** and **shipping samples.**

5. After collecting samples, prepare and demonstrate the process as detailed in the **shipping samples** section of **2.1 Key Facts**.

6. At the end of the activity, come together and present the information your group wrote on the bag, according to proper procedures.

7. Listen to the trainer's observations and feedback.

Points to Remember

- The content of the protocol specifies the guidelines of a procedure/method.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Identify each statement as either **true** or **false**:
   a. When taking a soil sample, you should avoid taking samples from areas such as lime piles, fertilizer spills, ant hills, poorly drained areas, fertilizer bands, or any other unusual areas.

   b. Soil samples do not always have to be accompanied by information about the site, cropping expectations and management.

   c. Label the sample bag carefully with your company name, farm name, field name, sample depth and date, and crop to be grown.

   d. Wet soil gives the most accurate reading/results.

2. What is the difference between procedure and protocol?

3. When is it NOT recommended to take a sample?

4. Give an example of an interferent in a soil sample and explain why it is considered an interferent.

Topic 2.2: Preparation of soil samples

Key Competencies:

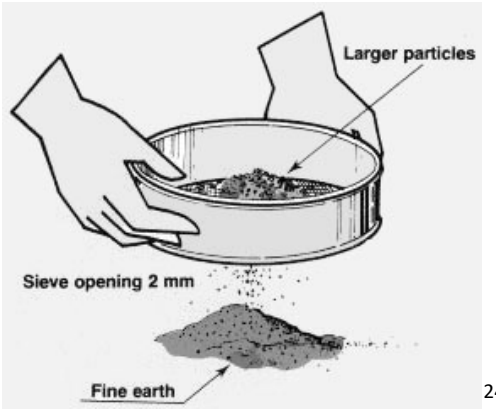
Knowledge	Skills	Attitudes
1. Explain soil sample drying guidelines	**1.** Dry moist samples	**1.** Team spirit
2. Explain soil sample preparation guidelines	**2.** Sieve soil samples	**2.** Analytical
3. Explain soil sample packing requirements	**3.** Pack soil samples	**3.** Accurate

Getting Started: What do we know and where are we going?

Topic 2.2 Task 1:

1. Look at pictures A, B, C, D, and E below and identify the items and actions with a partner. Use what you already know about soil sampling to make your predictions.

A.



[24] **B.**

[25]

[24] User: MerileyR. (2020, May 6). *GR000083* [Diagram]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:GR000083.jpg
License: https://creativecommons.org/licenses/by-sa/4.0/legalcode

[25] CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). (2016, May). *Drying soil and plant samples at farmer's place_1* [Photograph].
Flickr. https://www.flickr.com/photos/cgiarclimate/27276509950/
License: https://creativecommons.org/licenses/by-nc-sa/2.0/legalcode

C.  [26]

2. Verify your answers with the trainer and look to the Key Competencies table to review the knowledge, skills, and attitudes you will learn in this topic. This topic will build on content you learned in Unit 1.

Problem Solving Activity

Topic 2.2 Task 2:

1. Now that you know the correct items and actions from the pictures in **Topic 2.2 Task 1**, form groups of five people and answer the questions from **Topic 2.2 Task 2:**

a. Why do you think it is important to sieve/filter a soil sample?

b. What purpose of drying have in preparing a soil sample?

c. Why do you need to weigh the soil sample when preparing it?

d. Why do you think it is important to mortar/crush/grind a soil sample?

e. Why do you think it is important to mortar/crush/grind a soil sample?

[26] Wessex Archaeology. (2005, January 13). *Weighing sample* [Photograph]. Flickr. https://www.flickr.com/photos/wessexarchaeology/298018312
License: https://creativecommons.org/licenses/by-nc-sa/2.0/legalcode

2. Each group member should have one question to answer. Discuss these questions and use the knowledge you have previously learned.

3. Present your answers.

4. Listen to the trainer's observations and feedback.

5. You will return to this activity to revise your answers after discussing **2.2 Key Facts**.

2.2 Key Facts

- **Sieving**:
  - **Sieve**: a device made of a wire or plastic mesh held in a frame
  - Used for straining solids from liquids, for separating coarser from finer particles, or for reducing soft solids to a pulp.
  - Used to assess the size of the particles (or gradation) of a soil by letting the material pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is stopped by each sieve.[27]
  - Used to separate soil particles and group them based on their size. This test is used for the purpose of classification of soil.

- **Weighing:**
  - Generally, desired amount is 1-1.5 cups of soil, but depends on the type of soil.
  - Too much soil can result in some soil being discarded because there simply is too much. This can cause issues, especially if the sample is a composite sample made up of several soil types and/or different topography.[28]

- **Drying:**
  - If samples cannot be sent to the laboratory immediately, they can be air dried at a temperature no more than 30°C until constant mass has been achieved.
  - Temperatures above 65 ° C can activate carbon oxidation.
  - Each soil sample must be dried separately.
  - Drying helps preserve the sample.

[27] Wikipedia. (n.d.). *Sieve analysis*. Retrieved 2020, from https://en.wikipedia.org/wiki/Sieve_analysis#:~:text=A%20sieve%20analysis%20(or%20gradation,and%20weighing%20the%20amount%20of

[28] Midwest Laboratories. (n.d.). *How much soil should you send to the laboratory for testing?*. https://midwestlabs.com/2013/10/21/how-much-soil-should-you-send-to-the-laboratory-for-testing/

- **Mortaring**:
  - The process of crushing and mixing the soil either by hand or with a machine.
  - Aggregates (combined lumps/big pieces of compacted soil) within the soil must be crushed and broken up. This helps keep the soil uniform and facilitates the process of sieving.
  - If you are crushing soil by hand, it can be placed into cloth bags or sturdy plastic bags to minimise spillage during manual crushing.[29]

Guided Practice Activity

Topic 2.2 Task 3:

1. Before the next activity, read through each section of **2.2 Key Facts** and make sure you understand the terminology used.

2. Next, go back to **Task 2** to revise your answers from **Question 1**. Share your revised answers to the questions using the information provided in **2.2 Key Facts**.

3. Watch the following videos to enhance your understanding of the material.

a. https://www.youtube.com/watch?v=Al1v-jARhLM (Search YouTube: Soil Sample Preparation)

b. https://www.youtube.com/watch?v=jQTOCfFbDUQ (Search YouTube: Soil Sample Processing: Sieving)

4. Now, separate into groups of four people and read the following scenario:

Your school wants to provide a training on how to prepare soil samples. Your class has been asked to prepare training materials that must include illustrations and explanations of each process detailed in **2.2 Key Facts.**

[29] Department of Agriculture, Water and the Environment, Australian Government. (2014, June 30). *Carbon farming initiative: Soil sampling and analysis method and guidelines*. https://www.environment.gov.au/system/files/pages/b341ae7a-5ddf-4725-a3fe-1b17ead2fa8a/files/cfi-soil-sampling-and-analysis-method-and-guidelines.pdf

5. Each group member is responsible for one of the sections of **2.2 Key Facts**. You must create an illustration of the process and write an explanation of it in your own words. You must not copy the exact words from **2.2 Key Facts**.

6. Present your materials to help train others at your school. Ask questions and provide feedback to each other.

Application Activity

Topic 2.2 Task 4:

1. Separate into groups of four people and receive the necessary items to prepare the soil samples: collected soil on drying trays, sieves, weighing devices, hammer/crushing device, bags for packaging.

2. Read the following scenario:

   With your group, practice crushing, sieving, weighing, and packaging soils samples that have already been dried. Be prepared to demonstrate this process to your trainer as well as the class. For this practice application, you will not have time to properly dry the soils.

3. At the end of the activity, volunteer to demonstrate certain parts of the process (weighing, sieving, crushing, etc.) to the class.

Points to Remember

- If samples cannot be sent to the laboratory immediately, they can be air dried at a temperature no more than 30°C.

- Always label soil samples before shipping.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Identify the following statements as either **true** or **false**:

a. Soil samples should be dried in direct sunlight until constant mass has been achieved.

b. The drying temperatures above 65 ° C can activate carbon oxidation.

c. All soil samples must be dried together to achieve good results

2. What is the purpose of mortaring?

3. What is a sieve and what role does it have in soil sample preparation?

Topic 2.3: Application of laboratory analyser recommendations

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain Information in a soil analysis report	**1.** Interpret a soil analysis report	**1.** Analytical
2. State normal range of soil analysis parameters	**2.** Apply soil analysis recommendations	**2.** Teamwork spirit
3. Explain guidelines in soil analysis recommendations	**3.** Apply laboratory analyser recommendations	**3.** Careful

Getting Started: What do we know and where are we going?

Topic 2.3 Task 1:

1. Turn and talk with a partner about the following terminology. Based on what you have learned about collecting and preparing soil samples, what do you think these terms mean and how do they relate to soil analysis?

- pH
- Acidity
- Nutrients
- Lime
- Fertilizer

2. After discussing with your partner, participate in a class discussion about the terms.

3. Observe the brainstormed ideas on the board/flipchart.

4. Look to the Key Competencies table to learn the knowledge, skills, and attitudes you will gain by the end of this topic.

Problem Solving Activity

Topic 2.3 Task 2:

1. Read the scenario and respond to the following questions with a partner:

Fabrice is a new farmer in Nyamata. He carefully followed the soil collection and preparation processes in order to send his soil samples to a lab for analysis. However, he does not know what information the lab will tell him about his soil or what he will need to do about the report they will give him. Fabrice knows you are studying growing media and soil analysis, so he asks you to help him understand the following:

a. Based on your education so far, what information do you think is included in a soil analysis report?

b. What advice do you have for Fabrice when he receives his lab report?

2. After discussing, share your answers and ideas with the rest of the group. Ask questions and provide feedback to other groups.

2.3 Key Facts

- **Key information in a soil analysis report:**
  - Client information
  - Sample
  - Identification
  - Date sample was received and processed
  - Nutrient analyses
    - Determines the concentration of nitrogen (N), phosphorus (P), and potassium (K) in the soil.
  - Soil quality parameters
    - Examples: pH, organic matter

        - Organic matter: the amount of soil that has of plant or animal matter in stages of breakdown (decomposition); most productive soils have 3-6% organic matter; contributes to soil productivity in many different ways.[30]
    - Fertilizer recommendations
        - What kind of fertilizer should be applied and how often.
        - Related to the nutrient analysis because the report can recommend a specific type of fertilizer – nitrogen based (K), phosphorus based (P), potassium based (K), or compound fertilizers which contain a combination of nutrients.

- **Choosing a suitable fertilizer compound:**
    - **Nitrogen (N) Fertilizer**: One of the most common categories of fertilizers produced out of nitrogen (N) chemical combinations.
    - **Potassium (K) Sulfate Fertilizer**: Commonly added to improve the yield and quality of plants.
    - **Diammonium Phosphate (DAP) Fertilizer**: The world's most widely used phosphorus fertilizer; made from two common constituents in the fertilizer industry; relatively high nutrient content and excellent physical properties
    - **Compound Fertilizers**: All other fertilizers containing more than one of the three primary nutrients (N, P, and K); may also contain one or more secondary elements and micronutrient elements.
    - **Note**: It is important to apply the fertilizer products that best supply the nutrient requirements in each field. A single compound fertilizer will not be suitable in every field.

- **Organic matter**
    - Decomposed (broken down) plant or animal matter in soil
    - Example: Compost
    - Most productive soils have 3-6% organic matter
    - Contributes to soil productivity
    - Acts as a revolving nutrient bank account by releasing crop-available nutrients over an extended period.

- **Information gained about soil based on the soil test:**
    - Soil pH and lime application
        - Acidity in soils is measured by soil ph, ranging from 0 to 10.

[30] Fenton, M., Albers, C., & Ketterings, Q. (2008). *Agronomy fact sheet Series: Soil organic matter*. Cornell University, Department of Crop and Soil Sciences. https://franklin.cce.cornell.edu/resources/soil-organic-matter-fact-sheet

- Soils with pH near 7.0 are considered neutral.
- Soils with pH below 7.0 are considered acidic.
- Soils with pH above 7 are considered alkaline.
- The pH of acid soils can be increased by applying lime.
- Lime does not need to be applied every year. Apply enough lime once every 3-5 years to reach a pH of 6.5. This will maintain the soil pH close to the optimum for several years.
- If your soil has a high pH, it is alkaline. You can lower your soil's pH or make it more acidic by using several products. These include sphagnum peat, elemental sulfur, aluminium sulphate, iron sulfate, acidifying nitrogen, and organic mulches.

- **Amount of spreading lime to apply**
  - Don't apply more than 7.5t/ha in a single application.
  - When lime requirements are greater than 7.5t/ha, apply 7.5t/ha initially, and then apply the remainder after two years.[31]

Guided Practice Activity

Topic 2.3 Task 3:

1. Read through **2.3 Key Facts** and make sure you understand the terminology used.

2. Read the following information and complete the tasks with your partner:

a. State the key information provided in a soil analysis report.

b. The school laboratory analysis results show that the soil pH is 3.5 and the N-P-K concentration is 12-7- 0.

i. What do these results mean?

ii. What are your suggestions to meet the crop requirements if the crop to be planted requires soil pH 5.5 and the N-P-K concentration is 20-20-10?

3. When you have finished working, stand up and present their answers using evidence from **2.3 Key Facts** to support your answers.

[31] Glanbia Connect. (2019, June 18). *Time to plan for lime*. https://www.glanbiaconnect.com/farm-management/detail/article/time-to-plan-for-lime

4. Listen to the trainer's observations and feedback.

Application Activity

Topic 2.3 Task 4:

1. Find a partner to work with for this activity.

2. Read the soil analysis report below with the class:

Rwandan Agricultural Board. Soil Analysis – 12, December 2019.

- Client: NSABIMANA, Jean Claude. 0782.999.000. JClaude@gmail.com. Northern Province, Rulindo District.

- Sample Information: Soil sample from prospective farm in Tumba, Rulindo.

- Received: December 11, 2019 at 1500h.
  Processed: December 12, 2019 at 0800h.

- Nutrient analysis & recommendations:
  a. N = 20%; Recommended = 10%
  b. P = 5%; Recommended = 20%
  c. K = 2%; Recommended = 20%

- Soil quality parameters:
  a. pH = 4.0; Recommended = 7.0
  b. Organic matter content = 2%; Recommended = 3-6%

3. Analyse the report and give fertilizer recommendations to Jean Claude according to the report. Write your recommendations below:

Fertilizer recommendations:

_____
_____
_____
_____

4. Read your recommendations to the class and exchange ideas with your peers. Note the trainer's feedback.

Points to Remember

- The normal range of each nutrient analysed should be taken into consideration when applying soil analyser recommendations.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Explain how to determine how much lime to apply to soil.

2. What do N, P, and K mean?

3. What is the difference between an N-based fertilizer and a compound fertilizer?

4. Identify each statement as either **true** or **false:**

a. The world's most widely used fertilizer is nitrogen.

b. A high pH means your soil is acidic.

c. Lime should be applied every year.

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the knowledge, skill, or attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Identify soil sample preparation procedures					
Follow soil sample preparation protocol					
Follow soil sample preparation procedures					
Follow soil sample drying, crushing, mortaring, weighing, and sieving guidelines					
Perform drying, crushing, mortaring, weighing, and sieving processes to soil samples					
Explain soil sample packing requirements					
Read information in soil analysis report					
State normal range of soil parameters					
Follow guidelines in soil analyser recommendations					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	**1.**	**1.**
2.	**2.**	**2.**

Unit 3: Soil tillage for planting

Topics

3.1 Selection of land for tillage according to soil structure and vegetation

3.2 Identification tools and equipment for tillage according to the land conditions

3.3 Identification tillage types according the crop requirements

3.4 Performance of tillage according to the soil structure

Unit Summary:

This unit will help trainees select land for tillage according to soil structure and vegetation, identify tools and equipment for tillage according to the land conditions, identify tillage types according the crop requirements, and perform tillage according to the soil structure.

Self-Assessment: Unit 3

1. Look at the unit illustration. What do you see? What do you think this unit will be about? What topics might be covered?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this survey. It is for your own use during this course. The trainer will read a skill that is listed in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, we'll take this survey again.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
List the criteria for selecting a land site					
Choose the land site for tillage					
Explain the criteria for choosing the land for tillage					
Explain the selection criteria for tools and equipment for tillage					
Choose tools and equipment for tillage					
Explain the working conditions of tools and equipment used for tillage					
Analyse the soil structure type for tillage purpose					
Explain the relationship between tillage type and soil structure					
Till the land according to the soil structure					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Explain the relationship between crops and tillage					
Explain the tillage types and other factors					
Choose tillage type based on the type of crop to be grown					

Topic 3.1: Selection of the land for tillage

Key Competencies:

Knowledge	Skills	Attitudes
1. List the criteria for selecting the land site	**1.** Select land for tillage using criteria	**1.** Team spirit
2. Explain the criteria for choosing the land for tillage	**2.** Choose the land site for tillage	**2.** Analytical
3. Explain the characteristics of the land for tillage	**3.** Analyse the land characteristics	**3.** Accurate

Getting Started: What do we know and where are we going?

Topic 3.1 Task 1:

1. Read the following information and discuss the questions that follow:
Discuss your experience with tilling: the preparation of land for growing crops.

a. Where did you till or see tilling?

b. Why were you or another person preparing the land?

2. Call out your responses as the trainer writes them on the board for you to observe.

3. Read the Key Competencies table to learn the knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 3.1 Task 2:

1. Form small groups of five people.

2. Think about all the factors that go into having a successful farm. Brainstorm with your group and write a list of all the factors that affect the decision of where to put a farm.

3. When your group is finished discussing, ask someone from your group to present your list of ideas. Ask questions and provide feedback to other groups as well.

4. After the class discusses **3.1 Key Facts**, you will go back to the list and revise your answers.

3.1 Key Facts

- **Field selection and the critical areas to be considered when selecting land:**
  1. **Water availability**
     - Crops requires a large quantity of water for sustainable growth.
     - Critical factors of water for irrigation purposes are:
       - Sustainability of the water source: How reliable is the source/How long will it be available?
       - Quantity of water available for irrigation: How much is there to use?
       - Distance to the field: How far away is the water source?
       - Quality of the water: How clean is the water?

  2. **Soil depth**
     - Important for root development
     - Influences drainage and leaching possibilities
     - Any obstructive layers must be evaluated to determine whether they will influence root development and whether they can be corrected.

3. **Soil quality**
   - Related to drainage capacity mainly when soils are salty or when the irrigation water is characterized with a high salt content.
   - Evaluating the soil quality:
     - Soil texture: Influences how much water the soil can hold/retain.
     - Nutrient content: Determines the corrective measures necessary for soil improvement.

4. **Soil salinity or acidity**
   - Plant growth is influenced by either saline or acid soil conditions.
   - Both result in a loss of potential yield (number of crops produced).[32]

Guided Practice Activity

Topic 3.1 Task 3:

1. Read through **3.1 Key Facts** with the class and make sure you understand the terminology used.

2. Go back to **Topic 3.1 Task 2** and revise the list you made based on **3.1 Key Facts**. Share what information you added to your list and what you removed.

3. You will now work in pairs with the person sitting next to you. Read the following scenario:

Karori would like to select some of his land for tillage in the next dry season. He has two different plots with the following characteristics:

Plot 1:
- Soil is slightly acidic
- Soil is 40 cm deep
- Water holding capacity is low.
- The water source is far away.

[32] Klein, P., & Zaid Date, A. (n.d.). *Chapter VI: Land preparation, planting operation and fertilisation requirements*. Food and Agriculture Organization of the United Nations. https://www.fao.org/3/Y4360E/y4360e0a.htm

Plot 2:

- Slightly acidic soil
- Soil is 30 cm deep
- Water holding capacity is high

4. With your partner, discuss which plot of land Karori should select for tillage and why.

5. While you work, be sure to use the information from **3.1 Key Facts** as evidence to support your answers.

6. Present your answers and support your answers with evidence from **3.1 Key Facts**.

Application Activity

Topic 3.1 Task 4:

1. Form groups of three people.

2. Analyse the following images and their details. With your group, discuss and explain which site location would be the best option for tillage:

[33]

Site A: Lowlands (Eastern plains). Elevation: Less than 1,600 meters. Temperature: 20-21 C. Rainfall: 700 – 1000 mm. Dry Season: 4 to 5 months. Major limitations: Slope and erratic rainfall.

[33] User:Rodrigue250. (2020, June 1). *Akagera natinal park* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Akagera_natinal_park.jpg

 [34]

Site B: Highlands (Kinigi). Elevation: 1900 meters. Temperature: 15- 17 C. Rainfall: 1250-2000 mm. Dry Season: 1 to 2 months. Major limitations: Slope and acidity.

 [35]

Site C: Midlands (Lake Kivu borders). Elevation: 1,600-1,900 meters. Temperature: 17-20 C. Rainfall: 1000- 1250 mm. Dry Season: 3 to 4 months. Major limitations: Slope and acidity.

[34] User:NinaR. (2015, November 21). *Kinigi, Ruanda* [Photograph]. Flickr. https://www.flickr.com/photos/150102727@N06/46266427272 License: https://creativecommons.org/licenses/by/2.0/legalcode

[35] Vick, A. (2020, June 4). *Lake Kivu in Rwanda* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:LAke_Kivu_in_rwanda.jpg License: https://creativecommons.org/licenses/by-sa/4.0/legalcode

3. Present your decisions for each image/location to the rest of the class. Ask questions to and challenge the ideas of other groups.

4. Listen to the trainer's observations and feedback.

Points to Remember

- When selecting land for tillage, always consider the type of crop to be grown.

Formative Assessment

After carefully reading the following items, answer the following questions individually.

1. Identify the following statements as either **true** or **false:**

   a. Soil depth should be taken into consideration when selecting the field site.

   b. Availability of water should not be taken into consideration when selection the field site for tillage.

   c. Soil quality should be taken into consideration when selecting the field site for tillage.

2. What influence does soil depth have on site selection?

3. Explain why the sustainability of a water source of a piece of land is important.

Topic 3.2: Identification of tools and equipment for tillage

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain the selection criteria for tools and equipment	**1.** Choose tools and equipment to use for tillage	**1.** Team spirit
2. Explain the working conditions of tools and equipment used for tillage	**2.** Determine the working condition of tools and equipment	**2.** Analytical
3. Explain the relationship between working conditions and the efficiency of tools and equipment	**3.** Determine the effectiveness of tools and equipment	**3.** Decisive

Getting Started: What do we know and where are we going?

Topic 3.2 Task 1:

1. Discuss the following questions with your class:
   a. What types of tools are used for tilling the land?

   b. How do you decide which tools to use for tilling?

2. Share your thoughts and ideas while the trainer writes the answers on the board.

3. Look at the Key Competencies table to understand the types of knowledge, skills, and attitudes you will acquire by the end of this topic.

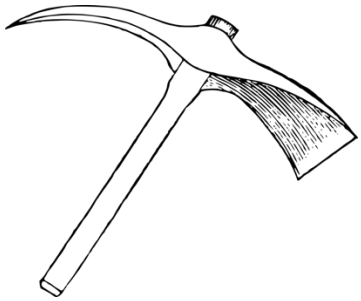
Problem Solving Activity

Topic 3.2 Task 2:

1. Work with the person sitting next to you to identify each image and its purpose on a farm.

A

B



C

D

E

F

G  [36]

2. Volunteer to write the name and role of one tool on the board/flipchart.

3. As your peers share their answers, ask them questions and challenge their ideas.

3.2 Key Facts

- **Tools used for tillage:**
  - Digging hoe, shovels, turning forks, rakes, pick, forked hoe, hand tiller
  - **Mouldboard plow**:
    - Digs 15-25 cm deep and inverts the furrow slice
    - Very effective for burying weeds and crop residues
    - Not good for dry soils
    - Does not handle rocky soils well
    - Does not work well in sticky, clay soils
  - **Disk plow**:
    - Well suited for hard, clay, rocky, or sticky ground
    - Does not bury residues well
    - Works well in drier areas where leaving residues on the surface cuts down wind and water erosion and reduces moisture evaporation.
    - Usually pulled by a tractor
  - **Subsoiler**:
    - Improves growth in all crops where soil compaction is a problem

[36] All photos in this section are either in-house illustrations or from PIxabay.com (License: https://pixabay.com/service/license/)

- Angled wings are used to lift and shatter the soil that builds up due to compaction[37]

- **Criteria for selecting tools and equipment:**
  - **Soil type**: In stony soil, forked hoe, pick, subsoilers are used because hand hoes become ineffective.
  - **Field topography**: Hand tools are effectively used on high slopes because tractors are not accessible. Tractors can easily be used in flat land areas.
  - **Climate conditions**: Tools to use in the rainy and dry seasons depend on the soil type. For example, clay soil becomes sticky in rainy season and compact in dry season, so different tools must be used.
  - **Crop type**: Crop to be to be grown determines the tillage type and well as the tools and equipment to be used.
  - **Cost**: Some tools and equipment are not affordable while others are. Depending on the scale of the farm (how big), one can decide to use tools and equipment which are expensive or cheap. For example, with cash crops (tobacco, tea, and coffee) more expensive tools are used.
  - **Working condition of tools**: Determine if tools/equipment are in bad working condition - corrosion and rust, broken handle, worn out, cracking.
  - **Durability**: Tools and equipment which can last longer are the ones to be selected for economic use.
  - **Availability**: When buying tools and equipment, look for the what is locally available and has available spare parts.

- **Soil Types**
  - **Clay soils**
    - Rich in nutrients.
    - Very fertile if they can be broken up by the addition of organic matter.
    - Breaking down the clay into separate crumbs makes the water and nutrients held within the clay more easily available to plant roots; also makes the soil warmer, more easily workable, and less prone to compaction.
    - Clay soil has a smearing quality and is sticky when wet.
  - **Sandy soil**s
    - Has a gritty element.
    - Can feel sand grains within it, and it falls through your fingers.

[37] Peace Corps. (n.d.). *How deep should land be tilled?*. New Zealand Digital Library. https://www.nzdl.org/gsdlmod?e=d-00000-00---off-0hdl--00-0----0-10-0---0---0direct-10---4-------0-1l--11-en-50---20-about---00-0-1-00-0--4----0-0-11-10-0utfZz-8-00&cl=CL1.16&d=HASH412cd503b5262205ac14c6.6.5>=1

- **Loams**
  - Perfect balance of all soil particle types.
  - Important to regularly add organic matter, especially if you are digging or cultivating these soils every year.
- **Peat soils**
  - Mainly organic matter.
  - Usually very fertile.
  - Hold a lot of moisture.
- **Chalky or lime-rich soils**
  - May be light or heavy.
  - Largely made up of calcium carbonate and are very alkaline (high pH).
- **Note**: Where building or landscaping has mixed up different soils, it can be very difficult to tell what type of soil you have, and it may change markedly over a short distance.[38]

Guided Practice Activity

Topic 3.2 Task 3:

1. Read through all of **3.2 Key Facts** and make sure you understand the terminology used.

2. Return to **Topic 3.2 Task 2** and revise your answers using the information from **3.2 Key Facts**.

3. Discuss the roles of each piece of equipment.

4. Now, work with a partner next to you. Read the scenario and discuss the questions that follow:

Eric is in Kigali to purchase equipment for his farm in Rulindo. His plot of land is on the side of a mountain and has clay soil that is very compacted.

a. What tools and equipment do you recommend he look at?

b. Give Eric some advice before he purchases equipment in Kigali.

[38] The Royal Horticultural Society. (n.d.). *Soil types*. https://www.rhs.org.uk/advice/profile?pid=179

5. Volunteer to stand up and present your answers to **Question 4**.

6. Listen to feedback from the trainer.

Application Activity

Topic 3.2 Task 4:

1. Read the following scenario and complete the tasks individually:

   A farmer next to the school needs guidance on how to select the appropriate tools and equipment to till his land. The farmer's land is flat and made up of clay soil. Right now, he wants to only grow potatoes and it is in the rainy season. The farmer has a lot of money to spend on his farm. As a technician in training, you have been requested to advise him on which tools to use based on the selection criteria of tools and equipment.

   a. Prepare a brief presentation (3-5 minutes) that you would present to the farmer.

   b. Your presentation should include options for the farmer and advice on getting the tools/equipment he/she will need.

2. Once you are prepared, take turns standing up and presenting the farmer's options and some advice for him/her to follow.

3. Challenge each other and provide feedback.

4. At the end, listen to the trainer' feedback and observations.

Points to Remember

- The criteria for selecting tools and equipment includes the type of soil, climate, topography in the area.
- The cost, conditions, durability, and availability of equipment must also be considered.
- Know the crop type to be planted before selecting tools and equipment to use.

Formative Assessment

After carefully reading the following items, answer the following questions individually.

1. Explain one advantage and one disadvantage of clay soils.
Advantage:

Disadvantage:

2. Identify each statement as either **true** or **false:**
a. Loam soils are considered nearly perfect soils.

b. Most disk ploughs are pulled by hand.

c. Hand tools are best when farming on high slopes.

3. What is a difference between a mouldboard plow and a disk plough?

4. Which of the following is **NOT** part of the criteria for selecting tools and equipment for tillage?
a. Soil type
b. Topography
c. Cost
d. Availability
e. None of the above

Topic 3.3: Identification of tillage types

Key Competencies:

Knowledge	Skills	Attitudes
1. State the crop-tillage relationship	**1.** Determine the type of tillage referring to the crop tillage requirement	**1.** Teamwork spirit
2. Explain tillage types and other factors (soil, soil moisture, conservation, climate, etc.)	**2.** Choose the tillage type according to the crop type	**2.** Analytical
3. Explain the tillage types	**3.** Identify the purpose of tillage	**3.** Careful

Getting Started: What do we know and where are we going?

Topic 3.3 Task 1:

1. Think about a time when you had to till the land on your family farm.

   a. At what points in the farming process did you till the land?

   b. What was the purpose of tilling the land?

2. Discuss your experiences as a class while the trainer writes some of the ideas and answers on the board.

3. Look at the Key Competencies table to understand the types of knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 3.3 Task 2:

1. You will receive a cards/small pieces of paper with either a key term or a definition from **3.3 Key Facts** written on it.

2. You must find the person with the corresponding key term or definition. If you have a term, you need to find the person with the correct definition and vice versa.

   Example:

   Card: Tillage ↔ Card: The preparation of land for growing crops.

3. Stand up and walk around, discussing what you think and if the cards align correctly.

4. After all the cards have been matched, present your term and definition to the class.

5. If there are any errors, you will revisit this activity after discussing **3.3 Key Facts.**

3.3 Key Facts

- **Tillage:**
  - Preparation of land for growing crops.
  - Many small farmers who lack equipment (or whose land is very steep or rocky) will prepare ground by slashing and burning the vegetation, then make seed holes with a planting stick or hoe.

- **Purposes of tillage:**
  - To break up and loosen the topsoil in order to encourage seed germination, seedling emergence, and root growth.
  - To chop up and/or bury the previous crop's residues so they won't interfere with the new crop.
  - To control weeds. An ideal seedbed is completely free of visible weeds at planting time.
  - To incorporate (mix into the soil) fertilizers or liming materials.

- To shape the type of seedbed best suited to the specific soil, crop, and rainfall conditions (e.g. raised beds, ridges, flat beds, sunken beds).[39]

- **Primary tilling:**
  - Tillage that is done to open up the packed soil.
  - The first tilling of the soil done after the harvest of the last crop.
  - Loosens the soil, while also aerating it (making it open to the air).
  - Creates a layer of soft soil that is at least of a depth of 10 cm.
  - Removes any unwanted plants, crop residues, and weeds in the soil.

- **Primary tilling is further classified into**:
  - **Deep tilling**
    - Turn out large size lumps/clods.
    - Required for certain types of crops, mainly for deep rooted and long duration crops.
    - Must consider the type of land and soil in order to benefit the harvest.
  - **Subsoiling**
    - Process that destroys the hardpans in the soil, if there are any.
    - Hardpan: a hardened layer, typically of clay, occurring in or below the soil that stops drainage and plant growth.
    - These can be clay pans, silt or aluminium pans that can prevent the roots of the crop from reaching deep in the soil.
    - Destroy hardpans without disturbing the layer of the soil on top.
    - Narrow cut in the soil is made, where the subsoiler will break the hard pans, with its share.
  - **Year round**
    - Carried out throughout the year.
    - Done in lands of dry farming.[40]

- **Secondary tilling**
  - Carried out after primary tilling.
  - Defines the lighter or less aggressive operations done in the soil.

[39] Peace Corps. (n.d.). *How deep should land be tilled?*. New Zealand Digital Library. https://www.nzdl.org/gsdlmod?e=d-00000-00---off-0hdl--00-0----0-10-0---0---0direct-10---4-------0-1l--11-en-50---20-about---00-0-1-00-0--4----0-0-11-10-0utfZz-8-00&cl=CL1.16&d=HASH412cd503b5262205ac14c6.6.5>=1

[40] Tamil Nadu Agricultural University (TNAU). (2016). *Types of tillage*. https://agritech.tnau.ac.in/agriculture/agri_tillage_typesoftillage.html

- Large lumps of soils and stalks that remain after the primary tilling of soil are reduced to more fine soil.
- Usually 2 to 3 secondary tillings are carried out for soil.

- **Purposes of secondary tillage:**
  - Improves the seedbed by increasing soil pulverization.
  - Conserves moisture through the destruction of weeds and cut up crop residues.
  - Uses various types of harrows, rollers, or pulverisers, and tools for mulching and fallowing.[41]

Guided Practice Activity

Topic 3.3 Task 3:

1. Read through all of **3.3 Key Facts** with your class and make sure you understand the terminology used.

2. Return to **Topic 3.3 Task 2** and hold up the correct term card with the correct definition card. Read the cards out loud to the class (only 2-4 examples as to not be repetitive). Correctly re-match the cards if needed.

3. Now, form groups of three people. With your group, read and discuss the following scenario:

To prepare for a school farm, the school wants to till a piece of land for the first time where a large tree has been cut down. Which tilling practices should be performed by the school and why?

4. Stand up and present your answers.

5. Listen to any feedback offered by the trainer.

[41] Encyclopedia Britannica. (n.d.). *Secondary tillage*. https://www.britannica.com/topic/secondary-tillage

Application Activity

Topic 3.3 Task 4:

1. Read the following scenario and complete the task individually:

The school wants to prepare seed bed in a field where 2 years passed without tillage. Write an explanation to the school about the different tillage practices that should take place. It should be at least five sentences long.

2. After you have finished, volunteer to stand up and present your writing sample.

3. Challenge and provide feedback to each other.

4. At the end, listen to the trainer's feedback and observations.

Points to Remember

- Tillage depth should be changed regularly to avoid soil compaction and hardpan formation.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Explain what a hardpan is and how to manage them?

2. What is the difference between primary and secondary tilling?

3. Complete the following sentences:

a. The primary function of tillage is to _____.

b. The purpose of secondary tillage is to improve _____ by increasing soil pulverization.

c. _____ tilling is done in lands of dry farming.

4. Jason is cutting up crop residue and destroying weeds in his garden. Is this considered primary or secondary tillage?

Topic 3.4: Performance of tillage

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain the soil structure type for tillage purpose	**1.** Analyse the soil structure type for tillage purpose	**1.** Teamwork spirit
2. Explain the relationship between tillage type –soil structure	**2.** Characterize the soil structure for tillage purposes	**2.** Hardworking
3. Explain the characteristics of soil structures	**3.** Till the land according to the soil structure	**3.** Precise

Getting Started: What do we know and where are we going?

Topic 3.4 Task 1:

1. Brainstorm the following:
   a. How many ways are there to plough or till a field?
   b. What are they? What are examples?

2. Discuss as a class while the trainer writes your ideas on the board. Give specific examples.

3. Look at the Key Competencies table and observe the types of knowledge, skills, and attitudes you will acquire after this topic.

Problem Solving Activity

Topic 3.4 Task 2:

1. Separate into groups of two people for this activity.

2. Read the following instructions and complete the task:

The card your trainer gave to you has either a term on it or a definition. If you have a term, you need to find the person with the correct definition. If you have a definition, you need to find the person with the correct term.

3. Be sure to use all the information you have learned so far in this unit to help you complete the task.

4. When all partners have found their corresponding team/cards, read the term cards with the definition cards. With your classmates, determine whether you think that team is correct.

5. Challenge each other and ask questions.

6. You will return to the answers of this activity after discussing **3.4 Key Facts** as a class.

3.4 Key Facts

- **Cultivation**:
  - The act of caring for or raising plants.
  - Most often used to talk about the ways that farmers take care of crops.

- **Types of tillage:**
  - Primary
  - Secondary tillage

- **Methods of primary and secondary tillage:**
  - **Ploughing**:
    - To turn up the earth (an area of land) with a plow, especially before sowing.

- **Direct drilling:**
  - To drill the seed into unploughed soil
  - Has become more widespread since the late 1980s
  - Maintains soil moisture, improves the soil structure, and results in less soil loss from wind.[42]
- **Shallow cultivation**:
  - To temporarily planted seeds shallow in the ground during and in between harvests.
  - Maintains organic matter, preserves good soil structure and breaks up any surface crust.
- **Disking:**
  - To work the upper layer of the soil with disk implements, such as disk harrows and shallow ploughs.
  - Adjust the angle, shape, sharpness, and weight of disks; Be aware of soil properties.
  - Adjustments affect the depth of loosening and how much soil is broken up, mixed, and turned over.
  - If the angle is decreased, there is less loosening and breaking up of the soil, and less soil is mixed and turned over.
  - Done before and after ploughing.
- **Loosening**:
  - The soil around existing plants is cultivated by hand using a hoe, or by machine using a cultivator
  - Destroy weeds and promote growth by increasing soil aeration and water infiltration.[43]

[42] Zydenbos, S. (2008, November 24). *Arable farming - Cultivation and planting*. Te Ara Encyclopedia of New Zealand. https://teara.govt.nz/en/photograph/17584/direct-drilling

[43] Encyclopedia Britannica. (n.d.). *Cultivation*. https://www.britannica.com/topic/cultivation

Guided Practice Activity

Topic 3.4 Task 3:

1. Read through **3.4 Key Facts** with your class and make sure you understand the terminology used.

2. Return to **Topic 3.4 Task 2** and hold up the correct term cards with the correct definition cards. Read them out loud to the class (only 2-4 examples as to not be repetitive). Correctly re-match the cards if needed.

3. Now, you will view and listen to some videos about performing tillage. The first viewing is to just watch.
   a. https://www.youtube.com/watch?reload=9&v=vzz08aUY9lU
      YouTube search: 1. Hand Ploughing – Agriculture

   b. https://www.youtube.com/watch?v=I2hCEc7t9dU
      YouTube search: Innovative tool to plough

   c. https://www.youtube.com/watch?v=AGjXFGau-Pw
      YouTube search: Ploughing field using bulls or Ox

   d. https://www.youtube.com/watch?v=mhNajeeiXjY
      YouTube search: "Mounted Disc Plough – UNIVERSAL

4. Read the questions below and watch them the videos again. You will discuss these questions in groups after watching the videos a second time.

   a. What actions do you see in these videos?

   b. What equipment and tools do you see in these videos?

   c. Based on your observations, what type of tillage is happening in these videos (primary or secondary)?

5. Work together in groups of three to answer the questions.

6. Volunteer to present your answers to **Question 4.**

7. Listen to the trainer's observations and feedback.

Application Activity

Topic 3.4 Task 4:

1. Visit a plot of land. Help the trainer bring hand tools and equipment from the school storeroom for practicing tillage.

2. Based on what you have learned, discussed, viewed, and practiced in class, you will till a small plot of land outside of the school.

3. In groups of two people, first perform primary tillage. Then, perform secondary tillage of the land. The types of crops to be planted are maize and the type of organic manure to be applied is farmyard manure.

   a. The person doing primary tilling will go first.

   b. The person performing secondary tilling will go after next.

4. While tilling this plot, the trainer will be moving around to assist you. Explain to them what they are doing and why.

5. After tilling, explain the difference between the roles of the two processes: primary and secondary tilling.

6. At the end, come together and share your thoughts and challenges regarding the activity.

Points to Remember

- The types of tools and climatic conditions are the two keys points to consider before tillage.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. What are the different methods of tillage?

2. What is a benefit of the direct drilling method of tillage?

3. Complete the following sentence:
   a. Cultivation is the act of _____.

4. Identify each statement as either **true** or **false:**

   a. Direct drilling takes place after ploughing.

   b. Shallow cultivation helps maintain organic matter.

   c. Disking is done before and after ploughing.

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills, and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the Knowledge, Skill, or Attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation.

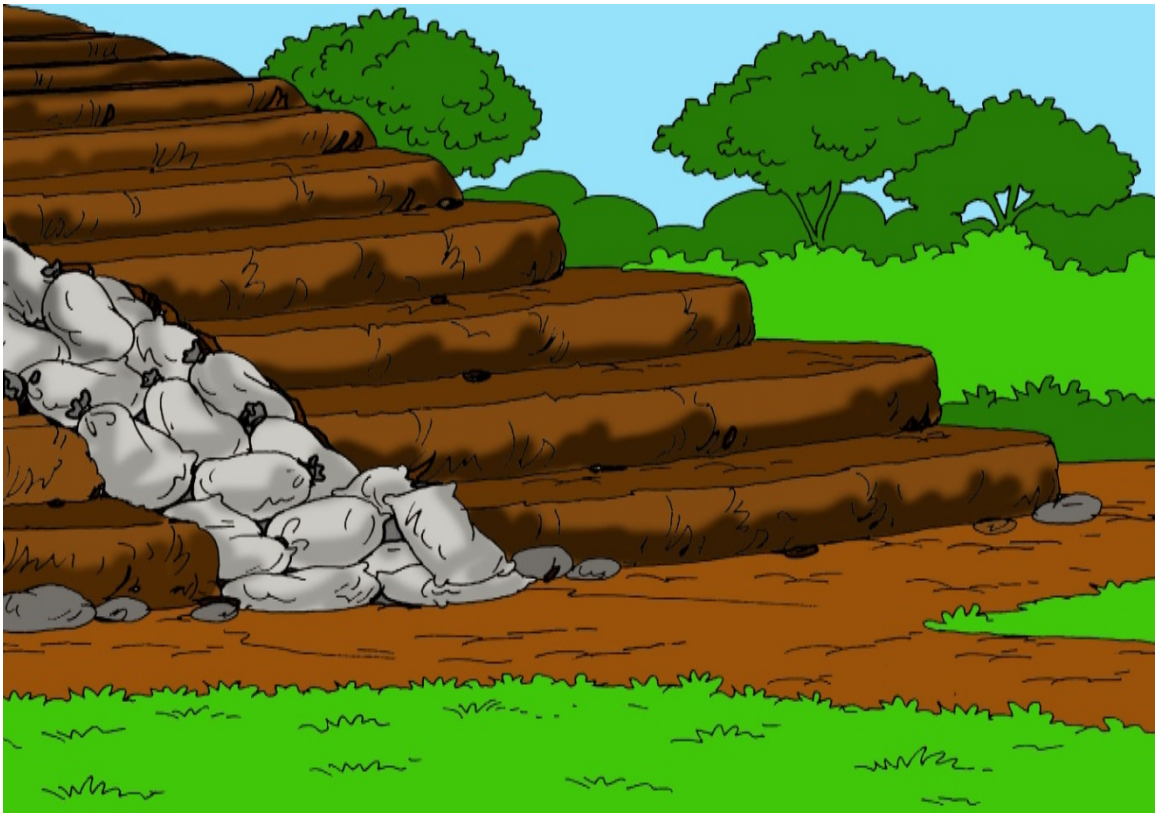
My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
List the criteria for selecting a land site					
Choose the land site for tillage					
Explain the criteria for choosing the land for tillage					
Explain the selection criteria for tools and equipment for tillage					
Choose tools and equipment for tillage					
Explain the working conditions of tools and equipment used for tillage					
Analyse the soil structure type for tillage purpose					
Explain the relationship between tillage type and soil structure					
Till the land according to the soil structure					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Explain the relationship between crops and tillage					
Explain the tillage types and other factors					
Choose tillage type based on the type of crop to be grown					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace.

Areas of strength	Areas for improvement	Actions to be taken to improve
1. **2.**	**1.** **2.**	**1.** **2.**

Unit 4: Soil maintenance



Topics

4.1 Application of soil conservation measures

4.2 Acquisition of soil amendments

4.3 Preparation of soil amendments

4.4 Application of soil amendments

Unit Summary:

This unit describes the knowledge, skills, and attitudes needed to successfully apply soil conservation measures. Trainees will learn the methods to acquire, prepare, and apply soil amendments.

Self-Assessment: Unit 4

1. Look at the illustration. What is happening? What do you think this unit will be about? What topics might be covered?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this survey. It is for your own use during this course. The trainer will read a skill that is listed in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, we'll take this survey again.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Apply crop rotation and fallowing conservation measures					
Apply agro-forestry trees and fodder crops methods as soil conservation measures					
Apply ditches and trenches as soil conservation measures					
Select soil amendments					
Follow soil amendment recommendations					
Identify the role of soil amendments					
Choose organic and inorganic amendments					
Characterize raw materials for inorganic amendment preparation					
Prepare soil amendments					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Identify soil amendment application methods					
Choose soil amendment application methods					
State the relationship between soil amendments and soil amendment application methods					

Topic 4.1: Application of soil conservation measures

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain crop rotation and fallowing practices	**1.** Apply crop rotation and fallowing as soil conservation measures	**1.** Team spirit
2. Explain the uses of planting agro-forestry trees and planting fodder crops	**2.** Apply agro-forestry trees and fodder crops as soil conservation measures	**2.** Analytical
3. Explain the uses of ditches and trenches	**3.** Apply ditches and trenches	**3.** Hardworking

Getting Started: What do we know and where are we going?

Topic 4.1 Task 1:

1. Discuss the following questions with your class:

   a. What does it mean to conserve something?

   b. What are some ways we can conserve the soil on our farms?

2. Share your ideas while the trainer writes those ideas on the board/flipchart for the class to see.

3. Turn to the Key Competencies table above to see the knowledge, skills, and attitudes you will learn by the end of the unit.

Problem Solving Activity

Topic 4.1 Task 2:

1. Note that if we do not conserve our natural resources, like soil and water, then food production could stop and the environment we live in could be damaged beyond repair. However, there are small things that farmers can do on their land to help conserve their soil, ensure their crop production and health, and help save the environment.

   Many of you have performed these duties in rural communities during Umuganda, such as by digging ditches and trenches on hillsides to prevent soil erosion.

2. Separate into groups of four people and read the following task:

   With your groups, brainstorm and discuss what you think these conservation techniques are. After you think of an explanation for each technique, explain their importance.

   a. Planting fodder crops

   b. Planting trees

c. Digging ditches

d. Letting a field lie fallow

3. When you have finished discussing, present your group's answers. As everyone presents, a volunteer writes the ideas on the board for the class to see.

4. You will return to this list and revise your knowledge after discussing **4.1 Key Facts**.

4.1 Key Facts

- **Soil conservation:**
  - Prevention of soil loss from erosion or prevention of reduced fertility caused by over usage, acidification, salinization or other chemical soil contamination.

- **Soil conservation measures:**
  1. **Crop rotation**
     - Systematic planting of different crops in a particular order over several years in the same growing space.
     - Helps maintain nutrients in the soil, reduce soil erosion, and prevent plant diseases and pests.
     - **Importance**: Continuous cultivation of the same crop leads to imbalance in the fertility demands of the soil.
     - Practiced in order to save the soil.

  2. **Fallowing**
     - To leave a field inactive.
     - A piece of land that is normally used for farming but that is purposefully left with no crops on it for a season in order to let it recover its fertility.[44]
     - **Importance/benefits:**
       - Gives time for soil to replenish nutrients which can be leached from certain plants or regular irrigation.
       - Saves money on fertilizers and irrigation.

[44] Your Dictionary.
(n.d.). *Fallow*. https://www.yourdictionary.com/fallow#:~:text=A%20field%20lies%20fallow.&text=The%20definition%20of%20fallow%20is,would%20be%20described%20as%20fallow

- Can cause potassium (K) and phosphorus (P) from deep below to rise toward the soil surface where it can be used by crops later.
- Raises levels of carbon, nitrogen (N), and organic matter.
- Improves moisture holding capacity.
- Increases beneficial microorganisms in the soil.

3. Planting agro-forestry trees

- **Agroforestry**
  - Type of agriculture that incorporates the planting, cultivation, and the conservation of trees alongside crops or livestock farming.
  - Integrates the unique relationships within a given ecosystem and offers many benefits, such as environmental, economic, and/or social.
  - Roots of trees firmly hold on to the soil. As trees grow tall, they also keep rooting deeper into the soil. As the roots of trees spread deep into the layers of soil, they hold it tightly, thus preventing soil erosion.
  - Soil under a vegetative cover is saved from erosion due to wind as this cover acts as a wind barrier.

- **How trees and agriculture work together:**
  - Healthy crops support healthy trees.
  - Trees provide shelter and food for livestock.
  - Erosion control.
  - Provides shade for crops and livestock.
  - Helps an ecosystem grow. [45]

- **Qualities of a good agroforestry tree**
  - Has deep roots so they do not compete with crops for water and nutrients.
  - Allows light through their leaves to allow crops to grow.
  - Survives regular pruning and cutting back.
  - Adds nutrients to the soil.
  - Leaves provide either animal fodder (food) or soil mulch.
  - Has uses that help the farm family.[46]

[45] One Tree Planted. (2017, September 27). *What is agroforestry? 5 ways trees and agriculture work together*. https://onetreeplanted.org/blogs/stories/what-is-agroforestry-trees-agriculture
[46] Tearfund Learn. (n.d.). *Agroforestry*. https://learn.tearfund.org/en/resources/publications/pillars/agroforestry/

4. Planting fodder crops

- Forage is a plant material eaten by grazing livestock.
- Addresses soil erosion and declines in organic matter and fertility, a problem caused by modern cultivation and fallowing practices.[47]
- Help reduce nitrogen fertilizer and energy costs.
- Benefits of using forages:
  - Increased soil fertility when legumes are used.
  - Increased soil quality.
  - Better water filtration and internal drainage.
  - More organic matter for soil health.
  - Less disease in subsequent cereal crops.
  - Reduced weed populations.
  - Increased yields in other crops.
  - Better economics in other crops.
  - Reduced greenhouse gas by holding carbon gases in the ground.
  - Increased soil fertility.

[47] Singh, K. M., Meena, M. S., & Kumar, A. (2012). An economic view to forage and fodder production in eastern India. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2030697

 [48]

5. Creating filtration ditches

- Small depressions created to channel water.
- Capture runoff to increase infiltration on the slope.
- Can be dug in forested or agricultural fields.
- Benefits:
  - Effective for draining steep slopes.
  - Prevents flooding.
  - Captures and conserves water for irrigation.

[48] Palmer, N., & CIAT. (2009). *Cut-and-carry forages in Nyagatare, in Rwanda's Eastern Province* [Photograph]. Flickr. https://www.flickr.com/photos/ciat/4108955316
License: https://creativecommons.org/licenses/by-sa/2.0/legalcode

 [49]

Guided Practice Activity

Topic 4.1 Task 3:

1. Read **4.1 Key Facts** with your class and make sure you understand the terminology used.

2. Return to **Topic 4.1 Task 2** and volunteer to explain some of the benefits of the soil conservation measures, such as fodder crops, trees, and ditches.

3. Now, in your group of four people, read and discuss the scenarios and questions below:

   a. Felix is a new farmer who wants to grow coffee as a cash crop. Coffee trees typically take about 3 to 4 years to begin producing beans. He has a plot of land with many large trees with deep root systems on it that he is thinking about cutting down for planting the coffee trees.

   Explain why he should plant his coffee under the large trees and how it will benefit his farm and product if he has forestry among his farm.

   b. Beatrice has a plot of land that she uses to grow potatoes, corn, and sorghum on. Unfortunately, her land always floods. This results in the soil becoming so loose and wet that her plants fall or drown.

[49] Hogg, J., & World Bank. (2009, June 18). *Farms in Massaca are irrigated by water from the reservoir* [Photograph]. Flickr. https://www.flickr.com/photos/worldbank/27226476455

What should Beatrice do about her problem?

4. After all the groups have finished discussing, come together and share your ideas.

5. Listen to the trainer's feedback and refer to **4.1 Key Facts** to confirm your answers.

Application Activity

Topic 4.1 Task 4:

1. Visit a farm and greet the farmer as well as any workers present.

2. Complete the following tasks:

a. Walk around the make a list of any soil conservation measures you observe.

b. Write down at least two questions to ask the farmer for a "Question & Answer" session with the farmer.

3. After you have observed the farm and thought of questions to ask the farmer, come together for a Q&A (Question and Answer) session with the farmer about soil conservation techniques.

4. After the Q&A, practice soil conservation activities the farmer needs help with, such as digging ditches or trenches, planting trees, etc.

5. Finally, come everyone together to share what you learned today. Express your thoughts and opinions about the field visit.

6. Thank the farmer and any staff who helped.

Points to Remember

- Soil conservation measures include crop rotation, fallowing, planting agro-forestry trees, planting fodder crops, and creating filtration ditches.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Identify each statement as either **true** or **false**:

a. Crop rotation is a soil conservation measure which is done by mixing crops on the same land.

b. Agroforestry is a type of agriculture that incorporates the planting, cultivation, and conservation of trees alongside crops or livestock farming.

c. Planting fodder crops can increase disease.

2. Explain how crop rotation, fodder crop, and ditches prevent soil erosion.

3. What is one benefit of fallowing?

Topic 4.2: Acquisition of amendments

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain the types of soil amendments	**1.** Select soil amendments	**1.** Careful
2. List factors to consider when choosing a soil amendment	**2.** Follow soil amendment recommendations	**2.** Accurate
3. State the role of soil amendments	**3.** Identify the roles of soil amendments	**3.** Precise

Getting Started: What do we know and where are we going?

Topic 4.2 Task 1:

1. Discuss the following with a partner:

Think about a time when you added something to soil to help plants/crops grow. What did you add and why did you add it?

2. Share your thoughts and ideas while the trainer writes them on the board/flipchart for the class to see.

3. Look at the Key Competencies table to learn the knowledge, skills, and attitudes you will acquire after this topic.

Problem Solving Activity

Topic 4.2 Task 2:

1. This activity will be an extension of the questions they just discussed from **Topic 4.2 Task 1**. Discuss the following with your partner:

a. From the content of the sentence below, what do you think “amendment” means?

Claude did not want to go to work today, so he made an amendment to his schedule.

a. a new job
b. to till soil
c. a change or addition
d. to be late

b. Make a list of what factors need to be considered when selecting a soil amendment.

2. When you are finished discussing, share your answers. Be sure to agree/disagree with others and listen to the trainer's feedback.

4.2 Key Facts

- **Soil amendment definition:**
  - Any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure.
  - Goal is to provide a better environment for the roots of your plants/crops.
  - Also called a soil conditioner.
  - Helps improve plant growth and health.
  - Type of amendment or amendments added depends on the current soil composition, the climate, and the type of plant.

- **Types of soil amendments:**
  - **Lime**: Makes soil less acidic by raising the pH
  - **Fertilizers for plant nutrients**: Manure, peat, or compost
  - **Materials for water retention**: Clay, organic matter, shredded bark, or vermiculite
  - **Gypsum**: Releases nutrients and improves structure; adding gypsum to clay helps relieve compaction.
  - **Plant-based**: low in salt; may be applied at higher application rates, more effectively improving the soil and overtime, and lowering the pH; typically higher in price.

- **Effects of amendments based on soil types:**
  - On clay soils, applying amendments help loosen compaction, increase porosity and permeability, and improve aeration, drainage, and rooting depth.

- On sandy soils, applying amendments increases the water and nutrient holding capacity.

- **Organic amendments**:
  - Come from something that was alive.
  - Examples:
    - straw
    - manure
    - sawdust
    - wood ash
    - peat
    - plant and food-based compost
  - Benefits
    - Increase soil organic matter content.
    - Improves soil aeration over time.
    - Improves water infiltration.
    - Improves both water and nutrient holding capacity.
    - Contain plant nutrients and act as organic fertilizers.
    - Important energy source for bacteria, fungi, and earthworms that live in the soil.
    - Lower a soil's pH over time; avoid by adding lime.

- **Inorganic amendments**
  - Either mined or human-made.
  - Examples:
    - vermiculite
    - perlite
    - tire chunks
    - pea gravel
    - sand

- **Selecting soil amendments:**
  - Factors to consider:
    - How long the amendment will last in the soil
    - Soil texture
    - Soil salinity and plant sensitivities to salts
    - Salt content and pH of the amendment

- Consider your goals:
  - Are you trying to improve soil physical properties quickly? Choose an amendment that decomposes (breaks down) rapidly.
  - Do you want a long-lasting improvement to your soil? Choose an amendment that decomposes slowly.
  - Do you want a quick improvement that lasts a long time? Choose a combination of amendments.

- **Soil Texture**
  - The way a soil feels.
  - Reflects the size of the soil particles.
  - Sandy soils: large soil particles and feel gritty.
    - Goal is to increase the soil's ability to hold moisture and store nutrients. To achieve this, use organic amendments that are well decomposed, like composts, peat, or aged manures.
  - Clay soils: small soil particles and feel sticky.
  - Both sandy soils and clay soils are a challenge for gardeners.
  - Loam soils: have the mixture of different size soil particles.[50]

- **Using amendments:**
  - Can add amendments to soil anytime.
  - Might add to alter the soil's pH level.
    - The pH of the soil needs to be within a range that will allow plants to access the nutrients in the soil.
    - Some plants prefer a slightly acidic or alkaline soil, and many require a soil in the neutral range of about 6.5 to 6.8.
    - Test your soil to determine what its current pH is.
    - Use the pH level and preferred pH range to determine how much lime to add

- **Ongoing adjustments:**
  - Soil is always changing.
  - Plants take the nutrients out of the soil, rain washes them away.
  - Even heavily amended soil will eventually revert to its natural state.
  - Need to amend your soil on a regular basis.
    - How often depends on the soil you are starting with.
  - Consider starting a compost pile.

[50] Davis, J. G., & Whiting, D. (2013, February). *Choosing a soil amendment*. Colorado State University Extension. https://extension.colostate.edu/topic-areas/yard-garden/choosing-a-soil-amendment/

- Can include pulled weeds and vegetable peelings.
- Won't add many nutrients but encourages a balanced ecosystem while improving the texture and drainage of the soil.

- **Important factors for calculating how much lime to apply:**
  - pH level of your soil: should be between 6.0 and 7.0.
  - The size of the area determines which form of limestone to use.
    - Powdered (left photo) or pelletized (right photo): Work the same, except that pelletized limestone is powdered lime mixed with a binder to form pellets and is typically cleaner and lest dusty to handle.
  - Soil texture: Denser the soil, more lime needed.
    - Depends on three basic soil types: sand, loam and clay.

- **How to calculate the amount of lime to use**
  - Refer to a lab's liming recommendations.

Guided Practice Activity

Topic 4.2 Task 3:

1. Read through all of **4.2 Key Facts** with your class and make sure you understand the terminology used.

2. Work in teams of two for the following activity. Read the task and questions as follows:

The soil where the school garden will be is acidic and sandy with very little organic matter in it. Suppose the school gives you the task of applying soil amendments on this land.

a. What are the factors will you consider while choosing the soil amendment?

b. Which amendments do you recommend?

3. Refer to **4.2 Key Facts** to look for guidance and evidence for your answers.

4. When you are finished discussing and writing their responses, present your findings. Provide feedback and challenge other groups' responses by agreeing or disagreeing.

Application Activity

Topic 4.2 Task 4:

1. Separate into groups of three. Each group will receive a card with a hypothetical scenario about a farmer's soil on it.

2. Each group member will have a role as follows:

    a. Writer – Write the answers your group provides to your scenario.

    b. Facilitator – Read the scenario to your teammates and your class.

    c. Presenter – Present your group's answer/advice to the class.

3. Everyone in the group must participate and contribute.

4. Discuss your scenario and refer to **4.2 Key Facts** for assistance.

5. When you are finished discussing, present your decisions one by one. Remember that each person must fulfil their role.

6. Listen to the trainer's feedback.

Points to Remember

- Soil properties to consider in choosing soil amendment include soil structure, soil texture, and soil pH.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Explain why a farmer would need to apply soil amendments.

2. Identify the following statements as either **true** or **false**:

a. Gypsum raises the pH.

b. Lime lowers the pH.

c. Manu, peat, and compost are inorganic amendments.

d. Plant-based composts are low in salt.

3. What does soil texture mean? Give an example.

4. When is it ok to use soil amendments?

Topic 4.3: Preparation of amendments

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain the types of organic and inorganic amendments	**1.** Choose organic and inorganic amendments	**1.** Collaborative
2. Characterize raw materials for preparation of organic amendments	**2.** Prepare organic amendments	**2.** Careful
3. Characterize raw materials for preparation of inorganic amendments	**3.** Prepare inorganic amendments	**3.** Accurate

Getting Started: What do we know and where are we going?

Topic 4.3 Task 1:

1. Discuss the following questions as a class:

   a. What organic or inorganic fertilizers have you used before on your family's land?

   b. Why did you choose to use that specific substance for the soil?

2. Note the meaning of the terms "organic" and "inorganic":
   a. Organic: relating to or coming from living matter.
   b. Inorganic: not consisting of or deriving from living matter.

3. Share your ideas and answers so the trainer can write them for the class to see.

4. Look at the Key Competencies table which includes the types of knowledge, skills, and attitudes you will acquire by the end of this topic. **Topic 4.3** will be an extension of **Topic 4.2**.

Problem Solving Activity

Topic 4.3 Task 2:

1. Separate into groups of three and complete the following tasks:

   a. Based on what you already know, what do you think the advantages and disadvantages of organic and inorganic fertilizers are? Make a list.

   b. Discuss why a farmer would choose one over the other.

2. Go back through past **Key Facts** from **Units 3 and 4** for assistance.

3. When all groups are finished, share your lists out loud with the class. Ask questions and provide feedback to other groups.

4. You will verify your responses after discussing **4.3 Key Facts** in the next activity.

4.3 Key Facts

- **Organic amendments**
  - Any material of plant or animal origin that can be added to the soil to improve its physical properties, including water retention, permeability, water infiltration, drainage, aeration, and structure.[51]

- **Benefits of organic matter**:
  - Loosens tight clay.
  - Helps sand hold more water.
  - Makes soil easier to dig into.
  - Adds nutrients.

[51] Davis, J. G., & Whiting, D. (2013, February). *Choosing a soil amendment*. Colorado State University Extension. https://extension.colostate.edu/topic-areas/yard-garden/choosing-a-soil-amendment/

- **Common organic matter additives are:**
  - Plant materials
  - Manure
  - Compost
  - Sawdust

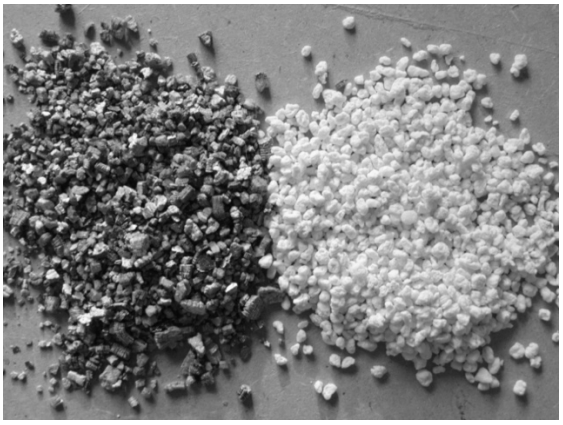
- **Soil types:**
  - Sandy soils
    - Do not hold enough water.
    - In windy areas, blowing sand can injure vegetables.
  - Clay soils
    - Hold too much water.
    - Do not allow enough air to enter the soil.

- **Common organic soil amendments:**
  - **Ground bark:**
    - Made from various tree barks.
    - Improves soil structure and helps soil retain water.
  - **Compost:**
    - Adds nutrients and helps soil retain water.
    - May also lower soil pH overtime.
    - Can include old food scraps, coffee grounds, tea leaves, and any waste that naturally decomposes.
  - **Leaf mould:**
    - Decomposed leaves that add nutrients and structure to soil.
  - **Lime:**
    - Raises the pH of acidic soil and helps loosen clay soil.
  - **Manure**:
    - Best if composted.
    - Supplies plants instantly with nitrogen, phosphorus, potassium and other nutrients
    - Warms the soil, which speeds up decomposition, and lowers the soil's acidity level, or pH, less than chemical fertilizers.
  - **Peat moss:**
    - Helps soil retain water.
    - Can lower soil pH level.
  - **Sand:**
    - Improves drainage in clay soil.

- **Topsoil:**
  - Usually used with another amendment.
  - Replaces existing soil.

- **Inorganic amendments:**
  - **Vermiculite**
    - Enables the plant to more easily absorb the ammonium, potassium, calcium, and magnesium necessary for vigorous growth.
    - See photo, on the left.

  - **Perlite**
    - Aids in water retention.
    - More porous and tends to allow water to drain much more readily than vermiculite. Covers a large surface area.
    - Good choice for plants that require levels of high humidity.
    - See photo, on the right.

 [52]

  - **Tire chunks**
    - Also known as rubber mulch.
    - Does not absorb water
    - Helps prevent fungal growth in plants.
    - Non-porous, so water and fertilizer pass through it and down to the soil.

[52] www.urbanturnip.org. (2017, January 14). *Perlite and vermiculite* [Photograph]. Flickr. https://www.flickr.com/photos/127368628@N08/31460506994

- Weeds cannot thrive on the rubber and can't get through the mulch layer down to the soil.[53]

- **Sand**
  - Repairs the soil
  - Much more porous than clay
  - When mixed with clay soils, can improve the **soil's** drainage.

- **Organic vs. Inorganic:**
  - **Composition**
    - **Organic fertilizers**: Contain only plant- or animal-based materials that are either a by-product or end-product of naturally occurring processes, such as manures, leaves, and compost.
    - **Inorganic fertilizers**: Manufactured artificially and contain minerals or synthetic chemicals. For example, synthetic nitrogen fertilizers are typically made from petroleum or natural gas. Phosphorus, potassium, and other trace elements in inorganic fertilizers are often mined from the earth.

  - **Nutrient availability**
    - **Organic fertilizers**: Release nutrients only when the soil is warm and moist, which is when the plant needs them the most; reduces the risk of nutrient leaching*, but it takes time to supply nutrients to plants.
    - **Inorganic fertilizers**: Provide this nutrition immediately. However, the concentration of nutrients increases the risk of burning the plant, and the rapid release of nutrients may leach them deeply into the soil and water table where plants can't access them.

      *** Leaching** is the loss of water-soluble plant nutrients from the soil, due to rain and irrigation

  - **Application**
    - **Organic fertilizers**: Nutrients and exact elements available can only be guessed.
    - **Inorganic fertilizers**: Applying is simple because the amount of a given element and the rate of application are known.

[53] Rubber Mulch. (2015, June 10). *The pros and cons of a rubber mulch garden*. The pros and cons of a rubber mulch garden. https://rubbermulch.com/blogs/rubbermulch/31581761-the-pros-and-cons-of-a-rubber-mulch-garden

- **Cost**
  - **Organic fertilizers**: Cost significantly more than inorganic fertilizers, but over time, this extra cost may be outweighed by the benefits it provides. Organic fertilizers continue to improve the soil long after the plants have taken the nutrients they need. Therefore, the longer your soil is fed with organic fertilizers, the better its composition and texture.
  - **Inorganic fertilizers**: Cheaper in the short term but adds less to the soil in the long term.

- **Environmental Impacts**
  - **Organic fertilizers**: May build up concentrations of some nutrients but build-up of toxicity is unlikely as long as the organic material is able to fully decompose. Because organic fertilizers are made from natural sources, only limited amounts of resources are used in production. Lower amounts of greenhouse gas released into the atmosphere than for inorganic fertilizers.
  - **Inorganic fertilizers**: Immediately available to plants, but subject to leaching (see definition above). Heavy applications can burn your plants and build up toxic salt concentrations in the soil, which can create chemical imbalances.[54]

Guided Practice Activity

Topic 4.3 Task 3:

1. Read through **4.3 Key Facts** as a class and make sure you understand the terminology used.

2. For the **Organic vs. Inorganic section** of **4.3 Key Facts**, separate into five groups and each group will be assigned a section. Read and study that section for five to ten minutes with your group. Then, share the key information from your assigned category with the class.

3. During the presentations, listen carefully and ask questions to seek clarification on organic compared to inorganic amendments.

[54] Miller, R. (2018, December 17). *Inorganic fertilizer vs. Organic fertilizer*. SF Gate. https://homeguides.sfgate.com/inorganic-fertilizer-vs-organic-fertilizer-39528.html

4. Now, go back into your group of three and refer to the following scenario and questions:

   The soil of the school farm site is acidic, less permeable (leaky/porous/penetrable) and some parts of the farm have less water holding capacity and a depletion of plant nutrients.

   a. What should be the raw material to be used for improving (amending) that soil?

   b. Explain why that amendment will overcome the problem mentioned above.

5. Discuss and select a soil amendment. When they are finished, ask groups to share their explanations.

6. Listen to the trainer's observations and feedback.

Application Activity

Topic 4.3 Task 4:

1. Help farmers improve their soil with the following characteristics by individually writing responses to the questions:
   Little water retention, little permeability, little water infiltration, little drainage, little aeration and poor soil structure, acidic soil, and few plant nutrients.

   a. What should be the raw material to be used for preparing soil amendment of farmers mentioned above?

   b. Explain to the farmer how to prepare the soil amendment for his soil.

2. When you are finished with your written response, share your answers out loud with the class.

3. Listen to the trainer's feedback and observations.

Points to Remember

- Common organic matter raw materials include plant materials, manure, compost, and sawdust.

- Common inorganic raw materials include vermiculite, perlite, rubber (tire), and sand.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Identify each statement as either **true** or **false:**

a. Composting material are used to prepare organic amendments.

b. Sandy soil is used to improve drainage in clay soil.

2. Identify the raw materials in an amendment used to improve each of the following:

a. Increase soil permeability:

b. Increase soil pH:

c. Increase soil water holding capacity:

3. Explain the difference between organic and inorganic amendments.

4. Name one advantage of using organic amendments and one advantage of using inorganic amendments.

Topic 4.4: Application of amendments

Key Competencies:

Knowledge	Skills	Attitudes
1. List soil amendment application methods	**1.** Choose amendment application methods	**1.** Accurate
2. Explain soil amendment application methods	**2.** Calculate soil amendments	**2.** Careful
3. State the relationship of soil amendments and soil amendment application methods	**3.** Apply soil amendments	**3.** Collaborative

Getting Started: What do we know and where are we going?

Topic 4.4 Task 1:

1. Review the following items:

a. Define soil amendments.

b. What are the two different categories of soil amendments?

c. What are some of the raw materials used in soil amendments?

2. Discuss and review with a partner. After your discussion, volunteer to write out the answers to the following questions on the board/flipchart for the class to see.

3. Identify if there is anything missing from the answers provided on the board. Give input and feedback.

4. Look at the Key Competencies table, which illustrates the types of knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 4.4 Task 2:

1. Work with a partner for this activity. You should use the knowledge you already have to read and determine which term belongs to which definition regarding the application of soil amendments. Do this without looking at **4.4 Key Facts**.

Broadcasting	Localized	Band	Spot	Plough Sole	Spray

   A. The uniform spreading of fertilizer over the entire field.

   B. This placement of fertilizers means the application of fertilizers in a continuous band at the bottom of the furrow when the field is being ploughed, with a furrow turning plough.

   C. Fertilizer is placed in a row (band) by the side of the crop, either along the row of crops or in the hill near each plant.

   D. When the placement of fertilizers is at the base of each pair of crop plants.

   E. Diluted solutions of nitrogenous and micronutrient fertilizers are sprayed on the crops and leaves readily absorb the nutrients.

   F. Fertilizers are applied very near the seed or the plant

2. Volunteer to match letters A – F. Feel free to agree or disagree with other trainees and explain why.

3. You will discover the correct answers after discussing **4.4 Key Facts.** They will have the opportunity to go back and revise their responses to **Topic 4.4 Task 2.**

4.4 Key Facts

- **Selection criteria for fertilizers and amendment application methods:**
  - Rooting characteristic of the crop to be planted (How do the roots typically spread in a certain plant?).
  - Crop demand for various nutrients at different stages of growth (What does this specific plant need?).
  - Physical & chemical characteristics of the soil (What does my soil analysis report say?).
  - Physical & chemical characteristics of the fertilizer material to be applied (What is in the fertilizer/amendment?).

- **Fertilizer rates from nutrient recommendations:**
  - Soil test recommendations are given in kg/ha of nutrients. To determine the fertilizer rate for a particular nutrient, multiply the rate of the desired nutrient by 100 and divide by the percentage of the nutrient in the fertilizer.
  - N – nitrogen, P – phosphorus, K – potassium, O – oxygen
  - **Example 1:**
    - Recommended rate of N is 80 kg/ha using 46-0-0
    - Rate of fertilizer required is: (80 x 100) / 46 = 174 kg/ha
  - **Example 2:**
    - Recommended rate of P_2O_5 is 40 kg/ha using 11-52-0
    - Rate of fertilizer required is: (40 x 100) / 52 = 77 kg/ac.
    - 77 kg/ha of 11-52-0 would also supply (11/100) x 77 = 8.5 kg/ha of N.
  - **Example 3:**
    - Recommended rate of K_2O is 15 kg/ha using 0-0-60
    - Rate of fertilizer required is: (15 x 100) / 60 = 25 kg/ha[55]

- **Frequency of fertilizer application:**
  - Usually larger quantities of fertilizers are added to clayey soils at longer intervals, than to the sandy soils
    - Because clayey soils are richer in organic components than sandy soils
    - Both clay and organic components have a high capacity to retain nutrients.
  - These absorbed nutrients can be gradually taken up by the roots.
  - If a heavy dose of water-soluble fertilizer is applied to a sandy soil, most of it will be drained by high rainfall.

[55] Province of Manitoba, Department of Agriculture. (n.d.). *Soil fertility guide: Calculating fertilizer rates from nutrient recommendations*. https://www.gov.mb.ca/agriculture/crops/soil-fertility/soil-fertility-guide/calculating-fertilizer-rates.html

- **Quantity of fertilizer to be applied:**
  - If the soils are low in one or more of the concerned nutrients (Nitrogen and/or Phosphoric acid and/or Potassium), apply in a full dose to the soil to increase the crop yield.
  - If the nutrients there are a medium amount of nutrients, only apply half the dose of that nutrient to the soil.
  - Different crops require different amounts of nutrients.
    - Vegetables and sugarcane require very high amounts.

- **Timing of application of fertilizer:**
  - Crops require less nitrogen immediately after germination because they grow less at that time.
  - Crops' demand for nitrogen increases from the early growth stage to the flowering stage, when their growth rate increases.
    - Therefore, nitrogen fertilizers should be applied in split doses at least twice.
    - Once just before sowing or planting the crop and then about one and half to two months after sowing or planting.

- **Placement of fertilizers:**
  - Place nutrients in the root zone, so that roots can absorb them quickly.
  - Fertilizers should come in minimum contact with the soil in order to reduce the fixation of nutrients like potassium, ammonium, and phosphate.

- **Methods of fertilizer application:**
  - **Broadcasting:**
    - Uniform spreading of fertilizer over the entire field.
    - Effective when the roots uniformly permeate the soil and when heavy doses of nitrogenous and potassic fertilizer are to be applied.
    - Can be done with a vehicle, a manual tool such as a spreader, or by hand.

  - **Localized placement:**
    - Apply very close to the seed or the plant.

  - **Drill placement**:
    - Place fertilizers in the soil with the help of drills.
    - Saves the cost of labour.

- **Plough sole placement:**
  - Apply fertilizers in a continuous band at the bottom of the furrow when the field is being ploughed, with a furrow turning plough.
  - Encourages the development of a deeper root system because fertilizers have been placed in the moist sub soil where roots develop.

- **Band placement:**
  - Place the fertilizer by the side of the crop, either along the row of crops or in the hill near each plant.
  - Can place on one or both the sides of the rows at a distance of 2.5 cm to 7.5 cm away from it.

- **Spot placement:**
  - Place fertilizers at the base of each pair of crop plants.

- **Spraying solutions:**
  - Spray diluted solutions of nitrogenous and micronutrient fertilizers on the crops.
  - Leaves absorb the nutrients.

Guided Practice Activity

Topic 4.4 Task 3:

1. Read through all of **4.4 Key Facts** with your class and make sure you understand the terminology used.

2. Return to your matching activity from **Topic 4.4 Task 2** and revise your answers if needed. Share a term and its definition.

3. Form groups of three and read the following scenario. Discuss the questions in your groups:

Jean Pierre is a potato farmer in Rubavu. He plans to plant seeds next week. His land is flat, and he does not have any machinery or large equipment. Provide Jean Pierre with the following advice:

a. Where in relation to his plants, should he apply his fertilizer and why?

b. What method(s) do you recommend and why?

c. What recommendation do you have for applying nitrogen fertilizer on Jean Pierre's potato farm?

4. Discuss with your group and locate evidence for your answers in **4.4 Key Facts.**

5. After your group has finished the task, share your answers. Support your answers with evidence from **4.4 Key Facts.**

Application Activity

Topic 4.4 Task 4:

1. In your same groups of three, visit the school farm site/to a nearby plot of land. Your group will be assigned three plots of $1m^2$. Obtain soil amendments and application equipment from the school storeroom. Read the specifications for each plot:

a. Your group will be given three small plots of land that are $1m^2$ each. With a tape measurer, verify the size of your plots. Each group is responsible for dividing the three small plots among your members:

i. One plot is acidic. Lime and available organic amendments are to be applied.

ii. Another plot is where potatoes will be planted and both organic manure and inorganic fertilizers will be used depending on their availability.

iii. Another plot needs sand to increase soil permeability. Select the method to be used and explain your choice.

b. Demonstrate applying the recommended amendments using all the available materials, tools, and equipment.

c. In your notebook, record which plot you chose, your application procedure, and your explanation for choosing that procedure. Be prepared to explain your process to your trainer and class.

2. After completing the tasks above, share your written record of your process.

3. Listen to the trainer's feedback and observations.

Points to Remember

- When applying soil amendments, consider the types of crop to be grown and research their nutrient specifications.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Explain the difference between broadcasting placement and spot placement when applying soil amendments.

2. Identify each statement as either **true** or **false:**

a. In acidic soil sand is applied to increase soil pH depending on the crop grown.

b. Organic amendments improve soil water holding capacity.

c. Broadcasting can be done with a vehicle, a manual tool such as a spreader, or by hand.

d. To determine the fertilizer rate for a particular nutrient, multiply the rate of the desired nutrient by 100 and divide by the percentage of the nutrient in the fertilizer.

3. Explain the band method of applying amendments.

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the Knowledge, Skill or Attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Apply crop rotation and fallowing conservation measures					
Apply agro-forestry trees and fodder crops methods as soil conservation measures					
Apply ditches and trenches as soil conservation measures					
Select soil amendments					
Follow soil amendment recommendations					
Identify the role of soil amendments					
Choose organic and inorganic amendments					
Characterize raw materials for inorganic amendment preparation					
Prepare soil amendments					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Identify soil amendment application methods					
Choose soil amendment application methods					
State the relationship between soil amendments and soil amendment application methods					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace.

Areas of strength	Areas for improvement	Actions to be taken to improve
1. **2.**	**1.** **2.**	**1.** **2.**

Unit 5: Sterilization of soil for organic growing medium

Topics

5.1 Identification of soil for organic growing medium

5.2 Identification of tools and equipment for soil collection and sterilization

5.3 Treatment of soil for organic growing medium

Unit Summary:

This unit describes the knowledge, skills, and attitudes required to sterilize soil for organic growing medium. This unit will help trainees identify soil, tools, and equipment for organic growing medium. It will also cover how to assist with sterilisation and treatment of soil for growing medium.

Self-Assessment: Unit 5

1. Look at the illustration. What do you see? What do you think this unit will be about? What topics might be covered?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this survey. It is for your own use during this course. The trainer will read a skill that is listed in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, we'll take this survey again.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Select the site for organic growing media					
Differentiate growing media					
Characterize the site for organic growing media					
Select the tools and equipment used for soil collection and sterilization					
Characterize tools and equipment used for soil collection and sterilization					
Explain site selection criteria for soil collection and sterilization					
Identify soil sterilization methods for growing media					
Select soil sterilization methods for growing media					
Sterilize the soil for growing media					

Topic 5.1: Identification soil for organic growing medium

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain the characteristics of tools and equipment used for soil collection and sterilization	**1.** Select tools and equipment used for soil collection and sterilization	**1.** Team spirit
2. State the selection criteria for tools and equipment used for soil collection and sterilization	**2.** Characterize tools and equipment used for soil collection and sterilization	**2.** Analytical
3. Explain factors for choosing tools and equipment for soil collection and sterilization	**3.** Identify key factors for selecting tools and equipment for soil collection and sterilization	**3.** Honest

Getting Started: What do we know and where are we going?

Topic 5.1 Task 1:

1. Participate in a class discussion using the following questions:

   a. What types of soil have you studied so far?

   b. What are they?

   c. What are their properties?

2. Discuss the different soil types and their properties based on what you remember from previously topics. Share ideas and answers for the trainer to write on the board for the class to see.

3. Look at the Key Competencies table with the types of knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 5.1 Task 2:

1. You have learned a lot of information that seems very similar. It can sometimes be confusing. The purpose of this activity is to help differentiate the terminology and aid your understanding for this new topic.

2. Form groups of three. In your group, read and answer the follow questions:

   a. What is the difference between a growing medium and an amendment?

   b. Based on what you know about the meaning of organic is, what are some things you would avoid if you were growing organic crops?

   c. Using what you know, try to define the following terms:
      - Greenhouse growing system
      - Potted growing system
      - Open field growing system

3. Be sure to use notes from previous topics to guide you. However, do not look at **5.1 Key Facts** for this topic.

4. Share your responses and challenge others by agreeing or disagreeing with them and explaining why.

5. You will return to this task after discussing **5.1 Key Facts** to revise your responses if necessary.

5.1 Key Facts

- **Factors to consider when selecting soil for a growing medium:**
  - **Soil requirement**
    - Includes soil type, depth, drainage, texture, organic matter content, pH, and fertility with respect to the macronutrient and micronutrient content of the soil.
  - **Topographic requirement**
    - The crop's natural adaptation or tolerance to land features such as elevation, slope, and terrain.
  - **Climatic factors**
    - Can influence the growth and yield of crops.
    - Includes temperature, water or rainfall, light (including photoperiod or light duration), relative humidity, and wind.
    - May vary with geographical location and, as to microclimate, from farm to farm.[56]
  - **Accessibility**
    - Must have access to supplies, equipment, and the market.
    - Must be provided with infrastructures (e.g. roads) and, if the product is intended to be sold elsewhere.

- **Growing Medium definition:**
  - Materials that plants grow in.
  - Designed to support plant growth.
  - Can either be a solid or a liquid.
  - Different components are blended to create homemade and commercial growing media.
  - Different types of growing media are used to cultivate various plants.
  - May also be known as grow media, culture medium, or substrate.

- **Major functions of growing media**:
  - Physically support plant growth.
  - Allow for maximum root growth.
  - Supply roots with necessities such as water, air, and nutrients.

- **Locations for growing media:**
  - **Greenhouses**

[56] CropsReview. (n.d.). *Climatic factors affecting plant growth*. https://www.cropsreview.com/climatic-factors.html

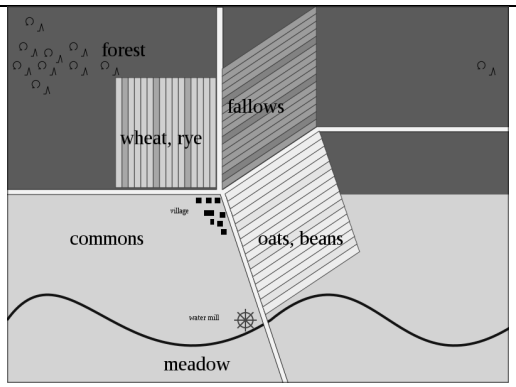
- Structures with walls and roof made chiefly of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown.
- Range in size from small sheds to industrial-sized buildings.
- A miniature greenhouse is known as a cold frame.
- Can be expensive to construct and maintain
- Offer complete control over growing conditions
- Can result in large profits depending on the crop grown.[57]


58

- **Open fields**
  - Allows crops to grow naturally
  - Crops should be well-adapted, under the appropriate climate, during the suitable season.

[57] User: martin_plethora. (2016, November 2). *Saving costs and increasing yields by adopting greenhouse over open FIELD farming. [Part 2].* Plethora Farms. https://plethorafarms.com/saving-costs-and-increasing-yields-by-adopting-greenhouse-over-open-field-farming-part-2/

[58] International Potato Center. (2017, May 17). *SpeedBreeders and genomics CoP visit Rubona Research Station in Rwanda (56)* [Photograph].
Flickr. https://www.flickr.com/photos/106872707@N03/34701560792/
License: https://creativecommons.org/licenses/by-nc-sa/2.0/legalcode



[59]

- **Pots**
  - Lower risk of soil-borne disease.
  - Eliminates weed problems.
  - Gives more control over moisture, sunlight & temperature.


[60]

- **Types of soil for growing media**
  - **Peat moss**
    - Dead fibrous material that forms when mosses and other living material decompose.
    - Clean and sterile: Doesn't have any bacteria, fungus, harmful chemicals, or weed seeds; perfect for seedlings, which are vulnerable to the surrounding environment.

[59] User: MScharwies. (2017, December 10). *Three field system*. https://commons.wikimedia.org/wiki/File:Three_Field_System.svg
License: https://creativecommons.org/licenses/by-sa/4.0/legalcode
[60] Leone, U. (2018, June 4). *Garden plant pots herbs terracotta* [Photograph]. Pixabay. https://pixabay.com/photos/garden-plant-pots-herbs-terracotta-3451740/
License: https://pixabay.com/service/license/

- Moisture retention: Can absorb and retain water very well; great for seed starting and mixing with other growing materials.
- Acidic: Low in pH from 3.5 to 6 on average
- Does not compact: Compaction makes it hard to create any space for water and air to pass through; makes the growing mix drain better.[61]


[62]

- **Expanded clay aggregate**
  - Often used in hydroculture.
  - Considered a soilless growing medium.
  - Can also be added to soil to improve drainage.
  - Helps the soil retain water during periods of drought.
  - Ideal to increase oxygen in the soil, which promotes vigorous plant growth.
  - Sometimes called hydroton, clay-pebbles, or light expanded clay aggregate.[63]

[61] User: Max. (2019, August 8). *What is peat moss? What is it used for?*. Green and Vibrant. https://www.greenandvibrant.com/peat-moss

[62] Ross, S. (2008, July 6). *Schultz sphagnum peat moss* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Schultz_Sphagnum_Peat_Moss.jpg

[63] Maximum Yield. (n.d.). *Expanded clay aggregate*. https://www.maximumyield.com/definition/2079/expanded-clay-aggregate

 [64]

- **Stones**
  - Gravel or pumice, clay pellets, or any other small rock.
  - Great for drainage.
  - Adds stability to container grown plants.
  - Does not hold nutrients well.
  - Dries out quickly.
  - Avoid using smooth stones.
  - Porous rocks are much better at holding some amount of nutrients and moisture for your plants.
  - Fertilizers for plants grown in stones should not be water soluble.[65]

 [66]

[64] Grant, S. (2007, November 2). *Hydroton* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Hydroton.jpg
License: https://commons.wikimedia.org/wiki/Commons:GNU_Free_Documentation_License,_version_1.2
[65] Bond, C. (2018, January 26). *5 growing mediums and their benefits*. Maximum Yield. https://www.maximumyield.com/5-growing-mediums-and-their-benefits/2/3756
[66] User: Kaszap2750. (2017, October 2). *Gravel stone garden yard casing* [Photograph]. Pixabay. https://pixabay.com/photos/gravel-stone-garden-yard-casing-2808793/
License: https://pixabay.com/service/license/

- **Sand**
  - Supports roots.
  - Allows air, nutrients, and water to pass.
  - Allows for root growth.
  - Can be "too good" at allowing water and nutrients to pass through.
  - Need to be watered much more often than other media.
  - Fertilizers that are water soluble are often leached out and much of it goes to waste in sand.[67]

- **Perlite and Vermiculite:**
  - Both: Inorganic products; sterile; often used as soil additives; very light-weight
  - Vermiculite: soft, spongy material made from super-heating mica; tan/brown colour; absorbs water in its plate-like structure; close to a neutral pH; hold moisture longer than perlite
  - Perlite: hard, highly porous material made by super-heating volcanic glass; white colour; traps water in its very porous, undulated structure; has a slightly more alkaline pH[68]

- **Soilless mixes**
  - All have some combination of similar ingredients: peat moss, vermiculite, perlite, lime, or sand.
  - Usually good, all-around mixes suitable for growing most vegetables.

- **Organic farming**
  - Method of crop and livestock production that involves much more than choosing not to use pesticides, chemical fertilizers, genetically modified organisms, antibiotics and growth hormones.
  - General principles (from the Canadian Organic Standards):
    - Protect the environment, minimize soil degradation and erosion, decrease pollution, optimize biological productivity, and promote a sound state of health.

[67] Bond, C. (2018, January 26). *5 growing mediums and their benefits*. Maximum Yield. https://www.maximumyield.com/5-growing-mediums-and-their-benefits/2/3756

[68] User: Nikhil. (2019, July 15). *Perlite & vermiculite market is expected to reach CAGR of 7.1% during 2019-2025*. A2Z Press Release. https://www.a2zpressrelease.com/chemicals-and-materials/perlite-vermiculite-market-is-expected-to-reach-cagr-of-7-1-during-2019-2025/

- Maintain long-term soil fertility by optimizing conditions for biological activity within the soil.
- Maintain biological diversity within the system.
- Recycle materials and resources to the greatest extent possible within the enterprise.
- Provide attentive care that promotes the health and meets the behavioural needs of livestock.
- Prepare organic products, emphasizing careful processing, and handling methods in order to maintain the organic integrity and vital qualities of the products at all stages of production.
- Rely on renewable resources in locally organized agricultural systems.[69]

Guided Practice Activity

Topic 5.1 Task 3:

1. Separate into small groups. With your group, read through all of **5.1 Key Facts** by reading and studying the content one section at a time.

2. After your group has read and studied the content of **5.1 Key Facts**, select one person from your group to stand up and read it to the class so that others may follow along.

3. After each section of **5.1 Key Facts** has been read aloud, ask any questions or request clarifications. As you read, go back to **Task 2** to revise your previous responses. Ask the questions from **Task 2** to make sure everyone participates and understands.

4. Next, watch the following videos:

a. https://www.youtube.com/watch?v=hVT9fAJllRk
YouTube search: Perfect Soil & Growing Medium for Organic Gardening

b. https://www.youtube.com/watch?v=x4JssQPTYF8
YouTube search: How to Make Hot Compost Complete Guide

5. Based on the videos, read and answer the following questions:

[69] Martin, H. (2009, December). *Introduction to organic farming*. Ontario Ministry of Agriculture, Food and Rural Affairs. https://www.omafra.gov.on.ca/english/crops/facts/09-077.htm

a. In the video on perfect soil and growing media, what is one way to grow crops that was not mentioned in **5.1 Key Facts**? What are the benefits of this method?

b. In the video about how to make compost, what are the ingredients needed to make compost? Are these readily available in Rwanda?

c. What is something new you learned in the videos? How does this relate to the information provided to you in **5.1 Key Facts**?

6. After the videos, write your answers down and discuss with a partner.

7. Share your responses. Provide your feedback and observations to others as well.

Application Activity

Topic 5.1 Task 4:

1. Visit a prepared area with your class. Separate into groups of three. Read the following instructions and complete the tasks with your group:

Today you are going to prepare your own compost to mix with soil and use as an organic growing medium for crops.

With the available equipment and materials, complete the following tasks:

a. Make a list of the ingredients and tools available that you will need for making your compost pile.

b. Write an explanation for the process of making your own compost.

c. Demonstrate how to begin the composting process.

d. Explain the benefits of using organic growing media, such as compost.

2. As you work with your group, discussing and mixing the compost, demonstrate the following to the trainer:

a. Measure the temperature of the pile.

b. Explain the process and ingredients for composting.

c. Explain the benefits of using organic growing media.

3. At the end of the activity, share your group's processes and show your completed work.

4. Listen to the trainer's observations and feedback. This activity was for practice, as compost takes months to break down.

Points to Remember

- The major functions of growing media are to physically support plant growth, allow for maximum root growth, and supply roots with necessities such as water, air, and nutrients.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. What are the three major functions of growing media?

2. What is a benefit and a disadvantage of growing crops in a greenhouse?

3. Why is peat moss an excellent growing medium?

4. Which of the following is NOT a factor when selecting a location for a growing medium?
   a. topographic requirements of a crop
   b. soil requirements of the crop
   c. accessibility to infrastructure/utilities/necessary resources
   d. climate requirements of a crop
   e. none of the above

5. Why is it important to practice organic farming when possible?

Topic 5.2: Identification tools and equipment for soil sterilization

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain the characteristics of tools and equipment used for soil collection and sterilization	**1.** Select tools and equipment used for soil collection and sterilization	**1.** Team spirit
2. State the selection criteria for tools and equipment used for soil collection and sterilization	**2.** Characterize tools and equipment used for soil collection and sterilization	**2.** Analytical
3. Explain factors for choosing tools and equipment for soil collection and sterilization	**3.** Identify key factors for selecting tools and equipment for soil collection and sterilization	**3.** Honest

Getting Started: What do we know and where are we going?

Topic 5.2 Task 1:

1. Complete the following task with a partner:

   a. Make a list of the tools and equipment you've learned about in the soil collection and analysing processes.

2. Share your ideas and responses so the trainer can write them on the board for the class to see.

3. The next two topics in this unit will build on content they previously learned, and this topic will rely on review.

4. Look at the Key Competencies table, which includes the knowledge, skills, and attitudes you will acquire after this topic.

Problem Solving Activity

Topic 5.2 Task 2:

1. Form groups of three people and discuss the following:

You've learned about tools for collecting and analysing soil as well as how to clean and maintain those tools.

a. Do you think the tools used to sterilize soil are different from those used to collect soil? Why or why not?

b. What characteristics in tools and equipment should a professional look for?

c. Think about what you have learned from past topics. What factors should you consider when selecting tools and equipment for soil collection and sterilization?

2. Use your notes and manuals to review and discuss previous content.

3. When each group has finished discussing and answering the questions, present your group's responses. Comment on or provide feedback to other groups.

4. Listen to the trainer's feedback and observations.

5.2 Key Facts

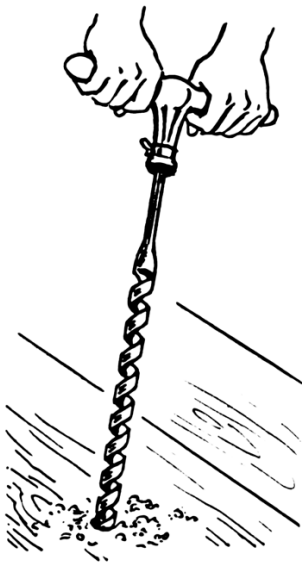
- **Characteristics of tools and equipment used for soil collection and sterilization:**
  - Strong enough to withstand intensive use at the work site
  - Resistant to wear so that they have a long working life.
  - Metal head should be made from carbon steel and heat-treated to give the correct strength and wear characteristics.
  - For the main excavation and striking tools such as hoes, pickaxes, mattocks and sledgehammers, the tool heads should be forged in a single piece.

- Timber handle should be made from a tough, preferably light, seasoned hardwood.
- Wood should be straight grained, with the grain lying along the length of the handle.
- Handles should not have any splits or knots, since these lead to handles breaking when used.[70]

- **Factors/criteria for selecting tools and equipment for soil collection and sterilization:**
  - Site conditions
  - Type of work that will be performed
  - Type of soil
  - Local skills and practice
  - History of the field
  - Availability in the region or vicinity to the work site
  - How to deliver it to the working site
  - How easy is it to operate
  - Cost and reliability
  - How big the farm is/how much farming will be done (the scale of the farm)
  - Availability of spare parts and repair facilities

- **Common tools used to collect and sterilize soil**
  - Sterilizer (depending on type of sterilization)
  - Hoe
  - Blades
  - PPE (personal protective equipment)
  - Weighing device/scale
  - Drying sheets
  - Soil probe
  - Auger
  - Tubes
  - Containers
  - Oven
  - Sieve
  - Sack/bags
  - Plastic sheets/covers

[70] *Building rural roads: Chapter 3: Tools and equipment*. (n.d.). International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/genericdocument/wcms_101009.pdf



71

Guided Practice Activity

Topic 5.2 Task 3:

1. Read through all of **5.2 Key Facts** and make sure you understand the content.

2. Observe the tools and equipment from **5.2 Key Facts** that are in front of the classroom. When the trainer points to a piece of equipment or tool, identify what it is.

3. For the next activity, work with the person sitting next to you and discuss the following questions:

The school has different tools and equipment for the collection and sterilization of soil to be used as a growing medium.

a. What characteristics will you look for while selecting the best tools and equipment for these tasks?

b. What factors affect your choice of tools and equipment used for collecting and sterilizing soil?

[71] Pearson Scott Foresman. (2007, December 16). *Auger 3 (PSF)* [Drawing]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Auger_3_(PSF).png
Public domain

c. How the process of identifying and selecting tools and equipment of collecting and sterilizing soil similar to other processes on the farm?

4. Remember to use evidence from **5.2 Key Facts** as well as the knowledge you have from past topics.

5. Stand up and present your group's findings. The trainer will write common responses on the board/flipchart for the class to see.

6. Consider the trainer's clarification, especially with the **part c.**

Application Activity

Topic 5.2 Task 4:

1. For this activity, work individually on the following task:

You've been asked to create a brochure that helps farmers properly identify and select the tools and equipment needed for collecting and sterilizing soil. Your brochure must include the following content:

a. Illustrations (drawings/pictures) that help the farmer understand the selection process.

b. Ten helpful tips/advice that the farmer should consider when selecting equipment, including the qualities or characteristics he/she should look for in tools and equipment.

c. Give your brochure a title. Make the information easy to understand and attractive to look at.

2. Observe the trainer's sample brochure as well as the photos below for guidance.

[72]

3. After you finish, give your brochure to someone else to read and look at. Make sure your colleague's brochure is easy to understand and helpful to farmers.

4. Share your finished product with the class. Consider the trainer's observations and feedback.

Points to Remember

- The cost and the scale (size and number of crops) of farming is the main criteria for choosing tools and equipment for soil collection and sterilization.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Which of the following are NOT criteria to consider when selecting tools?
   a. how easy it is to operate
   b. type of soil
   c. how much it costs
   d. the size and number of crops grown on the farm
   e. none of the above

2. Explain why the availability of spare parts is an important factor when selecting tools and equipment.

[72] Courtney, E. (2013, January 9). *Brochure design* [Photograph].
Flickr. https://www.flickr.com/photos/mufan96/9198371336
License: https://creativecommons.org/licenses/by/2.0/legalcode

3. Identify each statement as either **true** or **false:**

a. The tools should be strong enough to withstand intensive use at the work site, and resistant to wear so that they have a long working life.

b. The best choice of tools stays the same from place to place

c. Excavation/Striking tools should be forged (made) from a single piece.

Topic 5.3: Treatment of soil for growing medium

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain soil sterilization methods for growing media	**1.** Identify soil sterilization methods	**1.** Accurate
2. List selection criteria for soil sterilization methods	**2.** Select soil sterilization methods	**2.** Careful
3. State the benefits of soil sterilization	**3.** Sterilize the soil for growing medium	**3.** Collaborative

Getting Started: What do we know and where are we going?

Topic 5.3 Task 1:

1. Discuss the following questions as a class:

a. What is the meaning of sterilization?

b. Where is sterilization used and how is it important in everyday life?

2. Use your notes and information from **Topic 1.2** for reference.

3. Share your ideas and responses so the trainer can write them for the class to see.

4. Look at the Key Competencies table, which includes the knowledge, skills, and attitudes trainees will gain in this topic.

Problem Solving Activity

Topic 5.3 Task 2:

1. Form groups of three people. Read and discuss the following with your group:

You have already learned and practiced sterilizing tools and equipment in **Topic 1.2**. It is also essential to sterilize soil before planting to ensure the best growth and health of your plants.

a. How do you think disinfecting and sterilizing soil to use as a growing medium is similar to or different from sterilizing tools and equipment?

b. What methods do you think there are to sterilize soils?

2. Use your notes and resources from **Topic 1.2** to review sterilization and brainstorm responses for this topic.

3. Share your responses and explain your answers. Provide input and feedback on each other's responses.

4. You will discover the correct information as you discuss **5.3 Key Facts** as a class.

5.3 Key Facts

- **Soil sterilization**
  - Soil can harbour pests, diseases, and weed seeds
  - It is always a good idea to sterilize garden soil before planting to ensure the most optimal growth and health of your plants.
  - Three methods:
    - Using steam
    - Using direct heat with an oven, microwave, or sunlight
    - Using chemicals[73]

- **Steam sterilization**
  - Sterilizes soil with steam in open fields or greenhouses.
  - Kills pests, such as weeds, bacteria, fungi and viruses through hot steam which causes vital cellular proteins to unfold.
  - Considered a partial disinfection.

[73] Tilley, N. (2019, August 7). *Tips to sterilize potting soil, garden soil and soil for seeds*. Gardening Know How. https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/sterilizing-soil.htm

- Can be done with expensive machinery, such as an industrial soil steamer as shown below, or it can be done at home with a pressure cooker or with pots and boiling water.[74]

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- **Sterilization with an oven**
  - Put some soil in an oven-safe container, like a glass or metal baking pan, covered with foil.
  - Place a thermometer into the centre and bake at 82-93°C for at least 30 minutes, or when soil temp reaches 82°C.[76]

[74] Wikipedia. (n.d.). *Soil steam sterilization*. Retrieved 2019, from https://en.wikipedia.org/wiki/Soil_steam_sterilization
[75] User: HKWestrum. (2018, June 13). *Soilsteam soilprep400* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Soilsteam_soilprep400.jpg License: https://creativecommons.org/licenses/by-sa/4.0/legalcode
[76] Tilley, N. (2019, August 7). *Tips to sterilize potting soil, garden soil and soil for seeds*. Gardening Know How. https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/sterilizing-soil.htm

- **Sterilization with a microwave**
  - Fill clean microwave-safe containers with moist soil (no foil).
  - Add a few ventilation holes in the lid.
  - Heat the soil for about 90 seconds per every couple of kilograms on full power.[77]

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- **Solar sterilization**
  - An environmentally friendly method of using the sun's power to control pests.
  - Cover the ground with a tarp to trap solar energy (Fig. 1).
  - Sun heats the soil to temperatures that kill bacteria, fungi, insects, nematodes, mites, weeds, and weed seeds.
  - Procedures:
    1. Clear the area of plants and debris.
    2. Water the soil until it is wet.
    3. Cover the area with clear plastic. Don't use white or black plastic because they don't allow enough heat to get to the soil.
    4. Bury the plastic edges in the soil to trap the heat.
    5. Leave the plastic in place for at least four weeks in the hottest part of the summer.
    6. Remove the plastic.
  - Works best on heavy soils (containing clay, loam, or mixtures of them), which can hold more water and for long enough to produce steam every day.
  - Steam is needed to kill nematodes, weed seeds, and insect eggs in the soil.[79]

[77] Tilley, N. (2019, August 7). *Tips to sterilize potting soil, garden soil and soil for seeds*. Gardening Know How. https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/sterilizing-soil.htm
[78] User: Clker-Free-Vector-Images. (2012, April 11). *Microwave oven appliance kitchen* [Vector image]. Pixabay. https://pixabay.com/vectors/microwave-oven-appliance-kitchen-29056/
License: https://pixabay.com/service/license/
[79] Masabni, J. G., & Franco, J. G. (n.d.). *Soil solarization*. Texas A&M AgriLife Extension Service. https://agrilifeextension.tamu.edu/library/gardening/soil-solarization-2/

- **Chemical sterilization**
  - Process by which chemicals are used to destroy living organisms that are capable of destroying plants and causing disease in the soil.
  - Chemicals are selective in nature: when they are used, they only affect particular diseases, weeds, and/or insects for which they are meant, without causing harm to the other organism that inhabit the soil.
  - Chemicals such as Methyl-Bromide, Formaldehyde, and Chloropicrin are all effective at destroying fungi, insects, and weeds.
  - Can be expensive.
  - Can be harmful if not handled properly.

- **Selection criteria for sterilization methods**
  - History and background of the field
  - Type of soil
  - Types of crop to be grown
  - The nature of the microorganisms that need to be destroyed or removed.
  - Additional considerations: time, safety, environmental health, and budget.

Guided Practice Activity

Topic 5.3 Task 3:

1. Read through **5.3 Key Facts** as a class and make sure you understand the content.

2. Watch the following videos that build on **5.3 Key Facts**:

a. https://www.youtube.com/watch?v=JjX9Z4aTLoo
YouTube search: Gardening Preparation Tips: How to Sterilize a House Plant's Potting Soil

b. https://www.youtube.com/watch?v=fUOfQQVubz0
YouTube search: How to Sterilize Soil in The Garden: Grow Guru

3. Now, write responses to the following prompts individually:

Based on your experience, the videos shown to you, and the information in **5.3 Key Facts**, what do you think is the most realistic and resourceful way for you to sterilize soil

here in Rwanda? Provide in your written answer in at least 3-5 sentences. Support your answer with reasons and evidence from **5.3 Key Facts**.

4. Refer to the trainer's written response as a sample.

5. Refer trainees to **5.3 Key Facts** for evidence.

6. When you are finished, give your written response to another trainee to read and verify that they answered the questions completely and accurately.

7. Share your responses with the class.

8. Listen to the trainer's observations and feedback.

Application Activity

Topic 5.3 Task 4:

1. Form groups of three and read the following scenario and task:

Jackson is a student who lives in an apartment in Kigali. He has some tomato seeds that he wants to grow in pots on his roof top. He dug some soil from a nearby field, put it in a bag, and wants to use it for his tomatoes. He knows that you are studying growing media, so he asked you to help him.

Jackson is a student, so he does not have a lot of money for Cash-power. His kitchen does have a microwave. He is permitted to have potted plants on his rooftop.

a. Provide your recommendation to Jackson on how he can sterilize his soil so that his tomato seeds have an excellent growing medium.

b. Consider all of the information about Jackson provided.

2. After reflecting, share your group's advice to Jackson. Challenge each other by agreeing or disagreeing.

3. Consider the trainer's observations and feedback.

Points to Remember

- Environmental protection is an important factor when treating soil for a growing medium.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Explain the difference between sterilization using an oven and sterilization using a microwave.

2. What is a benefit of chemical sterilization?

3. Which of the following is NOT a step in the solar sterilization process?
   a. Clear the area of plants and debris.
   b. Use a reflective mirror to make the sunlight stronger.
   c. Water the soil until it is wet.
   d. None of the above.

4. What are the three methods of soil sterilization?

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the Knowledge, Skill or Attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Select the site for organic growing media					
Differentiate growing media					
Characterize the site for organic growing media					
Select the tools and equipment used for soil collection and sterilization					
Characterize tools and equipment used for soil collection and sterilization					
Explain site selection criteria for soil collection and sterilization					
Identify soil sterilization methods for growing media					
Select soil sterilization methods for growing media					
Sterilize the soil for growing media					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	**1.**	**1.**
2.	**2.**	**2.**

Unit 6: Setting up growing medium for planting

Topics

6.1 Identification of materials for growing media

6.2 Preparation of growing media

6.3 Placing sterilized soil and amendments in growing media

Unit Summary:

This unit describes the knowledge, skills, and attitudes required to set up organic growing medium for plants in a greenhouse, including how to identify growing medium materials, prepare growing media, and place sterilized soil and amendments in growing media.

Self-Assessment: Unit 6

1. Look at the illustration. What is happening? What do you think this unit will be about? What topics might be covered?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this survey. It is for your own use during this course. The trainer will read a skill that is listed in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, we'll take this survey again.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Explain the characteristics of materials for growing media					
Differentiate the materials for growing media					
Select the materials for growing media					
Characterize the materials for growing media					
Select growing medium constituents					
Prepare growing media					
Characterize growing media					
Follow guidelines for mixing growing media					
Follow mixing ratios to prepare growing media					
Characterize mixed growing media					

Topic 6.1: Identification of materials of growing media

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain the characteristics of the materials for growing media	**1.** Characterize the material for growing media	**1.** Collaborative
2. State the ingredients for growing media	**2.** Select the material for growing media	**2.** Analytical
3. State the characteristics of materials for growing media	**3.** Differentiate the material for growing media	**3.** Decisive

Getting Started: What do we know and where are we going?

Topic 6.1 Task 1:

1. Participate in a class discussion using the points below:

   a. Think about the materials used by farmers when preparing organic growing medium.

   b. Why are these criteria taken into consideration when selecting the material for growing medium?

2. Share your ideas and answers while the trainer writes them on the board.

3. Read the Key Competencies table, which includes the knowledge, skills, and attitudes you will gain. In this topic, you will continue to discuss identifying the materials for growing media.

Problem Solving Activity

Topic 6.1 Task 2:

1. With a partner, read and discuss the following information and questions:

Growing medium ensures that the plant can grow healthily by providing the soil with a range of essential elements, including an optimum rooting environment for physical stability, storage of air for the roots, water absorption and retention, and a supply of nutrients for the roots.

a. What are the ingredients in growing media?

b. What are the three basic types of growing media and their functions?

2. Refer to **Topic 5.1** to activate previous knowledge.

3. Share your answers with the class. Agree and disagree with the others and explain why.

4. The correct answers will be discussed in **6.1 Key Facts** and you will be given an opportunity to revise your answers from this task.

6.1 Key Facts

- **Essential elements provided by growing medium:**
  - optimum rooting environment for physical stability
  - storage of air for the roots
  - water absorption and retention
  - availability to the plant when needed
  - supply of nutrients for the roots[80]

- **Growing media ingredients may include:**
  - Peat
  - coir pith

[80] Growing Media Europe AISBL. (n.d.). *Growing media: A short introduction*. https://www.growing-media.eu/news-1

- wood fibres
- bark
- composted materials
- mineral constituents, such as perlite, pumice, clay, and vermiculite
- Usually enriched with fertilizers, lime, and sometimes biological additives in order to achieve the correct balance of physical, chemical, and biological properties for the plants.

- **Uses of different growing media:**
  - Use wood fibres or bark for young trees and shrubs because it provides more physical stability.
  - Use clay for plants with high water needs because it can store the water longer.
  - Use perlite to enhance the water drainage.[81]

- **Criteria for selection growing media:**
  - Provides growing conditions that are predictable and reliable for the grower and contribute to higher yields and more efficient growing.
  - Irrigation technique and set up
  - Drippers density and discharge
  - Container size and shape

- **Qualities of different growing media**
  - Sand: Dries quickly
  - Peat moss: Dries slowly
  - Choir: Hard to get wetted
  - Water: Little air
  - Pearlite: Too much air
  - Vermiculite: Expensive
  - Potting soil mixes: Just right

[81] Growing Media Europe AISBL. (n.d.). *Growing media: A short introduction*. https://www.growing-media.eu/news-1

- **Three basic types of media**
  - **Soil**: Natural layer of the earth that supports life.
  - **Soilless**: Any material for growing plants not containing topsoil
    - A single or a mix of growing media that is used to grow plants.
    - Does not include soil.
    - Generally, does not contain bacteria or fungi, so they are considered sterile media.
  - **Hydroponics**: a method of using mineral nutrient solutions in a water.
    - Growing medium takes the place of the dirt/soil.
    - A porous soil-less material that can hold the moisture and oxygen that the root system requires to grow.
    - Non-porous materials can be used as well, but watering cycles would need to be more frequent, so the roots don't dry out between watering

- **The functions of the growing media**
  - Must provide air
  - Must provide water
  - Must provide nutrients
  - Must provide support

Guided Practice Activity

Topic 6.1 Task 3:

1. Read through **6.1 Key Facts** and make sure you understand the content. As you discuss **6.1 Key Facts**, revise your answers from **Task 2.** Share the correct answers.

2. Watch the following video that builds on what you read and discussed in **6.1 Key Facts**:

- https://www.youtube.com/watch?v=Tf9jI7mcmcA
  YouTube search: CIB – Mixing Your Own Growing Media

3. Work with a partner to complete the task:

   With the materials available in the classroom, identify and select the ingredients for a growing medium that is ideal for young fruit trees. Fruit trees grow best in well-drained soil with a sandy, loamy* texture. They also need deep soil to support their deep root systems.

   * Loam soil is a mixture of soil that is the ideal plant-growing medium. It is actually a combination soil: equal parts of clay, silt, and sand, which gives the benefits of each without the disadvantages.

4. After completing the task, share what you and your partner selected and why those ingredients are a good choice as a growing medium for young fruit trees.

5. Listen to the trainer's advice and support and observe the trainer's thought process in selecting ingredients to learn best practices/standards.

Application Activity

Topic 6.1 Task 4:

1. Read the following scenario and complete the task individually:

   The school wants to you to select the ingredients they would need a growing media to be used for the following purposes:

- To be used to grow young trees and shrubs
- Plants with high water needs
- Good drainage of water
- Provides physical stability for the plants

Write a list of the ingredients that the school should select to meet the above requirements. Explain your reasoning.

2. Listen to the trainer's sample response to learn best practices and standards.

3. Refer to **6.1 Key Facts** for evidence.

4. When you are finished, exchange your written response with another trainee to read and verify that they completed the task accurately.

5. Share your responses out loud with the class.

6. Listen to the trainer's observations and feedback as needed.

Points to Remember

- The three major types of growing media are soil, soilless, and hydroponic.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. List five ingredients in growing media:

1.
2.
3.
4.
5.

2. What are the functions of growing media?

3. What is a benefit of using clay as an ingredient in a growing medium?

4. What are the ingredients to making compost?

Topic 6.2: Preparation of growing medium

Key Competencies:

Knowledge	Skills	Attitudes
1. List growing media constituents	**1.** Select growing media constituents	**1.** Detail-oriented
2. State growing media preparation rules	**2.** Prepare growing medium	**2.** Analytical
3. Explain the characteristics of a well-prepared growing medium	**3.** Characterize growing media	**3.** Precise

Getting Started: What do we know and where are we going?

Topic 6.2 Task 1:

1. Participate in a class discussion using the following questions:

   a. What should you consider when preparing growing media?

   b. Why should growing media have different constituents/ingredients?

2. Share your ideas and answers while the trainer writes them on the board.

3. Read through the Key Competencies table, which includes the knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 6.2 Task 2:

1. Discuss the following question with a partner:

a. When preparing a growing medium one should follow different rules so that the prepared growing medium is consistent and provides good health to the crop to be grown.

b. Based on what you know now, what do you think some of the rules are to be followed?

c. What do you think are the characteristics of a well prepared growing medium?

2. Refer to your notes and previous topics to activate previous knowledge.

3. Share your answers with the class. Agree and disagree with other trainees' responses and explain why.

4. The correct answers will be discussed in **6.2 Key Facts** and that you will be given an opportunity later on to revise your answers from this task.

6.2 Key Facts

- **Preparing growing media**
  - Can be a challenge depending on what a grower is looking for.
  - Organic growers often choose to use composts, peat, bark and other materials to make an organic growing medium.
  - Some components are acidic and will require pH adjustment.
  - Most organic components are hard to wet with water.
  - Rules/Considerations
    - Be sure to have the correct ingredients.
    - Be sure to mix the right amount/ratio of ingredients together.
    - Consider the crop requirements (What does the plant need?).

- Consider the soil properties.[82]

- **Qualities of a good potting soil**
  - Drains well
  - Lightweight
  - Able to hold nutrients and moisture even in the heat.

- **Potting soil mixes:**
  - Most common core ingredients: fine sphagnum peat moss, coconut coir, perlite, vermiculite, compost, and sometimes granular fertilizers and ground limestone.
  - Most mixes have variations of these components.

- **Sphagnum peat moss:**
  - Natural product harvested from bogs.
  - Harvest is debated because many bogs have been destroyed or badly damaged.
  - Acidic, retains moisture well, and helps break apart other soils and mixes.

- **Coconut coir**
  - By-product of coconut harvesting
  - Made from the fibres on the outside husk.
  - Neutral pH between 5.2 – 6.8.
  - One of the better ingredients due to its water holding capability, air space, and good drainage.
  - Blend of sphagnum peat moss and coconut coir makes an excellent potting soil base

- **Perlite**
  - Natural volcanic glass that is mined and then heated up until it expands into round, white particles.
  - Main function is to break up the soil and allow air movement
  - Helps retain moisture, but not as well as vermiculite.

- **Vermiculite**
  - Natural materials
  - Like perlite, is heated up and expands into form when processed.
  - Main advantage is its water holding capabilities

[82] Buechel, T. (2018, October 5). *Simplifying organic growing: The best growing media components*. PRO-MIX. https://www.pthorticulture.com/en/training-center/simplifying-organic-growing-the-best-growing-media-components/

- Helps with aerating the soil, but not to the extent that perlite does.
- Varies in particle size depending on the grade and intended use.
  - Small and medium sized particles commonly used for making potting soils.

- **Compost**
  - Made of decomposed organic matter.
  - When used in potting mixes, should be free from chunks of wood chips, bark or other bulky materials. Sift thoroughly before adding it to potting soil mixtures.
  - Usually has a neutral pH level.
  - Provides an abundance of nutrients.
  - Helps retain moisture.

- **Granular fertilizers and ground limestone**
  - Most common organic amendments are blood meal (for nitrogen) and bone meal (for phosphorus).
  - Nitrogen is essential for foliage growth.
  - Phosphorus is essential for developing strong roots and flowering.
  - Ground limestone comes from crushed up limestone or chalk.
  - Used to help neutralize soil pH by reducing soil acidity through increasing alkalinity.[83]

- **Characteristics of a well-prepared growing media**
  - optimum rooting environment for physical stability
  - air storage for the roots
  - water absorption and retention
  - available to the plant when needed
  - supply of nutrients for the roots[84]

[83] Bootstrap Farmer. (n.d.). *Beginners guide to soil, media, amendments and fertility*. https://www.bootstrapfarmer.com/blogs/how-to-grow-seedlings/beginners-guide-to-soil-media-amendments-and-fertility

[84] Growing Media Europe AISBL. (n.d.). *Growing media: A short introduction*. https://www.growing-media.eu/news-1

Guided Practice Activity

Topic 6.2 Task 3:

1. Read through **6.2 Key Facts** and make sure you understand the content. As you discuss **6.2 Key Facts**, revise your answers from **Task 2.** Share the correct answers.

2. Next, separate into groups of three. Carefully view the video and answer the following questions with your group:

   Video: https://www.youtube.com/watch?v=E2TY57-uyME
   YouTube search, Potting mix vs Potting soil – EX & Cheap DIY Potting Mix Recipe

   a. What rules for preparing a growing medium did the gentleman in the video follow?

   b. Did the potting mix in the video contain soil or was it soilless?

   c. What are the benefits of creating a potting mix such as the one shown in the video?

3. Watch the video again so that you are able to fully understand and answer the questions.

4. Share your answers. Use evidence from **6.2 Key Facts** as well as the video to support your responses.

5. Next, watch the video you previously viewed from **Topic 5.1** for further review:

   Video: https://www.youtube.com/watch?v=x4JssQPTYF8
   YouTube search: How to Make Hot Compost Complete Guide

6. Now, go outside to maintain your compost piles that you started in **Topic 5.1.** Tell the trainer why you are maintaining compost piles and what rules you should follow to prepare a growing medium.

Application Activity

Topic 6.2 Task 4:

1. Work with a partner sitting next to you. Read and discuss the scenario and questions below:

The school has different constituents/materials to be used for preparation of growing media for growing flowers.

a. What are the rules to be followed?

b. What are the characteristics of a well prepared growing medium?

2. Write your answers down in addition to discussing them.

3. Share your responses and explanations out loud with the class. Be sure to ask questions and provide feedback to other trainees.

4. Consider the trainer's feedback and observations.

Points to Remember

- When preparing growing media, always remember to make sure that you have the correct ingredients and that you are mixing the correct amount of ingredients together.
- Always consider the crop requirements and the soil properties before you prepare growing medium.
- A well-prepared growing medium will have an optimum rooting environment for physical stability, storage of air for the roots, water absorption and retention, and a supply of nutrients for the roots.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Identify each statement as either **true** or **false**:

a. A good growing medium should drain well.

b. A good growing medium should not have the ability to hold nutrients and moisture, even in the heat.

c. Coconut coir is a good base for potting soil.

2. List three rules to follow when preparing growing media and explain why they are important.

1.
2.
3.

3. List five constituents/ingredients of growing media.

1.
2.
3.
4.
5.

Topic 6.3: Placement of sterilized soil and amendments in growing medium

Key Competencies:

Knowledge	Skills	Attitudes
1. List guidelines for mixing growing medium	**1.** Follow guidelines for mixing growing medium	**1.** Accurate
2. State mixing ratios for growing media preparation	**2.** Follow mixing ratios for growing media preparation	**2.** Analytical
3. Explain the characteristics of a well-mixed growing media	**3.** Characterize mixed growing media	**3.** Detail-oriented

Getting Started: What do we know and where are we going?

Topic 6.3 Task 1:

1. Participate in a class discussion using the following questions:

- **a.** What are soil amendments?
- **b.** What are growing media?
- **c.** How are they related?

2. Share your ideas and answers while the trainer writes them on the board.

3. Read the Key Competencies table, which includes the knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 6.3 Task 2:

1. Read the following scenario and discuss the questions with a partner:

Kalisa and Gahire work at a company that prepares bagged growing media. Recently, customers have complained that their growing media do not have any air circulation or water filtration.

a. What do you think caused poor air circulation and water filtration in the growing media?

b. Advise Kalisa and Gahire on how to produce quality growing media for their customers.

2. Refer to your notes and other topics to activate previous knowledge.

3. Share your answers with the class. Agree and disagree with each other and explain why.

4. The correct answers will be discussed in **6.3 Key Facts** and you will be given an opportunity to revise your answers from this task later.

6.3 Key Facts

- **Guidelines for mixing growing medium:**
  - Avoid compacting growing media: Containers should be lightly filled with the excess brushed off the top; do not stack growing containers or pre-fill them too far in advance.
  - Add water to peat-based mixes before filling plug trays to create more aeration.
  - Test the pH, electrical conductivity, and wettability before use.
  - Do not make changes to your current growing media without experimenting first to see if changes may affect your practices.
  - If mixing your own media, thoroughly mix components, but do not over-mix, especially if a media contains vermiculite or controlled release fertilizer.
  - Do not store media that contains fertilizer especially if the media is moist.
  - Avoid contamination of components for finished media by keeping amendments in closed bags or by covering piles.

- Avoid contamination of bagged commercial media by keeping any broken bags covered.
- Wear a dusk mask when handling dry peat moss or vermiculite to avoid inhaling these materials.

- **Mixing ratio:**
  - Mixes do not contain wetting agent or starter fertilizer.
  - Should be able to get wet without a problem, but make sure they are thoroughly moistened before planting. Begin fertilizing shortly after planting.
  - Ratios are as follow: 1:1:1 mature compost, field soil, and field sharp sand or perlite.[85]

- **Characteristics of a well-prepared growing media**
  - optimum rooting environment for physical stability
  - air storage for the roots
  - water absorption and retention
  - available to the plant when needed
  - supply of nutrients for the roots[86]

Guided Practice Activity

Topic 6.3 Task 3:

1. Read through **6.3 Key Facts** and make sure you understand the content. As you discuss **6.3 Key Facts**, revise your answers from **Task 2.** Share the correct answers.

2. Now, form groups of three and refer to the scenario and task below:

You are requested to mix growing media using different constituents available in the school workshop. The mixing ratio to follow is 1:1:1 mature compost, field soil, and field sharp sand or perlite.

[85] UMASS Center for Agriculture, Food and the Environment. (n.d.). *Effects of growing media on water and nutrient management*. https://ag.umass.edu/greenhouse-floriculture/greenhouse-best-management-practices-bmp-manual/effects-of-growing-media-on

[86] Growing Media Europe AISBL. (n.d.). *Growing media: A short introduction*. https://www.growing-media.eu/news-1

Using the mixing guidelines for growing media, you are requested to follow the mixing ratio to avoid overmixing and to meet the characteristics of a well-mixed growing media.

3. Observe the trainer as he or she demonstrates how to complete this activity.

4. Then, complete the task by mixing the growing medium in a bucket/container within your space.

5. Share your thoughts and ideas as well as challenges from this activity.

Application Activity

Topic 6.3 Task 4:

1. Separate into pairs and read the following as a class:

You are requested to mix growing media constituents for tomato plants. The mixing ratio to follow is 1:2:1 mature compost, field soil, and field sharp sand or perlite.

Using the guidelines, mix the growing media with all the characteristics as required by your crop.

2. Read the following information about tomato crops:

a. Soil Types and Textures

Loam and sandy loam soils are best for tomato production, but tomatoes will grow in almost all soil types, except heavy clay. If you your soil has lots of clay, you can improve the texture by tilling the soil and incorporating sand, sawdust, peat moss or other amendments before planting. The soil should be loose and well-drained. Tomatoes don't do well in dry soil, but avoid planting them in excessively wet, waterlogged soil, or anywhere standing water gathers after a rain.

b. Soil pH Level

A soil's acidity or alkalinity is measured by its pH level. A pH of 7 is considered neutral, while anything lower is acidic and anything higher is alkaline. Tomatoes grow best in neutral or near-neutral soil, so you may have to modify your soil's pH for best results. If necessary, you can raise pH by incorporating ground agricultural lime into the soil

before planting. You can lower pH by adding elemental sulphur or fertilizers that contain ammonium sulphate.

c. Fertility

Tomatoes grow well in moderately fertile soil with lots of organic matter. You can incorporate compost when you prepare the soil. Adding an all-purpose fertilizer containing potassium and phosphorous can also be helpful. Avoid fertilizers with high nitrogen content, because these can result in bushy plants that produce little fruit.

d. Note

A good starting point is to have your soil tested. The results of the soil test will reveal nutrient content and pH, as well as make recommendations for soil amendments.

3. Read the crop requirements, select materials, and verify the guidelines using evidence from **6.3 Key Facts**.

4. When everyone is finished, share your group's process. Listen carefully to other groups and offer support/suggestions.

5. Listen to the trainer's observations and any additional feedback.

Points to Remember

- While mixing your own media, thoroughly mix components, but do not over-mix, especially if a media contains vermiculite or a controlled release fertilizer.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Identify each statement as either **true** or **false**:

a. Clay is frequently used for plants with high water needs because it can store the water longer.

b. Perlite is a material used to break up the soil and enhance air circulation.

c. It is acceptable to make changes to the medium before experimenting with it first.

d. Fill growing containers with soil lightly and avoid compaction.

2. Explain why it is important to both sterilize the soil and place amendments.

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the Knowledge, Skill or Attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Explain the characteristics of materials for growing media					
Differentiate the materials for growing media					
Select the materials for growing media					
Characterize the materials for growing media					
Select growing medium constituents					
Prepare growing media					
Characterize growing media					
Follow guidelines for mixing growing media					
Follow mixing ratios to prepare growing media					
Characterize mixed growing media					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	**1.**	**1.**
2.	**2.**	**2.**

Unit 7: Setting up water delivery systems for growing media

Topics

7.1 Identification of materials, tools, and equipment for installing watering systems

7.2 Installation of water supply systems

7.3 Watering according to the crop requirements

Unit Summary:

This unit describes the knowledge, skills, and attitudes required to set up a water delivery system for growing media, including how to identify materials, tools, and equipment for installing watering systems, install water supply systems, and water according to the crop requirements.

Self-Assessment: Unit 7

1. Look at the illustration. What do you see? What do you think this unit will be about? What topics might be covered?

2. Fill in the self-assessment below.

There are no right or wrong ways to answer this survey. It is for your own use during this course. The trainer will read a skill that is listed in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation. At the end of this unit, we'll take this survey again.

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Identify the selection criteria for tools and equipment for installing an irrigation system					
Select tools for installing an irrigation system					
Select equipment for installing an irrigation system					
Identify methods of irrigation					
Choose an irrigation method					
Install a water supply system					
Identify factors affecting crop water requirements and needs					
Calculate the irrigation time					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Identify the soil, slope, and crops suitable for drip, surface, and sprinkler irrigation systems					

Topic 7.1: Identification of materials, tools, and equipment for installing a watering system

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain the selection criteria of tools and equipment for installing an irrigation system	**1.** Characterize tools and equipment for installing an irrigation system	**1.** Team spirit
2. List tools for installing an irrigation system	**2.** Select tools for installing an irrigation system	**2.** Analytical
3. State the characteristics of an irrigation site	**3.** Characterize the site for irrigation	**3.** Honest

Getting Started: What do we know and where are we going?

Topic 7.1 Task 1:

1. Participate in a class discussion using the following questions:

a. How does a farmer maintain her crops in the dry season?

b. What different ways to water crops have you seen/experienced?

c. What are some of the tools you have used or seen when watering crops?

2. Share your ideas and answers while the trainer writes them on the board.

3. Read the Key Competencies table, including the knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 7.1 Task 2:

1. Form groups of three and refer to **Topic 7.1 Task 2** in your manuals.

2. Using what you already know, properly identify some of the tools and make educated guesses about the others.

A

B

[87]

C

D

E

F

[87] Schellhase, M. (2007, July 28). *Wire cutter* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Wire_cutter.png License: https://creativecommons.org/licenses/by-sa/3.0/legalcode

G 

H 

I 
[88]

J 
[89]

K 
[90]

A.	B.
C.	D.
E.	F.
G.	H.
I.	J.
K.	

3. After completing the task, share your answers for pictures A – N. Agree or disagree with other groups and state why.

4. Listen to the trainer's observations and feedback.

[88] User: Arz. (2007, May 17). *Shovels*. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Shovels.png License: https://creativecommons.org/licenses/by-sa/3.0/legalcode

[89] All images, unless otherwise cited, are from Wikimedia Commons (Public Domain) or Pixabay.com (License: https://pixabay.com/service/license/)

[90] Стрелец Игорь. (2017, August 16). *PVC pressure* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:PVC_pressure.jpg License: https://creativecommons.org/licenses/by-sa/3.0/legalcode

7.1 Key Facts

- **Selection criteria for tools and equipment for irrigation system**
  - Method of irrigation
  - Water quality
  - Cost of tools and equipment
  - Farming scale (How much/How big?)
  - Cost and benefit for an irrigation system
  - Soil types

- **Tools to install in an irrigation system:**




[91]



[92]

  - Basic tool requirements: A shovel, hacksaw, wire cutter, a couple of wrenches, and a knife will get the job done in most cases.
  - Some special tools make the work much easier and faster to perform. Here is a list of the tools commonly used by professionals:

- trenching shovel/spade
- tamper bar
- digging bar
- PVC pipe cutter
- Sledgehammer

[91] Schellhase, M. (2007, July 28). *Wire cutter* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Wire_cutter.png License: https://creativecommons.org/licenses/by-sa/3.0/legalcode

[92] All images, unless otherwise cited, are from Wikimedia Commons (Public Domain) or Pixabay.com (License: https://pixabay.com/service/license/)

- pry bar
- measuring tape
- landscape rake
- garden hose
- 2 cm PVC pipe to female garden hose adapter
- Water storage tank/cistern
- Screwdriver
- trencher machine
- hose sweeper nozzle
- riser extractor
- pipe wrench
- Gutters for catching rain
- 2 cm PVC pipe to male hose thread adapter

[93]

- **Irrigation equipment**
  - Pipes
  - Pipe connector fittings
  - Flow control devices
  - Filters
  - Fertigation equipment
  - Water emitters
  - Automation equipment
  - Operation equipment
  - Water-lifting devices

[93] Sustainable Sanitation Alliance (SuSanA). (2011, July 3). *Rainwater harvesting tank (5981896147)* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Rainwater_harvesting_tank_(5981896147).jpg License: https://creativecommons.org/licenses/by/2.0/legalcode

 [94]

Guided Practice Activity

Topic 7.1 Task 3:

1. Read through **7.1 Key Facts** and make sure you understand the content. As you discuss **7.1 Key Facts**, refer to the pictures in **Task 2** and verify that you have matched the correct names for the tools and equipment. Share the correct answers with the trainer.

2. As an extra resource to help you better understand the content, watch the following video:

   Video: https://www.youtube.com/watch?v=amrCMakolKA
   YouTube search: What is Irrigation?

3. Now, find a partner and read the following scenario and answer the questions:

   Munyanziza and Munyemana are farmers growing vegetables. They want to continue planting in the dry season, but they are worried they will not have enough water for their crops. They would like to buy tools and equipment to install an irrigation system on their farm so they can supply water to their crops during the dry season.

   a. Name the tools and equipment needed to install a basic irrigation system on their land.

   b. What are the criteria to consider when selecting tools and equipment for irrigation?

[94] Стрелец Игорь. (2017, August 16). *PVC pressure* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:PVC_pressure.jpg
License: https://creativecommons.org/licenses/by-sa/3.0/legalcode

4. Share your group's answers. Ask questions and provide feedback to other groups.

5. Listen to the trainer's observations and feedback.

Application Activity

Topic 7.1 Task 4:

1. Visit a farm to observe a watering system in action. Greet the farmer and any workers present.

2. Choose a partner for this activity and refer to the following instructions:

   You are visiting a farm with functioning watering systems. As you tour the farm, discuss and answer the following questions:

   a. Make a list of the tools and equipment you see for the water supply system.

   b. What are their purposes?

   c. Ask the farmer: How did he/she select the equipment and types of watering system? What were the criteria he/she considered?

3. Discuss with the farmer about the watering system. Ask the farmer any questions you still have about watering/irrigation systems.

4. Come together to share your findings.

5. Ask questions and provide feedback to other groups.

6. Listen to the trainer's observations and feedback.

Points to Remember

- A basic watering system requires a shovel, hacksaw, wire cutter, a couple of wrenches, knife, hose, and water tank.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Identify the following statements as either **true** or **false**:

a. Any tool can be used for installing an irrigation system.

b. Different irrigation methods have different tools and equipment.

c. When selecting tools and equipment, remember the type of irrigation method to be used.

2. List the tools and equipment for capturing rainfall into a tank.

3. What is the purpose of a flow control device?

Topic 7.2: Installation of water supply system

Key Competencies:

Knowledge	Skills	Attitudes
1. Explain types of irrigation methods	**1.** Characterize different irrigation methods	**1.** Collaborative
2. List the criteria for choosing an irrigation method	**2.** Choose an irrigation method	**2.** Analytical
3. List the irrigation components	**3.** Install a water supply system	**3.** Determined

Getting Started: What do we know and where are we going?

Topic 7.2 Task 1:

1. Participate in a class discussion using the following questions:

Think about the irrigation and watering systems you have seen.

a. What are their components?

b. What methods have you seen or experienced?

2. Share your ideas and answers while the trainer writes them on the board.

3. Read the Key Competencies table, including the knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 7.2 Task 2:

1. Work with a partner to complete the following:

An adequate water supply is important for plant growth. When rainfall is not sufficient, the crops must receive additional water from irrigation.

a. What criteria should you consider when choosing any irrigation method?

2. Refer to your notes and other topics to activate previous knowledge.

3. Share your answers with the class. Agree and disagree with each other and explain why.

4. The correct answers will be discussed in **7.2 Key Facts** and you will be given an opportunity later on to revise your answers from this task.

7.2 Key Facts

- **Selection criteria for surface, sprinkler, or drip irrigation systems:**
  - Natural conditions
  - Type of crop
  - Type of technology
  - Previous experience with irrigation
  - Required labour inputs
  - Costs and benefits

- **Irrigation**
  - Adequate water supply is important for plant growth.
  - When rainfall is not sufficient, the plants must receive additional water from irrigation.
  - Three commonly used methods: surface irrigation, sprinkler irrigation, and drip irrigation.

- **Surface irrigation:**
  - Application of water by gravity flow to the surface of the field.

- Either the entire field is flooded (basin irrigation) or the water is fed into small channels (furrows) or strips of land (borders).[95]

- **Components of surface irrigation system:**
  - **Diversion structures**: Directs runoff or extra water to storage locations to save for a dry period.
  - **Conveyance, distribution, and management structures**: Any structure that conveys water from one location to another; requires similar structures to those found in major canal networks; can be an earthen ditch, a buried pipe, or a lined ditch.
    - Water management: flow measurement, sediment and debris removal, and water level regulators
    - Flow measurement: Weirs, flumes, orifices
  - **Field distribution systems**: Most fields have a head ditch or pipeline running along the upper side of the field from which the flow is distributed onto the field.[96]

- **Sprinkler irrigation:**
  - Similar to natural rainfall.
  - Water is pumped through a pipe system and then sprayed onto the crops through rotating sprinkler heads.

- **Components of sprinkler irrigation:**
  - Pump unit
  - Mainline and sometimes sub mainlines
  - Laterals
  - Sprinklers

[95] Energypedia. (n.d.). *Surface irrigation*. https://energypedia.info/wiki/Surface_Irrigation

[96] Walker, W. R. (1989). *Guidelines for designing and evaluating surface irrigation systems: Surface irrigation systems*. Food and Agriculture Organization of the United Nations. https://www.fao.org/3/T0231E/t0231e04.htm#2.4.2%20conveyance,%20distribution%20and%20management%20structures

 [97]

- **Drip irrigation**
  - Water is conveyed under pressure through a pipe system to the fields
  - Water drips slowly onto the soil through emitters or drippers, which are located close to the plants.
  - Only the immediate root zone of each plant is wetted.

 [98]

- **Drip system components:**
  - Pump unit
  - Control head
  - Main and submain lines
  - Laterals
  - Emitters or drippers

[97] International Institute of Tropical Agriculture (IITA). (2011, July 6). *Sprinkler irrigation in cowpea field* [Photograph]. Flickr. https://www.flickr.com/photos/iita-media-library/5908565297
License: https://creativecommons.org/licenses/by-nc/2.0/legalcode
[98] Sipler, D. (2008, June 3). *Drip irrigation* [Photograph].
Flickr. https://www.flickr.com/photos/photofarmer/2552390830
License: https://creativecommons.org/licenses/by/2.0/legalcode

Guided Practice Activity

Topic 7.2 Task 3:

1. Read through **7.2 Key Facts** and make sure you understand the content. As you discuss **7.2 Key Facts**, revise your answers from **Task 2**. Share the correct answers with the trainer.

2. As an extra resource, watch the following videos:
   - Video: https://www.youtube.com/watch?v=tmEj3MQPlTY
     YouTube search: Drip Irrigation Basics

   - Video: https://www.youtube.com/watch?v=mzD6eH4fmIw
     YouTube search: Overhead Sprinkler Irrigation

   - Video: https://www.youtube.com/watch?v=rZzG_Mfhicg
     YouTube search: Using Rain Barrels to Irrigate Your Garden

3. Now, work in pairs to do the following:

   a. Based on the illustrations, **7.2 Key Facts**, and the videos: What are the advantages and disadvantages of the sprinkler, drip, and surface/channel irrigation methods?

   b. Make a list and be prepared to support your reasons with evidence.

4. For this activity, the information is not directly stated in your manual or the videos. You must make inferences (educated guesses based on evidence) from the resources provided and use your experience.

5. Share your lists of advantages and disadvantages for each system while the trainer makes notes of your reasons on the board for the class to see. Agree or disagree with each other and state why.

6. Listen to the trainer's observations and feedback.

Application Activity

Topic 7.2 Task 4:

1. First, separate into pairs and read the scenario:

A farmer would like to grow tomatoes in a greenhouse like the one shown below. You are requested to assist in the installation of a watering system.

[99]

2. With your partner, discuss the following questions about the scenario:

a. What type of irrigation system do you recommend and why?

b. What tools and equipment will you need to get started?

3. As you discuss and analyse the picture, refer to **7.2 Key Facts**.

4. The answers to these questions are not directly stated in **7.2 Key Facts**. You must think critically, combining the information given with your own experience and previous knowledge.

[99] User: W.carter. (2017, August 22). *Small greenhouse with grapevines escaping - side view* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Small_greenhouse_with_grapevines_escaping_-_side_view.jpg
Public Domain

5. When you are finished, share your answers and listen carefully to other groups. Listen for any mistakes and offer support/suggestions.

6. After everyone has presented their responses, listen to the trainer's observations and any additional/necessary feedback and support.

Points to Remember

- Consider the farm scale as well as the costs and benefits when installing a water supply system.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Identify each statement as either **true** or **false**:

   a. With drip irrigation, only the immediate root zone of each plant is wetted.

   b. Sprinkler systems do not need a pump.

   c. Surface irrigation using channels can be fed by a gravity system.

2. What are the benefits of a drip system?

3. What are diversion and conveyance structures?

Topic 7.3: Watering according to the crop water requirements

Key Competencies:

Knowledge	Skills	Attitudes
1. List the factors affecting crop water requirements /needs	**1.** Identify factors affecting crop water requirement/needs	**1.** Accurate
2. State the rules followed for watering crops	**2.** Calculate the irrigation time	**2.** Analytical
3. List the environmental and economic benefits of irrigation techniques	**3.** Choose a watering technique based on environmental and economic benefits	**3.** Conservative

Getting Started: What do we know and where are we going?

Topic 7.3 Task 1:

1. Participating in a class discussion based on the following situation:

Crops are suffering from insufficient water to the point that if water is not supplied, the crops will dry up and there will be no yield. Some farmers grow paddy rice and beans in a low land area and think that water from a small river passing around the plot is sufficient for both paddy rice and beans without any additional water. After trying this, the paddy rice failed as compared to the beans which gave the targeted yield.

2. What are the causes of the differences in yield between paddy rice and beans?

3. As you discuss, share your ideas and answers while the trainer writes them on the board.

4. Read the Key Competencies table, which includes the knowledge, skills, and attitudes you will acquire by the end of this topic.

Problem Solving Activity

Topic 7.3 Task 2:

1. Work with a partner to complete the following tasks:

a. Write: A list of what factors you think should be considered when watering crops.

b. Discuss: What are watering guidelines you should follow with any crop?

2. Look back at your notes and other topics to activate your previous knowledge.

3. Share your answers with the class. Agree and disagree with each other and explain why.

4. The correct answers will be discussed in **7.3 Key Facts** and you will be given an opportunity later to revise your answers from this task.

7.3 Key Facts

- **Water processes:**
  - Plant roots suck or extract water from the soil to live and grow.
  - **Transpiration:** Process in which a plant's water escapes to the atmosphere as vapour through the leaves and stem; happens mainly during the daytime.
  - **Evaporation**: When water from an open water surface escapes as vapour to the atmosphere during the day. The same happens to water on the soil surface and to water on the leaves and stem of a plant.
  - **Evapotranspiration**: Crop water need consists of transpiration plus evaporation.

- **Water requirements:**
  - Crop water need is usually expressed in mm/day, mm/month or mm/season.
  - If the water need in a very hot, dry climate is 10 mm/day, then each day the crop needs a water layer of 10 mm over the whole area where the crop is grown
    - Does NOT mean that this 10 mm has to be supplied by rain or irrigation every day.

- Possible to supply 50 mm of irrigation water every 5 days. The irrigation water will then be stored in the root zone and gradually be used by the plants: every day 10 mm.[100]

- **Crop water need mainly depends on:**
  - Climate
  - Crop type
  - Growth stage

- **Recommendations for watering:**
  From Garden's "10 golden rules for watering" guide:
  - **Maintain good soil moisture levels**: Keep an even level of moisture but dry out a little before watering to promote root growth of the plants.
  - **Water less often, but thoroughly.**
  - **Water late in the evening or early in the morning:** Less water evaporates when cooled soil is watered in the evening or at night, than it would on hot soil during the day. The plants can supply themselves with water before the next day's heat.
  - **Keep leaves dry to avoid diseases:** Wet leaves become diseased leaves. Leaves that are made wet in the sun develop slight burn marks (burning glass effect of the water droplets). Leaf-mould diseases may result.
  - **Ensure the water reaches the roots.**
  - **Apply gradually:** Allow water to fully penetrate the soil without run-off. Water needs a moment to seep into the soil. Water repeatedly in certain parts/areas before precious water in the bed flows away unused.
  - **Water evenly around the plant:** Promotes a balanced well-developed root system. Always watering at only one root point leads to one-sided root growth and thereby to poorer nutrient absorption in the soil. Therefore, always water around the plant and distribute in the entire irrigation area
  - **Use water-saving irrigation methods, like drip irrigation.**
  - **Avoid waterlogging**: Waterlogging suppresses the breathing air of the roots out of the soil. Root cells drown without oxygen
    Use quality, clay-rich soil: Promotes better water retention. Plant soil rich in clay minerals has better expanding properties and can therefore hold water in the soil

[100] Brouwer, C., & Heibloem, M. (1986). *Irrigation water management: Irrigation water needs: Chapter 2: Crop water needs*. Food and Agriculture Organization of the United Nations. https://www.fao.org/3/s2022e/s2022e02.htm

better and in a more even way. In wet summers and in winter, ensure water drainage to prevent waterlogging.[101]

Guided Practice Activity

Topic 7.3 Task 3:

1. Read through **7.3 Key Facts** and make sure you understand the content. As you discuss **7.3 Key Facts**, refer to your answers from **Task 2**. Share the correct answers with the trainer.

2. As an extra resource, watch the following video:

   Video: https://www.youtube.com/watch?v=5H-QjSuHnxU
   YouTube search: How to Water for Better Tasting Crops

3. Now, separate into groups of five people. Read the following information and questions:

   More than 100 varieties of the potato exist. A potato plant needs soil temperatures of about 15 to 21 degrees Celsius in order for tuber formation to occur. If soil temperatures become too warm, 26 degrees Celsius or warmer, potatoes don't develop.

   Irrigation Schedule
   Provide enough water to a potato plant so that its soil is moist, but not saturated. The general rule is to provide it 2.5 to 5 cm of water per week, including rain fall. A consistent water schedule of once every four to five days is ideal for a young plant. Increase the frequency to once every two to three days when potatoes form, which happens about the same time the plant flowers, to encourage uniform potatoes. Regular watering also helps keep soil temperatures cooler. Stop watering a potato plant when its leaves turn yellow and start to die back. Stop irrigating a plant once it begins to wilt provides potatoes longer time to cure or dry before they're picked.

[101] Gardena. (n.d.). *10 golden rules for watering*. https://www.gardena.com/int/garden-life/garden-magazine/10-golden-rules-for-watering/

Watering Method

Drip irrigation from a garden hose works best for potatoes. Overhead irrigation can injure a young, fragile plant. Furthermore, use of a watering can tends to direct too much water to the top of the plant and too little to its roots where it's needed most. Warm, wet foliage encourages fungal growth and weakens the plant structure.

Considerations

Over-watering a potato plant causes irregular tuber formation, promotes rot and increases risk of disease. Under- watering a plant so that its soil dries out completely prohibits canopy and tuber formation and often leads to irregular potatoes with various imperfections. The effects of poor watering practices results in a stressed plant that takes several days, even after the issue is corrected, for it to overcome.

a. What type of soil conditions are right for potatoes?

b. When and why should you discontinue irrigating the potato plants?

c. Which form of irrigation is ideal (best) for potatoes?

d. What is a result of over-watering potato plants?

e. How often should you water a young potato plant?

4. Read and discuss the article and answer the questions as the trainer walks around to help and make sure everyone participates.

5. After all the groups have answered the questions, present your group's answers. You must support every answer with evidence from the text and be specific.

6. Listen to the trainer's observations and feedback.

Application Activity

Topic 7.3 Task 4:

1. For this activity, work in groups of two. Read the following article and questions with your partner and use evidence from the article to support each answer. Underline or mark the text where you find the answers or information that can help you.

Tomatoes are one of the most popular vegetables grown. One of the reasons is that they are relatively easy to grow. But that does not mean that they grow without care. One of the most crucial parts of their care is knowing how much water tomato plants need.

The number one rule of watering tomatoes is to make sure that you go slow and easy. Never rush watering tomato plants. Use a drip hose or other forms of drip irrigation to deliver water to your tomato plants slowly.

Water regularly: How often should you water tomato plants? There is no hard and fast rule to this. It depends on how hot it is and if the plant is actively growing. A good rule of thumb is to supply water once every two or three days during the hot and dry season. Remember that water supplied by rainfall counts towards watering tomato plants in the garden. Once the weather cools and fruit has set, scale back watering to once a week.

Water at the roots: When watering tomatoes, it is normally recommended that you water straight to the roots rather than from above, as this can cause disease and pests to attack the plants. Watering tomato plants from above also encourages premature evaporation and unnecessarily wastes water.

Mulch: Using mulch helps to keep water where the plants need it. Use mulch to slow down evaporation.

a. What is the “number one rule” of watering tomato plants?

b. How can you slow down evaporation and conserve water for your plant’s roots?

c. When it is hot and dry, how often should you water tomato plants?

d. What is the recommended irrigation method for tomato plants?

2. Present your group's answers out loud to the class. Challenge other groups by asking them to identify the evidence for their answers.

3. Listen to the trainer's observations and feedback.

Points to Remember

- The amount of water a crop needs depends mainly on the climate, the crop type, and the growth stage.

Formative Assessment

After carefully reading the following items, answer the following questions individually:

1. Which of the following options do crop-water needs NOT depend on?
   - **a.** climate
   - **b.** tools available
   - **c.** growth stage of the crop
   - **d.** crop type
   - **e.** size of the water storage tank

2. Explain why waterlogging should be avoided.

3. What part of the plant must receive the water?

4. List five of the ten rules of watering.
   1.
   2.
   3.
   4.
   5.

Self-Reflection

1. You have come to the end of the unit. You are going to do the survey you did at the beginning of the unit again to help you do self-assessment of your knowledge, skills and attitudes.

Again, there are no right or wrong answers to this survey. It is for your own use to gauge your knowledge, skills and attitudes after the unit. Read the Knowledge, Skill or Attitude in the left column. Think about yourself: do you think you can do this? How well? Read the statements across the top. Put a check in column that best represents your situation

My experience **Knowledge, skills, and attitudes**	**I don't have any experience doing this.**	**I know a little about this.**	**I have some experience doing this.**	**I have a lot of experience with this.**	**I am confident in my ability to do this.**
Identify the selection criteria for tools and equipment for installing an irrigation system					
Select tools for installing an irrigation system					
Select equipment for installing an irrigation system					
Identify methods of irrigation					
Choose an irrigation method					
Install a water supply system					
Identify factors affecting crop water requirements and needs					
Calculate the irrigation time					
Identify the soil, slope, and crops suitable for drip,					

My experience Knowledge, skills, and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
surface, and sprinkler irrigation systems					

2. Complete the table below by identifying areas from the unit where you have improved and where you need improvement with the actions/strategies you will use to help you improve when receiving and interpreting information at the workplace.

Areas of strength	Areas for improvement	Actions to be taken to improve
1. **2.**	**1.** **2.**	**1.** **2.**

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