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Ministry of Labor and Skills

Crop production

Level-III

Based on June 2022, Version 1 Occupational Standard

Module Title: - Preforming Soil test and apply integrated soil fertility management

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Introduction to the Module

This module covers the process of performing soil test and applying integrated soil health and fertility management technologies and practices required for agricultural crop production. This unit specifies the competence required to implement to boost productivity of soils crops while maintaining soil health and fertility. The unit involves Soil sampling, conduct soil analysis and interpret results, preparing for Integrated soil fertility management, identify integrated soil fertility management practices and carry out Integrated soil fertility operations. Besides, it includes operation and quality control application issues

LG #1	LO#1 **Soil sampling and prepare for Integrated soil fertility management**

Instruction Sheet 1
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Preparing job sheet or work order
- Identifying of field Surveying activity and contractors
- Identifying and applying sampling operations and techniques
- Performing and dispatching sample collection,
- preparing and labelling of composite soil
- Undertaking precautions during collection and storage of soil samples
- specifying of integrated soil fertility technologies and practices
- Selecting and preparing tools and equipment
- Selecting and checking integrated soil fertility inputs
- Identifying existing and potential OHS hazards
- Preparing Emergency operating procedures
- Selecting, using and maintaining PPE
- Recording sample data

This guide will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Prepare job sheet or work order
- Identify of field Surveying activity and contractors
- Identify and apply sampling operations and techniques
- Perform and dispatch sample collection,
- prepare and labelling of composite soil
- Undertake precautions during collection and storage of soil samples
- specify of integrated soil fertility technologies and practices
- Select and prepare tools and equipment
- Select and check integrated soil fertility inputs
- Identify existing and potential OHS hazards
- Prepare Emergency operate procedures
- Select, use and maintain PPE
- Record sample data

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the "LAP test"

Information Sheet 1

Introduction

Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that forms on the Earth's surface and serves as a medium for plant growth. It is a complex and dynamic system that is influenced by many factors, including climate, topography, geology, vegetation, and human activity. The properties of soil can vary widely depending on these factors, and different soils can have different nutrient contents, pH levels, and physical structures.

A soil sample is a small amount of soil that is collected and analysed for its properties and characteristics. Soil sampling is an important practice in agriculture, environmental science, and engineering because it allows for the determination of nutrient levels, contamination, and other factors that can affect plant growth and environmental health. Soil samples are generally taken by inserting a tool, such as a probe or shovel, into the soil to collect a representative sample from a specific depth. These samples are then processed and analyzed using various methods to determine their physical, chemical, and biological properties.

Integrated Soil Fertility Management (ISFM) is an approach to sustainable agriculture that emphasizes the management of soil fertility as an integrated system rather than focusing on individual nutrient inputs. The goal of ISFM is to improve soil health and fertility by using a combination of practices that are tailored to the specific needs of the soil and crops being grown. These practices can include the use of organic matter, such as compost and manure, crop rotation, inter cropping, and the application of mineral fertilizers where necessary. By combining these practices, ISFM aims to improve soil structure, increase nutrient availability, and reduce erosion and soil degradation, while also improving crop yields and food security for farmers. The effectiveness of ISFM depends on a variety of factors, including the local context, soil type, and the specific crops being grown.

1.1. Preparing work sheet or work order

Soil sample record sheet: - In addition to location descriptors (see Sample labelling above), relevant information about slope, irrigation, drainage, previous cropping history, fertilizer and manure applied, and other relevant information must be recorded and sent along with the soil samples as required.

Table 1.1. Soil sampling information submission sheet for laboratory

Sample collector Name: ------------------- Phone: --------- Email address: ---------------

Organization: -------------------------------- Phone: ---

GPS datum: -------------------------

Sample code	sampling date	sampling depth	Latitude	longitude	Altitude
__________	__________	___________	_________	__________	__________
__________	__________	___________	_________	__________	__________
__________	__________	___________	_________	__________	__________

Slope: ________________

Landscape position (High, medium or low): ________________________________

Location (Region, Zone, Woreda and Kebele): ________________________________

Production systems (irrigated, rain-feed and land use): ________________________________

Previous season crops or land use: ____

Parameters to be analysed and methods__________________

1.2. Identification of field Surveying activity and contractors

During soil test and analysis, field surveying activities may include collecting soil samples, mapping out geo-technical properties of the soil or documenting any subsurface features. To identify contractors involved in these activities, you may want to check for signs of work being done on site such as construction trucks, drilling and excavation equipment, or workers in safety gear. you may also reach out to local contractors or consult with experts in the field to get a better understanding of who is typically involved in soil testing and analysis activities.

Field surveying activities during soil tests may involve mapping out the existing topography and document any existing features such as man-made structures and natural features such as rivers and creeks. Surveyors may also collect soil samples from different depths and locations on a site to be analysed by experts in soil science. The contractors involved in these activities may include surveyors, geotechnical engineers, environmental consultants, or drilling and excavation crews.

list of surveying activities that are commonly used for soil testing and analysis:

1. Site inspection and analysis
2. Soil testing, including collecting soil samples and testing for pH levels, nutrient content, and other important parameters
3. Site mapping and layout determination
4. Land surveying to determine boundaries and accuracy of measurement
5. Topographical surveys to determine elevation changes and slope stability
6. Geotechnical analysis, including subsurface exploration to determine soil strength and composition

7. Water table measurement to assess the presence and depth of underground water sources

8. Environmental impact assessments to understand the impact of soil samples on the surrounding ecosystem

1.3. Identifying and applying sampling operations and techniques

1.3.1. Identifying the sampling area

Before taking any sample the first thing to do is to delineate the area for sampling and know which area the sample represents. It is sometimes important to have topographic and soil survey map of the area to easily point the sampling areas, therefore we need to have a sampling plan.

Making the site plan for soil sampling

The goal of the sampling plan is:-

- To determine where and when to collect soil samples that are representative of the field to be fertilized.
- If soil is submitted from only a few locations that do not represent the entire area to be fertilized, the fertilizer added may be too much or too little for the majority of the area, causing decreased yields, reduced crop quality, or wasted fertilizer

Sampling depth and timing of sampling are critical components of a well-designed sampling plan.

- To help the producer determine where to fertilize.

Considerations in determining the sapling area

- The sample should be truly representing the field/area it belongs to.
- A field can be treated as a single sampling unit if it is uniform. Generally an area not exceeding 0.5 ha is taken as one sampling unit.
- Variations in slope, color, texture, crop growth, and management practices are the important factors that should be taken in to account for sampling. Separate samples are required from areas differing in these characteristics.Recently fertilized plots, bunds,

channels, marshy tracts, and areas near trees, wells, compost piles or other non representative locations must be carefully avoided during sampling.

- An area of about 3-3 meters along all the sides of the field should be left in large fields.
- Larger area may be divided in to appropriate number of smaller homogeneous units for better representations of the field.

Locating services

- Water supply
- Gas
- Electricity
- Telecommunications
- Irrigation
- Storm water and drainage

1.3.2. Implementing technique for soil sampling

Each soil series has different characteristics, and will likely have different amounts of available nutrients. In addition, the soil maps are based on aerial photographs that can prove useful in determining your relative location when out in the field. soil samples are generally collected from several locations within a field and composited (mixed) in a clean bucket prior to submitting to an analytical laboratory.

Method of soil sampling (Sampling pattern)

Area (cell) sampling

The sampling pattern should be selected to best represent the field, accounting for known sources of variability:-

- major soil type changes

- Past cropping patterns, etc.).

Grid point sampling

grid pattern is usually the best way to be sure the entire field is represented.

- To better characterize the field for site-specific management and variable-rate application,
- Point samples can be used to measure the variability across the field.
- Dividing the field into 2 ½ acre grids and collecting a sample for each cell,
- The grids lines help ensure a good spatial representation of the field that can be used to develop a nutrient map.
- The collection of data for all points in the field provides the basis of nutrient variability maps.

Separate soil samples should be collected from areas or fields that have

- Different crop history
- Yield and
- Fertilizer treatments or
- That varies substantially in slope, texture, depth, or soil color.

Figure 1.1 sampling technique and composite

Number of soil samples to be collected

This is dependent on

- The size of the field
- The variability within the field
- The fertilizer application equipment
- How feasible it is to change application rates within a field, and
- How much time and money you have allocated for sampling.

Depth of sampling

The depth of penetration by plant roots is the guiding principle in deciding the depth of sampling. Therefore, the following factors may be kept in mind:

- For **cereals, vegetables and other seasonal crops** the samples should be drawn from 0-15cm i.e., plough layer or furrow slice.
- For **deep rooted crops** or longer duration crops like sugar cane or under dry farming conditions, samples should be collected from different depths depending on the requirements of individual situations.
- For **plantation crops or fruit trees**, composite sample from 0-30, 30-60, and 60-90cm depths should be made from 4-5 pits dug in about 0.5 ha field.
- For **alkalinity, acidity and salinity** testing the sample may be drawn up to 15 cm depth from surface.
- In case the composite samples are drawn from profile depths exceeding 15 cm as for certain flowering plants like roses, the actual depth of sampling should be indicated.

1.4. Performing and dispatching sample collection

Taking samples from field

Take the necessary care such as:-

- Giving a temporary label
- Tying the bags to prevent mix up of samples and contamination.
- The bags should also be clean and not used priory for holding fertilizer or old soil samples.
- If the soil sample is used to test the moisture content it should be protected from evaporation in polyethylene bags and tied.
- For nutrient analysis purpose the samples will be prepared to suit the analysis methods

Procedures for soil sample

Soil tests can be only as accurate as the samples on which they are made. Proper collection of soil samples is extremely important. Chemical tests of poorly taken samples may actually be misleading.

1. Establish a plan for soil sampling. Prepare a farm map to include boundaries for each field. Give each field a permanent number. Keep this map and all soil test reports for a long term record. Plan to sample each field at 3 to 5 year intervals depending on cropping system.

2. Sample only uniform areas. Soils that are different as to colour, slope, elevation, crop growth, degree of erosion, or past fertilizer and lime treatment should be sampled separately.

3. The sample should be taken from all over the area. Soil from a single place cannot adequately represent the soil in an area. Take soil from 10 to 15 different places in the field, lawn or garden. Sample to a depth of 6 inches. Remove plant residue from the surface and use a spade, soil auger or soil sampling tube as illustrated. Place the soil in a clean bucket or container, mix thoroughly and take approximately 1 pint to send to the lab.

4. Complete the Information Sheet on the opposite side.

5. Details of tests and fees.

1.5. . preparation and labelling of composite soil

Sample labelling: -

Proper labelling of soil samples is as important as the care needed to obtain the samples. Samples need to be labelled properly for identification. A label of thick paper with an identification mark and other details should be put inside the sample bag, and another one carrying the same details tied/pasted outside the bag. In case the soil sample is wet (for calibration studies), the label should be written with a lead pencil or a permanent ink marker, or put inside a small separate plastic bag before air-drying. With the advance of digital technology, it is advisable to use bar coded or digitized sample labelling and tracking procedures in all soil and agronomic research activities. A sample label should contain the following:

- Production and cropping system
- Site name: district, kebele, and farmer's name
- Site geographic coordinates
- Altitude [m]
- Sampling
- Date [dd/mm/yyyy]
- Sampling depth [cm]

Figure 1.2 recording data

1.6. Undertaking precautions during collection and storage of soil samples

Precaution during sampling

For all sampling guidelines, avoid sampling areas that would not be considered representative of an area. This includes:

- land immediately adjacent to drainage ditches
- highly eroded areas
- areas close to trees, roads, and fences
- current or previous manure piles
- fertilizer storage areas
- livestock excrement in grazed areas
- small areas of the field that are known to have distinctly different soils due to depth or texture

General Precautions

1.6.1 **Safety**

Proper safety precautions must be observed when collecting soil samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions.

These guidelines, however, should only be used to complement the judgement of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.6.1.1 Procedural Precautions

The following precautions should be considered when collecting soil samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location.
- Collected samples
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader in the project files.

1.7. specifications of integrated soil fertility technologies and practices

Integrated nutrient management

Adequate plant nutrient supply holds the key to improving the food grain production and sustaining livelihood. Nutrient management practices have been developed, but in most of the cases farmers are not applying fertilizers at recommended rates. They feel fertilizers are very costly and not affordable and due there is a risk particularly under dry land conditions. Therefore, INM plays an important role which involves integrated use of organic manures, crop residues, green manures, bio fertilizers etc. with inorganic fertilizers to supplement part of plant nutrients required by various cropping systems and thereby fulfilling the nutrient gap.

The **basic concept** underlying the principle of integrated nutrient management is to **maintain** or adjust plant nutrient supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients. The basic objectives of IPNS are to reduce the inorganic fertilizer requirement, to restore organic matter in soil, to enhance nutrient use efficiency and to maintain soil quality in terms of physical, chemical and biological properties. Bulky organic manures may not be able to supply adequate amount of nutrients, nevertheless their role becomes important in meeting the above objectives.

Integrated soil fertility technologies and practices can vary depending on the specific needs and conditions of each location, but there are some general specifications that can be used as guidelines. These may include:

- Soil testing and analysis to determine the nutrient content and pH of the soil
- application of appropriate amounts and types of fertilizer based on the results of the soil analysis
- use of organic materials such as compost or manure to improve soil structure and increase nutrient availability
- crop rotation to prevent depletion of specific nutrients in the soil
- use of conservation tillage techniques to reduce erosion and maintain soil health 6) implementation of appropriate irrigation practices to ensure efficient use of water.
- Effective weed management strategies to minimize competition for nutrients and water
- Use of cover crops to maintain soil health and prevent erosion
- Agroforestry systems that integrate trees, crops, and livestock, which can help improve soil fertility, reduce erosion, and increase crop yields
- Use of bio fertilizers such as mycorrhizae or rhizobia to enhance nutrient uptake by plants

- Integration of livestock into cropping systems to improve soil nutrient cycling
- Use of green manure crops to fix nitrogen and add organic matter to the soil.

1.8. Selecting and preparing tools and equipment

Identifying tools and equipments

Tools and equipments for soil sampling includes the following,

- Shovel
- Spade
- Soil auger or sampling probe
- Bucket (pail) of 8 – 10 litters capacity or a wooden box
- To collect individual samples and mix them to make a composite or average sample.
- Paper sack (soil bag)
- Sieve, mortar and pestle
- Ruler, pencil and note pad for labelling each container and recording information.
- Drier

Figure 1.3 A soil probe, auger, spade and knife should be used in sampling soils

1.9. Selecting and checking integrated soil fertility inputs

some commonly used integrated soil fertility inputs:

- Compost
- Green manure crops
- Crop rotation
- Cover cropping
- Application of chemical fertilizers (in conjunction with organic inputs)
- Agroforestry systems
- Conservation agriculture practices such as minimum tillage and inter cropping

Selecting and checking integrated soil fertility inputs is an important aspect of implementing successful soil fertility management practices. Here are some things to consider when selecting and checking inputs:

- **Quality:** Ensure that the inputs meet minimum quality specifications or standards. For example, fertilizers should contain the nutrients indicated on the label, and biological inputs such as biofertilizers should contain active bacteria or fungi.
- **Nutrient requirements:** Check fertilizer formulations to ensure that they provide the required nutrients for the crop being grown, based on soil analysis results.
- **Compatibility:** Ensure that all inputs used in soil fertility management are compatible with each other and do not negatively interact. For example, some herbicides may reduce the activity of rhizobia, which are important for nitrogen fixation in legume crops.

- **Safety:** Check material safety data sheets (MSDS) for all inputs being used to ensure that they do not present any hazards to human or animal health or the environment.
- **Storage:** Ensure that inputs are stored in a secure location that is protected from moisture, sunlight, heat, and pests.
- **Application rates and timing:** Follow recommended application rates and timing guidelines to maximize uptake efficiencies and minimize losses.
- **Regular monitoring**: Regularly monitor crop growth and pest incidence to ensure that fertilization plans are on track and amendments are made if needed.

1.10. **Identifying existing and potential OHS hazards**

Definition: Occupational health and safety is concerned with health and safety in its relation to work the working environment.

Aims of occupational health

Occupational health should aim at:-

1. The promotion and maintenance of the highest degree of physical, mental and social well being of workers in all occupation
2. The prevention amongst workers of departures from health caused by their working conditions.
3. The protection of workers in their employment from risks resulting from factors adverse to health.
4. The placing and maintenance of workers in an occupational environment adapted to his physiological and psychological capabilities and
5. To summarize the adaptation of worker to man and of each man to his job.

Hazards

These may be introduced into fresh fruit and vegetable products at numerous points in the production chain as a result of bad agricultural practices.

Hazards associated with production flow that could be harmful to the consumer

There are three main types of hazards associated with fresh produce:

- Biological
- Chemical
- Physical
- Ergonomic hazrd
- Psychological hazards

Biological hazards

- **Food-borne micro-organisms**, such as **bacteria, viruses and parasites**, are often referred to as biological hazards .Some fungi are able to produce toxins and also are included in this group of hazards.
- **Micro-organisms** able to cause human disease may be found on raw produce. Sometimes they are part of the fruit or vegetable micro flora as incidental contaminants from the soil, dust and surroundings. In other instances they get introduced onto the produce through poor production and handling practices, such as the use of untreated manure, the use of contaminated irrigation water or unsanitary handling practices.
- **Pathogenic bacteria**

Microbiological Risks Reason for occurrence

- Slurry spread
- Pathogens present (or numbers too high)
- Contamination from livestock and human sewage
- Water, Salmonella, Poor quality control at harvest
- Inadequate pre-harvest container and equipment cleaning
- Harmful and domestic animals
- Inadequate temperature control during storage
- Decaying matter, Poor stock management
- Parasitism
- Poor waste management

Chemical hazards

- Chemical contaminants in raw fruits and vegetables may be naturally occurring or may be added during agricultural production, post-harvest handling and other unit operations. Harmful chemicals at high levels have been associated with acute toxic responses and with chronic illnesses.

Examples of chemical hazards:

- Pesticides
- Fertilizers
- Antibiotics
- Heavy metals
- Oils and grease

Chemical hazards Risks Reason for occurrence

- Residues of non-approved pesticides
- Wrong pesticide selection
- Incorrect dosage/concentration
- Harvest interval not observed
- Poor calibration of sprayer
- Sprayer drift
- Inadequate cleaning between uses
- Contamination of produce due to pesticide storage conditions
- Spillage of pesticides on produce
- Use of contaminated water to mix spray
- Oils, grease and fuel contamination
- Inappropriate use of produce containers to store pesticides, fertilizers or oil
- Lack of inspection and servicing equipment
- Heavy metals

Physical hazards: foreign bodies

Examples of physical hazards include:

- Residual soil and **stones f**ound on fruits and vegetable
- Packaging remaining from harvesting (**wood, metal**, etc.)
- Packing materials and storage facilities, e.g. packaging plastics and cardboard
- Foreign matter collected during harvesting
- **Glass and sharp objects**
- Personal effects: **jewels, hair, pens**.

Physical hazards Risk Reason for occurrence

- Soil Presence in finished products
- Machinery
- Dirty packaging materials
- Inadequate inspection of field equipment and packing facilities
- Inadequate maintenance of containers and machinery
- Discarded rubbish, e.g. bottles, cigarette butts
- Inadequate cleaning schedule
- End product contains: jewellers and pieces of clothing
- Staff untrained in personal hygiene
- Inappropriate working clothes

1.11. Emergency operating procedures

the general EOPs to consider when conducting soil sampling:

1. Wear appropriate personal protective equipment (PPE), such as gloves, eye protection, and respiratory protection if necessary.

2. Be aware of potential hazards in the sampling area and take appropriate precautions (e.g., mark any areas with sharp objects, avoid areas with visible signs of contamination).

3. Follow proper handling and storage procedures for soil samples to prevent contamination and ensure their accuracy for later analysis.

4. Immediately report any injuries or incidents to the appropriate parties (e.g., supervisor, safety officer).

5. If needed, establish protocols for decontamination of personnel and equipment after soil sampling. It's important to note that specific EOPs may vary depending on the location and nature of the soil sampling being conducted. For example, if the sampling is being done near a hazardous waste site, additional precautions may be necessary.

If you have specific concerns about soil sample collection, it is recommended to consult with safety professionals or regulatory agencies for appropriate guidance and procedures.

1.12. **Selecting, using and maintaining PPE**

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

Selecting personal protective clothing and equipment

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

Select PPE based on the PPE Hazard Assessment

Consider these factors when selecting PPE:

- **Type of hazardous materials**, processes, and equipment involved
- Routes of potential exposure (ingestion, inhalation, injection, or dermal contact)
- Correct size for maximum protection
- Minimal interference with movement

Personal protective clothing and equipment may include:

- boots
- hat/hard hat
- overalls
- gloves
- protective eyewear
- hearing protection]
- respirator or face mask
- sun protection, e.g., sun hat, sunscreen

Different types of PPE are described below

Foot protection Workers must wear closed-toe shoes at all times to protect feet from chemical spills and sharp objects. Steel-toed footwear and puncture-resistant soles. Slip-resistant shoes for anyone who works in wet environments.


figure 1.4

Eye protection: Use safety glasses for minor splash hazards, goggles for moderate hazards, and goggles combined with a face shield for severe hazards.


figure 1.5

Hand protection: Hand protection is indicated for the possibility of severe cuts, lacerations, or abrasions, punctures, temperature extremes, and chemical hazards. (Nit rile loves are usually a good choice for general use.) Use heavy-duty gloves for non-incidental contact and gross contamination.


figure 1.6

Body protection: Protective clothing includes lab coats, smocks, scrub suits, gowns, rubber or coated aprons, coveralls, uniforms, and pierce-resistant jackets and vests.

Head protection: Hard hats must be worn by electricians, construction workers, and any other workers when there is a danger of objects falling from above.


figure 1.7

1.13. Recording sample data

A record-keeping system doesn't need to be complicated, although some systems are.

- Information should be organized by date or time, because every observation will have a time associated with it.
- A paper-based record-keeping system can be just as useful.
- A soil sampler should try to keep track of the following information from observation to observation. This is not an exhaustive list, nor is it necessary to record all of these items for every observation. Generally, with more information available, better sampling decisions can be made.

Records that need to be taken during sampling

- Sampling Date
- Irrigation system
  - ✓ Drip
  - ✓ flood
  - ✓ sprinkler
  - Depth to ground water
  - Farm
  - Home
- Sample Depth
- Last season/year crop
- Organic amendments
- Liquid
- Solid
- Water Nitrate-N credit
- Sample location
- Orchard
- Field ID

Self-Check 1	Written test

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

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

Test I: Matching

A	**B**
1. PPE	A. sampling materials
2. auger	B. Eye goggle
	C. Measuring materials

Test II: Short Answer Questions

1. What is the importance of delineating/determining the sampling area and sampling points.
2. What is soil sample contamination?
3. What is the importance of soil sampling?
4. What is the sampling area?

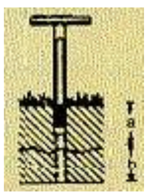
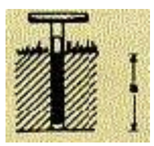
Operation Sheet 1	Soil sampling

Procedure for soil sampling

1) To take soil sample you make ready a sampling tube, auger or spade, and a clean plastic pail. Get sample containers from the lab where you are standing the samples for analysis

2) Sample different soils, or areas treated differently in the past. Get equal sized acres or slices from 15 or more places in each sampling area using probe, auger or spade. Do not mix light-and dark-coloured soils together.

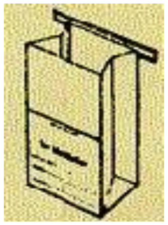
3) Take samples for P, K, and lime from the top 0-8inches in tillage systems such as mouldboard plough, chisel, and or disk. Take samples for P and K from. Take samples from the top 0-4 inches for lime only in no till fields. But, take samples for P, K, from the top 0-8inches in no till fields. No till fields which will be ploughed periodically should be sampled to plow depth.

Left tilled field sampled 0-8inches; right no till soil 4inc pH, 0-8 to P,K

- Place cores or slices in a clean plastic pail. Mix them together thoroughly, breaking up the cores or slices. If soil is muddy, dry it before mixing. If soil crumbles easily, dry after mixing

- Spread mixture out on clean paper to dry. Do not heat in the oven or on the stove. Do not dry in places where fertilizer or manure get in to the sample
- Fill the sample bag to the line with air dry soil, discard the rest. Label and number the sample container



Filling the bag to the line

- Identify the sample and record the cropping the fertilizer information required using a field and cropping information sheet provided by the lab doing the analysis.

- Draw a field sketch or farm map on a separate sheet and keep it in your records, and to assist in developing your management plan.

After taking the samples use the procedures in the information sheet 1 and dry the sample, winnow it grind and sieve for different testes, then subdivide pack and label the sample for physical and chemical tests.

LAP Test	Performance sheet

Name: ________________________________ Date: __________________

Time started: __________________________ Time finished: __________________

2. **Task 1. perform technique of soil sample ?**

LG #2	LO #2 Conducting soil analysis and interpreting results

Instruction Sheet 2
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Determining physical, chemical and biological characteristics of soil
- Cleaning and returning sampling and testing tools and equipment
- Recording results
- Classifying the soil types
- Determining the acceptable soil physical and chemical parameters

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

- Determine physical, chemical and biological characteristics of soil
- Clean and return sampling and testing tools and equipment

● Record results ● Classify the soil types Determining the acceptable soil physical and chemical parameters
Learning Instructions:
1. Read the specific objectives of this Learning Guide. 2. Follow the instructions described below. 3. Read the information written in the information Sheets 4. Accomplish the Self-checks 5. Perform Operation Sheets 6. Do the "LAP test"

Information Sheet 2

2.1 **Determining physical, chemical and biological characteristics of soil**

Soil characteristics

Basically soil is the rooting medium and a store house for nutrients and water. Hence it is essential that the roots fully exploit the soil to obtain the nutrient s and reduce water stress. The yields of the crop is often directly related to the availability of stored soil water. The tillage system affects root distribution with depth. When soil is cultivated manually ,for instance corn root develop more extensively below 10cm than with no tillage system, while intermediate root distribution occur with roto till and chase. Hence under production of an agricultural crops it is important to take in to consideration soil characteristics while developing soil health and plant nutrition.

2.1.1. Identifying properties of soil

I. Physical properties:-is refers to the function and management of the soil in an ecosystem in determining the success or failure of agricultural crop production based on soil texture, structure, consistence and colour.

II. Chemical properties: - is deal with the nature of colloids (organic and in organic). It mainly focuses on the mineral and chemical composition, charges and exchange of ions, salinity, and alkalinity and acidity of the soil. It is important from the point of view of nutrient availability for agricultural crops.

The most chemical characteristics of soils are:

- Its content of essential nutrients and their availability to plants
- The exchange capacity

- The buffer capacity (the ability of soil to resist change in PH of the soil solution if acid or base is added).
- Acidity or alkalinity and
- Content of organic and in organic colloids (humus).

III. Biological properties

Soil abounds in the following various types and forms of plant and animal life:

Animal life (fauna):

- Macro fauna (earthworms, termites, ants, grubs, slugs and snails, centipedes and millipedes),
- Micro fauna (protozoa, nematodes and rotifers);

Plant life (flora)

- Macro flora (plant roots, and macro-algae),
- Micro flora (actinomycetes, fungi and algae).

Beyond the soil-forming activities of earthworms, termites and other large soil fauna, the multitude of different soil organisms (colloquially also called soil life) contributes significantly to the soil physical and chemical conditions, especially in the transformation of organic matter and plant nutrients. The rate of transformation of most nutrients into available forms is controlled largely by microbial activity. Their huge number represents an enormous capacity for enzyme-based biochemical processes. A special case is N fixation by N-fixing free-living or symbiotic bacteria. Another case relates to the solubilization of insoluble phosphates by several types of soil micro-organisms.

Soil micro-organisms have similar requirements of soil conditions for optimal activity in terms of air, moisture and pH, as do crops. In general, fungi are more active under acidic conditions, while bacteria prefer neutral–alkaline reaction. Any improvement in soil fertility for crops should also improve conditions for the activity of soil flora and fauna. Microbial activity not only determines soil fertility but it also depends on good soil fertility.

2.2. Cleaning and returning sampling and testing tools and equipment

For the soil sampling and testing tools and equipment, you'll want to make sure to follow these steps:

1. Start by removing any excess dirt or debris from the equipment using a brush or scraper.

2. Next, rinse the tools and equipment with water to remove any remaining soil or dirt.

3. Use a disinfectant solution to sanitize the tools and equipment. This will help to kill any bacteria or pathogens that might be present on the surface of the equipment. Follow the instructions on the disinfectant solution carefully, and make sure to apply it evenly and thoroughly to all surfaces of the equipment.

4. Rinse the tools and equipment again with clean water to remove any remaining disinfectant solution.

5. Wipe down the tools and equipment with a clean cloth to dry them off. After cleaning, you can package the tools and equipment securely and return them to the appropriate location or contact person.

2.3. Recording results

A record-keeping system doesn't need to be complicated, although some systems are.

- Information should be organized by date or time, because every observation will have a time associated with it.
- paper-based record-keeping system can be just as useful.

Table: Soil Testing Record (prepared record keeping formats)

CMU/Field ID	Lab	Date Sampled	Soil Test Levels			Soil Test Report Levels 1 (If not in ppm)	
			pH	ppm Mehlich-3 P	ppm K	Phosphorus (lbs P or lbs P2O5)	Potassium (lbs K or lbs K2O)

Table: Manure Sampling Record

Manure Group	Lab	Date Sampled	Total Nitrogen (N)	Ammonium N (NH4-N)	Total Phosphate (P2O5)	Total Potash (K2O)	Percent Solids	P Source Coefficient Value
			Note lb/ton or lb/1000 gal	Note lb/ton or lb/1000 gal				

Table: Manure Group/Fertilizer Application Record format

Manure Group		Date		Manure	

				Source/Location	
Spreader ID 1		**Spreader Calibrated Rates**			
Temperature 1		**Wind Speed & Direction 1**		**Weather Conditions 1**	
Applicator 1			**Notes**		

Field Information			**Manure Application Information**			
CMU/Field ID	**Field Acres**	**Acres Covered**	**Application Rate**	**Application Method**	**Days to Incorporation (if < 7 days)**	**Total Amount Applied**

2.4. Classification of the soil types

Soil can be classified based on several factors such as texture, structure, color, depth, and chemical properties.

Sandy Soil

The first type of soil is sand. It consists of small particles of weathered rock. Sandy soils are one of the poorest types of soil for growing plants because it has very low nutrients and poor water holding capacity, which makes it hard for the plant's roots to absorb water. This type of soil is very good for the drainage system. Sandy soil is usually formed by the breakdown or fragmentation of rocks like granite, limestone and quartz.

Silt Soil

Silt, which is known to have much smaller particles compared to sandy soil and is made up of rock and other mineral particles, which are smaller than sand and larger than clay. It is the smooth and fine quality of the soil that holds water better than sand. Silt is easily transported by moving currents and it is mainly found near the river, lakes and other water bodies. The silt soil is more fertile compared to the other three types of soil. Therefore, it is also used in agricultural practices to improve soil fertility.

Clay Soil

Clay is the smallest particle among the other two types of soil. The particles in this soil are tightly packed together with each other with very little or no airspace. This soil has very good water storage qualities and makes it hard for moisture and air to penetrate into it. It is very sticky to the touch when wet but smooth when dried. Clay is the densest and heaviest type of soil which does not drain well or provide space for plant roots to flourish.

Loamy Soil

Loam is the fourth type of soil. It is a combination of sand, silt and clay such that the beneficial properties of each are included. For instance, it has the ability to retain moisture and nutrients; hence, it is more suitable for farming. This soil is also referred to as agricultural soil as it includes an equilibrium of all three types of soil materials, being sandy, clay, and silt, and it also happens to have humus. Apart from these, it also has higher calcium and pH levels because of its inorganic origins.

Figure 2.1 soil type

1.5. Determining the acceptable soil physical and chemical parameters

Physical Properties: -

- **Soil texture:** soils with a loamy texture (i.e., good balance of sand, silt, and clay particles) are generally preferred, as they promote good drainage, water retention, and nutrient availability. Sand particles are the largest and allow for good drainage but can result in poor water retention, while clay particles are the smallest and allow for good water retention but can result in poor drainage
- **Soil structure:** well-structured soil (i.e., with good pore space for air and water) is important for root development, soil aeration, and water infiltration.
- **Soil depth**: the depth of the topsoil layer should be sufficient to support plant growth (at least 10-15 cm).
- **Soil pH**: the pH level of the soil should fall within the 6.0-7.5 range, as this is optimal for most crops.

Chemical Properties: -

- **Soil fertility**: soil should contain adequate amounts of essential nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), as well as micro nutrients like iron (Fe), manganese (Mn), and zinc (Zn).
- **Soil organic matter**: organic matter adds important nutrients to the soil, improves soil structure and water holding capacity, and supports beneficial micro-organisms.
- **Electrical conductivity (EC)**: EC gives an indication of the salt content in the soil. Acceptable levels vary depending on the crop being grown, but generally fall within 1-4 dS/m.
- **Cation Exchange Capacity (CEC)**: CEC measures the ability of soil to hold positively charged cations. It is generally desirable to have a higher CEC, as this means that soil can hold onto essential nutrients better

Self-Check 2	Written test

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

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

Test I: Write True or False

1. Acidity or alkalinity are chemical characteristics of soils.

2. EC gives an indication of the salt content in the soil.

Test III: Short Answer Questions?

1. List and discuss soil property?
2. What does mean soil test?
3. What are the tools and equipment for soil analysis?

Operation Sheet 2	Soil analysing

Procedure for soil analysis

1. Air-dry the soil sample and remove any rocks, debris, or plant material.

2. Crush any large soil aggregates into smaller particles.

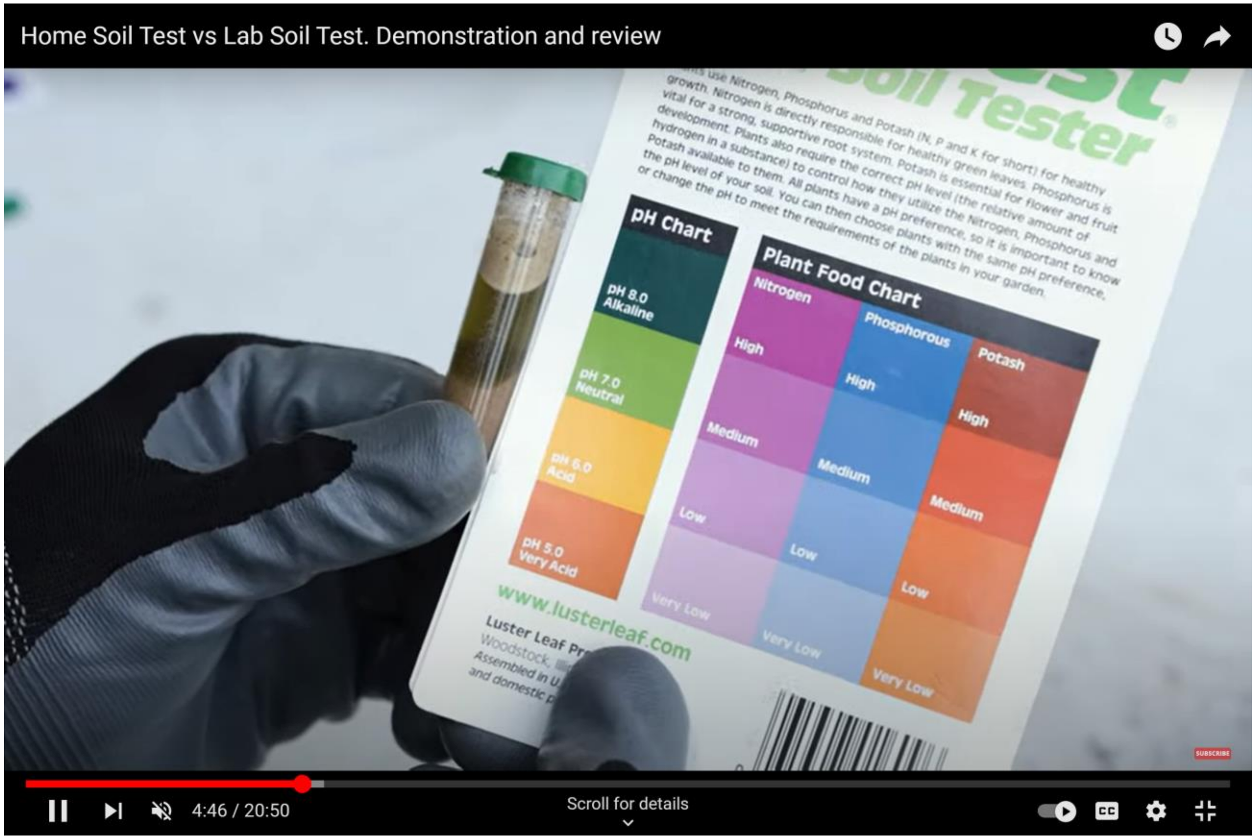
3. Identify the texture of the soil by feeling it between your fingers, then categorize it as sandy, loamy, or clayey.

4. Test soil pH using a pH meter or a soil test kit.

5. Add distilled water to a portion of the soil sample in a test tube and shake well. Allow the mixture to settle for a few minutes, then measure the turbidity of the solution to determine the cation exchange capacity (CEC).

6. Determine the levels of macronutrients (nitrogen, phosphorus, and potassium) using chemical tests. Follow standard protocols to perform tests such as the Kjeldahl method for nitrogen or colorimetric methods for phosphorus and potassium.

7. For micro-nutrients, such as iron and zinc, use an appropriate extractant chemical to dissolve them and measure their quantity with an atomic absorption spectrophotometer. These steps can help you get a comprehensive idea of the soil type and nutrient contents, which can be useful in determining what crops can grow successfully in the soil and what type of fertilizers may be required for optimal plant growth.



Source; https://www.youtube.com/watch?v=nB-wX0ZYNME, Acessed 23, 2023

LAP Test	Performance test

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Task 1. perform soil analysis technique?

LG #3	LO #3 Identifying Integrated soil Fertility Management Practices

Instruction Sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Identifying and confirming integrated soil fertility technologies and practices • Measuring and transporting required quantities of integrated soil fertility inputs • Monitoring and checking inputs • Preparation of integrated soil fertility and equipment • Selecting application method of integrated soil fertility input This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Identify the goals and targets site of soil fertility status • Identify the availability & storage site for soil and plant treatments materials • Locate services for plant nutrition programme using site plans

• Identify OHS hazards and control their risks • Obtain Material safety data sheets (MSDS) • Select, use & maintain suitable PPE
Learning Instructions:
1. Read the specific objectives of this Learning Guide. 2. Follow the instructions described below. 3. Read the information written in the information Sheets 4. Accomplish the Self-checks 5. Perform Operation Sheets 6. Do the "LAP test"

Information sheet 3

3.1 Identifying and confirming integrated soil fertility technologies and practices

Integrated soil fertility management (ISFM) is defined as a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs and improved germ plasm combined with the knowledge on how to adapt these practices to local conditions, aiming at optimizing agronomic use efficiency of the applied nutrients and improving crop productivity.

The definition focuses on maximizing the efficiency with which fertilizer and organic inputs are used since these are both scarce resources in the areas where agricultural intensification is needed.

Soil fertility simply as the capacity/quality of the soil to supply essential nutrients in quantities and proportions for the growth and its successful production during plant life.

Soil fertility management is one of the major components to ensure food security and economic growth in a sustainable way.

Identifying problems is the first step in developing ISFM plan or program as it helps to set priorities for interventions and managing soil fertility. Use of both inorganic and organic fertilizers often results in synergism, improving efficiency of nutrient and water use.

Agriculture practices is a set of activities combining farming system and soil conservation practices for promoting sustainable agriculture and enhancing land productivity. Farming system management and soil conservation techniques are agriculture practices considered effective for soil erosion control and sustaining agricultural productivity.

The practices necessarily include appropriate fertilizer and organic input management in combination with the utilization of improved germplasms. All inputs need to be managed following sound agronomic and economic principles. These include;

Cropping system

A cropping system is a system in which we determine the types of crops that should be grown in a field. By improving soil fertility, weeding, disease and pest control, this production system can increase production and reduce the loss of crops due to natural disasters, as well as increase food and nutritional security, additional income and improve land use.

Mineral /Chemical /synthetic/ inorganic fertilizers

Mineral fertilizers are synthetic products of plant nutrient sources and mostly highly soluble, and their nutrients are quickly available to plants. However, its continual uses without of inputs can decline yields because of: Imbalance /deficiency of certain nutrients, Soil acidification, Deterioration of soil structure, and Pollution of ground water and air.

Conservation Agriculture

Conservation agriculture can be practiced by reducing plowing, cultivating crops with biological cover crops, or by recycling crop residues. To ensure that the soil is permanently covered and adapted to the local ecological zone. Conservation agriculture Improved practices and technologies using a combination of soil, water, soil nutrient Production and productivity by conserving nutrients and energy supplies for agriculture

Planting with Precision

Precision seeding is a method of seeding that involves placing seed at a precise spacing and depth. This is an advantage, in that it saves seed and it avoids crowding, or the need for thinning, allowing plants the space to grow efficiently.

Cover Crops

A cover crop is a plant that is used primarily to slow erosion, improve soil health, enhance water availability, smother weeds, help control pests and diseases, increase biodiversity and bring a host of other benefits to your farm.

Green manures

Green manures are plants that are deliberately grown for the purpose of incorporation into the soil to improve the organic matter content and soil fertility. Leguminous plants are largely used for green manuring due to their ability to fix biological nitrogen, their drought tolerance, quick growth, and adaptation to adverse conditions. Sometimes green manures are referred to as cover crops as their roles are similar. While the main purpose of growing a cover crop is to cover the soil with a low vegetation cover to protect the soil from exposure to sun and rain as well as to suppress weeds. Green manures are grown with the prime purpose of building as much biomass as possible. However, they also play a role in covering the ground and protecting it from solar radiation and soil erosion. Crops which serve both these functions are often referred to as green manure cover crops

Crop residues

Crop residues are materials left in an agricultural field or orchard after the crop has been harvested. These residues include stalks and stubble (stems), leaves and pods. When plant residues are returned to the soil, various organic compounds undergo decomposition. The continual addition of decaying plant residues to the soil surface contributes to the biological activity and the carbon cycling process in the soil.

Farmyard Manure (FYM)

Farmyard Manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle.

Organic manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition.

Bio-fertilizer

Bio-fertilizer is a substance which contains living microorganisms which, when applied to seed, plant surfaces, or soil colonizes the rhizosphere or interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. The most commonly used soil inoculants are rhizo-bacteria that live symbiotically with legumes such as peas and beans.

Acid soil management

Ag-lime is the major means of ameliorating soil acidity because it has very strong acid neutralizing capacity, which can effectively neutralize existing acidity. Since lime contains Ca and /or Mg that displace H+, Fe3+ and Al3+ ions from soil colloids which is attributed to the precipitation of exchangeable and hydroxy H, Fe and Al. This reduces P sorption in acid soils resulting in increased available P in soils.

Liming increases the uptake of nutrients such as P, Mg and Ca, stimulates biological activity and reduces toxicity of metals such as Al and Mn.

Saline soil management

The terms salt and salinity are often used interchangeably and sometimes incorrectly. These salts often originate from the earth's crust. They also can result from weathering, in which small amounts of rock and other deposits are dissolved over time and carried away by water.

More recently soils became considered salt-affected starting at a lower EC level of 2 mSm/ sm, as several fruit, vegetable and ornamental crops suffer from salinity within the EC interval of 2 to 4 mSm/cm. In saline soil Gypsum ($CaSO_4 \cdot 2H_2O$) is applied to soils as a Ca or sulfate fertilizer, as an soil aggregation aid to water infiltration, to prevent crusting, and to reduce erosion; to aid in alleviation of subsoil Al phyto-toxicity, and as a Ca source to remediate sodic soils (contain excessive Na).

Desalination/Restoration

Biosaline agriculture can be a sustainable solution to traditional agricultural because it allows ecosystem restoration. Halophytes have properties that can desalinate, capture heavy metals in soil, and don't require fresh water to produce. By planting multiple cycles of halophytes, the ground can be restored to a healthier state for traditional agriculture use. Ecosystem restoration can occur through transfer of halophyte to salt sensitive plants. This increases the salt tolerance of glycophytes, salt sensitive species that make up the majority of agriculture crops.

Improved germplasm/variety

Improved germplasm means seeds, seedlings and other planting materials that have been bred to meet particular requirements of the environment in which they are to be grown . It is important that the quality of material offered to farmers meet minimum standards such as: seed purity, diseases and pest free, uniform in size; and high viability.

Compost

Compost is a mixture of ingredients used to fertilize and improve the soil. It is commonly prepared by decomposing plant and food waste and recycling organic materials. The resulting mixture is rich in plant nutrients and beneficial organisms, such as worms and fungal mycelium. Compost improves soil fertility in gardens, landscaping, horticulture, urban agriculture, and organic farming. The benefits of compost include providing nutrients to crops as fertilizer, acting as a soil conditioner, increasing the humus or humic acid contents of the soil, and introducing beneficial colonies of microbes that help to suppress pathogens in the soil. It also reduces expenses on commercial chemical fertilizers for recreational gardeners and commercial farmers alike. Compost can be used for land and stream reclamation, wetland construction, and landfill cover.

Vermi compost

Vermi compost is the product or process of composting using various worms, usually red wigglers, white worms, and other earthworms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast. Vermicast, also called worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by an earthworm. Vermi-compost is an excellent, nutrient rich organic fertilizer and soil conditioner. Vermi-compost contains more nitrogen, phosphorus and potassium than farmyard manure and contains more manganese,

Vertisols Management/ BBM for vertesoil

Vertisols aresoils that have high clay content and properties with swelling and cracking nature depending on the extreme water contents. These extreme water contents make vertisols inappropriate for traditional farming. They are deep, dark-colored clayey soils of predominantly smectitic mineralogy. These soils are generally hard when dry and sticky when wet, a very low infiltration rate when the surface is sealed, very low saturated hydraulic conductivity and compaction as a result of swelling, and therefore presents serious limitations to their use. Crop production on these soils is limited because of impeded drainage, difficulty of land preparation, soil erosion and low fertility.

Figure 3.1 Aybar Broad Bed Maker

3.2 Measuring and transporting required quantities of integrated soil fertility inputs

A containment approach should be adopted for the handling and use of inputs. This means that during the transport, storage, and any other handling operations, operators should ensure that inputs are contained within the transport vehicle or storage site so that possible adverse environmental effects from spillage should be avoided.

- The loss of product during the handling, transport, or storage of fertilizer is a potential point source of pollution, which can be effectively managed if appropriate actions are taken.
- Exposure to high dust levels may irritate the skin, eyes, nose, throat, or upper respiratory tract. Therefore, as much as possible, minimize dust generation and accumulation and avoid breathing

- In storage areas, provide ventilation sufficient to control airborne dust levels. If dust is being generated, wear the appropriate eye protection, such as safety glasses or goggles, and a dust respirator
- Depending on the distance from input locations where there is used, trucks, rail cars, and river barges may be used for transportation. :
- Minimize water interaction;
- Reduce dust
- Balance capital investment, cash flow requirements, and labor costs, and
- Maintain good physical condition
- Storage is needed to provide handling and spreading flexibility.

3.3 Monitoring and checking inputs

Better management of available resources or better integration of crop and livestock management, use of household waste, composting and incorporating crop residues into the soil are promising ways to improve nutrient cycling within the farm. Bedding in stables absorbs urine and conserves nutrients. Organic matter sources with a low C/N ratio mineralize very quickly and will supply nutrients for plant growth, but this will not lead to a rapid increase in soil organic matter in the soil. The effectiveness of an organic resource as fertilizer decreases with increasing C/N ratio. Chicken manure and vegetable residues have C/N ratios of about 10 and are most effective as an alternative to mineral fertilizer.

Cattle and pig manure are intermediate (C/N ratios of about 20), and straw is least effective as fertilizer. The quality for its soil amendment increases with increasing C/N ratio, but decreases at extreme values. Soil N availability may even decrease if soil amendments are used with very high C/N ratios as the microorganisms that decompose the material temporarily block N otherwise available to the crop.

Composting is a process where material with a high C/N ratio (e.g. maize straw) is converted into material with a low C/N ratio. Farmers may improve the nutritional quality of compost by adding ashes and droppings of small ruminants. During composting, about 50% of the carbon in the initial material is typically lost but mineral nutrients are mostly conserved. Finished compost is therefore generally more concentrated in nutrients than the initial combination of raw materials used and can serve as an effective means of building soil fertility.

Increasing the proportion of legume plants in compost preparation, increases the quality of compost and shorten period of compositing to use for immediate soil amendment.

The quality of manure depends on the quality of feed, storage and handling conditions, ambient temperature, moisture levels, and length of exposure to the environment. Quality manure can be determined by the absence of undecomposed materials, no smell, and dry product while poor quality manure is characterized by bad odor, whitish in color, visibility of raw materials, high temperatures and wet product

Quality compost is obtained using biodegradable wastes, earthworms and materials with good C:N ratio.

3.4 Preparation of integrated soil fertility and equipment

We need to consider for 'local adaptation' in the preparation for integrated soil fertility and equipment, because taking into account in variability:

- Between farms, in terms of farming goals, and objectives, size, labour availability, ownership of livestock, importance of off-farm income; and
- In the amount of production resources (i.e. land, money, labour, crop residues and animal manures) that different farming families are able to invest in the fields in their farm. Thus, local adaptation also refers to the need to take into account differences in the responsiveness of soils:
- Only small amounts of fertilizer are required to replenish nutrient stocks and maintain the fertility of fertile fields.
- For responsive soils, fertilizer recommendations should be targeted to each field based on anticipated or proven responses. The recommendation should also include soil amendments and other soil fertility management practices (e.g. organic inputs) required to achieve a full response.

• Non-responsive soils often have complex and less understood sets of constraints to crop production. Rehabilitation should only be carried out where solutions have been developed and tested and have been found to be practical and economical.

Another point emphasized in ISFM is the importance of identifying 'entry points' where ISFM components can be introduced and will produce a large return for the farmer to input use or changes to production practices.

Farming systems analysis (FSA) is carried out to identify and prioritize entry points:

• Which parts of the farming system should be prioritized for improvement?

• What will be the impact of improvements in the prioritized part of the farming system on other farming system components?

3.5 Selecting application method of integrated soil fertility input

The adaptations of ISFM to local conditions lead to specific management practices and investment choices, and are interative in nature leading to better judgments by farmers concerning weed management, targeting of fertilizer in space and time and choice of crop varieties. Farmer resource endowment also influences ISFM, as do market conditions and conducive policies .

A set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at optimizing agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed following sound agronomic and economic principles

The ISFM approach embraces the principles of plant production ecology where yield is a function of the interaction between genotype, environment and management:

Yield = G (genotype) ´ E (environment) ´ M (management) where:

• Genotype is the seed or plants used in the farming system. They may be local or improved varieties.

• Environment refers to the soils and climate in the particular location.

• Management refers to the farmer's ability and skill in managing crops and the farming system

Source: https://www.youtube.com/watch?v=TnSVgP5Pjro.Acessed May 25, 2023

3.5.1 Technology Description of Compost

Compost is a mixture of ingredients used to fertilize and improve the soil. It is commonly prepared by decomposing plant and food waste and recycling organic materials. The resulting mixture is rich in plant nutrients and beneficial organisms, such as worms and fungal mycelium. Compost improves soil fertility in gardens, landscaping, horticulture, urban agriculture, and organic farming. The benefits of compost include providing nutrients to crops as fertilizer, acting as a soil conditioner, increasing the humus or humic acid contents of the soil, and introducing beneficial colonies of microbes that help to suppress pathogens in the soil. It also reduces expenses on commercial chemical fertilizers for recreational gardeners and commercial farmers alike. Compost can be used for land and stream reclamation, wetland construction, and landfill cover.

Composting is the natural process of recycling organic matter, such as leaves and food scraps, into a valuable fertilizer that can enrich soil and plants. Anything that grows decomposes eventually; composting simply speeds up the process by providing an ideal environment for bacteria, fungi, and other decomposing organisms (such as worms, sow bugs, and nematodes) to do their work. The resulting decomposed matter, which often ends up looking like fertile garden soil, is called compost.

Purpose of Composting

The purpose of composting is to convert organic matter into growth promoting substances, for sustained soil improvement and crop production.

The organic matter is partially decomposed and converted by microbes. These microbes require proper growth conditions, for their activity i.e moisture content: 50% and 50% aeration of total pore space of the composting material.

Soil microorganisms constitute sufficiently to the decomposition of organic matter through their continuous activities. The majority of these soil animals provide optimal conditions in their digestive track for their synthesis of valuable permanent humus and stable soil crumbs.

It enriches soil, helping retain moisture and suppress plant diseases and pests. It reduces the need for chemical fertilizers. It encourages the production of beneficial bacteria and fungi that break down organic matter to create humus, a rich nutrient-filled material. It reduces methane emissions from landfills and lowers your carbon footprint.

Area/agro ecology preference for the technology

Agro ecology for compost should be made of all sorts of organic materials, the right micro- organisms, has to be present. To make the best possible compost, the micro-organisms must be able to work optimally. This can be achieved if the following four factors are combined to the best advantage

- type of organic material
- air
- moisture
- temperature

Materials/Input required for the technology

Organisms that decompose organic waste need four key elements to thrive: nitrogen, carbon, air, and water. Since all compostable materials contain carbon, with varying amounts of nitrogen, composting successfully is just a matter of using the right combination of materials to achieve the best ratio of carbon to nitrogen and maintaining the right amounts of air and water to yield the best results. The ideal carbon-to-nitrogen ratio for a compost pile is 25 to 30 parts carbon for every part nitrogen. If your pile has too much carbon-rich material, it will be drier and take longer to break down. Too much nitrogen-rich material can end up creating a slimy, wet, and smelly compost pile. Fortunately, these problems are easily remedied by adding carbon-rich or nitrogen-rich material as needed.

Compost Preparation

Composting is most rapid when conditions that encourage the growth of the microorganisms are established and maintained. The most important conditions include: the climate, the carbon to nitrogen ratio, aeration, moisture, material size and turning. All are vital to the composting process.

Compost preparation Methods: There are two basic methods of making compost:

i. **Heap method**
ii. **Pit method**

The heap method, and the pit method, both referred to as piling methods. The only difference between the two is that the heap is built above the ground, while the pit method requires digging of large pits. The heap method of composting is suitable for high rainfall areas, irrigated areas and during the rainy season and does not require expenditure and is easy to manage.

In areas where there is scarcity of moisture and during the dry season, the pit method of composting is used.

The compost heap or pit is built up of layers of materials, like in a big sandwich. These materials are dry plant materials, green plant materials and animal manure.

Operational procedure for compost preparation

Layer 1: A layer of dry plant materials 20–25 cm thick. Water or manure slurry should be sprinkled with a watering can evenly over this layer. The layer should be moist but not soaked.

Layer 2: A layer of moist (green) plant materials, either fresh or wilted, e.g. weeds or grass, stems and leaves left over from harvesting vegetables, damaged fruits and vegetables. Leafy branches from woody plants can also be used if the materials are chopped up. The layer should be 20–25 cm thick. Water should not be sprinkled or scattered over this layer.

Layer 3: A layer of animal manure collected from fresh or dried cow dung, horse, mule or donkey manure, sheep, goat or chicken droppings. The animal manure can be mixed with soil, old compost and some ashes to make a layer 5–10 cm thick.

Layers are added to the heap in the sequence, Layer 1, Layer 2, Layer 3, until the heap is about 1–1.5 meters tall. The layers should be thicker in the middle than at the sides so the heap becomes dome-shaped. If the heap is much taller than 1.5 meters, the microbes at the bottom of the heap will not be able to work well. Layers 1 and 2 are essential to make good compost, but Layer 3 can be left out if there is a shortage or absence of animal manure. It is important to place one or more ventilation and/or testing sticks at 45 degree in the compost heap/pit. The stick should be long enough to stick out of the top of the heap. Ventilation and testing sticks are used to check if the decomposition process is going well, or not.

A hollow stick of bamboo grass (Arundo donax) or bamboo makes a good ventilation stick as it allows carbon dioxide to diffuse out of and oxygen to diffuse into the heap. A testing stick can be taken out at regular intervals to check on the progress of decomposition in the heap.

i. **Pit composting**

The pit method is best done at the end of the rainy season or during the dry season. If the pit method of compost preparation is made during the rainy season or in very wet areas, water can get into the bottom of the pit. This will rot the materials producing a bad smell and poor-quality compost. Poor quality compost will not be productive, and this can discourage farmers and others from trying to make better quality compost. In wet areas, it is better to make compost through the heap method.

Site and pit dimension

The site should be accessible for receiving the materials, including water and/or urine, and for frequent watching/monitoring and follow-up. The site should be protected from high rainfall, flooding, strong sunlight and wind. A temporary shed may be constructed over it to protect the compost from heavy rainfall. The pit should also be marked or have a ring of stones or small fence around it so that people and animals do not fall into it. The pit should be about 1 m deep, 1-2 m wide and of any suitable length. Pits should not be deeper than 1 meter, because it can be cold at the bottom and the micro-organisms cannot get enough oxygen to work properly.

Filling the pit compost

Before the pit is filled, the bottom and sides should be plastered with a mixture of animal dung and water (slurry). If animal dung is not available, a mixture of topsoil and water can be used. The plastering helps to seal the sides of the pit so that moisture stays in the compost making materials. Then the compost pit is filled with layers of materials, like in a big sandwich. The basic sequence is as described on the above.

Turning over the compost

The material is turned three times during the period of composting; the first time within -30 days after filling the pit, the second after another 30 days and the third after another month. At each turning, the material should be mixed thoroughly, moistened with water, and replaced in the pit.

ii. Heap composting

This method of composting is usually used in high rainfall areas, irrigated areas and during the rainy season.

Site and heap dimensions

The site should be accessible for receiving the materials, including water and/or urine, and for frequent watching/monitoring and follow-up. It should also be protected from high rainfall, flooding, strong sunlight and wind, e.g. in the shade of a tree, or on the west or north side of a building or wall.

The basic heap dimension is about 2 m wide at the base, 1.5 m high and 2 m long. The sides are tapered so that the top is about 0.5 m narrower in width than the base. A small bund is sometimes built around the pile to protect it from wind, which tends to dry the heap.

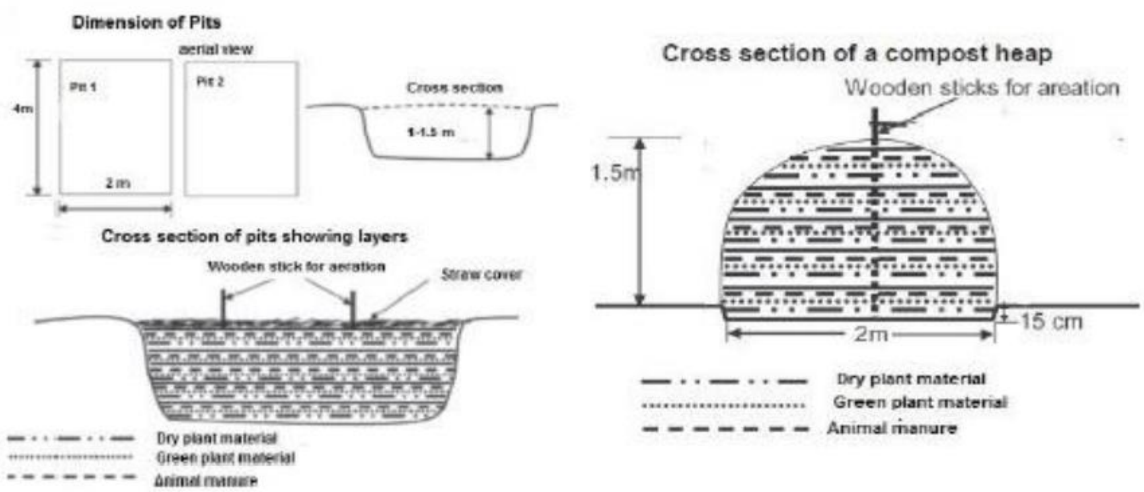


Figure 3.2 Heap and pit method of compost preparation

The 4 stages **Stages of Composting**

1. The Mesophilic(Heating) Phase
2. The Thermophilic Phase
3. The Cooling Phase
4. The Curing Phase

1. The Mesophilic Phase

It is the first stage in the composting process. Bacteria combine with oxygen and water to start the process. Carbon dioxide and energy are produced as a result, and it is used for the reproduction and growth of bacteria. The remaining energy is given off as heat.

The temperature of the pile is raised due to the reproduction of bacteria, and the temperature can reach up to 111°F (44°C). The mesophilic bacteria work only well in this temperature range, and their growth and reproduction are limited as soon as the temperature starts to go up. The first stage lasts for a week or so. The compost settles down during this stage and is ready for the next stage.

2. The Thermophilic Phase

The second stage is the thermophilic stage; the temperature goes up to 158°F (70°C) as the thermophilic organisms become active and produce a lot of heat during this phase. When the temperature reaches such a high point, the harmful bacteria die, the seeds from weeds are killed, and the pile starts to break down rapidly. You must keep the pile damp and make sure that there is sufficient air in the bin or pile. It acts as a catalyst during this process. Remember to turn the pile upside down once or twice in this stage, as it will ensure that oxygen reaches the center of the pile and all other areas as well.

3. The Cooling Phase

In the cooling stage, the pile cools down to the normal temperature. A lot of organic waste is still pending to be decomposed and become usable as compost. You may notice the color of the compost turning to be brown in portions, but it is not fully complete at this time.

4. The Curing Phase

The last and final stage is the curing phase. Depending upon the composition of your compost, it may take up to months. Most experts are of the view that the final stage takes up to 6 months or so before the compost is finally ready to be used. You can check the condition of compost after a month or two months, if it is brown, large pieces are broken down, and overall appearance is consistent, your compost is ready. Turning your compost after 15-20 days in the final stage is helpful. Please do not add more waste in the near-completion compost as it can cause disturbances in the process.

3.5.2 Farm Yard Manure Technology Description

Farmyard Manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle.

Organic manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition.

Manures can be grouped into bulky organic manures and concentrated organic manures based on concentration of the nutrients. Bulky organic manures contain small percentage of nutrients and they are applied in huge quantities.

Purpose of Farmyard manure

- To supply plant nutrients including micronutrients,
- It improve soil physical properties like structure, water holding capacity etc.,
- It increase the availability of nutrients,
- To release carbon dioxide during decomposition acts as a CO2 fertilizer, and
- To control plant parasitic nematodes and fungi by altering the balance of microorganisms in the soil.
- Increased soil carbon and reduced atmospheric carbon levels.
- Reduced soil erosion and runoff.
- Reduced nitrate leaching.
- Reduced energy demands for natural gas-intensive nitrogen(N) fertilizers

Area/Agro-ecology preference of the Farmyard Manure

The ecology farmyard manure prefer when the availability of cattle, sheep, goat and other animals. It is a varying mixture of animal manure, urine, bedding material, fodder residues, and other components is the most common form of organic manure. Farmyard manure has a high proportion of organic material which nurtures soil organisms and is essential in maintaining an active soil life. In areas with limited fuel sources, dried manure is used as a cooking fuel. An alternative fuel source can be created by planting trees for firewood as living fences.

Operational procedure of Farmyard Manure

The daily collection of the mixture of cattle dung and urine-soaked litter is spread over the previous layer. And this is continuing till the manure heap rises about 30cms above the ground. It is then watered carefully and mud-plastered. The Farmyard Manure is ready in about 6 months.

Quality measurement of FYM

The quality of FYM depends on what animals have eaten. If they have been fed with poor-quality forage or grazed on poor soils, their manure will be of poor quality. If they have been fed good-quality feed, the manure will be rich in nutrients. The type of animal also influences its quality because different species of animals eat different things. In general, manure from pigs and poultry is of better quality than manure from goats and cattle. It is possible to enrich cattle manure by mixing it with manure from other types of animals. Another factor which affects quality is storage and handling conditions. FYM storage and handling practice by farmers is sometimes poor. If it is stored in the open and exposed to rain, many of the nutrients will be washed away. Nutrient and carbon losses during manure storage vary substantially. Nitrogen losses for example may vary from less than 10% to about 90%. Nitrogen losses tend to be lower for more compact and anaerobic manure storage systems

3.5.3 Bio slurry Technology Description

Bio-slurry is the mixture of manure and water in semi liquid form used as a feedstock for the bio-digester. This is referred to as “undigested slurry”. The residue after the fermentation process is a sludge, known as “bio-slurry” or digestate.

Characteristics of digested bio-slurry

- Being fully fermented, bio-slurry is odorless and does not attract flies.

- Pathogens present in the manure are reduced in bio-slurry when compared to raw manure and even further when the bio-slurry is composted.
- It is an excellent soil conditioner, adding humus and enhancing the soil's capacity to retain water.
- To reduce weed growth by up to 50%.

Composition of bio-slurry

The composition of bio-slurry depends upon several factors: the kind of dung, water, breed and age of animals, types of feed and feeding rate.

Bio-slurry can be used to fertilize crops directly or added to composting of other organic materials. Bio-slurry is an already-digested source of animal waste and if urine (animal and/or human) is added, more nitrogen is added to the bio-slurry which can speed up the compost-making process. This improves the carbon/nitrogen (C/N) ratio in the compost. But this also depends on the kind of digester. With the right amounts of materials, the composition of the bio-slurry can exist of 93% water and 7% of dry matter, of which 4.5% is organic matter and 2.5% inorganic matter with an NPK content of approximately 0.25% N, 0.13% P and 0.12% K. The bio-slurry also contains phosphorus, potassium, zinc, iron, manganese and copper, the last of which has become a limited factor in many soils. Nutrients in bio-slurry especially nitrogen, are more readily available for plants compared to FYM, leading to a higher short-term fertilization effect. However, risks for N losses through volatilisation and leaching are larger for bio-slurry than for manure.

Purpose and Benefits of Bio-slurry

Bio-slurry has economic, social and environmental benefits.

Economic benefits

- Those includes the production of a high-quality fertilizer
- potentially marketable organic fertilizer, which will improve soil structure
- To increase soil water retention capacity and yields.
- To increase yields

Social benefit

- These include reduced labour and time savings, especially for women, in not collecting firewood or other sources of energy
- To reduce exposure to indoor smoke and smoke-induced health impacts
- To improve air quality improvement in household sanitation, and the absence of soot and ashes in the kitchen

Environmental benefits

- To improve soil health and fertility and crop productivity through reducing the removal of biomass, manure, and crop residues for fuel.
- To reduce methane emissions due to reduced inorganic fertilizer application as well as improved manure management
- To reduce fuel wood demand, contributing to reduced deforestation and forest degradation, and reduced greenhouse gas (GHG) emissions through substitution of fuel wood or charcoal with biogas.
- Aerobic pathogens are reduced through treatment in the digester

Limitation of bio-slurry

- Storage

Bio-slurry needs to be stored since it will only be required in specific periods of the growing season, while the bio-slurry will be produced continuously. Options for storage include vessels or tanks, closed or uncovered ponds or lagoons.

- Incomplete digestion

If anaerobic digestion is not fully complete, additional digestion will occur during storage, when CO2, CH4 and NH3 will be released losing nutrients and producing damaging gases

- Food safety risks

The risk of pathogen contamination is lower for fresh bio-slurry than for fresh manure, although after storage pathogen risks are similar.

Post Operational and Utilization of bio-slurry

Bio-slurry can be separated into liquid and solid fractions and stored separately, the solid fraction being stored in a similar manner to compost or FYM. These allow the separated fractions to be handled more easily. Transport of the solid fraction will be less costly compared with large volumes of liquid digestate. It can also be sold as a valuable fertilizer, while the liquid fraction can be used close to the bio-digester. Bio-slurry can be used in different ways

The liquid component can be mixed in a 1:1 composition with water and applied directly to the soil around vegetables or fruit crops. In this form it is particularly beneficial for root vegetables, sugarcane, fruit trees, and for nursery seedlings. For large quantities, application along irrigation channels can be undertaken.

The solid fraction can be added to compost and used on field crops or sold as a bio fertilizer.

Many farmers prefer the dry form of bio-slurry as it is easier to transport than the liquid form. However, application of the dried form and is the least efficient due to losses in nutrient value. The composted form of bio-slurry is the best way to overcome the transportation issue related to liquid bioslurry and the nutrient loss of the dried form.



Figure 3.3 Bioslurry compost

3.5.4 Vertisols Management Technology

Long-term adaptations to climate changes on Vertisols management require structural changes to overcome the harsh conditions. Vertisols have considerable productive potential, but they are usually underutilized in the traditional production system. Hence, achieving sustainable and improved management of Vertisols has been a major challenge for Ethiopian farmers for many years. Vertisols management technologies essentially usedare drainage using BBM, Tied ridge using Tieridger, Camber Bed,early planting,improved variety, and fertilizers application were developed to effectively and efficiently utilize these soils. Early planting of short maturing wheat and teff varieties opened an opportunity for double cropping.

Broad Bed Maker (BBM)

The Broad Bed Maker (BBM) was developed in the late 1980s from the traditional dual oxen drawn plough, the maresha; modified for the construction of raised beds and furrows. By construction of an effective bed width of 80 cm and 20 cm furrows, it is intended to facilitate surface drainage through the furrows between the beds (Jutzi and Mesfin, 1987) so that the crops grow on the beds. The role of the BBM was to make raised seedbeds and furrows more efficiently and effectively, thus reducing water logging and encouraging early planting of a cereal crop of an improved cereal variety which could then be followed by a second crop of pulses in the same growing season.

The water logging situation constrains crop yields in two major ways. First, muddy soil complicates plowing, forcing farmers to delay planting until the end of the main rainy season, using the short growing period on residual moisture. Second, water logging leads to modification of soil physical and chemical characteristics, leading to a decrease in output. A surface drainage technology known as “Broad Bed and Furrow” (BBF), constructed by Broad Bed Maker (BBM), has been developed for tackling the problem of water logging situation.

Advantages of BBM

Broad Bed Maker (BBM) is used at planting time in order to drain excess water away from crops. It is a multi-purpose ridger and bed maker used to drain excess water and conserve moisture in dry areas. Modified Broad bed maker technology is appropriate in places where the vertisol affects selected areas, where there is shortage of the manpower for hand weeding and shortage of draught animal for ploughing. The wise use of the technologyreduces the work load of women and the labour. The modified version of broad Bed maker is light, low cost and a simple technology, its application does not require farmers to have or develop advanced skills and can make broader bed row than the convention broad bed maker.

Example Aybar BBM technology has enabled farmers to use agricultural inputs more efficiently, raising crop yields from 0.5-1.5 ton per hectare to 3.5-7 tons per hectare, The Aybar BBM is a low-cost (with initial investment capital of about 93 Birr), an oxen powered plough developed by modifying a local farm implement called maresha, .

Limitations

- Weed infestation induced by early planting,
- available time limitation for broad bed furrow(BBF) preparation,
- difficulty in appropriate site selection are among the technical constraints that limited the success and adoption of the technology
- Broad bed maker technology does not operate at a place where the land is too rocky, the soil is too wet(muddy) and/or the soil is too dry.
- It also has limitations in draining excess water from highly water logged area
- It can be used only on soils with slope greater than 2% and if the soil is not muddy.
- If the slope of the land is less than 2% it can only be used for teff

Operation Procedure

The instructions to use Aybar BBM are:

(i) 80 cm width of the bed;

(ii) Use of BBM only, for Vertisol;

(iii)Slope of field should not be completely flat, but between 2-8% and

(iv)Not to use Aybar BBM when there is too much rain

Broad bed maker is a detachable, winged metal unit that is fixed to a plough frame and drawn by oxen, and a separate attachment to the rear of the unit. The winged unit makes the furrow while the attachment to the unit makes the bed. The bed-making attachment can be adjusted according to the conditions of the soil.The separate parts are inserted into each other, making the entire device convenient for smallholder farmers who tend to lack access to nuts andbolts.When the bed maker is removed, the winged unit can also be used in dry areas to make ridges to conserve moisture, for digging and even for planting potatoes.

The pre-operational requirement needed before using this technology consists;

- Making the land to be favorable for the operation(checking the soil moisture to be neither too wet nor too dry).
- Preparing seed and fertilizer after checking the precondition mention above,
- After sowing seed and fertilizer, make bed and furrow the with this technology, cover the seed and check it once again.

Figure 3.4 Aybar Broad Bed Maker

Self-Check 3	Written Test

Name: _________________________ ID________ Date: _______________

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

Test I: Matching

A	B
1. BBM	A. Soil fertility
2. Compost	B. Animal waste
3. FYM	C. Water logging
4. Bioslurry	D. Uses irrigation channels
5. Soil condition	E. Fertility status

Test II: Short Answer Questions

1. Define Integrated soil fertility management.
2. Differentiate between Integrated management and conventional fertility management approach.
3. What are the challenges of application of integrated soil fertility management?
4. Explain how to assess OHS risk during implementing plant nutrition.
5. Which type of integrated soil fertility management input can be applied? Why?.

LG #4	LO #4 Carrying out Integrated soil fertility operations

Instruction Sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Handling and transporting integrated soil fertility inputs • Applying integrated soil fertility inputs • Cleaning and sterilizing tools and equipment • Disposing off waste and debris • Completing workplace records • Inspecting and checking integrated soil fertility inputs • Recording and documenting This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Handle and transporting integrated soil fertility inputs

- Apply integrated soil fertility inputs
- Clean and sterilize tools and equipment
- Dispos off waste and debris
- Complete workplace records
- Inspect and check integrated soil fertility inputs
- Record and document

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information sheet 4

4.3 Handling and transporting integrated soil fertility inputs

4.3.1. Sterilizing tools and equipment

4.3.1.1 Cleaning tools and equipment

Cleaning and sterilizing tools and equipment after application of integrated soil fertility inputs is important to prevent the spread of diseases and pests. Make sure to rinse them thoroughly with water after sterilization to remove any residual

The major steps in cleaning are:

- Washing
- Rinsing and
- Drying and
- Finally storing

4.3.1.2 Sterilization of work site and equipments

Establish decontamination areas for “dry” and/or “wet” decontamination, depending on the decontamination needs at the site.

Before decontamination, place clean plastic sheeting on the ground or inside the solids containment vessel to collect material removed from the equipment.

Place an equipment table covered with clean plastic sheeting near the dry decontamination area to facilitate disassembly of the contaminated sampling equipment.

Place drums nearby to contain waste material. Use a liquid containment vessel to contain wet decontamination waste. Use Tubs, Buckets, Brushes and Spray bottles to wet decontaminate. Establish the decontamination area

4.3.2 Disposing off waste and debris

Waste disposal procedures step by step

I. Find an appropriate container for your waste
II. Label your waste as outlined in this document
III. Check that you list of waste corresponds with the list waste to be disposed of safely

4.3.3 Completing workplace records

After applying integrated soil management input, it is important to record and document the following:

- The type of input applied.
- The date of application.
- The rate of application.
- The location of application.
- The crop(s) grown after application.
- The yield of the crop(s) grown after application.
- Any observations made during the growing season.

This information can be used to evaluate the effectiveness of the integrated soil management input and make adjustments for future applications after documenting the results of the evaluation..

4.6 Inspecting and checking integrated soil fertility inputs

Self-Check 4	Written Test

Name: ________________________ **ID**________ **Date:** _______________

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

Test I: Matching

A	B
1. PPE	F. Soil fertility
2. Hazards	G. Physical data
3.	H. sterilization
4. Cleaning	I. Prevent injuries
5. Farm records	J. Identify hazards

Test II: Short Answer Questions

1. Define Sustainable agriculture?.
2. Discuss the contribution of ISFM on sustainable of agriculture.
3. What is the economic & environmental befits of ISFM.
4. Why do we need to record and document inputs & results of ISFM?

5. When & how can we monitor or inspect effects of ISFM input? .

Reference Materials

Books

Soil Science Simplified" by Helmut Kohnke and Piotr Nannipieri 2004

"The Nature and Properties of Soils" by Raymond Weil and Nyle Brady 2020

"Soil Fertility and Fertilizers" by John Havlin, Samuel Tisdale, Werner Nelson, and James Beaton 2019

"Introduction to Soil Science" by Henry D. Foth and Lloyd B. Voorhees

"Soil Testing and Plant Analysis" by Westerman, and Jones

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