Agricultural TVET College

Small Scale Irrigation Development

Level III

MODEL TTLM

Learning Guide#08

Unit of Competence: Implement Soil Fertility Management

Module Title: Implementing Soil Fertility Management

LG Code: AGR SSI3 M08 LO1-LO3

TTLM Code: AGR SSI3 TTLM08 $1218V_1$

Nominal Duration: 45 Hours

Instruction Sheet	Learning Guide 08

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

- Monitor indicators of soil fertility
- Assess soil-related factors for selected plants
- Select and implement appropriate agronomy and fertility techniques

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

- ✓ Assess the nutritional health of plants grown by the enterprise,
- ✓ Access and apply appropriate products to plants and soils to meet the goals and objectives of the plant nutrition program.
- ✓ Describe the relationship between soil characteristics and the availability of nutrients, including macro and micro elements, to plants
- ✓ Explain the environmental implications for the external environment of soil ameliorant and fertilizer use, which may include over-spraying, run-off, nutrient overload, erosion, toxicity, noise and dust.
- ✓ Communicate with work team members, supervisors, and suppliers,
- ✓ Interpret manufacturers and plant nutrition program specifications, utilize preformed reporting, analysis and work procedure documents, and understand labels and symbols
- ✓ Estimate treatment and product requirements, material sizes and quantities, interpret specifications, and calculate areas, ratios, proportions and application rates

Learning Activities

1. **Read the specific objectives of this Learning Guide.**
2. **Read the information written in the "Information Sheet"**
3. **Accomplish the "Self-check".**
4. **If you earned a satisfactory evaluation proceed to the next "Information Sheet". However, if your rating is unsatisfactory, see your facilitator for further instructions or go back to Learning Activity.**
5. **Submit your accomplished Self-check. This will form part of your training portfolio.**
6. **Read and Practice "Operation Sheets".**

7. **If you think you are ready proceed to "Job Sheet".**
8. **Request you facilitator to observe your demonstration of the exercises and give you feedback.**

INFORMATION SHEET#1	Monitor indicators of soil fertility

Introduction

Soil is a medium for plant growth, which serves as a source and reserve of plant nutrient, a means of water storage, supply and purification; as well as providing mechanical support, oxygen for roots, and moderated temperature. The productivity of a given soil is largely dependent on its ability to supply a balance of these factors to the plant community. Thus, soil properties indicate what types of plants grow in a soil or what particular crops grow in landscapes.

Soil fertility: is defined as "the physical, biological, and chemical characteristics of a soil, for example its organic matter content, acidity, texture, depth, and water-retention capacity all influence fertility.

Soil productivity: is the ability of the soil to provide the necessary plant nutrients and water at the required amount and timing for sustainable production of crops, forages, trees and other plants.

1.1 Undertaking work in an environmentally appropriate manner.

Most of the time monitoring indicators soil fertility work is undertaken in;

- An environmentally appropriate manner and according to workplace information
- Based on principles of organic agriculture (i.e: Organic agriculture should sustain and enhance the health of soil, plant, animal and human as one and indivisible.)
- Occupational health and safety requirements and
- Enterprise guidelines and standards:- These standards require that products bearing the ISO, USDA organic label be grown and processed without the use of toxic and synthetic pesticides and fertilizers, genetic engineering, antibiotics, synthetic growth hormones, artificial flavors, colors, preservatives, sewage sludge and irradiation.

1.2 Conducting soil testing at reference sites

In agriculture, a **soil test** commonly refers to the **analysis** of a **soil** sample to determine:

- Nutrient content,

- Composition and other characteristics such as the acidity or pH level.

A soil test can determine fertility, or the expected growth potential of the soil which indicates nutrient deficiencies, potential toxicities from excessive fertility and inhibitions from the presence of non-essential trace minerals. The test is used to mimic the function of roots to assimilate minerals.

These soil testing are carried out based on the three soil properties these are physical, chemical and biological properties.

1.2.1: Determining physical properties of soil

The physical properties of soil are characteristics that can be seen, felt, or measured. These includes

- **Color:-** Organic matter, the soil minerals present, and the drainage conditions all influence soil color. Color alone is not an indicator of soil quality, but color does provide clues about certain conditions.
- **Texture**:- Soil texture is an estimate of the relative amounts of sand, silt and clay particles in a soil. Soil texture affects the movement and availability of air, nutrients and water in a soil and is often used to estimate other soil properties, particularly soil water properties, if no direct measurements are available. Properties that are influenced by soil texture include porosity, permeability, infiltration, shrink-swell rate, water-holding capacity, and susceptibility to erosion.
- **Structure:-** Soil structure refers to the grouping of individual soil particles into larger pieces called peds or aggregates. Soil structure affects aeration, water movement, and conduction of heat, plant root growth and resistance to erosion.
- **Water-holding capacity:-** Water-holding capacity is the retention of water moving through soil which mainly depends on differences in soil pore space.

1.2.2: Determining chemical properties of soil

There are strong relationships between soil physical properties and soil chemical properties, which is highly influenced by the inherent geology, climate, and management and erosion intensity, particularly in the Ethiopian context. These include:

- **Cation Exchange Capacity (CEC):-** Cation exchange capacity is the ability of the soil to hold on nutrients (the amount of negative charge in soil that is available to bind positively charged ions, called cations) and prevent them from leaching beyond the roots.

- **Soil organic matter (SOM):-** Organic matter consists of the remains of plants, animals and microbial material, both living and dead and gives soil a gray to very-dark-brown color.
- **Soil PH:-** Soil pH, a measure of the acidity or alkalinity of the soil, is defined as the negative logarithm of the hydrogen ion concentration. The level of pH affects soil fertility and the availability of nutrients. Soil pH has a great effect on the solubility of minerals or nutrients. Most of the essential plant nutrients are obtained from the soil and are not available to the plant unless dissolved in the soil solution.

1.2.3: Biological properties of soil:

This includes all the activity of beneficial microorganisms. Bacteria that decompose soil organic matter are hindered in soils. This helps organic matter to breaking down, resulting in an dispersion of organic matter and the tie up of nutrients, particularly nitrogen, that are held in the organic matter.

1.2.4 Conducting basic soil testing practices at site level

Depending on the purpose of the test and to select appropriate reference or control soils, the following parameters should be measured in each sample:

- PH (measures soil acidity or alkalinity)
- Moisture content/soil porosity
- Bulk density
- Total organic matter/total organic carbon
- Soil type and texture(sand, silt, clay)
- Grain size/mineralogy
- Cation exchange capacity
- Exchangeable cation concentrations (potassium, calcium, sodium, magnesium)
- Salinity(as assessed byelectrical conductivity)

1.3 Assessing and recording soil acidity or alkalinity (pH), mineral balances and organic matter levels.

1.3.1 Assessing soil acidity or alkalinity (pH)

The only way to diagnose soil acidity is to sample the soil and test the pH.

Soil sampling

Topsoil pH can be quite different from the subsurface soil pH and sampling only the topsoil may lead to inadequate lime applications. Acidity in the subsurface cannot be detected or estimated by knowing the topsoil pH. Samples should be taken at 0-10, 10-20 and 20-30 centimetres (cm) to determine a soil pH profile.

Figure_1: Profile of subsurface soil

Ideally, soil samples should be taken in summer, when most soils are hot and dry with minimal biological activity. This will minimize the impact of seasonal variations in pH, which will be further reduced by measuring pH in a calcium chloride solution rather than water.

1.3.2 Assessing soil mineral balances and organic matter levels

Mineral balances

It is essential that land user understand the importance of mineral balance in their soils. Some of these driving measures of the levels of the major cations in the soil, namely calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and sometimes aluminium (Al).

The other component influencing the mineral storage capacity of a soil is humus. Humus is the only storage system in the soil that holds onto both cations (positively charged atoms) and anions (negatively charged atoms). It is also the only soil component that can hold onto the anions sulphur (S), boron (B) and nitrate-N, all of which are crucial for effective soil fertility.

Organic Matter

Organic Matter is defined as all living and decaying residues, including weeds, crop residues, decaying roots, microorganisms and anything which is added to the soil in the form of composts, manures, cover crops, mulches, leaves, etc.

These materials all contain many nutrients for future plant growth; including carbon which is the most basic food source for the soil's microlife and (indirectly) for the plants themselves. This carbon feeds the microbes and earthworms, stimulating their activity and increasing their populations.

Increasing the organic matter content will improve water penetration, water-holding capacity, soil structure, microbial biomass, nutrient availability, drought, and heat stress resistance, resistance to compaction and more. Increasing the soil's organic matter content is perhaps the most important improvement a farmer can make. Soils which are below 2% organic matter (OM) in the upper horizon are low in organic matter. They do not have enough essential food (carbon) to feed the micro and macro organisms which provide all fertility to plants.

It is good to add organic matter and humus at least once a year to most soil, more often to soils with very low (under 2%) OM contents. The two best ways to increase the OM are to add compost and to grow cover crops. OM can also be increased with manures and sheet-composting but the results are definitely inferior to those achieved through aerobic composting and cover cropping.

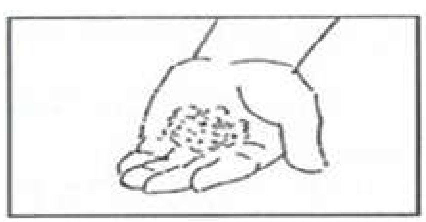
1.4 Assessing and recording soil texture, structure, salinity and Sodicity.

1.4.1: Assessing and recording soil texture, structure

Field or hand texturing is a measure of the behavior of a small handful of soil when moistened and kneaded into a ball slightly larger than the size of a golf ball or bolus and pressed out to form a ribbon between the thumb and forefinger. The behavior of the soil during bolus formation, and the ribbon produced, characterizes the field texture.

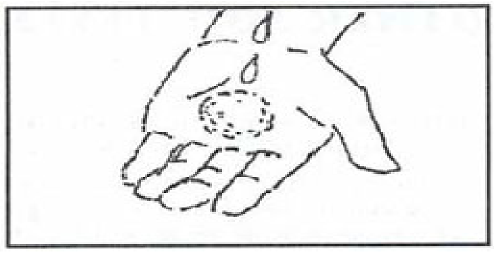
The steps of measuring soil texture by field method are described as following.

Step 1. Take a sample of soil 25 gm by hand, grab a handful of soil and feel the dry soil in your hands, look for any obvious gravels or sand particles, note these if they are present.

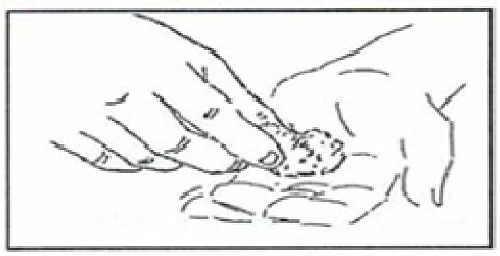


Step 2. Remove any grass, leaves or root hairs.

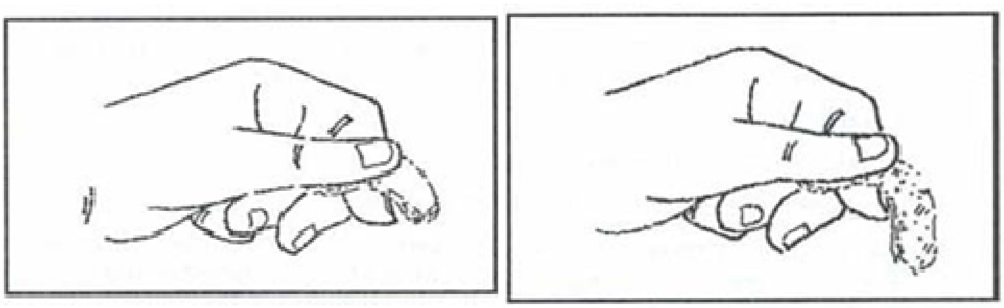
Step 3. Moisten the dry soil in your hand with small amounts of water. It is important that the soil is damp but not wet.



Step 4. Manipulate the soil in the palm of your hand, rolling it into a ball (bolus).



Step 5. Using thumb pressure against the middle joint of the index finger, press out a 2mm thick ribbon from the damp bolus, allowing it to break off naturally.



Step 6. Measure the length of the ribbon noting the length and repeat Steps 5 and 6 a further two times to gain an average length.

Step 7. Using the information gained from observing and feeling the soil and the average ribbon length, refer to Table 2 Guide to common soil textures and find the corresponding soil texture.

Table 1: Soil texture and behavior of moist bolus

Texture Grade	Behavior of moist bolus (ball formed in palm of hand)
Sand	Coherence, nil. Single sand grains adhere to fingers. If you press the bolus between your fingers, holding close to your ear, you will hear the sand grains rubbing against each other.
Loamy Sand	Slight coherence. Discolour fingers with dark organic stain. Ribbon length 1.0 cm.
Clayey Sand	Slight coherence; sticky when wet. Many sand grains stick to fingers. Discolours fingers with clay stain. Ribbon length 1.0 cm.
Sandy Loam	Bolus just coherent but very sandy to touch. Ribbon length 1.3-2.5 cm. Can hear sand grains (see Sand description above).
Loam	Bolus coherent and spongy. Smooth feel, may be greasy. Ribbon length 2.5 cm.

Structure

Soil structure refers to the grouping of individual soil particles into larger pieces called peds or aggregates. Good soil structure allows for extensive root development; poor structure can limit root growth. Supplying an adequate amount of organic matter and working the soil only when it is not excessively wet promotes good topsoil structure.

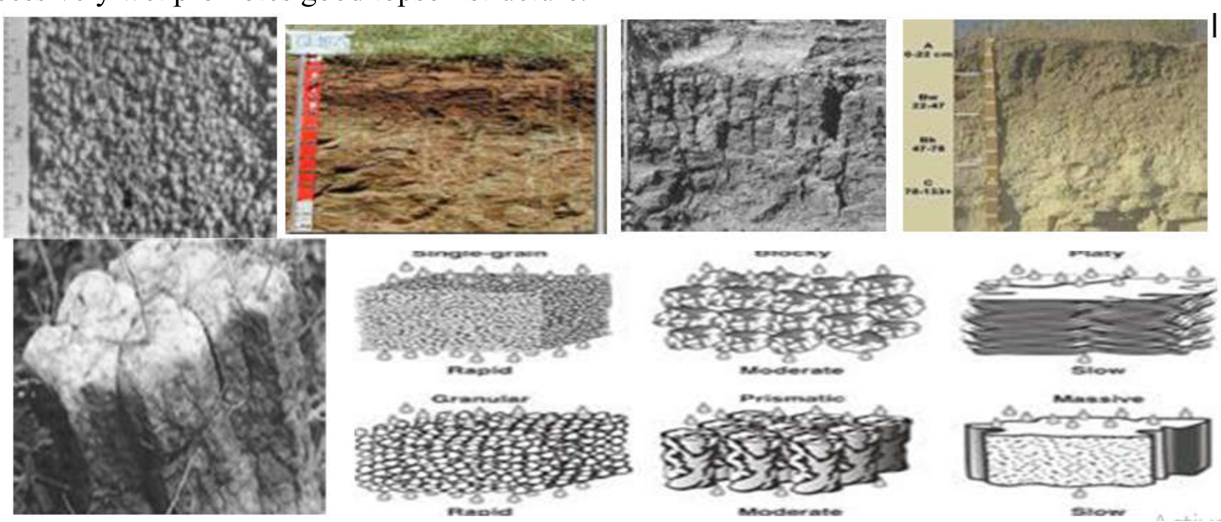


Figure_1: Some Example of soil structure and water percolation characteristics

Based on the size of peds, there are five different classes of soil structures:

a. Very fine or very thin: <1 mm platy and spherical; <5 mm blocky; <10 mm prism like.

b. Fine or thin: 1–2 mm platy, and spherical; 5–10 mm blocky; 10–20 mm prism like.

c. Medium: 2–5 mm platy, granular; 10–20 mm blocky; 20–50 prism like.

d. Coarse or thick: 5–10 mm platy, granular; 20–50 mm blocky; 50–100 mm prism like.

e. Very coarse or very thick: >10 mm platy, granular; >50 mm blocky; >100 mm prism like.

1.4.2: Assessing and recording soil salinity and Sodicity

Salinity

Salinity is the accumulation of salts (usually sodium chloride) in soil and water to sufficient levels that impact on human and natural assets (e.g. plants, animals, aquatic ecosystems, water supplies, agriculture or infrastructure).

Understanding what causes salinity, where the salt comes from, how it moves and the effect that it has on the environment is vital in targeting management strategies. If salt in the environment remains well below the soil surface away from the root zone of plants and water bodies, it is not a problem. However, if it is transported to locations where it impacts on humans and natural assets, then both the severity and cause of the problem need to be evaluated and addressed.

Measuring salinity

Soil salinity is measured to determine soil suitability for its intended use, such as agriculture, and to assist in land use planning decisions

An electrical conductivity (EC) meter is used to measure salinity. Electrical Conductivity meters can be small hand-held pocket meters, larger portable meters designed for field use or more sophisticated bench-top models designed for use in a laboratory. The concentration and composition of salts determine the electrical conductivity of the soil or water tested. Electrical conductivity increases as salt concentration rises.

There are a number of different sources of salt in the landscape. Salt deposits are often classified according to the source of the salt or its transport process.

These classifications include:

- ☞ Primary salinity occurs;

- connate/fossil,
- rock weathering (parent material in-situ),

☞ Secondary salinity occurs where salt is mobilised and redistributed closer to the soil surface and/or into waterways. This can occur due to:

- rising saline groundwater (dryland agriculture processes)
- rising saline groundwater (irrigation agriculture induced)
- rising saline groundwater (urban development induced)
- use of saline irrigation water (pumped groundwater) and
- Cyclic and aeolian processes (salt redistributed).

Sodicity:

Sodicity is a term given to the amount of sodium held in a **soil**. A sodic soil is one containing sufficient exchangeable sodium to adversely affect soil stability, plant growth and/or land use.

Measuring Sodicity

Sodium salts occur as part of the total soluble and exchangeable inorganic salt load in a soil. Whether these salts have been derived from geological weathering or applied to land as part of a wastewater reuse program does not detract from the potential problems that sodium salts may have on both the vegetation and the soils. When the adsorption of sodium on the surface of clays exceeds 6% of the total CEC, the soil is sodic and subject to serious structural degradation.

1.5 Analyzing results to identify trends and areas for improvement.

Most of the time these results are analyzed to identify trends and areas which are focused on the improvements of soil fertility through introducing soil fertility management interventions

1.5.1 Introducing Soil Fertility Management Interventions

The most important soil fertility management intervention is to ensure that the inherent soil and the applied nutrient is not washed away by external forces of wind and water erosion; employing soil and water conservation practices.

Once a physical structure is in place, soil fertility could be improved using the following interventions. Most of these practices are easy to adopt by farmers, if they are provided with market incentives, good information and effective demonstrations.

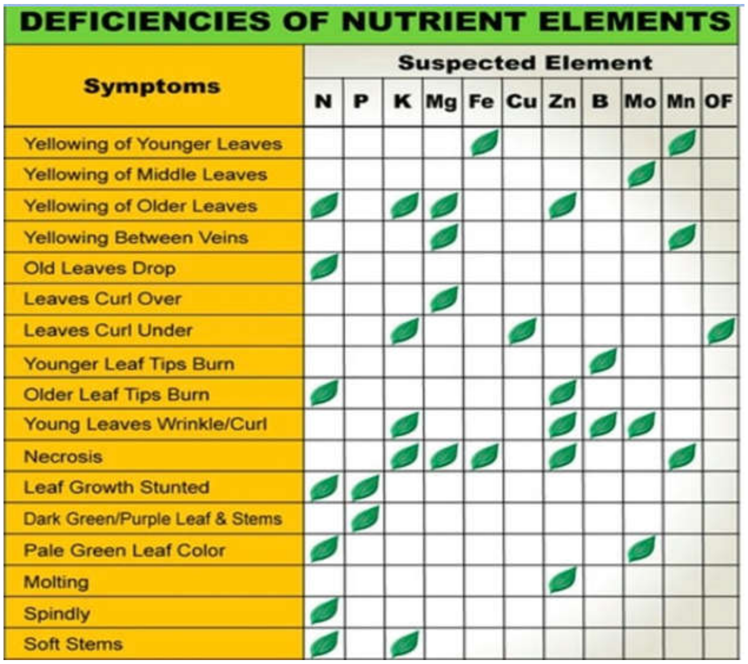
1. **Use of Farmyard manure (FYM):** farmyard manure is the accumulation of animal droppings where the animals are enclosed during the night or in a zero-tillage unit. Its accumulation is enhanced by adding vegetative materials as bedding, which also helps to absorb and store the nitrogen-rich animal urine.
2. **Use of compost:** itis a process where waste organic materials derived from plants and/or animals are decomposed by microbial action under aeration to produce a friable homogenous product that is added to soil.
3. **Use of green manures:** theyare commonly N-fixing leguminous plants deliberately grown for the purpose of soil fertility improvement. Forage legumes and legume cover crops are the most commonly grown green manure plants.
4. **Crop rotation:** It is one practices widely used Ethiopian farmers,It is the order of specific crops planted on the same field in rotation on regular basis.
5. **Liming:** Most agricultural soils in high potential areas of Ethiopia are found to be acidic. Liming is the practice of adding liming materials to improve acid soils for the purpose of increasing soil pH and maintaining a favorable soil environment for plant and microbial growth. The quantity of lime added depends on the type of soil, liming material, crop species, cultivar (within species) and economic considerations, which may range from 5 to 20 tons per hectare.
6. **Use of inorganic fertilizer:** There is an increased use of chemical fertilizers in Ethiopia, particularly in market-oriented irrigated systems. The traditional sources of fertilizers were urea (contains 40% N) and di ammonium phosphate (DAP), which contains 18 and 46% nitrogen and phosphorus, respectively.
7. **Use integrated soil and water management practices:** Farmers use different physical and biological soil and water conservation practices like minimum tillage, mulching, and tied ridging, terracing, soil/stone bund construction, use of grass/forage strips agro-forestation, watershed conservation, and irrigation and drainage.

1.6 Identifying common nutrient deficiency and toxicity problems in plants

1.6.1: Identifying common nutrient deficiency

The availability of soil nutrients for plant growth and productivity is governed by both the plant factor and the soil factor. Some crops or varieties are more efficient in their nutrient acquisition and use than others. Some soils are fixing nutrients and making the nutrients unavailable to the plant despite the presence of enough amounts of nutrients in the soil.

The pH of the soil, soil moisture availability, presence or absence of root infecting mycorrhiza are all affecting the availability of nutrients to crops. Nutrient Deficiencies symptoms on major Vegetable Crop are described below.



DEFICIENCIES OF NUTRIENT ELEMENTS

Symptoms	Suspected Element										
	N	P	K	Mg	Fe	Cu	Zn	B	Mo	Mn	OF
Yellowing of Younger Leaves					✓					✓	
Yellowing of Middle Leaves									✓		
Yellowing of Older Leaves	✓		✓	✓			✓				
Yellowing Between Veins				✓						✓	
Old Leaves Drop	✓										
Leaves Curl Over				✓							
Leaves Curl Under			✓			✓					✓
Younger Leaf Tips Burn								✓			
Older Leaf Tips Burn	✓						✓				
Young Leaves Wrinkle/Curl			✓				✓	✓	✓		
Necrosis			✓	✓	✓		✓			✓	
Leaf Growth Stunted	✓	✓									
Dark Green/Purple Leaf & Stems		✓									
Pale Green Leaf Color	✓								✓		
Molting							✓				
Spindly	✓										
Soft Stems	✓		✓								

Figure_3: Nutrient Deficiency in Vegetable Crops: General Symptoms

1.6.2: Visual symptoms as a diagnostic tool

Interpreting visual nutrient deficiency and toxicity symptoms in plants can be difficult and plant analysis or soil testing is necessary to confirm nutrient stress. Precautions in identifying nutrient stress symptoms include the following:

1. ***Many symptoms appear similar.*** For instance, N and S deficiency symptoms can be very alike, depending upon plant growth stage and severity of deficiencies.
2. ***Multiple deficiencies and/or toxicities can occur at the same time.*** More than one deficiency or toxicity can produce symptoms, or possibly an abundance of one nutrient can induce the deficiency of another (e.g. excessive P causing Zn deficiency).
3. ***Crop species, and even some cultivars of the same species, differ in their ability to adapt to nutrient deficiencies and toxicities.*** For example, corn is typically more sensitive to a Zn deficiency than barley and will show Zn deficiency more clearly.
4. ***Pseudo (false) deficiency symptoms (visual symptoms appearing similar to nutrient deficiency symptoms)***. Potential factors causing pseudo deficiency include, but are not limited to, disease, drought, excess water, genetic abnormalities, herbicide and pesticide residues, insects, and soil compaction.

5. ***Hidden hunger.*** Plants may be nutrient deficient without showing visual clues.

6. ***Field symptoms appear different than 'ideal' symptoms.*** Many of the plants grown under controlled nutrient conditions, and deficiency/toxicity symptoms observed in the field may or may not appear as they do here. Experience and knowledge of field history are excellent aids in determining causes for nutrient stress. In addition to the above precautions, visual observation is also limited by time. Between the times a plant is nutrient deficient (hidden hunger) and visual symptoms appear, crop health and productivity may be substantially reduced and corrective actions may or may not be effective. Therefore, regular soil or plant testing is recommended for the prevention and early diagnosis of nutrient stress.

If visual symptoms are observed, record which crop(s) are affected, their location with respect to topography, aspect, and soil conditions, a detailed description of symptoms and time of season that the symptoms first appeared. Affected field locations can be marked and monitored over time using either flagging or GPS readings. This information will be useful in preventing nutrient stress in subsequent years.

1.6.3: Diagnosing Nutrient Deficiencies and Common Deficiency Symptoms

A first step in diagnosing nutrient deficiencies is to describe the symptoms. Each deficiency symptom is related to some function of the nutrient in the plant. Symptoms caused by nutrient deficiencies are generally grouped into five categories:

1) **Stunted growth:-** can be indicated as decreased growth; shorter height of the affected plants.

2) **Chlorosis:** It is general yellowing of the plant tissue; lack of chlorophyll

3) Interveinal chlorosis: It is yellowing in between leaf veins, yet veins remain green.

4) **Purplish-red coloring:** Plant deficiencies are often encouraged by a number of factors including poor soil, insect damage, too much fertilizer, poor drainage or disease.

5) **Necrosis:** Indicates death of plant tissue; tissue browns and dies.

Nitrogen (N)

Nitrogen is needed by plants for the production of proteins, nucleic acids (DNA and RNA) and chlorophyll. Symptoms of N deficiency are general chlorosis of lower leaves, stunted and slow growth and necrosis of older leaves in severe cases. N deficient plants will mature early and crop quality and yield are often reduced. In cereals, yellow discoloration from the leaf tip backward in the form of a 'V' is common.

Insufficient amounts of N in cereals will result in few tillers, slender stalks, short heads, and grain with low protein content. Leaf curling and small tubers are common in potatoes deficient of N. Fields deficient in N can be either uniform or patchy in appearance, depending on the cause of the deficiency.

Figure_4: Uniform distribution of N deficiency symptoms as a result of fertilizer application 'misses'

For example, fertilizer application 'misses' will result in uniform strips of deficiency, whereas N deficiency as a result of soil characteristics such as organic matter content will be patchy.

Phosphorus (P)

Plants require P for the development of ATP (energy), sugars and nucleic acids. Cool soils during the early growing season may be a factor causing P deficiency. P deficiency symptoms are usually more noticeable in young plants, which have a greater relative demand for P than more mature plants.

Nutrient Deficiency symptom	Picture
P deficient plants generally turn dark green (both leaves and stems) and appear stunted	 Figure_5: P deficiency in alfalfa (left) and normal alfalfa (right

Older leaves are affected first and may acquire a purplish discoloration due to the accumulation of sugars which favors anthocyanin synthesis; in some cases, leaf tips will brown. Plants suffering from P deficiency appear weak and maturity is delayed. Leaf expansion and leaf surface area may also be inhibited, causing leaves to curl and be small. Small grains with P deficiency tend to be stressed and predisposed to root rot diseases, and some cultivars will turn red or purple	 Figure_6: P deficiency in corn. Leaves are purplish and tips are brown and necrotic

Potassium (K)

Potassium is utilized by plants in the activation of enzymes, photosynthesis, protein formation and sugar transport. K deficiency does not immediately result in visible symptoms (hidden hunger). Initially, there is only a reduction in growth rate, with chlorosis and necrosis occurring in later stages. Affected older leaves will show localized mottled or chlorotic areas with leaf burn at margins.

Figure_7: K deficiency in corn. Older leaves are chlorotic and leaf edges are burned, but the midrib remains green.

Chlorotic symptoms typically begin on the leaf tip, but unlike the ‘V’ effect caused by N deficiency, K deficient chlorosis will advance along the leaf margins towards the base, usually leaving the midrib alive and green.

Iron (Fe) Iron plays an important role in plant respiratory and photosynthetic reactions. Fe deficiency reduces chlorophyll production and is characterized by interveinal chlorosis with a sharp distinction between veins and chlorotic areas in young leaves.

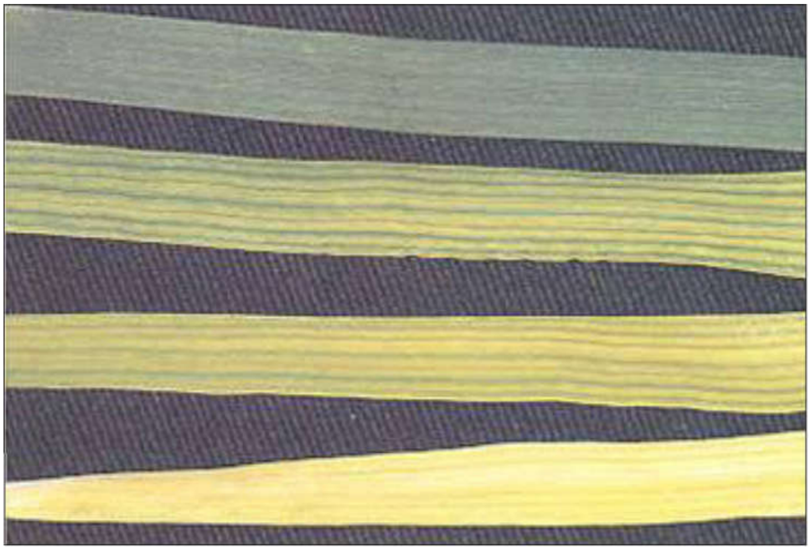


Figure_8: Progression of Fe deficiency in wheat leaves. Top leaf normal; middle leaves showing interveinal chlorosis with prominent green veins; and bottom leaf entirely chlorotic.

As the deficiency develops, the entire leaf becomes whitish-yellow and progresses to necrosis. Plant growth is slow. When viewed from a distance, Fe deficient fields exhibit irregularly shaped yellow areas, especially where the subsoil is exposed at the surface.

1.6.4: Diagnosing Nutrient Toxicities

As insufficient nutrient content can cause visual symptoms to occur in plants, so too can an excess. In Montana and Wyoming, macronutrient (N, P and K) toxicities most often occur as a result of the over-application of fertilizers or manure. Secondary macronutrient (Ca, Mg and S) toxicities are rare in this region and toxic effects on crop health have not been documented.

Micronutrient toxicities can occur and are likely caused by over-application of fertilizer or manure, using irrigation water high in micronutrients or salts, or in areas where soil micronutrient concentrations are abnormally high (i.e. areas exposed to mining activity or high metal minerals in subsoil).

In addition, high amounts of non-essential elements such as arsenic (As), cadmium (Cd) and lead (Pb) can be directly toxic to plants and livestock or cause a nutrient imbalance in the plant, in which essential nutrient deficiencies or toxicities may possibly occur.

N, P and K

Plants with excess N turn a deep green color and have delayed maturity. Due to N's positive effect on vegetative growth, excess N results in tall plants with weak stems, possibly causing lodging. New growth will be succulent and plant transpiration high (low water use efficiency). N toxicity is most evident under dry conditions and may cause a burning effect.

Excess P indirectly affects plant growth by reducing Fe, Mn and Zn uptake; thus, potentially causing deficiency symptoms of these nutrients to occur (see specific deficiency descriptions). Zn deficiency is most common under excess P conditions. Due to a cation imbalance, K toxicity can cause reduced uptake and subsequent deficiencies of Mg, and in some cases, Ca

Note:

In addition to the visual observation further consultancy from the supervisor and/or nutritional specialist is essential to determine causes of nutritional or toxicity problems.

Self-Check #1	Written Test

Name: _________________________ Date: _______________

Directions: Answer all the questions listed below.

1. Define what is soil salinity mean (2 points)
2. Describe the different sources of salt in the landscape (10 points)
3. Write the five categories of symptoms caused by nutrient deficiencies (10 points)
4. Describe the diagnostic effect of the excess **N, P and K** (3 points)

Note: satisfactory Rating-13 and above pts.   Unsatisfactory Rating-below 13 pts.
You can ask your teacher for the copy of the correct answers

Operation Sheet	Measuring and recording soil salinity

Objective:- To create basic candidates knowledge and skill on the measurement of salt concentration around the root system.

Materials, Tools and equipments used

- Electrical conductivity (EC)

Quality precautions':

- Use the appropriate PPE

Procedures

The following procedures should be taken into account to:

1. Taking 50 gm soil sample from root zone
2. Mix it with distilled water
3. Measure the salinity rate using Electrical conductivity (EC)

INFORMATION SHEET 2	Assess soil-related factors for selected plants

2.1. Identifying nutritional requirements of selected plant species

Plant nutrition is the practice of providing to the plant the right nutrient, in the right amount, in the right place, at the right time. The nutritional requirements of the crop are dependent on factors such as:

- ✓ Soil fertility,
- ✓ Weather,
- ✓ Planting age and
- ✓ Crop load, all of which change over time.

Therefore, the amount of nutrients the grower needs to provide the crop may also change over time. As the soil is the 'store house 'for nutrients, the best approach to meeting the nutritional requirements is to establish hy our crop in fertile, well drained soils with the appropriate soil pH. Once the crop is planted, routine evaluation of plant nutrient status and soil composition are essential to developing sustainable nutrient management practices. Only relatively few chemical elements are necessary for plant growth. To be an **essential chemical element** from the perspective of plant nutrition

The elements that plants need to survive are called nutrients. Nutrients are usually adsorbed from the soil solution in the form of ions. Ions are dissolved salts (nutritive salts) that have an electrical charge. Positively charged particles are called cations (e.g. ammonium NH4+), and negatively charged particles are called anions (e.g. nitrate, NO3-, phosphate, H2P04-). These ions will be mentioned again later.

The nutrients that a plant requires to progress through an entire growth cycle are called the essential nutrients. A deficiency of any one of these will have consequences for the plant, such as limited growth, or a lack of flowers, seeds, or bulbs. In addition to the essential nutrients, plants absorb other nutrients that they do not need (e.g. sodium Na) or that can even be harmful (e.g. aluminium Al or manganese Mn). Plants do not need equal amounts of each nutrient. For this reason, the essential nutrients are divided into two namely macro & micro nutrients. Macro/primary nutrients required in large amount are N, P and K and micro/secondary are Ca, Mg and S. Micro nutrients elements required in very small amounts but their role is equally as important as the macronutrients are B, CU, Cl, FE, Mn, Mo, Na and Zn.

The mechanism of plant nutrient mineral absorption may be grouped in to **passive** and **active absorption**.

1. **Passive absorption**:-It has been assumed that ions are taken up by the roots along with mass flow of water under the influence of transpiration pull. Generally the salt content of the plants differ from that solution in which roots grow and hence this concept was disordered.
2. **Diffusion:-**Mulder (1851) hypothesized that difference in concentration results in net movement of particles by diffusion. When a small quantity of a solute is added to water ,there is a diffusion of particles of the solute from a region of high concentration to low concentration.
3. **Ion exchange**:-ion can move across permeable membrane if there is no disturbance in the balance of electrical change on the two sides of membrane. This process occurs just like ion exchange between soil colloid and soil solution. For example, the ion potassium f the external solution exchange with a hydrogen ion, absorbed to the surface of the membrane.
4. **Active absorption:-**the transpiration of ions with the aid of metabolic energy has been termed as active absorption.

2.2. Conducting soil analysis and selecting suitable testing facilities

After soil samples are received at a laboratory, a number of tests can be performed. A general understanding of soil testing will help you know how the results can be interpreted and to appreciate the accuracy of analytical results. Soils supply most of the mineral nutrition for higher plants through the plant's root system. The root system extracts nutrients from the soil over a long period of time; two to three months for most annual crops, years for perennial crops. In contrast, a soil test determines the soil's nutrient supplying capacity by mixing soil for only a few minutes with a strong extracting solution (often an acid or a combination of acids). The soil reacts with the extracting solution, releasing some of the nutrients. The solution is filtered and assayed for the concentration of each nutrient. The nutrient concentration is then related to field calibration research that indicates the yield level reached with varying soil nutrient concentrations. This method works very well for some nutrients, but is less accurate for others, for example those nutrients supplied largely from organic matter (OM) decomposition such as nitrogen and sulfur. This is primarily due to the difficulty of estimating or predicting the rate at which OM will decompose and release these nutrients in plant-available forms.

Individual analyses included in a 'standard' or 'routine' soil test varies from laboratory to laboratory, but generally include soil pH, and available phosphorus (P) and potassium (K). They sometimes also include available calcium (Ca) and magnesium (Mg), salinity, and often include an analysis of OM content and soil texture. Most laboratories offer nitrogen (N), sulfur (S), and micronutrient analyses for additional cost. The methods used to test soils vary depending on chemical properties of the soil.

2.3. Conducting soil sample collection for soil and plant tissue

Soils sampling collection

Taking a soil samples important to ensure that the sample taken is representative of the whole field as the chemical properties of the soil can vary from point to point in the same field. This can be achieved by taking a number of sub-samples from different areas and Combining them to create one sample. If there are obvious differences in the soil composition within the same fieldifthereispoordrainedarea,thenaseparatesampleshouldbetakenforeacharea.A large number of sub-samples will reduce variability and provide a more reliable representation of the field as a whole.

Media size

The best media particle size is usually between 3 to 8mm. These permits rapid drainage while allowing fresh air to be drawn in to the root zone. The growing media should also be inert, to preventinteractionswiththenutrientsolution.Thecapillaryactionofthemediaalsoaffects the optimum size. For example, Rock wool has 0.005mmfiberswith96%pore space. This works extremely well as it is porous and allows for drainage and aeration. Through the products provided by High Nutrients, you may be able to elude many of the factors that will limit the growth of a given crop. The following figure shows how sample are taken.

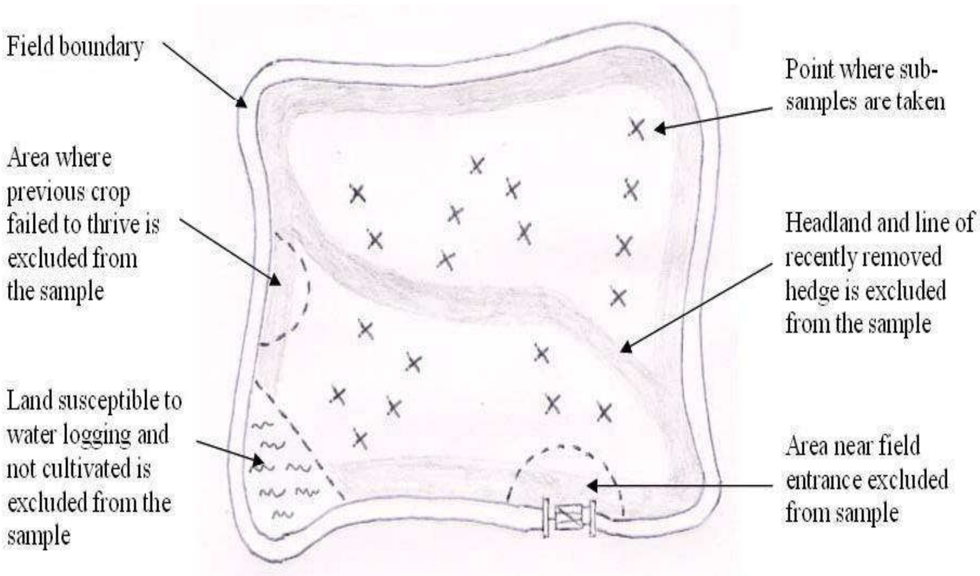


Fig 5 *Example of a field soil sampling pattern*

A sample is taken to a laboratory to be analyzed. It is air-dried, crushed (not breaking the stones) and then passed through less than 2mmsieve. The analysis is carried out on the 'fine earth 'fraction to determine the following:

- ✓ Concentration of nutrients available to plants
- ✓ Organic matter content
- ✓ pH
- ✓ Soil texture

Collecting and Preparing plant tissue Sample

If you suspect a nutrient deficiency:

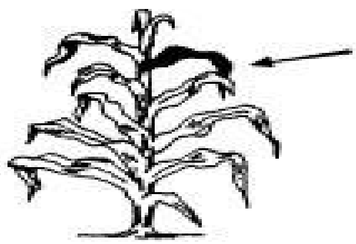
1. Sample when the symptom first appears
2. In the same field or area, collect similar samples of plant materials from plants that appear abnormal.
3. Make sure that the symptoms are not due to a factor unrelated to plant nutrition.
4.

The parts of plants

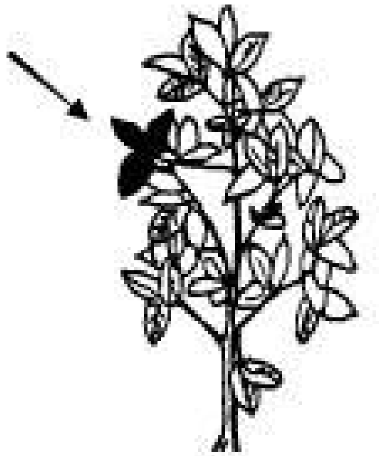
To be sampled

- ✓ When to sample — depend on plant type and its growth stage
- ✓ Where to sample
- ✓ Number to sample

Corn------before tasseling

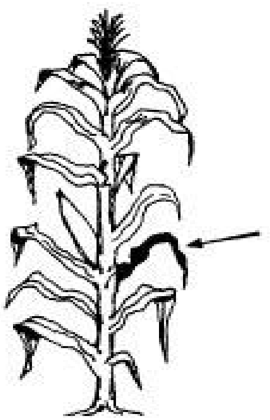


Collect the first fully developed leaves from the top of 15-20 plants. If the plant is less than 12 inches tall, collect the entire above-ground portion.



Soybeans

Collect recently mature trifoliate leaves from the top of 20-30 plants before or during bloom



Corn—fromtasselingtosilking collect the leaves below and opposite from the ear of15-20 plants.

Sorghum Collect the second leaf from the top of20-30 plants before or at heading.

If specific sampling guidelines are not given here, collect recently mature leaves just below the growing point from at least 10 plants.

When gathering the tissue sample in the field,

- Use a clean container.
- a paper bag works best
- Never use met a container because it can contaminate the sample.

If the plant samples have soil, fertilizer, dust, or spray residues on them,

- ✓ They will need to be cleaned. A dry brush works best,
- ✓ Wipe the samples with a damp cloth.
- ✓ Do not prolong the washing because it can leach nutrients out of the tissue.
- ✓ Air-dry the samples in the shade, not in the sun. Never place fresh plant tissue samples in plastic bags for mailing.
- ✓ The plastic bags do not allow the samples to dry, so they may decompose.

Provide Information with the Sample When mailing samples to the laboratory; be sure to provide the following information:

- ✓ Type of crop.
- ✓ Variety.
- ✓ Soil type (if known).
- ✓ Current crop fertilization and management practices (such as stand, kind sand rates of fertilizer, method of fertilizer application).
- ✓ Last year's crop fertilization practice sand yield.
- ✓ Irrigation frequency and quality of irrigation water.
- ✓ Visual appearance of crop.
- ✓ Insect and disease problems (if any).This information is necessary for sound interpretation of the plant tissue analysis

Things to Avoid-

Do not sample the following:

- ✓ Young, emerging leaves; old, mature leaves; and seeds. These plant parts usually are not suitable because they are not likely to reflect the nutrient status of the whole plant.
- ✓ Diseased or dead plants.

- ✓ Plants that have insect or mechanical damage.
- ✓ A single plant showing visual deficiency symptoms, unless it is possible to sample normal plants from an adjacent area in the field. Normal plants give a reference to help interpret the chemical analysis of the deficient plant sample.
- ✓ Do not collect tissue that is covered with soil or dust.
- ✓ Also, sampling is not recommended when plants are under moisture or temperature stress.
- ✓ Samples must be protected from dirt and fertilizer materials and should be placed in clean plastic bags.

2.4 Analyzing results of soil and tissue testing

As with soil analysis, sampling and sample preparation of plant tissues are often the weakest steps in the testing process. The sample should represent the overall plant population in the field; otherwise all the careful and usually costly analytical work is wasted.

Plant tissue analysis

Tissue testing is away to monitor the nutrient status of healthy crops to identify changes in Nutrient needs as the growing season progresses.

Plant tissue analysis may be useful to:-

- ✓ Diagnose plant nutritional problems or
- ✓ Monitor effectiveness of a soil fertility program.

Plant tissue analysis shows:-

- ✓ The nutrient status of plants at the time of sampling
- ✓ Whether soil nutrient supplies are adequate
- ✓ detect unseen deficiencies and may confirm visual symptoms of deficiencies
- ✓ allow corrective fertilizer application in the same season (when from young plant sampling)

A plant analysis has little value if the plants come from fields that are

- ✓ Infested with weeds, insects, disease organisms
- ✓ Stressed for moisture
- ✓ mechanically injured

There are two major ways of plant testing

1. Total plant analysis
2. Green tissue analysis

1. **Total plant analysis**:-partsoftheplantwillbetakenforrepresentingthesampleofthe population

which will be submitted for analysis after drying

2. **Green tissue analysis:-**differ from in that the green succulent plant tissue is analyzed see miquantatively for the concentration of soluble nutrients –particularly nitrogen, phosphorus, and potassium. Test can be performed rather rapidly either in the laboratory or in the field where the plants are growing. For this reason green tissue tests are commonly referred as 'quick tissue test'.

The Plant Analysis Report

The plant analysis report has three sections:

- ✓ Laboratory results,
- ✓ Interpretation
- ✓ Recommendations.

Results include concentrations of essential plant nutrients and sodium, on a dry-weight basis. Ratios of important elements, including N,: K, N:Sand Fe: Mn, are also provided.

Soil testing and plant tissue analysis are similar in that:-

- ✓ They both measure nutrients necessary for plant growth.
- ✓ When growth problems occur, both tests are necessary to provide a complete
- ✓ Diagnose is of a crop's nutritional status and the best corrective action.
- ✓ Soil test and plant analysis together results often reveal the reason.

The Difference between soil test and plant tests are:-

Soil tests

- ✓ Soil tests are most useful before planting to predict lime and fertilizer needs;
- ✓ Soil tests measure levels of specific nutrients in a soil
- ✓ Soil tests are also not reliable indicators of nitrogen and sulfur (which leach readily from the soil) or iron and boron
- ✓ The best way to assess soil pH

Plant test

- ✓ Plant Tissue tests are best used during the growing season to monitor plant nutrient uptake.
- ✓ Plant tissue analysis indicates whether adequate concentrations of essential plant nutrients are present at the time of sampling.
- ✓ Alone, it does not provide enough information to explain why nutrient levels may be high or low.
- ✓

2.5 Assessing soil condition for drainage, compaction, aeration and water infiltration

Soil drainage and aeration

Drainage and aeration is improved by soil amendments, but there must be some place for the water to go. Yards should be graded so surface water drains off. Drainage sensitive plants such as Japanese maples, daphne and heather should be planted on a mound at least a foot tall or on a slope. Vegetables are best grown in raised beds, which provide better drainage and warmer soil in the spring for an earlier start.

In mostly flat yards, subsurface drainage may have to be provided. Perforated plastic drainpipe can be buried about a foot deep. It is important that drainpipes slope evenly so dirt doesn't clog up the low spots. Drain pipes can drain into down spouts if allowed by local building codes.

Aeration can be improved on existing lawns and beds without tearing up the soil. Sod core aerators cut out plugs of soil and leave holes about six inches apart and four inches deep. Root feeders can be used around trees and shrubs to create holes eighteen inches deep. These holes allow air and water to quickly penetrate deep into the soil. The holes will stay open much longer if sand or Profile Soil Conditioner is raked into the holes to fill them.

Soil compaction

Soil compaction is the process of increasing the density of soil by packing the soil particles closer together causing a reduction in the volume of air. Soil water acts as a lubricant increasing compaction when a load is imposed on the soil. If near saturation, however, the load is likely to exceed the soil strength and bearing capacity, resulting in excessive wheel slippage and rutting as well as soil mixing and smearing. It has been estimated that, given conventional tillage practices and other planting-harvesting farm operations, as much as 90 % of a paddock will be wheel tracked on an annual basis and that much of the area receives 4 or 5 wheel passes. Compaction usually results in less plant root proliferation in the soil and lowers the rate of water and air movement. Because of the root restriction the amount of water available to the crop is often decreased. Slower internal drainage results in poorer subsurface drain performance, longer periods of time when the soil is too wet for tillage following rainfall or water application, increased de nitrification and decreased crop production. Increased compaction also adds to the energy consumption by tractors for subsequent tillage. Most effects of compaction are detrimental. However, in some cases, slight compaction near seeds can aid germination and improve plant growth in times of low soil moisture caused by low rainfall or low water-holding capacity soils.

Soil infiltration

Soil infiltration refers to the soil' stability to allow water movement in to and through the soil profile. It allows the soil to temporarily store water, making it available for uptake by plants and soil organisms. Infiltration rates are a measure of how fast water enters the soil and are typically expressed in inches per hour. For initial in-field assessments, however, it is more practical to express infiltration time in the number of minutes it takes soil to absorb each inch of water applied to the soil surface. Water entering too slowly may lead to ponding on level fields, erosion from surface runoff on sloping fields, or inadequate moisture for crop production. An adequate amount of water must infiltrate the soil profile for optimum crop production. Porous soils allow water to infiltrate and recharge ground-water aquifer sand sustain base flow in streams.

An infiltration rate that is too high can lead to nitrate-nitrogen or pesticide leaching, if they are not managed correctly. Management measures, such as residue management, cover crop scan improve infiltration.

Impermeable layers
To assess a soil it is important to look not just at the top layer, but also at the underlying layers. Most of the organic matter and nutrients are usually in the top layer. However, the plant roots also get a lot of water and nutrients from the underlying layers. If the roots cannot penetrate through the second layer of soil, they will have to get all of their water and nutrients from the top layer. This means that less water and fewer nutrients are available for them, and the root system will be limited. This can be seen in Figure 2. A deficiency of water and nutrients is thus more likely in soil that has an impermeable layer.

Figure 6: The effects of an impermeable layer on the root system.

If the impermeable layer is close to the surface (less than half a metre deep), the soil will probably not be able to sustain crops. With mechanized agriculture it is possible to break through an impermeable clay layer by ploughing very deep. The underlying layer is then mixed with the layer above it. However, it is nearly impossible to do this manually.
Another problem that can occur with impermeable layers is that rainwater after a heavy rain cannot infiltrate into the subsoil. All the pores above the impermeable layer then become saturated with water and the roots cannot get enough oxygen. Without oxygen the roots cannot breathe or absorb water and nutrients.

2.6 Assessing soil biological activity by identifying and evaluating presence of organisms

Soil biology encompasses the collective biomass and activities of soil-dwelling organisms from an array of tropic levels that are present in staggering quantities, even though individuals may not be visible to the unaided eye. For example, it is estimated that the retreat least one billion bacterial cells per gram of soil distributed among thousands to millions of individual species. It has been calculated that the microbial biomass existing underground may approach the sum of all living biomass on the earth's surface. Viewing the tree-of-life (based on genetic relatedness), one begins to understand the diversity of the unseen microbial world, especially since only the three branches at the top right (Animalia, Fungi, and Plantae) contain individual organisms that can be seen with the unaided eye.

Soil Biota

The soil environment is teeming with biological life and is one of the most abundant and diverse ecosystems on earth. Soil biota, including ora (plants), fauna (animals) and microorganisms, perform functions that contribute to the soil's development, structure and productivity. General characteristics and functions of these groups are presented below.

1. **Soil Flora**

Plants act on the soil environment by aiding in structure and porosity, and in supplying SOM via shoot and root residue. Root channels can remain open for some time after the root decomposes, allowing an avenue for water and air movement. Roots also act to stabilize soil through aggregation and intact root systems can decrease soil loss. The 'rhizosphere,' the narrow zone of soil directly surrounding plant roots, is the most biologically active region of the soil. It contains sloughed root cells and secreted chemicals (i.e., sugars, organic acids) that provide organisms with food.

2. **Soil Fauna**

Soil fauna work as soil engineers, initiating the breakdown of dead plant and animal material, ingesting and processing large amounts of soil, burrowing 'bio pores' for water and air movement, mixing soil layers, and increasing aggregation. Important soil fauna include *earthworms, insects, nematodes, arthropods and rodents*. Earthworms are considered one of the most important soil fauna. Through the process of burrowing, they provide channels that increase a soil's porosity, WHC, and water infiltration (Lee, 1985; Figure 10). They also increase further biotic activity by breaking down large amounts of SOM through digestion and supplying nutrient-rich secretions in their casts (Savin et al., 1994). *Furthermore, earthworms are able to build soil by moving between 1 to 100 tons of subsoil per acre per year to the surface, possibly helping o set losses by erosion (Magdo and van Es, 2000).*

3. **Soil microorganisms**

Soil microorganisms are responsible for mineralizing organic compounds, including potential contaminant molecules such as pesticides. Half-lives of agrichemicals are based on the bio-degradative abilities of the soil microbial community, as well as the local environmental conditions. In mineralizing organic compounds (native eroded), microbial communities release combined elements (e.g. N, P) in their chemically-reduced forms, generally increasing their availability to plants. Soil microbes also perform direct redoxtrans formations of many inorganic elements using them as electrondonorsoracceptorsin energy-yielding metabolic processes. In short, micro organisms moderate the abundance, speciation, and plant bio availability of nutrients in the soil. Nitrogen-fixing bacteria exist in symbiotic and associative relationships with plants and as free-living communities in the soil to provide N to plants.

Symbioses of N-fixing bacteria with soil invertebrates have been shown to be particularly important to the N cycling in some soils. Nitrogen-transforming microorganisms (e.g.nitrifiers, denitrifiers) also moderate the speciation and therefore mobility of soil N affecting its propensity to stay or leave the system. Phosphate-solubilizing bacteria and fungi produce organic acids that either complex Porchange micro site local pH to increase plant-available P.

General activities of soil microbes result in the release of extra cellular phosphates enzymes which mineralize organic P, some of which becomes available to plants. Obligate plant symbiotic fungi, AM fungi, use a variety of mechanisms to uptake and translocation immobile nutrients (*i.e.*, P, Zn, and Cu) and water to their host plants in exchange for fixed carbon.

Ecosystem Services Provided by Soil Biota

- ✓ Regulation of biogeochemical cycles
- ✓ Retention and delivery of nutrients to primary producers
- ✓ Maintenance of soil structure and fertility
- ✓ Bioremediation of pollutants
- ✓ Provision of clean drinking water
- ✓ Mitigation of floods and droughts
- ✓ Erosion control
- ✓ Regulation of atmospheric trace gases
- ✓ Pest and pathogen control
- ✓ Regulation of plant production via non-nutrient biochemical

2.7 **Assessing soil health by identifying and evaluating plant species present**

Soil health has been defined as: "the capacity of soil to function as a Living system. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and pests.

Healthy soil food web with a diversity of macro invertebrates has been shown to increase the release of P via the activities of grazers and predators. The activity of tunneling organisms such as earthworms redistributes carbon and nutrients in the soil profile.

What are some features of good soil?

Any farmer will tell you that a good soil:

- ✓ drains well and warms up quickly in the spring
- ✓ soaks up heavy rains with little runoff
- ✓ stores moisture for drought periods
- ✓ resists erosion and nutrient loss
- ✓ supports high populations of soil organisms
- ✓ Produces healthy, high quality crops (productive soil) etc.

All these criteria indicate a soil that functions effectively today and will continue to produce long in to the future. Creating soils with these characteristics can be accomplished by utilizing management practices that optimize the processes found in native soils.

Soil quality is a function of many factors, including agro climatic factors, hydrogeology, and cropping/production practices. Soil quality can be degraded through three processes:

1. Physical degradation such as wind and water erosion and compaction;
2. Chemical degradation such as toxification, salinization, and acidification; and
3. Biological degradation, which includes declines inorganic matter, carbon, and the activity and diversity of soil fauna.

Slowing down or stopping these processes will help maintain soil quality. Reversing the processes will improve soil quality over time.

Self-Check -2	**Written Test**

Name: __________________________ Date: ________________

Directions: Answer all the questions listed below.

1. Write the factors for selecting plant species for nutritional requirements of the crops? (5pt)
2. What is the advantage of soil sample collection for soil and plant tissue? (5pt)
3. What is the difference and similarity between soil test and plant tests? (2points)
4. Write the mitigation measures if the plants sample have soil , fertilizer, dust, or spray residues present on the area?(5 pt)
5. Write the important of soil plant tissue analysis?(3points)
6. What are soil drainage, aeration, compaction and infiltration means? (5points)
7. Describe the advantage to know the characteristics of soil drainage, aeration, compaction and infiltration in soil fertility management? (5pts)

Note: satisfactory Rating-30 and above pts.   Unsatisfactory Rating-below 30 pts.
You can ask your teacher for the copy of the correct answers

INFORMATION SHEET 3	Select and implement appropriate agronomy and fertility techniques

3.1. Identifying range of allowable inputs

The National Standard for Organic and Bio□Dynamic Produce (referred to as the Standard) was first implemented in 1992 as the Australian Export Standard for products labeled organic or bio□dynamic.A second edition was released in 1998. Since inception it has provided the organic industry with a nationally agreed Standard.

The Standard stipulates minimum requirements for products placed on the market with labeling which states or implies they have been produced under organic or bio□dynamic systems. In this Standard, the production procedures are an intrinsic part of the identification and labeling of, and claim for, such products.

The Standard provides a framework for the organic industry covering production, processing, transportation, labeling and importation. Furthermore the Standard aims to ensure conditions of fair competition in the market place by distinguishing those products produced according to this Standard from those produced by other means. Use of this Standard provides transparency and credibility for the industry and protects the consumer against deception and fraud.

The Standard contains three distinct components:

The first component identifies General Principles that apply to organic and bio□dynamic activities. General principles are intended to give there adera general appreciation of what the Standard intends to achieve.

The second component stipulates the specific conditions (or Standards) which must be met by an operator of an organic or bio□dynamic unit. These are in normal print.

Finally, the only exceptions allowed to this Standard are clearly noted under the heading Derogation. Derogations will be available when a situation is defined and thus a temporary digression to the Standard may be made.

Important information

- Requirements out lined in this Standard are complementary and additional too the health, agricultural or food standard so regulatory requirements recognized by or enacted by the Common wealth, States or Territories. These include but are not limited to food safety, animal wolf are and environmental management and social justice.

- Operators are responsible for the use of inputs and must adhere to relevant Common wealth, State/Territory or Local/Statutory laws.
- Up on adoption of the Standard, approved certifying organizations will implement these requirements immediately for newly applying operators; or for existing operators within 12 months from date of adoption.
- This Standard is subject to alteration in light of further experience with technical details or changes to international or importing country requirements. Amendments may be requested through submission of a completed Application to Alter the National Standard for Organic and Bio□Dynamic Produce form as provided at the end of this document.
- This Standard may be copied or reproduced without the expressed written consent of the author. Should any part of this Standard be used or referenced in any other document, author recognition is required. However, any reference to compliance with this Standard may only be made where the Standard is implemented in full.

3.2. Identifying and evaluating suitable nutrient cycling techniques

Soil nutrient availability changes over time. The continuous recycling of nutrients into and out of the soil is known as the *Nutrient Cycle*. The cycle involves complex biological and chemical interactions, some of which are not yet fully understood. A simplified version of this cycle of plant growth is shown in Figure 1.

The simplified cycle has two parts: *"Inputs"* that add plant nutrients to the soil and *"Outputs"* that extract plant nutrient from the soil largely in the form of agricultural products. Important input sources include inorganic fertilizers; organic fertilizers such as manure, plant residues, and cover crops; nitrogen generated by leguminous plants; and atmospheric nitrogen deposition. Nutrients are extracted from the field (soil) through harvested crops and crop residues, as well as through leaching, atmospheric volatilization, and erosion.

The difference between the volume of inputs and outputs constitutes the nutrient balance. Positive nutrient balances in the soils (occurring when nutrient additions to the soil are greater than the nutrients removed from the soil) could indicate that farming systems are inefficient and, in the extreme, that they may be polluting the environment .Negative balances could well indicate that soils are being mined and that farming systems are unsustainable over the long term.

In the latter instance, nutrients have to be replenished to maintain agricultural output and soil fertility into the future.

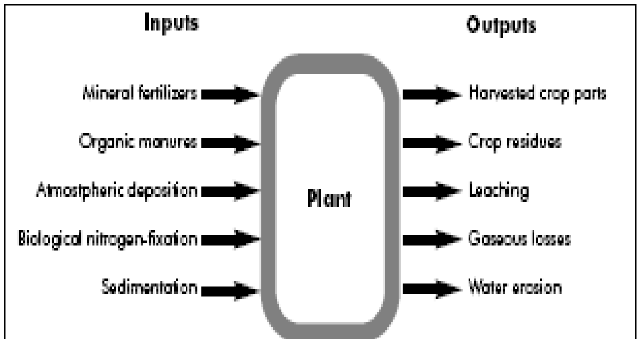


Figure 7. The plant nutrient balance system

3.3. Calculating appropriate inputs

A. Determination of Fertilizer Needs

The type and amount of fertilizers to be applied depend on the crop type to be grown and the nutrient- supply capacity of the soils of each specific field. Determination of the level of soil nutrients allows deficiencies to be detected and to calculate appropriate rates of fertilizers to be recommended. There are a number of methods for determining the nutrient status of soils, among which the following are more important to be taken into consideration.

I. Visual diagnosis

Careful observation of the plant health, particularly the growth patterns of plants, discoloration and malformation of leaves and other parts of the plants, is a useful method in qualitative assessment of the soil fertility status. When a nutrient is insufficient quantity for normal growth and development, plants exhibit characteristic symptoms. These symptoms can be used to diagnose the nutrient deficiency that is present and decide on the remedial action to be taken. The method is rapid and elaborate apparatus is not required, but it has the following limitations /drawbacks:

- The deficiency symptoms may develop before they can be identified and by the time, it may be too late to apply remedial measures for the crop, particularly for cereal crops;
- Symptoms of certain deficiencies are not very distinct and may be visible only when the deficiency is acute enough to cut down yield by 30- 60 %. By the time it may be too late to take appropriate actions;

- Deficiency symptoms may be complicated or suppressed by factors such as weather or pest and disease damage.

II. Plant tissue analysis

The crop can be tissue- tested, while growing in the field for N-P-K-S-Zn levels in the sap. Plant analysis may be semi- quantitative (rapid tissue tests) or fully quantitative. Both tests and chemical analysis of the plant sap may be able to provide an indication of nutrient deficiencies before causing recognizable deficiency symptoms. This method is especially useful for perennial or long duration plants such as fruit trees, sugarcane to identify deficiency symptoms and to be corrected on time.

III. Soil test

Soil testing by a reliable laboratory is the most accurate and convenient method for determining appropriate fertilizer rates to be used. Most laboratories routinely test for available P and K and measure soil pH and exchange capacity. Soil testing in combination with plant tissue analysis could help in accurately determining the nutrient need of the plant before the crop is severely affected. It is simple and less time consuming if laboratory facilities are available.

IV. Conducting field trials /experiments/

The best way to determine the nutrient needs of crops is to conduct field trials on fertilizer types and rates. In the trial sites, differing fertilizers are applied to the same crop under the same management, and crop responses are observed and final yields are measured. Based on the yield obtained the optimum rates of fertilizer are calculated. The method has the following advantages:

1. It is the best way to determine the nutrient needs of crops and soils accurately for advising farmers ;
2. Trials and demonstrations could clearly show the benefits of fertilizers to farmers;
3. Economic evaluation of the results will give a better insight into fertilizer needs;
4. Fertilizer response is easily recognized from the crop performance and plays vital role as demonstration purpose.

However, the disadvantages of field experiments are:

1. Expensive
2. Time consuming and

3. Results are applicable mainly to the specific localities and to the crops covered by the experiment.

V. Making an educated guess

If no soil test results are available, a reasonable estimate of N-P-K needs could be made based on the following criteria:

- Using available soil test results from nearby farms with the same soil type and a similar fertilizer history, if there is any;
- Using data from fertilizer trials on the same soil type, if they are available;
- Referring to an extension pamphlet on the crop fertilizer recommendations for the similar soils;
- The particular crop's relative nutrient needs and the crop value;
- A thorough observation of the soil for depth, drainage, texture, filth, slope, and other factors that may limit crop yield;
- Yield history and past management of the farm regarding fertilizer application and
- Farmer's available capital, and
- Farmers' willingness to use complementary practices like improved seed, insect control, etc.

B. Efficient Use of Fertilizers

Inorganic fertilizers

Efficient use of fertilizers depends on the application of the right amount of fertilizers at the right crop stages corresponding to crop and soil needs. Similarly, for normal plant growth and development and for obtaining optimum yields it will be important to apply fertilizers along with best management practices.

Optimum application rate

It is recommended to use location specific fertilizer recommendations whenever available in your area. If the recommendations are given in the form of nutrients, then it has to be converted to commercial form of fertilizers to know the exact amount of commercial fertilizers to be used as shown below.

Fertilizer calibration

Soil test based fertilizer calibration is defined as a process of determining the crop nutrient requirement at different soil test values. Fertilizer calibration is important to be considered in determining the right amount of fertilizers required, but it needs continual updating and revaluation. . The main objectives of fertilizer calibration are the following:

- To determine the rate of nutrients to be applied per unit area;
- To calculate the amount of commercial fertilizers required for a given area of land.

Procedures for calculation:

1. in situations when two or more nutrients are to be applied simultaneously to a field by using compound fertilizers or double carriers. For instance, if N and P are to be applied by using diammonium phosphate, which contains 18 kg of N and 46 kg of P per 100 kg of the fertilizer and urea with the application rate of 50 - 50 - 0. Then please calculate the amount of commercial fertilizers needed to get the required amount of nutrients per ha as follows.

Steps for calculation:

First calculate the required quantity of DAP to provide the nutrient with the highest content in the compound, which is P 50 kg ha^{-1}.

Given: DAP contains 18 kg of N and 46 kg of P;

Therefore, 46 kg of P is available from 100 kg of DAP; 50 kg of P would be supplied from;

$$\frac{50\ kg \times 100\ kg}{46\ kg} = 108.7\ kg\ of\ DAP$$

Now find out the N available from 108.7 kg of DAP, if 100 kg of DAP has 18 kg N:

$$\frac{18\ kg \times 108.7\ kg}{100\ kg} = 19.8\ kg = 20\ kg\ N$$

The required amount of nitrogen fertilizer to be applied per ha is 50 kg out of which 20 kg will be supplied through 108.7 kg of DAP per ha. The balance that will be required from Urea will be then30 kg.

Urea contains 46 % of N and 30 kg N will be available from:

$\frac{100 \text{ kg X } 30 \text{ kg}}{46 \text{ kg N}}$ = 65 kg of urea

e) Therefore, 108.7 kg of DAP and 65 kg of urea will be required to provide 50 kg N and 50 kg P per ha.

2. How much nutrient of nitrogen and phosphorus are applied, if we used the commercial products of 130 kg of DAP and 50 kg of Urea?

Solutions:

a) The amount of phosphorus applied: $\frac{130 \text{ X } 46)}{100}$ = 59.8 kg ~ 60 kg of P_2O_5;

b) When we applied 100 kg of DAP at the same time 18 kg of N are applied together.

Then: $\frac{130 \text{ X } 18}{100}$ = 23.4 kg ~ 25 kg of N;

c) The amount of N from 50 kg Urea: $\frac{50 \text{ X } 46}{100}$ = 23 kg;

d) Therefore, the total amount of N is equal to 23.4 + 23 = 46.4 kg N and the amount of P 60 kg P_2O_5.

The calculation procedure could be similarly applied for other fertilizer types and rates of recommendations as well.

3.4. Selecting and managing cover crop and pasture systems

Intensively managed farming systems require good soil fertility management to ensure long term sustainability of own food production. That is why proper soil fertility management is of central importance in organic crop production and farming. Basically organic farming approach soil fertility management by *conserving and protecting their soils from sun, rain and wind*, and *feeding it with organic material in an appropriate way*, so as to allow it to feed the plants in a balanced way. When the soil is fertile in the organic sense, it can produce good crop yields for several years.

Growing Cover Crops

Cover crops are usually low-growing perennial plant species, which are sown with the main intention to protect the soil, prevent weed growth and maintain soil fertility. They are also called 'green' or 'living mulch'. Cover crops are used in a similar way as green manures with the main difference that green manures are grown to produce maximum biomass mainly and are usually slashed before flowering and incorporated into the soil. Cover crops may also require regular slashing, mowing or grazing to avoid competition with the main crop.

Some information sources do not distinguish between cover crops and green manures, as both can include the same species, and differences are little depending on their management. But it makes sense to approach them separately due to the different functions they can have in a cropping system.

The primary strength of cover crops is to rapidly cover the soil and to maintain it permanently covered. Cover crops benefit both short and long term productivity of a cropping system. They improve physical properties of the soil, reduce runoff and erosion, suppress weeds and, if the cover crop is a legume, transfer nitrogen to the main crop, when mulched. Soil organic matter levels are usually maintained under a cover crop from a combination of increased input of residues, reduced soil organic matter decomposition due to reduced exposure as a result of reduced or zero tillage, and decrease of soil temperature.

The benefits of cover crops can be limited by the competition of the cover crop for water and nutrients and the very slight increase of soil organic matter level. Slashing, mowing or selective cultivation temporarily reduce competition from the cover crop. While leguminous cover crops supply some nitrogen to the main crop, pure grass-based cover crops require nitrogen for proper growth.

The following characteristics make an ideal cover crop:

- It is low-growing and not climbing;
- It grows fast and covers the soil in a short time;
- It is resistant against pests and diseases, and does not transmit any to the main crops;
- It tolerates drought;
- It fixes nitrogen from the air;
- It develops a deep root system which is able to loosen the soil and contribute to regeneration of degraded soils;
- It is easy to sow and to manage, and can be slashed, grazed or cut for fodder;

How to integrate cover crops

Cover crops can be planted in different ways depending on the site conditions, the main crop and intended benefits:

- **Intercropping**: The cover crop is planted at the same time as the main crop. In this case, the main crop should be one that grows high like maize to avoid being smothered by the cover crop. Creeping cover crops like mucuna should be avoided, because they will also smother the main crop. Intercropping is preferable in perennial crops.
- **Relay cropping:** The cover crop is planted in an advanced growth stage of the main crop. For example, in a maize-bean intercrop the cover crop can be planted after beans are harvested. Here the farmer is able to harvest more crops and the risk of competition is greatly reduced. The cover crop is then left to continue growing, protecting the soil and smothering weeds.
- **Crop rotation and improved fallows**: In this case, the cover crop is planted after the harvest of the main crop. If the soil has enough moisture, this can be done immediately after harvesting or it can be done as part of the main crop rotation cycle or incorporated during the fallow season.

3.5 Developing, applying and monitoring mulching and composting systems

Mulching

Mulching is the process of covering the topsoil with plant material such as leaves, grass, twigs, crop residues or straw. Sometimes artificial mulches, such as plastic cover, are used (for weed control mainly; they do not provide the same advantages as organic mulch). Mulching has many advantages, including protecting the topsoil from being washed away by strong rain and from drying out by the sun. Protection reduces evaporation of water and thus keeps the soil humid. As a result the plants need less irrigation or can use the available rain more efficiently. A humid soil also enhances the activity of soil organisms such as earthworms, and microorganisms as rhizobia and mycorrhiza.

Organic mulch material is an excellent food source for soil organisms and provides suitable conditions for their growth. As the mulch material decomposes, it also releases its nutrients, while part of the mulch material is transformed to stable humus, contributing positively to the soil's organic matter content. A thick mulch layer further suppresses weed growth by inhibiting their germination. For all these reasons mulching plays a crucial role in preventing soil erosion.

Application of mulching materials

Sources of mulching material include weeds or cover crops, crop residues, grass, pruning material from trees, cuttings from hedges and wastes from agricultural processing or from forestry. Fast growing nitrogen-fixing shrubs that tolerate strong trimming provide good and considerable amounts of mulching material. The shrubs can be grown in hedgerows.

The kind of material used for mulching greatly influences its effect. In humid climates green material will decompose rapidly making nutrients available nutrients to the crops during the process. Soil protection is then limited to 1 to 3 months. In this case application can be repeated. Hardy materials such as straw or stalks in contrary will decompose more slowly and therefore cover the soil for a longer time. Where soil erosion is a problem, slowly decomposing mulch material (with low nitrogen content and a high carbon to nitrogen ratio) will provide long-term protection compared to quickly decomposing material.

When carbon rich materials are used for mulching, nitrogen from the soil may be used by microorganisms for decomposing the material (a process called immobilization). During this time, the microbes compete with the plants for nitrogen and the crop may suffer from malnutrition. To avoid nitrogen immobilization, old or rough plant materials should be applied to the soil at least two months before planting or sowing the main crop. The decomposition of the mulch material can be accelerated by spreading organic manure such as animal dung on top of the mulch, thus increasing the nitrogen content.

Composting

Compost is a common name used for plant and animal material (mainly animal manure) that has been fully decomposed in a targeted process initialized and controlled by man. Compared with uncontrolled decomposition of organic material as it naturally occurs, decomposition in the composting process occurs at a faster rate, reaches higher temperatures and results in a product of higher quality.

Composting is a means of ensuring or improving long-term soil fertility, especially to smallholder farmers with no or little access to manures and fertilizers. Compost is more than a fertilizer. It is not just a nutrient source, but also acts on the structure of the soil and on its capacity to hold and provide nutrients and water. Its main value lies in its long-term effect on soil fertility.

Compost contributes to an increase of the organic matter content of the soil and thus to a better soil structure. It clearly enhances drought resistance of crops.

During the composting process diseases, pests and weed seeds are destroyed. Even viruses are destroyed, if a high temperature is reached. Thus, composting helps solve common problems associated to the management of plant residues. Compost also increases biological activity of the soil and its capacity to positively influence biological control of root rot diseases from fungi, bacteria and nematodes.

In the composting process nutrients are absorbed into the organic matter, microorganisms and humus. The humic substances are relatively resistant to microbial decomposition. Thus, the nutrients are released slowly and are not easily lost.

The total nutrient content of compost is similar to that of cow manure with an average nutrient content of 0.5 % N, 0.1 % P and 0.5 to 2 % K. Nevertheless, the values of compost cannot be estimated high enough. Compost has proven to be the best type of organic fertilizer in dry climates. It also increases the effect of even small amounts of manure. Deficiencies of trace elements are less likely, when compost is applied, as compost contains trace elements as well. Compost also increases the availability of phosphorus to plants in soils rich in iron oxides. Due to its neutral pH, compost improves the availability of nutrients in acid soils. Where soils tend to be water-logged, composting helps avoid nitrogen losses occurring from incorporation of green plant material under such conditions.

3.6. Designing and implementing rotations to optimize soil fertility

The crop rotation planning procedure works through a series of steps. You will
(1) organize your information,
(2) develop a general rotation plan (optional),
(3) construct a crop rotation planning map,
(4) plan future crop sequences for each section of the farm, and
(5) refine your crop sequence plan.

The procedure is easiest for a farm that produces only a few crops and has uniform field conditions, but it is most useful for farms with complex operations. Examples of farms with relatively simple rotation problems include most grain farms and some wholesale vegetable operations, where all of the crops can be grown on all of the fields. The procedure can be used to plan rotations with more crops and multiple soil types, but the process is time consuming. The rewards of systematic crop rotation planning increase, however, with the number of crops and the complexity of the fields. On farms that grow only a few crops, reasonable rotations can be maintained using a few rules of thumb. With a complex operation, however, a long-term problem can develop without the farmer realizing that the rotation practices are suboptimal.

The crop rotation planning process becomes more complex if the crop mix is highly diverse, if you plant the same crop multiple times each season, if you double or triple crop fields, or if the fields vary in their ability to grow various crops. For farms that require a complex cropping plan, using Microsoft Excel spreadsheets instead of paper worktables is advised. For any farm, the computer worksheets will simplify data entry and sorting.

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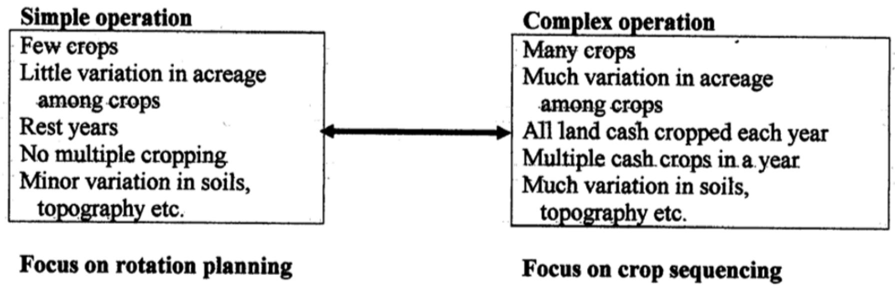

Figure 8 .The complexity of your farm determines how you plane

Rotation planning vs. crop sequencing

Cropping plans have two aspects: development of a general rotation plan and sequencing particular crops. The general rotation plan might specify, for example, that nightshade crops will be followed by mustard family crops, then salad greens other than mustards and finally cucurbits, or that full season crops will be followed by a year of cover crops and then early planted short season crops. The rotation plan provides the framework; the sequencing plan provides the details of what crop goes where in succeeding years. The rotation plan needs to be general enough to allow flexibility in sequencing. The sequencing plan is necessarily tentative and ideally leaves room for alternative crops in case weather or markets force last minute changes. The relative importance of rotation planning vs. crop sequencing in overall crop planning depends on the farm. In general, as the complexity of the farm operation increases, rotation planning becomes less possible and careful crop sequencing becomes more critical (Figure 2). If your farm operation is suited to rotation planning, developing a plan will greatly simplify your crop sequencing. If, however, your operation is highly complex (Figure 2) then following a general plan is likely to prove futile. In that case, detailed record keeping and careful placement of crops become key to avoiding rotation problems.

Crop Rotation

Nutrient management should target the cropping system. A well-conducted crop rotation program can help to achieve this goal, due to benefits related especially to root development, nutrient requirement, and capability in extracting nutrients from the soil. For example, farms in the figure below use balanced nutrition for second crop (late planted) corn leading to addition of nutrients (N-P_2O_5-K_2O) through soil fertilization similar to crop removal of these nutrients. (See figure.) Crops included in this rotation include soybean, cotton, millet, Brachiaria grass, and corn.

Figure 9. Second crop (late planted) corn in a no-till crop rotation system leading to optimization of fertilizer inputs.

The situation above is only possible due to planning and management of the system, which includes careful site-specific selection of the best corn cultivar, inter-row spacing of 45 cm, and plant population varying with time of seeding, in addition to crop rotation. Also very important to achieving effective results in the crop nutrition of second-crop corn are the practices utilized in the other crops in rotation, and especially for the soybean crop that precedes the corn. These practices include, but are not limited to: no-till practices with periodic sub-soiling; application of herbicide at the correct time; and use of early maturity soybean cultivars.

Another good example of a successful cropping system is inclusion of pasture with the cultivation of cereal crops. This approach has been used with great success in parts of Brazil to produce plant residues of good quality for no-till cultivation, or even to be used as feed during winter. This combination generally consists of annual crops—corn, sorghum, millet, or upland rice—with pasture crops, usually Brachiaria. The best crop rotation system, and management that goes with the system, should be defined locally and only agronomic experimentation will lead to optimum results.

3.7. Selecting and implementing cultural practices to enhance soil fertility

Cultural practices that support the development of healthy, vigorous root systems result in efficient uptake and use of available nutrients. Many cultural practices help accomplish these goals, including establishing diverse crop rotations, reducing tillage, managing and maintaining using all available wastes or byproducts, liming to maintain soil pH, applying supplemental fertilizers, and routine soil testing. These beneficial management practices have multiple effects on nutrient cycling and soil fertility, which make it important to integrate their use and examine their effects on the complete soil-crop system, rather than just a single component of that system. There are many good ways to farm, so different solutions or combinations of practices are appropriate for different systems to reach similar goals.

Cultural Practices

1. Minimizing soil disturbance

Farmers till land for various reasons: to loosen the soil and prepare a seed bed to encourage seed germination, control weeds or incorporate manure and plant material into the soil. Turning the entire surface area of the fi eld that is to be planted is common in many African countries. General ploughing, discing and harrowing are encouraged by the introduction of tractors. But also ridging using a hoe involves disturbance of the entire surface. These soil cultivation systems leave bare soil exposing it to erosion and water loss through evaporation, result in capping of the soil surface, accelerate decomposition of soil organic matter and contribute to destruction of soil structure. Repeated working depth and cultivation of soil in humid condition bears the risk of soil compaction and creation of a hardpan at the working depth. Mixing of soil layers can also severely harm certain soil organisms such as earthworms.

Most farmers, who plough their land, must wait for the rains to cultivate the soil. In this case planting cannot happen as long as the land is not prepared. In many regions each day of delay in seeding after the first rains results in yield loss. Cultivation of the entire surface area of a field is labour, energy and time intensive. Preparing a field may take several days or weeks, requires strong draught power and much fuel if a tractor is used.

Traditional organic farming practices involve deep soil cultivation with inversion of the soil to allow incorporation of plant material and animal manure, and bury weeds. Increasing knowledge on the negative impacts of such a practice on soil organic matter, nutrient losses, soil biology, climate, use of energy and costs presently results in a basic change in the approach to soil cultivation with increasing adoption of practices, such as they are promoted by the approach of soil conservation farming.

Any soil cultivation activity has a more or less destructive impact on soil structure. But there are soil cultivation systems that minimize soil disturbance, maintain a protective cover on the soil surface and allow early land preparation before the rains. Such systems contribute to a good soil structure, reduce the risk of soil compaction, increase water infiltration and reduce runoff, reduce evaporation and thus improve water storage. When the soil is protected and stays undisturbed, the topsoil layer becomes a favourable habitat for plant roots, worms, insects and microorganisms such as fungi and bacteria. This soil life recycles the organic matter from the soil cover and transforms it into humus and nutrients, and thus contributes to fertile soil and plant nutrition. This process may also be called ‘biological tillage’.

Reduced soil cultivation and maintenance of a soil cover, as they are recommended by the conservation farming approach, allow farmers to prepare their land after the harvest of the previous crop. Early land preparation allows planting at the onset of rains and early weeding.

The soil conservation farming approach is very suitable to women, as labour for soil cultivation is reduced and can be done over a long period without loss of nutrients and precious time.

Soil cultivation should provide good growing conditions for seeds and seedlings, loosen the soil in a way to facilitate the penetration of the young plant roots, destroy or control weeds and soil pests, if necessary, and repair soil compaction caused by previous activities. Whether soil cultivation should serve incorporation of crop residues and manures into the soil or not, is a basic decision that needs to be taken in the local context.

To minimize the negative impacts of soil cultivation while benefiting from its advantages, farmers should aim on reducing the number of interventions to the minimum and choose methods that best conserve the natural qualities of the soil.

There is not just one right way to cultivate the soil. There is a range of options. Finding the most appropriate soil cultivation method depends on the crops that are grown, the cropping system, the soil type, climate, weed pressure and other factors. Thus, each farmer must assess the soil cultivation practice which is most suitable for his or her conditions minimizing the negative impacts of soil cultivation while benefiting from its advantages. Organic farmers should aim to keep the number of interventions to a minimum and choose methods that conserve the natural qualities of the soil. Adoption of reduced soil tillage by farmers, who fully rely on natural practices and avoid herbicides and chemical fertilizers, may require specific adaptations to prevent weed problems and ensure appropriate plant nutrition.

Zero-Tillage or No-Till Systems

No-till systems work without any soil tillage and seeds are planted or drilled directly into the vegetation cover without any seedbed preparation. Crop residues are left on the soil surface. The vegetation cover and weeds are destroyed by slashing them manually or mechanically or using herbicides to avoid competition between the crop and the soil covering vegetation. In conventional farming, synthetic fertilizers are either broadcasted or applied during seeding. For seeding, usually a narrow slot only wide and deep enough to obtain proper seed coverage is made, while crop residues basically remain undisturbed on the soil surface.

Zero-tillage systems help to build-up a natural soil structure with crumbly topsoil rich in organic matter and full of soil organisms. Nutrient losses are reduced to a minimum as there is no sudden decomposition of organic matter and nutrients are caught by a dense network of plant roots. Soil erosion will not be a problem as long as there is permanent plant cover or sufficient input of organic material. Last but not least, farmers can save a lot of labour.

Zero-tillage requires soils with good drainage. Water-logged soils and soils with poor drainage are not suitable for zero-tillage, as the seeds and plant roots will rot in the soil. In compacted soils, sub-soiling deeper than the soil pan may be necessary to enhance drainage. Or deep rooting crops such as pigeon peas are grown in rotation to break pans before weaker rooting crops.

Successful zero-tillage depends on high biomass production to ensure a thick mulch cover. Proper crop rotation including leguminous green manure crops is essential to this system. Managing weed growth may be a challenge to organic farmers, who renounce the use of herbicides and rely on mechanical or natural methods for weed control only. Nevertheless, there is potential for introducing zero-tillage in organic farming.

In annual crops, for instance, zero-tillage can be applied easily when sowing a legume crop after a grain such as maize, wheat, sorghum or millet between the stalks.

Zero-tillage with living mulch is good mainly for perennial crops, for example coffee or banana, where competition by annual vegetation is limited and weeds can be controlled by regular slashing.

Minimum Tillage Systems

Reduced tillage is shallow soil tillage or loosening of the soil by a chisel without deep soil cultivation or making furrows or holes where seed is planted. Minimum tillage promotes build-up of organic matter in the soil, activity of soil organisms and contributes to more stable soil aggregates resulting in better water infiltration. Minimum tillage also implies reduced labour and about half as much energy and effort for land preparation. The greater the part of the soil surface that remains undisturbed and covered, the more positive the impact is. Ideally the seedbed is prepared only where the seeds are planted and the residues remain on the topsoil and are not buried.

Minimum tillage involves techniques such as scraping out shallow planting holes with a hoe, planting with a dibble stick or digging narrow furrows with a chisel-shaped ripper pulled by animals or a tractor. The distance between the furrows results from recommended spacing for the crop. Compared to a conventional plough a ripper is smaller, lighter and easier to operate, and also cheaper to buy and maintain. As a ripper requires about half of the draught force of that of a plough, farmers can use weaker and smaller animals also. For making planting holes with a hoe a long string with knots or bottle tops indicating the planting distance and pegs are helpful.

Reduced or minimum tillage is well suited to many tropical soils, in which intensive tillage leads to rapid breakdown of the soil structure and loss of water and organic matter. However, the adoption of reduced tillage also involves some challenges. The most important is weed control.

Farmers who renounce the use of herbicides depend on mechanical weed control or on a thick mulch cover or on cover crops and proper crop rotation to prevent weed growth.

In systems, however, where the inter-row is never ploughed, weed pressure decreases over time, as weeds are not allowed to germinate.

2. Soil and water conservation practices

Soil erosion removes topsoil, which is the richest layer of soil in both organic matter and nutrient value. Implementing soil and water conservation measures that restrict runoff and erosion minimizes nutrient losses and sustains soil productivity. Tillage practices and crop residue cover, along with soil topography, structure, and drainage, are major factors in soil erosion. Surface residue limits erosion by reducing detachment of soil particles by wind or raindrop impact and restricting water movement across the soil. Tillage practices manage the amount of crop residue left on the soil surface. Reduced tillage or no-till maximizes residue coverage. Water moves rapidly and is more erosive on steep slopes, so reducing tillage, maintaining surface residue, growing sod crops, and planting on the contour or in contour strips are recommended conservation practices. Using diverse rotations and growing cover crops also can reduce erosion.

Soils with stable aggregates are less erodible than those with poor structure, and organic matter (including the activity of living soil organisms and fine roots) helps bind soil particles together into aggregates. Tillage breaks down soil aggregates and also increases soil aeration, which accelerates organic matter decomposition. Well-drained soils with rapid water infiltration are less subject to erosion, because water moves rapidly into and through them and does not build up to the point where it moves across the surface. Drainage improvements on poorly drained soils reduce runoff, erosion, and soil compaction. Improving drainage also decreases N losses from denitrification, which can be substantial on waterlogged soils, by increasing aeration. Improving aeration in the plant-root zone also promotes healthy root growth. A negative consequence of improved drainage is loss of nitrate-N and other nutrients through tile outlets to surface waters. Especially important are flushes of residual N after late winter/early spring rains.

3. Cover Crops and Green Manures

Growing cover crops and green manure crops can be viewed as a type of crop rotation, where adding a non-revenue generating crop between annual cash crops extends the growing season. Many of the benefits, therefore, are the same as those achieved with crop rotation.

The terms cover crop and green manure are frequently used synonymously. They perform many similar functions and many of the same plant species are used as both cover crops and green manure crops. The main difference between the two is that the primary purpose of growing a cover crop is to protect the soil surface from raindrop impact, runoff, and erosion and the primary purpose of a green manure is as a soil-building crop to produce organic material for incorporation into the soil. Winter grains like cereal rye planted after potatoes are cover crops that are designed to hold soil in place until the next main crop is planted in the spring, but they also add organic matter to the soil when they are turned under. Rapidly growing summer annuals like buckwheat and sorghum-sudangrass are planted between short-season vegetable crops as green manures to add organic matter to the soil, but they also protect the soil from erosion between spring and fall vegetables.

Growing legume cover crops adds biologically fixed N. The additional plant diversity with cover crops stimulates a greater variety of soil microorganisms, enhances carbon and nutrient cycling, and promotes root health. The soil surface is covered for a longer period of time during the year, so nutrient losses from runoff and erosion are reduced. This longer period of plant growth substantially increases the amount of plant biomass produced, which in turn increases organic matter additions to the soil

4. Manure Management

Returning manure to crop fields recycles a large portion of the plant nutrients removed in harvested crops. On farms where livestock are fed large amounts of off-farm purchased feeds, manure applied to crop fields is a substantial source of nutrient inputs to the whole farming system. However, just as nutrients can be lost from the soil, nutrient losses from manure during storage, handling, and application are both economically wasteful and a potential environmental problem. Soluble nutrients readily leach from manure, especially when it is unprotected from rainfall during storage. N is readily lost through volatilization of ammonia, both during storage and when manure is not incorporated soon after field application. Nutrient losses from manure also occur when it is applied at rates exceeding crop nutrient requirements.

Analyze manure for its nutrient content and adjust application rates according to crop needs, soil tests, and frequency of manure applications. Avoid applying manure at rates that exceed crop requirements for any nutrient, but especially for N and P on fields that receive manure on a regular basis. This often means that rates should be based on P requirements rather than N requirements. Following heavy manure applications with crops that have high nutrient requirements (especially for N and P) reduces losses and increases nutrient-use efficiency. In addition to nutrient value, manure adds organic matter to the soil, which can improve soil structure and increase CEC.

5. Compost & other Soil Amendments

In addition to manure, organic amendments such as biosolids, food processing wastes, animal byproducts, yard wastes, seaweed, and many types of composted materials are nutrient sources for farm fields. Biosolids contain most of the essential plant nutrients, and are much "cleaner" than they were twenty years ago, but regulations for farm application must be followed to prevent the possibility of excessive trace metal accumulation. Biosolids are also not an acceptable nutrient source for certified organic production.

Composting is a decomposition process similar to the natural organic matter breakdown that occurs in soil. Proper composting conserves volatile and soluble N, and other mobile nutrients in waste products, by incorporating them into organic forms where they are more stable and less readily lost. Composting reduces the bulk of organic wastes and makes transportation and field application of many waste products more feasible. On-farm composting of manure and other farm wastes also facilitates their handling. Most organic materials can be composted, nearly all organic materials contain plant-nutrient elements, and recycling all suitable wastes or byproducts through soil-crop systems by either composting or direct field application should be encouraged. These practices build up soil organic matter and provide a long-term, slow-release nutrient source. Some compost also have disease-suppressive properties that improve root growth and health.

5. **Fertilizer Applications**

Many materials can be applied to soil as sources of plant nutrients, but the term "fertilizer" is often used to refer to relatively soluble nutrient sources with a high analysis or concentration. Commercially available fertilizers supply essential elements in a variety of chemical forms, but many are relatively simple inorganic salts. Advantages of commercial fertilizers are their high water solubility, immediate availability to plants, high concentration and low price per unit of nutrient, and the uniformity and accuracy with which specific amounts of available nutrients can be applied. Because they are relatively homogeneous compounds of fixed and known composition, it is fairly easy to calculate precise application rates and attain relatively consistent performance. This is in contrast to organic nutrient sources, which are a much greater challenge to manage, because of their variable composition, variable nutrient availability, and patterns of nutrient release that are greatly affected by temperature, moisture, and other conditions that alter biological activity.

6. Soil Testing

The first step in maintaining soil fertility is to know current nutrient levels. This is accomplished by soil testing, which is an important soil management tool and effective basis for nutrient and lime recommendations. The goal of soil testing is no longer simply to find out whether the soil contains adequate plant nutrients for optimum growth. It also is a tool for determining whether nutrient levels are excessive and prone to move off-site. Soil fertility today is a social issue as well as a crop production concern.

Soil tests each field every 1-3 years, depending upon crop rotation, field history, and the value of the crop. Testing every 3-5 years is probably sufficient for agronomic crop fields with a stable rotation, long-term record of soil tests, and no recent manure or compost applications (only commercial fertilizer since the last soil test). Choose a reliable, experienced laboratory that makes recommendations suitable for the soil types and growing conditions in your location.

3.8. Identifying, comparing, selecting and sourcing soil ameliorants to improve soil fertility

Soil ameliorants

- There are a number of different soil composition improvement agents available. All these agents have a slightly different effect on the soil.
- Manure is generally widely available. Manure usually causes a decrease in soil pH it decomposes. Manure should be well rotted before it is used. Manure contains a small amount of a large number of plant nutrients. Manure can however also contain weed seeds. Although rate carryover of herbicide residues into manure has been recorded.
- Peat usually makes the soil acid. It is usually expensive costly and is becoming a scarce natural commodity. Pest mining also has a negative environmental impact. Peat is usually rich in nitrogen and other plant nutrients, but not usually in phosphate. It does not contain many weed seeds, and the coarse grades are best for soil composition improvement.
- Compost if well made is a very useful material, but is generally weaker at soil improvement than peat or manure. It does not supply much plant food and usually contain weeds and some diseases if not properly made. Regular use is needed for and effect.
- Spent Mushroom Compost is one of the few types of organic matter to have a slightly alkaline effect on the soil. It is therefore good for soils that need both composition improvement and increased in pH, or soils at the right pH level that would become too acid if peat or manure were used. It is a waste product of the mushroom growing industry but expensive. It is generally widely used and in great demand in the gardening sector.
- Straw is very good for improving soil composition, but reduces the available nitrogen for a period when first added. This is because the addition of straw stimulates microbial activity, which uses high levels of nitrogen. It is better if straw is used once it has been rotted somewhat.

- Gypsum is an excellent soil improver for heavy soils. It should be ploughed in well and mixed intimately with soil particles. The tiny soil particles are chemically attracted to each gypsum particle and then stick together around it so that the whole clay "lump" behaves just as though it were a sand sized multi-particle. Gypsum is not usually expensive. Gypsum works in the same way as lime, but without raising the soil pH.
- Lime is available in different forms. Lime works in the same way as gypsum but lime causes the soil pH to increase.
- Bacterial products are usually freeze dried bacterial cultures which are useful on soils which do not have any bacteria present such as in desert sands, or subsoil. These products are also used for specific purposes such as metabolism of pollutants.
- Aquifiers and Aqeupulses were developed recently. These are compounds that act like a wetting agent breaking down the surface tension of water, thereby improving drainage. These compounds can be leached out of the soil with rain. The other types turn to a gel when wetted, and release the water more slowly as the soil dries out. The use of these type of compounds have not yet been widely demonstrated in agriculture but some success has been shown in gardens and glass-houses

Self-check-3	Written test

Name: ___________________________ Date: ________________

Directions: Answer all the questions listed below.

1. What is nutrient cycling manes and write the components parts for nutrient cycling techniques? (**5pts**)
2. Write and explain the methods for determining the nutrient status of the soil? (**5pts**)
3. Write the main objective of fertilizer calibration? (**5pts**)
4. Explain the advantage of selecting and managing cover crops and pasture system in soil fertility managements? (**5pts**)
5. Write the advantage of developing, applying and monitoring mulching and composting system in soil fertility management? (**5pts**)
6. List the cultural practices to enhance soil fertility? (5pt)

Note: Satisfactory rating – 25 points and above Unsatisfactory - below 25points

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