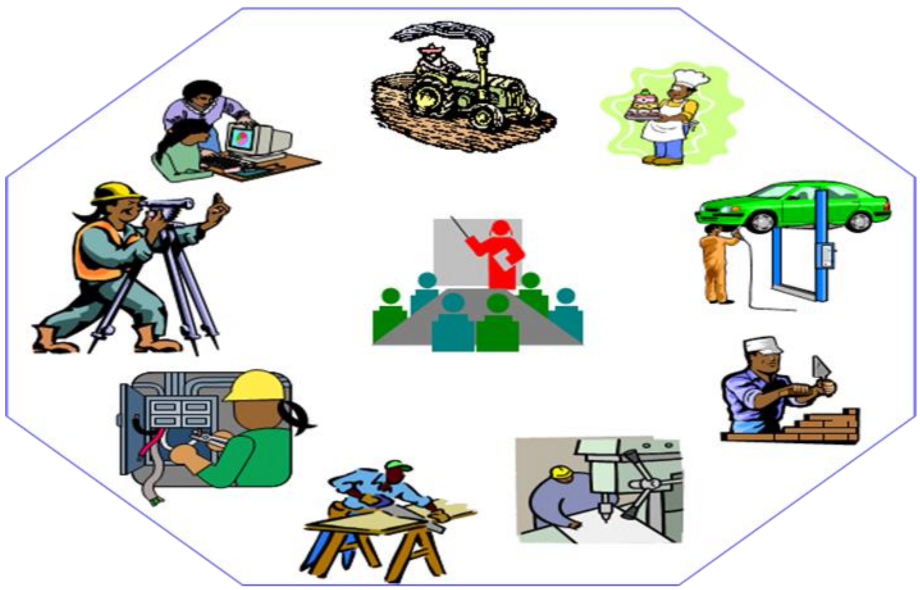
Crop Production
Level-III

Based on March 2018, Version 3 Occupational standards



Module Title:-Applying plant nutrition program and fertigation
LG Code: AGRCRP3 M09 LO (1-6) LG (34-39)
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LG #34	LO #1- Prepare for applying of plant nutrition program

Instruction sheet

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

- Identifying goals and target site
- Identifying materials for soil and plant treatments
- Locating services using site plans and
- Identifying OHS hazards**,** assessing risks, implementing controls and reporting
- Selecting, using and maintaining suitable PPE

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

- Goals and target site for implementation of the plant nutrition program include soils, plant species and varieties are identified according to enterprise work procedures.
- Materials for soil and plant treatments available to the enterprise are identify and the storage site or supplier details locate.
- Services are locate use site plans and in consultation with the supervisor.
- OHS hazards identify, risks assesse, controls implement and report to the supervisor.
- Suitable PPE , select, use and maintain.

Learning Instructions:

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

Plant nutrition is an important aspect for enhancing production. Realization of higher crop yield required intensive use of fertilizers. After green revolution, the fertilizer use was increased with the introduction of high yielding varieties. But at present, application of fertilizer is not able to give higher yield and the fertilizer use efficiency is decreasing day by day. There is a need to explore new methods and sources for plant nutrition for getting higher yield and improving input use efficiency..

Due to this improved control, crop yields and quality are higher than those produced by a simple fertilizer application. According to Hagin et al.(2002), fertigation is a modern agro-technique, which provides an excellent opportunity to maximize yield and minimize environmental pollution. The essential nutrients required by higher plants are exclusively inorganic, a feature distinguishing these organisms from man, animals and many species of microorganisms which additionally need organic foodstuffs to provide energy. By contrast, plants absorb light energy from solar radiation and convert it to chemical energy in the form of organic compounds, whereas at the same time taking up mineral nutrients to provide the chemical elements essential for growth.

Elements necessary for the normal growth of plants are called *essential elements*. Out of the 118 (92 natural) elements known so far only 17 are recognized as essential to plants growth. For an element to be essential, the following *three criteria* should be fulfilled (criteria for essentiality)

1.1There are two major functions of nutrients for plants.

1. They are part, constituent, of the plant tissue.

2. They act as catalysts in other metabolic activities. Sixteen (16) elements are known to be essential in plant growth. They can be grouped based on their sources and based on the amount they are required by plants.

General importance of nutrients

- Provide basic structure to the plant
- Energy storage and transfer and bonding
- Charge balance
- Enzyme activation and electron transport
- Promote growth and development
- Increase both yield and quality

Table .1 Essential nutrient elements and their source

Essential elements used in relatively large amount		Essential elements used in relatively small amounts	
Mostly from air and water	From solid soils	From soil solids	
Carbon	Nitrogen	Iron	Chlorine
Hydrogen	Phosphorous	Manganese	Cobalt
Oxygen	Potassium	Boron	
	Calcium	Molybdenum	
	Magnesium	Copper	
	Sulfur	Zinc	

Note*:* Sodium, Fluorine, Iodine, Silicon, Strontium and Barium may increase crop growth when supplied at small amount, but they are not essential. Though the majority of the elements come from the soil, they make up very small part of the plant tissue as plant tissues are mainly made of C, H and O (94-99.5%). C, H and O are not limiting under normal condition as they are supplied by the atmosphere.

Categories of Essential Nutrients: Based on the amount they are required plants.

Major nutrient /Macronutrients:.

- **Primary nutrients**
  - ✓ Nitrogen
  - ✓ Potassium
  - ✓ Phosphorus
- **The Secondary nutrients**, (also known as sub-major nutrients), are Calcium, Magnesium and Sulphur Of the 17 essential plant nutrient elements, nine (9) are required in relatively large quantities and are thus referred to as they are Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorous Potassium, Calcium, Magnesium, Sulphur, C, H, O, N, P, K, S, Ca, and Mg.

Minor nutrient/ Micronutrients

The other 8 nutrient elements: - Iron, Manganese, Copper Zinc, Molybdenum, Boron, Chlorine, Nickel (Fe, Mn, Cu, Zn, B, Mo, Cl, Ni) are required by plants in very small amounts, hence the name *micronutrients* or *trace elements*.

Note: Elements, other than the 17 essential nutrients, which can be found in plants, are called beneficial elements. These are not essential elements.

Beneficial elements include: Nickel (Ni), Sodium (Na), Silicon (Si), Cobalt (Co), and Selenium (Se).etc.

Classification of essential elements of plant nutrients

Essential elements can be classified based on:-

- The amount required
- Their mobility in the soil
- Their mobility in a plant

The amount required

On the bases of amounts in which these elements are taken up by the crop plants, they are classified as.

Mobility of nutrients in the soil

- Mobile
- Less mobile and
- Immobile

Mobility of nutrients in plants

Based on mobility of nutrients in plants, nutrients can be classified as

- Highly mobile:-N, P, K
- Moderately mobile:-Mg
- Less mobile:-S, Fe, Mn, Cu, Mo, and Zn
- Immobile:-Ca ,B and Cl

1.2 Goals and Targets for the Plant Nutrition

Several factors need to be considered when designing and preparing to implement a plant nutrition programme

The SoilI s the basis for life there are diverse viewpoints about what a soil is. For a farmer, and a homeowner, the soil is a habitat for plants. For him it is more than useful, it is essential

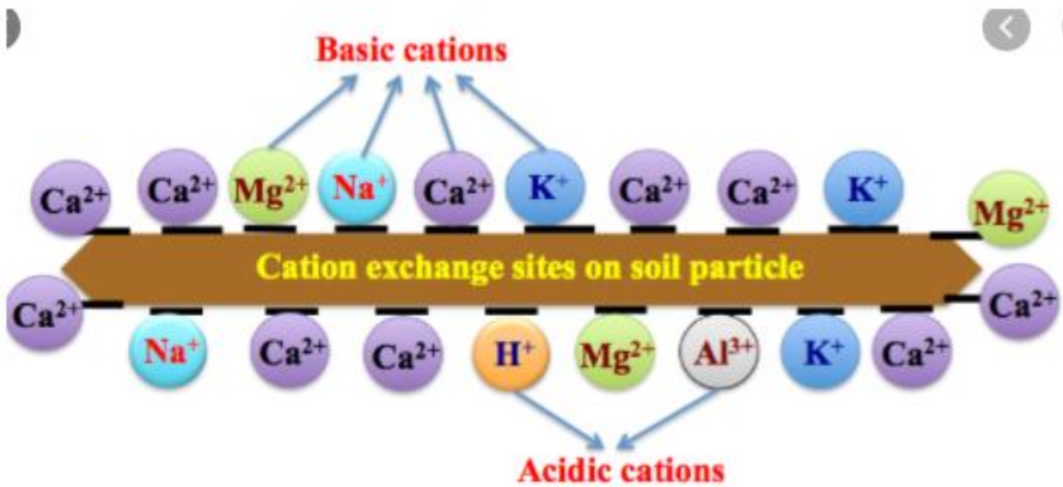
The soil type will affect the natural fertility of the soil and the leaching potential of the soil. Clay soils and soils with high clay or organic matter content have high Cation Exchange Capacity (CEC), so tend to be naturally more fertile and less susceptible to nutrient loss by leaching than sandy soils

Sandy soils do not have a high CEC so nutrients are easily leached out in the rainy season. This problem can be reduced by addition of organic matter to the soil and by making fertiliser application to the crop as several small applications rather than one or two large applications.

Physical analysis of the soil and or a finger test of the feel and pliability of the soil will tell you about the type of the soil in the area where the crop is to be grown.

Chemical analysis of the soil will give you details about the available nutrient content of the soil so that the amount of fertiliser needed to meet the needs of the crop and maintain soil fertility can be calculated.

Please consult your notes for Module 1 for more details about soil types, properties and analysis.



Cation exchange on soil particle

The plant species to be grown

Different types of crop have different requirements for the total amount of fertiliser needed and the balance of the nutrients needed at the different stages of growth.

For small Farmers in Ethiopia, the Ministry of Agriculture produces recommendations, based on experimentation carried out at the various EIAR sites, for fertiliser regimes for the most common crops grown in Ethiopia.

For large scale farmers, who have access to greater resources and are less risk sensitive, crop nutrition programme are based on their own experience and the advice of specialists from the sector. These farmers are usually using higher rates of fertiliser application than those recommended by the Ministry of Agriculture.

Variety selection and the use of Irrigation

Variety selection and the use of irrigation affect the yield potential of a crop.

Use of Improved varieties or Hybrid seed creates potential to produce higher yields than those produced by the older open pollinated varieties.

Then use of irrigation helps to ensure that yield potential is achieved when sufficient fertiliser is applied. Realisation of the higher yield potential of 'high yielding Varieties' requires the use of higher amounts of fertiliser than that recommended for low yielding varieties.

Note. However that use of fertiliser is subject to the 'Law of Diminishing Returns.

Fertiliser is expensive and over use can result in development of saline soil leading to restricted or in some cases lower yield and crop profitability. Consult with a plant nutrition specialist if you are considering the use more than the recommended amount of fertiliser or more than you used last year.

Self-check 1	**Written test**

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

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

Test II: Short Answer Questions

1. What do we mean essential plant nutrients?(3pts)
2. Mention the criteria for essentiality of an element(3pts)
3. What is the difference between macro-nutrients and micro-nutrients? Give examples for each.(5pts)
4. In relation to the soil , classify the following(Ca^{++},NO_3^-, NH_4^+,$SO_4^=$,$H_2PO_4^-$) in to mobile ,less mobile and immobile nutrients(5pts)
5. List down the sources of plant nutrients(3pts)
6. In what forms do plants absorb N,P,and K?(1pts)

Part Matching Column with Column B

COLUMN A	COLUMN B
----------- 1,Micronutrients	A. Mg
------------ 2.Beneficial elements	B. Ca ,B and Cl
-------------3.Highly mobile:-	C. Fe, Mn, Cu, Zn, B, Mo, Cl ,Ni
-------------4. Moderately mobile	D. H, O, N, P, K, S, Ca, and Mg.
-------------5. Less mobile:-	E. Na, Si, Co), Se and Ni
------------6. Immobile	F. S, Fe, Mn, Cu, Mo, and Zn
------------7. Macronutrients	H. N, P, K

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

Note: **Satisfactory rating - 20 points** **Unsatisfactory - below 20 points**

Information Sheet 2- Identifying materials for soil and plant treatments

2.1 Identifying Material for soil treatment

Those to modify soil pH

Soil acidity is commonly decreased by adding:

- Carbonate E.g. $CaCO_3$,Dolomite
- Oxides or hydroxides of calcium And Magnesium
- Wood ashes(Local)
- and increased by
- Traces of inorganic acids such as HNO_3,$H_2SO_4$and H_3PO_4

Soil ameliorants

- cover crops
- animal manures
- Gypsum and lime.
- Compost
- Wood Ash
- Bone Meal

Fertilizers: - natural or synthetic chemical substance or mixture used to enrich soil so as to promote plant growth.

- Urea
- Dap
- Ammonium phosphate

Self-Check – 2	**Written test**

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

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

1. How do you decrease soil acidity? (3pts)
2. How do you decrease soil alkality? (3pts)
3. What do you mean when you say soil ameliorants? (3pts

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

***Note:* Satisfactory rating - 9 points** **Unsatisfactory - below 9 points**

Information Sheet 3- Locating services using site plans and supervisor

3.1 Locating services using site plans

Services that need to be considered include surface water sources and drainage channels, water hydrants and water reticulation systems and wires used for electricity and telecommunications.

Services should be shown on a farm map but in practice, discussion with the supervisor or Manager and a field visit is often more informative.

Water sources should be protected from contamination by fertiliser:

- Do not store fertiliser close to water sources or where there is risk of flooding
- Do not apply fertiliser right up to the edge of lakes and rivers. Better to leave a vegetation barrier between the crop and the water source to absorb leachate from the cropped area before it reached the water source.

Water hydrants, reticulation systems and electricity or telecommunication wires all need protection from physical damage, particularly when machinery is used for fertiliser application.

Services may also be important for the use of some types of Fertiliser (Fertigation) application equipment, e.g.

- For complex fertigation units, as used in Greenhouse crop production in Ethiopia, the availability, reliability and stability of voltage are all important
- For mechanical distribution of fertiliser by broadcasting, availability of suitable tractor and fertiliser spreader for own use or hire is a limiting factor

Self-Check – 3	**Written test**

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

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

Test I: Short Answer Questions

1. To make observations in the field

1. Species type
2. Environmental conditions
3. Requirements (for what purpose is the plantation established)
4. Soil conditions
5. Plant condition (symptoms

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

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

Information Sheet 4 Identifying OHS hazards, assessing risks, implementing controls and reporting

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

Aims of occupational health

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

- ✓ **Hazards**

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

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

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

- ✓ Biological
- ✓ Chemical
- ✓ Physical

Biological hazards

- ✓ **Food-borne micro-organisms**, such as **bacteria, viruses and parasites**, are often referred to as biological hazards. Some fungi are able to produce toxins and also are included in this group of hazards.

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

Microbiological Risks Reason for occurrence

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

Chemical hazards

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

Examples of chemical hazards:

- Pesticides

- Fertilizers
- Antibiotics
- Heavy metals
- Oils and grease

Chemical hazards Risks Reason for occurrence

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

Physical hazards: foreign bodies

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

Physical hazards risk reason for occurrence

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

Self-Check – 3	**Written test**

Name: ___________________________ Date: ________________

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

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

Information Sheet 5-Selecting, using and maintaining suitable PPE

5.1 Personal protective equipment

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

5.1.1. Selecting personal protective clothing and equipment

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

5.1.2. Select PPE based on the PPE Hazard Assessment

Consider these factors when selecting PPE:

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

Personal protective clothing and equipment may include:

- Hoots
- Hat/hard hat
- Overalls
- Gloves
- Protective eyewear
- Hearing protection]
- Respirator or face mask
- Sun protection, e.g., sun hat, sunscreen
-

Different types of PPE are described below

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

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

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

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

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

Self-Check – 3	**Written test**

Name: ___________________________ Date: ________________

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

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

Operation Sheet 1- Identification of target site for plant nutrition implementation

To identify **target site for plant nutrition implementation**s follow the following steps

1st **–** make observations in the field

- Species type
- Environmental conditions
- Requirements (for what purpose is the plantation established)
- Soil conditions
- Plant condition (symptoms)
- 2nd – compile a report based on your observation

Operation Sheet 2- Prepare to implement the plant nutrition programme

Prepare to implement the plant nutrition programme in your student plot or similar crop situation presented by your Instructor

1. Find out the crop, variety and the yield potential of the variety to be grown
2. Inspect the field and identify soil type and services
3. Establish what plant nutrients are available in the farm store and at the local suppliers
4. Discuss the nutrient programme (Fertilisers to use and method of application) with your Instructor and complete an OHS Risk Assessment for the storage, measuring and application of fertilisers and compost or manure to be used.
5. Select appropriate PPE to be used for measuring and application

Prepare and submit your 'Implementation work plan'

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions:

Task 1 to Identification of the crop, variety and the yield potential of the variety to be grown

Task 2 to inspect the field and identify soil type and services

Task to identify the availability of irrigation and fertigation equipment

Task to preform Establish what plant nutrients are available and prepare a requisition for additional materials required:

LG #35	LO #2- Monitor soil PH

Instruction sheet

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

- Monitoring soil PH in relation to plant nutrition.
- Identifying, comparing, selecting and sourcing Products useful in changing soil pH
- Assessing product application methods

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

- Monitoring soil pH in relation to plant nutrition
- Identifying, comparing, selecting and sourcing Products useful in changing soil pH
- Assessing product application methods

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Information Sheet 1- Monitoring soil PH in relation to plant nutrition

1.1 Monitoring soil PH in relation to plant nutrition.

PH is a measure of the concentration of hydrogen (H+) ions, sometimes called protons. The greater the H+ ion concentration, the more acid the solution, hence a lower pH. pH controls the uptake of nutrients. If the pH is not in the desired range, individual nutrients cannot be taken up, creating a nutrient deficiency, or the nutrient can be taken up too readily, resulting in a nutrient toxicity.

These nutrient imbalances will occur even when proper amounts of nutrients are applied to the media, if the pH is too high or too low. Nutrients are available to plants at different media pH. Nitrogen and potassium are readily available at a wide pH range. Although phosphorus is more readily available at a low pH, phosphorus problems are not commonly observed in greenhouse crops. Calcium and magnesium are more readily available at a higher pH. At a low pH, the minor nutrients (iron, manganese, boron, zinc and copper) are readily available. Minor nutrient toxicities are relatively common at a low pH (<5.8), while deficiencies frequently occur at a high pH (>6.5)

1.1.1 Soil pH/reaction

- Is an indication of the acidity or basicity of the soil
- Is measured in pH units/scale ranging from 0-14
- Is the negative logarithm of hydrogen ion concentration
- It is a measure of acidity or alkalinity/ basicity of the soil.
- The pH value of a soil is a measure of its alkalinity or acidity.
- It is defined as pH= log 10 $^{1/[H+]}$ = -log10 $^{[H+]}$
- **pH is – Log [H^+]** In words The pH is minus Log of Hydrogen Ion Concentration in the solution measure

✓ The pH represents the [H^+] in solution, and does not measure the undissociated or potential acidity.

✓ Active acidity=dissociated H^+= [H^+] in a solution in lt/mole/Molar(M)

✓ Potential acidity=undissociated H^+= adsorbed H^+

Types of soil reactions/ pH

- Acidic = $[H^+] > [OH^-]$
- Alkaline= $[H+] < [OH^-]$
- Neutral= $[H+] = [OH^-]$

Soil reaction is the degree of acidity or alkalinity of the soil. In other hand it expressed as the soil PH. **PH** is the negative logarithm of the hydrogen ion concentration.

The terms commonly used to describe soil pH are the following:

Extremely acid	less than pH 4.0
Acid	PH 4.0-5.0
Moderately acid	PH 5.1-6.0
Slightly acid	PH 6.1-6.9
Neutral	PH 7.0
Slightly alkaline	PH 7.1-7.5
Moderately alkaline	PH 7.6-8.0
Alkaline	PH 8.1-9.0
Extremely alkaline	Over PH 9.0

The variability of soil reaction is largely controls plant nutrient availability and microbial reaction in the soil. The PH of soil helps to determine the numbers and kinds of soil organisms that change plant residues in to valuable soil organic matter.

This diagram details the influence of soil pH on the availability of different nutrients to plants plants.

Nitrogen is most available at pH levels of between 6.0 and 8.0.

Phosphorus is most available at pH levels of between 6.5 and 7.5 and 8.75 to 10.0. However it is least available at 8.5.

Potassium and **Sulphur** are most available at pH levels of between 6.0 and 10.0.

Calcium is most available at pH levels of between 7.0 and 8.5.

Magnesium is most available at pH levels of between 6.5 and 8.5.

Iron is most available at pH levels of between 4.0 and 6.0.

Manganese is most available at pH levels of between 5.0 and 6.5.

Boron is most available at pH levels of between 5.25 and 7.0 and 8.75 to 10.0. However, it is least available between 8.0 and 8.5.

Zinc and **copper** are most available at pH levels of between 5.0 and 7.0.

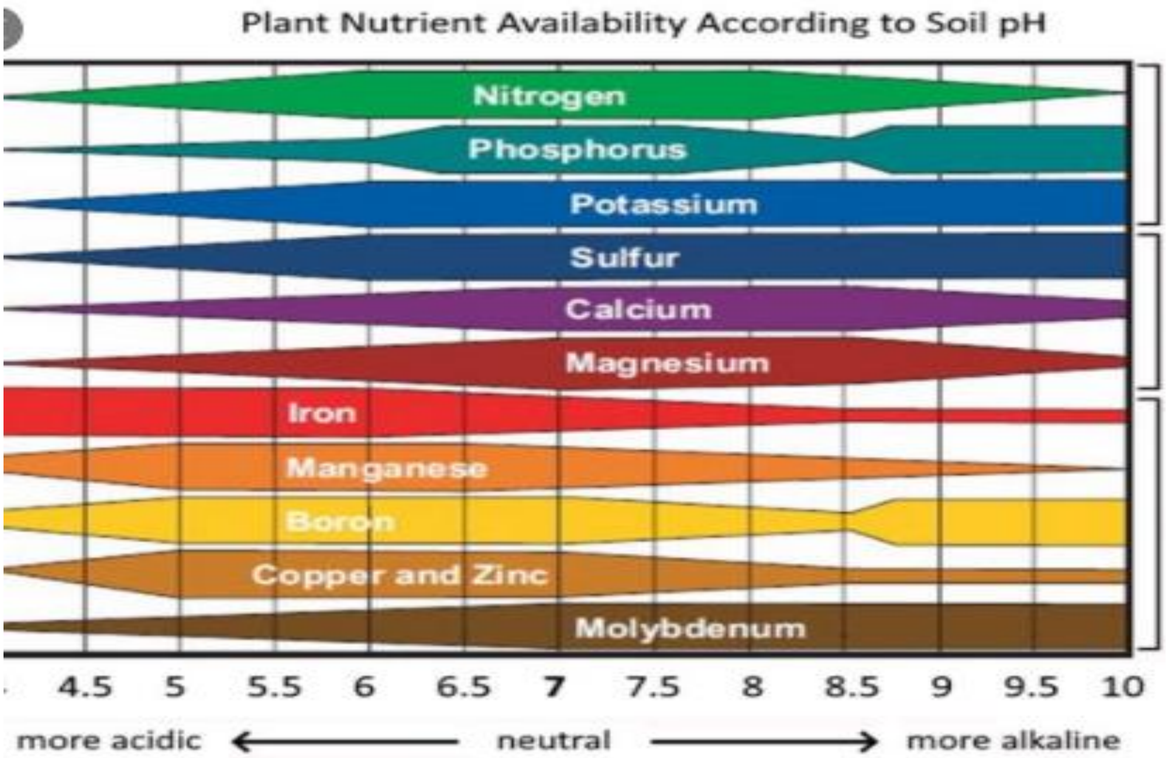
Determination of soil PH

Samples are collected in the field and the PH is measured directly or the samples are brought to the laboratory for more accurate PH determination.

Potentiometric method

The most accurate method of determining soil PH is with a PH meter.

Dye method Dye methods take advantage of the fact that certain 0rganic compounds change color as the PH is increased or decreased. Mixture of such dyes provides significant color changes over a wide PH range 3-8. After standing a few minutes the color of the dye is compared to a color chart that indicates the approximate PH.



Soil Acidity

Acidity in soils comes from H^+ and Al^{3+} ions in the soil solution and sorbed to soil surfaces. While pH is the measure of H^+ in solution, Al^{3+} is important in acid soils because between pH 4 and 6, Al^{3+} reacts with water (H_2O) forming $AlOH^{2+}$, and $Al(OH)_2^+$, releasing extra H^+ ions. Every Al^{3+} ion can create 3 H^+ ions. Many other processes contribute to the formation of acid soils including rainfall, fertilizer use, plant root activity and the weathering of primary and secondary soil minerals. Acid soils can also be caused by pollutants such as acid rain and mine spoiling.

Rainfall: Acid soils are most often found in areas of high rainfall. Excess rainfall leaches base cation from the soil, increasing the percentage of Al^{3+} and H^+ relative to other cations. Additionally, rainwater has a slightly acidic pH of 5.7 due to a reaction with CO_2 in the atmosphere that forms carbonic acid.

Fertilizer use: Ammonium (NH_4^+) fertilizers react in the soil in a process called Nitrification to form nitrate (NO_3^-), and in the process release H^+ ions.

Plant root activity: Plants take up nutrients in the form of ions (NO_3^-, NH_4^+, Ca^{2+}, $H_2PO_4^-$ etc.), and often, they take up more cations than anions. However plants must maintain a neutral charge in their roots. In order to compensate for the extra positive charge, they will release H^+ ions from the root. Some plants will also exude organic acids into the soil to acidify the zone around their roots to help solubilise metal nutrients that are insoluble at neutral pH, such as iron (Fe).

Weathering of minerals: Both primary and secondary minerals that compose soil contain Al. As these minerals weather, some components such as Mg, Ca, and K, are taken up by plants, others such as Si are leached from the soil, but due to chemical properties, Fe and Al remain in the soil profile. Highly weathered soils are often characterized by having high concentrations of Fe and Al oxides.

Acid Rain: When atmospheric water reacts with sulphur and nitrogen compounds that result from industrial processes, the result can be the formation of sulphuric and nitric acid in rainwater. However the amount of acidity that is deposited in rainwater is much less, on average, than that created through agricultural activities.

- **Mine Spoil:** Severely acidic conditions can form in soils near mine spoils due to the oxidation of pyrite.

Ni general there are two adsorbed cations are responsible largely for soil acidity that a reaction **aluminum and hydrogen**.

- ✓ Co2 It makes the soil acidic by the following reaction Co2 +H2o gives H_2 CO_3 it cames from the soil organisms as result of respiration
- ✓ Up take of exchangeable cations (basic) by products
- ✓ Release of H+ by plants for contact exchange
- ✓ Aluminum containing fertilizer NH4+2H2O gives NO_3+H_2O+H+
- ✓ Sulfur
- ✓ Acid rain there are gases like C02,S02 NO, when they react with water they produce acid rain

- On strong acidic soil the majority crops produce yield less than their potential because of the following reasons:

- ✓ Aluminum toxicity
- ✓ Reduced microorganism activity
- ✓ Manganese toxicity
- ✓ Iron toxicity
- ✓ Calcium deficiency
- ✓ Magnesium deficiency
- ✓ Molybdenum deficiency

- **Sources of salinity and alkalinity**

Salinity: is the amount or the concentration of abnormally high level of salt .
It frequently occurs in association with irrigation and leads to the death of plants and loss of structure of soils
Alkalinity is the degree of increased in concentrationof OH- ions in the soils of arid and semi-arid areas because of water from rain or snow is insufficient to leach the base forming cations i.e Ca, Mg,K.Na etc.

- **Source of alkalinity**

✓ Base forming cations
✓ Role of carbonates(Co32-) and bi-carbonates (HCo3-)
✓ Natural salts such as NaCl ,K cl,Cacl,and Mgcl,

Alkalinity/ Basic soils have a high saturation of base cations (K^+, Ca^{2+}, Mg^{2+} and Na+). This is due to an accumulation of soluble salts are classified as either saline soil, sodic soil, saline-sodic soil or alkaline soil. All saline and sodic soils have high salt concentrations, with saline soils being dominated by Ca and Mg salts and sodic soils being dominated by Na. Alkaline soils are characterized by the presence of carbonates.

Fertilizers are categorized into one of two groups: acid-residue or alkaline-residue. The fertilizers themselves are not acidic or alkaline, but they react with microorganisms in the media and plant roots to affect media solution PH. Fertilizers with ample ammonium or urea tend to acidify the media, i.e., lower the PH. Fertilizers with ample nitrates tend to raise the pH of the media solution slowly over time. Alkalinity is one measure of the quality of water used for irrigation.

- **Water Quality/Alkalinity**

Water's capacity to neutralize acids. In other words, irrigating with bicarbonates in water is equivalent to applying lime with each irrigation. The bicarbonates react with hydrogen ions and remove them from solution. This process effectively decreases the H+ ion concentration in the media and thus increases the media solution PHS The reverse situation can also occur. Very pure water (low bicarbonates) can cause media solution pH to decrease over time. The pH drops, because there may not be enough bicarbonates to absorb excess hydrogen ions. Thus, the H+ concentration in the media increases. The most common solution for pure water sources is to increase the amount of pulverized dolomitic limestone incorporated into the media prior to transplanting plants into the media. Another solution is to top-dress containers with the limestone. Finally, bicarbonate can be added to irrigation water in the form of potassium bicarbonate to improve the buffering capacity of the media solution (i.e., reduce PH fluctuation).

- **Fertilizers Applied**: Fertilizers are categorized into one of two groups: acid-residue or alkaline-residue. The fertilizers themselves are not acidic or alkaline, but they react with microorganisms in the media and plant roots to affect media solution pHs Fertilizers with ample ammonium or urea tend to acidify the media, i.e., lower the pH Fertilizers with ample nitrates tend to raise the PH of the media solution slowly over time.

Self-Check – 1	**Written test**

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

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

Test I: Short Answer Questions

1. Define soil reaction (pH)
2. What are the major responsible elements (cation) for soil acidity?
3. What are the sources of acidity?
4. Define soil salinity
5. List sources of alkalinity
6. What are the effects of salinity and alkalinity?
7. Haw does soil pH affects nutrient availability? (3 point)
8. Which nutrient is most available at 6-8 PH? (3 point)
9. How do you determine soil pH? (3 point)
10. Which method of pH measurement is accurate and why? (3 point)
11. What is pH? (3 points)

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

Note: **Satisfactory rating – 11points** **Unsatisfactory - below 11 points**

Information Sheet 2- Identifying, comparing, selecting and sourcing Products useful in changing soil PH

2.1 Identifying, comparing, selecting and sourcing Products useful

There are many products which can be used to adjust soil or media pH and the selection of what products to use will depend on a number of factors, including:

- Whether the pH needs to be raised or lowered and how much change is needed
- Time available for making adjustment
- Availability and cost of materials
- Methods of application available

A brief guide to the types of products in common use in Ethiopia and the respective properties of these products is provided overleaf.

Products to use when the pH is too high, for most crops 'too high' is usually:

> PH 7.0 for mineral soils and > pH 6.0 for organic soils and inert media.

High soil or media pH can be the result of lime in the soil parent material and / or high concentration of bicarbonate ions in the irrigation water.

Treatments to address high pH work by the adding of hydrogen ions directly or indirectly to the root zone.

Products that can be used to lower the pH include:

- Organic matter
- Ammonium fertilisers
- Elemental sulphur
- Aluminium of Iron Sulphate
- Concentrated Nitric, Phosphoric or Sulphuric Acid

Organic matter

Microbial breakdown of organic matter in soil, releases Hydrogen ions which will lower the pH of the soil. This process is slow and the resulting change in pH is quite small. Therefore whilst the regular addition of organic matter to soil pre planting and as organic mulch has many beneficial effects, its main use is not primarily for pH adjustment.

Ammonium fertilisers

Ammonium fertilisers release Ammonium ions (NH_4^+) when dissolved in water. These Ammonium ions are changed to Nitrate ions (NO_3^-) by microorganisms in the soil and this process releases Hydrogen ions that will lower pH of soil or media.

The pH change that can be achieved is quite small but the advantages are that the change can be made as part of the routine fertiliser programme pre-planting and / or whilst the crop is growing and that the fertilisers are equally suitable for application as solid fertiliser or by fertigation.Fertilisers that can be used to reduce pH are Ammonium Sulphate, Urea, Ammonium Nitrate and Mono Ammonium Phosphate.

These fertilisers all contain Nitrogen so their use for pH adjustment is only possible when the Nitrogen content can be integrated into the planned Nitrogen fertiliser programme for the crop.

Elemental Sulphur

Elemental sulphur can be applied and incorporated into the soil at least one month before planting. Microbial action in the soil will turn the Sulphur into Sulphuric Acid which will increases the hydrogen ion concentration in the root zone and lower the pH. The amount of Sulphur required will depend on the soil type (buffering capacity) and the change in pH required.

General guidelines for application rates can be found in the literature but it is more practical and relevant to consult the Plant Nutrition specialists at the laboratory providing your soil analysis service who will be able to provide the necessary advice.

Aluminium Sulphate or Ferrous sulphate

Use of these products in Ethiopia is not common for soil grown crops. Application of these products to soil pre-planting creates chemical reactions in the soil leading to a lowering of pH. Great care is needed when using Aluminium Sulphate as overdosing can lead to Aluminium toxicity and severe crop loss.

Ferrous sulphate is however often used an as Iron source in fertigation for greenhouse crops grown in inert media.

Concentrated Nitric, Phosphoric or Sulphuric Acid

Concentrated Acids are dangerous to handle and are only used routinely in greenhouse fertigation programmes. Nitric and Phosphoric acids contribute N and P respectively to the nutrient programme but Sulphuric Acid is more usually the product of choice as it is cheaper.

Products that can be used to raise the pH .

- Various forms of Lime
- Nitrate fertilisers in place of Ammonium fertilisers

Lime and Dolomite Lime

Lime is a naturally occurring product quarried from the ground as Chalk, Limestone or Dolomite Lime. Chalk and Limestone contain a high proportion of Calcium Carbonate whilst Dolomite Lime contains both Calcium and Magnesium Carbonate.

In some countries, Limestone is heated to very high temperatures to create 'Quick Lime' (Calcium oxide) then on addition of water, slaked Lime (Calcium Hydroxide) is formed. Slaked lime is a fine white powder containing higher levels of Calcium that the original Limestone so produces greater and faster changes in soil and media pH.

In Ethiopia, Ground Limestone is the most commonly available Lime and is widely used for raising the pH of Acid soils and growing media.

Limestone is not made of pure Calcium Carbonate so the potency (Neutralising Value) of the Lime varies with the source. Neutralising value of a Lime source is measured in a Laboratory by comparing the ability of the Lime source to neutralise soil acidity with that of Calcium Oxide. Therefore the amount of Lime needed for treatment depends on a combination of factors:

The Neutralising Value of the lime source to be used

The difference between the actual soil or media pH and the target pH

The Type (buffering capacity) of the soil

The Soil Analysis Service Provider used by the Farm will be able to provide 'exact' recommendations.

The hardness of the Lime and the particle size of the source to be used are also important as these affect the rate of solubility in soil and therefore the rate of pH adjustment. Soft Lime and small particle size give the fastest response.

Lime should be incorporated into the soil to a depth of about 15 cm and in moist soil (near to field capacity), Farmers should allow at least 6 weeks between application and planting. Lime application as top dressing to a growing crop will have negligible effect on the pH in the root zone until the next rainy season or round on cultivation so this practice is not recommended.

Selection and use of Nitrate Fertiliser

Traditionally the Nitrogen Fertiliser of choice in Ethiopia has been Urea. Urea is relatively quick acting, cheap and readily available. It does however provide Nitrogen in the form of Ammonium ions NH_4^+ so contributes to the acidity of the soil of Growth media. (H^+ is released into the soil when the Ammonium ion is converted to Nitrate)

Where small increases in pH are needed, particularly in intensive horticultural production systems, a change from Urea to Calcium or Ammonium Nitrate applied either as base dressing and /or top dressing or fertigation can produce the desired effect.

Table 1. in summary:

Properties	Materials to Lower pH (i.e. To be used when the pH is too High)			
	Organic matter	Sulphur	Ammonium Fertilisers	Concentrated Acid
Rate of Change of pH	Very slow	2-6 weeks	1 week	1 week
Amount of change possible	Small	Limited only by rate of application	Small	Limited only by rate of application
Apply before planting and incorporate into soil or media	Yes	Yes	Yes	No
Apply to growing crop by top dressing or fertigation	As manure Tea	No	Yes	Yes Fertigation only
Other advantages	Good for micro-organisms and soil moisture retention Small nutrient value		Change can be achieved by fertiliser selection for use in the routine fertiliser programme	
Other disadvantages	Needs very high application rates to have much effect on pH.			Dangerous product Application only possible using advanced 3 tank fertigation systems

Properties	Materials to Raise pH (i.e. To be used when the pH is too Low)	
	Lime	Nitrate Fertilisers
Rate of Change of pH	Slow .... allow at least 6 weeks before planting	2-3 weeks whilst crop is growing
Amount of change possible	Limited only by rate of application	Small
Apply before planting and incorporate into soil or media	Yes	Yes
Apply to growing crop by top dressing or fertigation	No	Yes
Other advantages	Cheap and readily available	Change can be achieved by fertiliser selection for use in the routine fertiliser programme
Other disadvantages		More expensive

Self-Check – 2	**Written test**

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

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

Test I: Short Answer Questions

1. Explain the Term pH (3pts)
2. List three reasons why soil or growing media pH may change(3pts)
3. Explain briefly how pH affects crop growth(5pts)
4. Explain how to monitor pH in field grown crop production systems((4pts)
5. Why do you amend soils? (3pts)
6. What is the importance of gypsum? (3pts)
7. What is the importance of calcium silicate? (3pts)
8. Which element is the most effective in improving saline and alkaline soil? (3 pts)
9. What does liming means? (3pts)

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

***Note:* Satisfactory rating - 30 points** **Unsatisfactory - below 30 points**

3.1 Assessing product application methods

3.1.1 Choice of Application method

The choice of application methods available to farmers includes:

Application to the soil and incorporation to a depth of 15 cm several weeks before planting

Application to the soil or growth media and incorporation as part of the base dressing

Application as Top dressing to a growing crop

Application as part of a Fertigation programme

In relation to the products used for adjustment of pH, the following Application methods can be used:Organic matter, Sulphur, Lime and Ferrous or Aluminium Sulphate are applied to the soil and incorporation to a depth of 15 cm several weeks before planting

Ammonium or Nitrate Fertilisers can be applied to the soil or growth media and incorporation as part of the base dressing and /or applied as Top dressing to a growing crop and / or applied as part of a Fertigation programme

Concentrated Acid can only be applied using a 3 tank fertigation system

3.2 Effects of treatment on the Environment

The impact of soil or growth media treatment to adjust pH depends on the materials and how the use of the materials is managed. Effects can be both positive and negative.

- **Effects on the environment: Organic matter (Manure and Compost)**

The risk to the environment is that concentrated leachate from storage heaps or leachate from the production area will contaminate water courses, rivers and lakes with Nitrate. This Nitrate supports weed and algae growth in rivers and lakes leading to Eutrification (Oxygen depletion) of the water and death of fish when the weed and algae die at the end of their season and the bacterial responsible for decay use the oxygen in the water.

This risk can be reduced significantly by careful siting of manure and compost preparation sites so that leachate does not enter water courses, lakes and rivers. Safe distance, suggest at least 50m from water, no risk of flooding and if necessary bunding will all contribute to protection of the environment.

Application rate is also important. The total available nitrogen applied by the manure or compost plus the planned application of mineral fertilisers should not exceed the crop requirements. This will minimise the risk of leaching of excess Nitrate into the ground water at the end of the crop and where irrigation is used over application leading to leaching whilst the crop is in place should be avoided. Environmentalists would like to see 'Buffer zones' (5 m of natural vegetation) separating cropped areas from Lakes and Rivers to further minimise the risk of leaching but this practice is not well established in Ethiopia.

On the positive side, the use of Compost and manure does also benefit the environment; Nutrients in their Organic form and Mineral nutrients are less easily leached from soils with high organic matter content, water holding capacity is increased so again less leaching and a lower requirement for irrigation and the presence of Organic matter supports the soil microflora and fauna needed for disease suppression and decomposition (nutrient recycling) of organic matter.

Effects on the environment: Sulphur, Lime and Ferrous or Aluminium Sulphate

The effect of these products on the environment is minimal provided correct application rates and procedures are used. After application all of these products become fixed in the soil so there is very little risk of these products leaching into the ground water.

During application care should be taken to minimise contamination of people, and the general surroundings with dust.

Effects on the environment : Ammonium or Nitrate Fertilisers

All Nitrate and Ammonium fertilisers are very readily soluble and therefore are easily leached from soils and media. Here risks to the environment are minimised by implementation of ‘Good Agricultural Practices’; Safe storage, careful handling to minimise spillage, application of the correct amount, use of split applications, minimising leaching by not over irrigating, etc.

Effects on the environment: Concentrated Acid

Concentrated Acids are a significant OHS Hazard but pose almost no risk to the environment. Any acid spillage of leakage into the environment is rapidly diluted and neutralised by water and contact with soil so the impact on the environment is minimal

Self-Check – 2	**Written test**

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

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

1. What is the importance of fertilizer application?
2. Discuss types of fertilizing materials(1pts)
3. Discuss different sources of NPK fertilizer. Which of them are commonly used with our farmers? Why most of our farmers do not use fertilizers as a source of K (5 Pts)
4. What are the selection criteria for fertilizer fertilizing material(10pts)
5. What are the factors that determine the rate of fertilizer application (10pts)
6. Discuss time of application for NPK and organic fertilizers (10pts)

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

Note: **Satisfactory rating – 36 points** **Unsatisfactory - below 36 points**

Operation Sheet 1- Soil pH measurement by pH meter

Purpose: To Know the pH of the soil

Equipment, Tools and Materials:

- Balance
- Beaker(100 ml capacity)
- Measuring cylinder
- pH meter with electrodes
- glass rod
- buffer solutions (usually pH 4 and pH 10)
- ordinary filter paper
- washing bottle (with distilled water)

Conditions:

- Uniformity in soil characteristics
- Adjusting temperature knob for the correct temperature
- Calibration of the electrodes in buffer solution
- two buffer solutions, one acidic and one alkaline
- Proper reading of the soil pH on the pH meter

Procedure

1) Weigh 20 g of air dry soil into a 100 ml beaker
2) Add 40 ml of distilled water(1:2 ratio) and stir briskly at least thrice over a 30 minute period
3) In the meantime, switch on the pH meter and set the temperature compensation knob at the buffer solution temperature and the range selector to zero
4) Dip the electrode into a buffer solution of known pH, turn the range selector and adjust the reading to the pH of the buffer solution
5) Check the instrument with two buffer solutions of known pH, viz one acidic and another alkaline

6) Rinse the electrodes with distilled water and carefully wipe with filter paper

7) Shake the soil solution and insert the electrodes into it

8) Turn the selector in the proper pH range and read the pH on the dial of the meter

Quality Criteria:

1. Tools and materials must be properly utilized
2. Electrodes should not touch the bottom of the container while dipping them in to the test solution
3. Wash electrodes with a stream of distilled water immediately after testing
4. Suspend the electrodes in the distilled water for storage after cleaning to avoid drying

LAP TEST	**Performance Test**

Name………………… ID……………………………..

time started: ______________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **1** hour. The project is expected from each student to do it.

Task 1 Perform pH measurements of different agricultural soils for better use

LG #36	LO # 3.Determine nutritional problems in plants
Instruction sheet	

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

- Identifying common nutrient deficiency and toxicity problems in plants
- Consulting the supervisor and/or nutritional specialist
- Identifying, comparing, selecting and sourcing soil ameliorants

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

- Identifying common nutrient deficiency and toxicity problems in plants
- Consulting the supervisor and/or nutritional specialist
- Identifying, comparing, selecting and sourcing soil ameliorants

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

1.1. Identify common nutrient deficiency and toxicity problems

Symptoms of Nutrient Deficiency occur in plants when the tissue in the plant part affected does not have a sufficient amount of the nutrient concerned present in that part of the plant.This does not automatically mean that sufficient nutrient is not available in the soil.

Symptoms of Nutrient Toxicity occur in plants when the tissue in the plant part affected has too much of the nutrient concerned present in that part of the plant.

The visual appearance of Nutrient Deficiency or Toxicity is often the first sign of nutrient disorder in the plant/ crop and can be used as a diagnostic tool.

Key factors to note are:

- The colour and type of leaf discolouration present
- Leaf distortion and necrosis
- The position of the discolouration on the plant and the starting position of the symptoms on the plant
- Fruit and flower distortion
- Root deformities and cavities

Check also for the presence of visible pests and diseases. Several of the visible symptoms of nutrient disorders are very similar to the symptoms caused by pest and disease infection.

Some pictures of common symptoms and causes of nutrient deficiencies and toxicities are shown overleaf but remember that:

- Symptoms vary between different types of crop
- Deficiency and toxicity in the field does not appear as only that of individual nutrient, e.g. Incorrect pH may cause deficiency or toxicity of all minor nutrients depending

on the soil type and reserves.Pictures on the Internet are usually taken from plants raise in experimental / laboratory cultures.

- Visual symptoms are useful for identifying common nutrient disorders and diagnosis can be supported by circumstantial evidence, e.g. Nitrogen deficiency after a period of heavy rain
- Where the visual symptoms are not conclusive and / or you are working with a high value or long term crop, additional testing may be required to give positive identification of the problem and in this case the Manager may arrange for soil and sap analysis to be carried out.

Carbon, hydrogen and oxygen are obtained by the plant directly through air and water. A problem of toxicity (oversupply) or deficiency (undersupply) does not exist with these elements as the turf plant can regulate its own intake.

Roles of nutrients in plant growth

- **Nitrogen(N)**

Nitrogen is a constituent of all amino acids, (proteins), cell walls, chlorophyll, coenzymes and nucleic acids Nitrogen is particularly important for vegetative leafy growth in crops

- **Phosphorous(P)**

Phosphorous is important in energy transfer as part of Adenosine Triphosphate, (ATP). It also has many regulatory functions in photosynthesis, carbohydrate metabolism, translocation, protein synthesis, ion transport and acts as a catalyst in many biochemical reactions within the plant.

Phosphorous is particularly important for root and fruit growth and large amounts are found in seeds where the mineral will be required for germination.

- **Potassium (K)**

Potassium is a constituent of many coenzymes and is particularly important for membrane permeability, osmoregulation of cells and the movement of sugars around the plant. Potassium is also important for flowering and fruiting in crops

- **Calcium**

Calcium is an important constituent in cell walls and cell membranes

- **Magnesium**

Magnesium is an important constituent in Chlorophyll, aids sugar and starch formation and facilitates the translocation of phosphorus around the plant

- **Sulphur**

Sulphur is important for the synthesis of proteins.

Sulphur is also involved in the production of chlorophyll and enzymes and assists in the uptake of nitrogen

- **Chlorine**

Chlorine works with Potassium to control the movement of stomata and contributes to maintaining the ionic balance of the plant

- **Iron**

Iron are involved in the production of chlorophyll and enzymes

- **Manganese**

Manganese are involved in the production of chlorophyll and enzymes

- **Zinc**

Zinc is important for the production of growth hormones and for internode elongation

Zinc are needed for the synthesis of various enzymes in the plant.

- **Copper**

Copper are needed for the synthesis of various enzymes in the plant

- **Boron**

Boron is needed for various processes including the translocation and metabolism of sugars and production of Gibberellins

- **Molybdenum** Molybdenum assists with the uptake of Nitrogen by plant roots

Symptoms and common causes of Major Nutrient Deficiencies

Where deficiency of major nutrients is a problem plants will appear starved and large areas of the field will be affected.

The general appearance of the crop will be discolouration of leaves and slow stunted growth. Poor growth results in poor uptake most nutrients so symptoms of many different deficiencies may develop if top dressing is not applied in good time.

Pest and disease infestations will also be more prevalent.

- **Nitrogen (N) deficiency**

Nitrogen is a mobile element in the plant so deficiency shows first in the older leaves which become yellow. Growth will also slow down …. Plants will be shorter, leaves will be smaller and growth will become ‘hard’. Typical causes of Nitrogen deficiency are insufficient application and leaching caused usually by heavy rainfall. Problems may also arise when large amounts of crop residue or compost have been applied. Soil organisms that break down this material require Nitrogen for their own growth and this nitrogen is taken initially from the soil reserve creating temporary **‘Lock Up’ of Nitrogen** and deficiency in the crop

- **Phosphorus (P) deficiency**

Leaves may develop purple coloration, and growth may be stunted. There may also be some delay in plant development.

Deficiency in soil is rare but is more common in substrates where contributory causes are likely to be high pH or high zinc levels.

Low temperature can also be a factor as this reduces the rate of uptake from the soil or substrate

Phosphorous deficiency is easily confused with the purpling (anthracynin production) causes by stress and low temperature

- **Potassium (K) deficiency**

Older leaves turn yellow initially at the tip and spreading around the leaf margins.

Leaf margins may die and fruit development may be irregular.

Potassium deficiency symptoms are rare and usually results from under application.

Symptoms and common causes of Secondary Nutrient Deficiencies

Symptoms of Magnesium and Calcium deficiency are often induced by high levels of Potassium in the soil. This in a particular problem with intensive production of fruiting crops, e.g. Tomatoes. Ratios of Potassium and the Secondary nutrients should be kept within recommended levels for the combination of crop type, stage of growth and soil type prevailing.

Soils in several regions of Ethiopia have been shown to be deficient is Sulphur and this element is now included in the new Blended Fertilisers being introduced and recommended by the Ministry of agriculture in Ethiopia.

Calcium deficiency

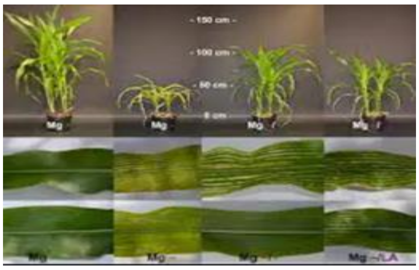
Calcium is immobile in the plant so deficiency shows in growing points and developing fruits where cell walls are being formed. This results in reduced growth or death of growing tips and poor fruit development. Blossom-end rot of tomato and pepper are common

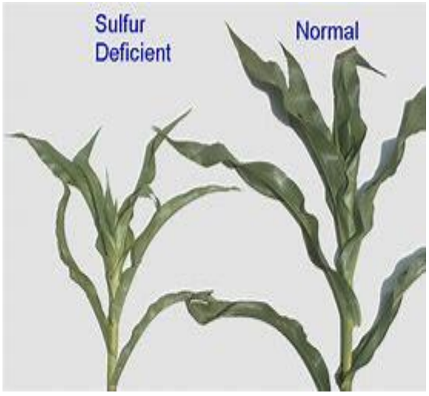
Deficiency is rarely due to lack of calcium in the soil and is more usually due to low uptake as a result of irregular watering and high concentrations of Magnesium or Potassium in the soil. Limited movement within the plant caused by high humidity and low transpiration rate can also be a factor.

Magnesium deficiency

Magnesium is a mobile element in the plant so deficiency shows initially as yellowing between leaf veins of old leaves. Deficiency will move progressively up to the younger leaves as the plant grows, unless treatment is applied. In tomatoes deficiency is common as fruit on the first truss approach maturity.

Deficiency is often related to high potassium levels in the soil and can be corrected by prompt application of foliar sprays of magnesium sulphate (Epsom Salts) or by inclusion of Epsom Salts in the Fertigation mix.



Sulphur deficiency Sulphur deficiency shows as overall stunting of growth and yellowing of the younger leaves and growing point eventually spreading to the whole plant. (Note this is distinct from Nitrogen deficiency where yellowing starts in the older leaves and spreads to the whole plant). Sulphur may be included in the fertiliser programme by selecting fertilisers containing sulphate ions, e.g. Ammonium Sulphate $(NH4)_2SO^4$ and all of the new **Blended Fertilisers** introduced by the Government do now contain Sulphur	 

Symptoms and causes of common Minor Nutrient (Trace Element) Deficiencies

The causes of deficiency of minor nutrients are complex due to their sensitivity to pH, binding to soil particles and interaction with other nutrients needed for plant growth. Plants are also very sensitive to the amount of minor nutrient available in the soil as the actual amount needed is very small so the difference in concentration needed for deficiency or toxicity is also very small.

Iron deficiency Iron deficiency is quite common when the soil pH is high.
Iron is not mobile in the plant and deficiency shows as a very distinct chlorosis of the growing points. Foliar application of Iron at an early stage of deficiency will reverse the chlorosis but delayed treatment results in permanent damage.

Manganese deficiency Manganese deficiency shows as interveinal chlorosis in the young leaves. Leaf veins may develop a purple grey colour

Boron deficiency Boron deficiency is common, particularly where the soil pH is neutral to alkaline. Cell division is affected and the first effects of deficiency are seen

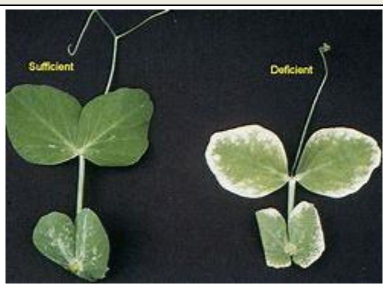
first in the growing point which will become distorted, growth is thick, stunted and the leaves are brittle. Stems may become hollow and cavities may develop in root vegetables.
Molybdenum deficiency Molybdenum deficiency shows as interveinal chlorosis in the older leaves where nitrate reduction to ammonium is affected. Molybdenum deficiency also prevents the nitrification of NH_4^+ (Ammonium) ions by Nitrifying bacterial in the soil.
Copper deficiency Copper deficiency results reduced growth, young leaves are pale in colour and may curl; leaf petioles will bend downwards
Zinc deficiency Zinc is involved with production of growth hormones so deficiency shows as stunted growth. Interveinal chlorosis becomes very pronounced in the middle leaves on the plant and necrotic spots may develop on the upper side of the young leaves.

Iron deficiency

Manganese deficiency

Boron Deficiency

Copper deficiency



Zinc deficiency

Molybdenum deficiency

Symptoms and common causes of Major Nutrient Toxicities

Nitrogen (N)

True Nitrogen toxicity is extremely rare but Over supply is quite common.

Over supply can result from over application or sudden release by Nitrogen 'Locked Up during the decomposition of organic matter in the soil and will result in soft luxurious deep green vegetative growth which may cause lodging, delayed flowering and fruiting and increased susceptibility to pests and disease infection.

Over application also results in extra fertiliser cost and a greater risk of leaching and environmental pollution.

Phosphorus (P)

Phosphorous toxicity is very rare. Large amounts of Phosphates are often present is soils but are fixed as insoluble compounds or bonded to soil particles so are not available to the plant and have no direct adverse effect on plant growth.

High levels of Phosphate in the soil do however precipitate (Fix) some Minor elements in the soil so deficiency of Iron and Zinc may be induced.

Potassium (K)

Potassium toxicity is also very rare but application of large amounts of potassium can cause magnesium and calcium deficiency by reducing the uptake of these elements.

Fertiliser programmes should provide K^+ and Mg^{2+} in the ratios needed for plant growth which is between 3:1 and 4:1

Heavy application of potassium (potash fertiliser) will also increase the conductivity of the soil or growing media and result in hard growth and leaves that are a dark blue green colour

Symptoms and common causes of sub Major Nutrient Toxicities

Toxicity of Calcium and Sulphur is extremely rare

Toxicity symptoms of Magnesium are also extremely rare but due to the antagonistic relationship between Calcium, Magnesium and Potassium, high Magnesium levels in the soil can cause Calcium deficiency

Minor Nutrient (Trace Element) and Aluminium Toxicity

Minor nutrient toxicity in field conditions is rare. However high levels of Manganese, Zinc and Aluminium do occur when the soil pH is low and can be a problem

Manganese toxicity can occur and High levels of Zinc will cause Iron deficiency

Aluminium toxicity is an indicator that the soil pH is too low for optimum crop growth.

Figure 1. Ten day old wheat seedlings gown in soils selected for a range of extracted aluminium. Low aluminium on the left, high aluminium on the right showing stunted roots with few branches. Photograph courtesy of Dr Steve Carr

Manganese toxicity **Aluminium toxicity**

Self-Check – 1	**Written test**

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

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

Part I. Choose the correct answer

1. Which one is false about deficiency symptoms of nutrients in plants?
   A. commonly recognized through visual observation
   B. It is easily identified symptom
   C. It is less accurate than plant analysis
   D. Nutrient deficiency can be masked by other causes

2. Deficiency symptoms of major nutrients is observed on __________leaves.

   A. Lower B. Young C. old D. B &C

3. Deficiency symptoms in plants can be similar to other causes A.True B. False

4. Soil testing is used whether the applied nutrient has entered the plant or not

   A. True B. False

Patr II. Match the letter with the correct answer from column 'B ' to column 'A'

A	B
_______1. Nutrient status	A. P deficiency
_______2. Interveinal chlorosis of lower leaves	B. N deficiency
_______3.Marginal burning of lowers leaves	C. Soil testing
_______4. Purplish color in lower leaves	D. K deficiency
_______5. Measures fertility status	E. Soil fertility
_______6. Yellowing of lower leaves	F. Mg deficiency

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

Note: **Satisfactory rating - 20 points** **Unsatisfactory - below 20 points**

Information Sheet 2- Consulting the supervisor and/or nutritional specialist

2.1 Consulting the supervisor and/or nutritional specialist

Plants require some nutrients in large quantities called macronutrients while some in smaller quantities known as micronutrients. Gases such as carbon dioxide and oxygen are provided through the air while hydrogen is provided by water. Soil supplies thirteen additional micronutrients (Iron, copper, zinc, chlorine, boron, manganese) and macronutrients (calcium, magnesium, potassium, nitrogen, phosphorous).

Deficiency of these nutrients inhibits the growth of plants, affects their life cycle, processes and decreases their immunity against diseases. Soil's fertility can be increased by providing nutrients in the form of manure and fertilizers.

Nutrient management refers to the efficient use of crops to improve productivity. It is necessary to balance the soil nutrient input with the crop requirement. If the nutrients are applied at the right time and in adequate quantities, optimum crop yield is obtained. If applied in huge amounts, it will harm the crop, and if applied in small quantities it limits the yield.

The nutrients that are not utilized by the crops leach into groundwater or nearby surface water.

Integrated nutrient management is the combined application of chemical fertilizers and organic manures for crop production.

Its main aim is the maintenance of soil fertility and the supply of plant nutrients in adequate amounts. It is ecologically, socially and economically viable.

- The nutrients stored in the soil.
- The nutrients purchased from outside the farm.
- Plant nutrients present in crop residues, manures, and domestic wastes.
- Nutrient uptake by crops at harvest time.
- Plant nutrients lost from the field during crop harvest or through volatilization

Nutrient Management Specialists examine and analyze current plant nutrient raising and processing techniques and attempt to improve them. First, they conduct research and collect data about the components that go into crop growing and plant nutrient analysis. After gathering their data, they examine it and create possible solutions to the problems discovered. They then communicate these ideas to the food processors and the scientific community as a whole. Many Nutrient Management Specialists work independently or with little supervision throughout much of their work process.

Table 2.1 Consulting nutritional specialist

Types of testing	Reasons for testing	Method and frequency of testing
EC (Electrical Conductivity) test Measures the amount of salts present in the soil profile or irrigation water.	To ensure the salt content of irrigation water is below the recommended range for the growth of plants. Salt levels may rise due to high levels in the irrigation water or from fertilizers	Tests can be performed for soil and water. On-job testing may be done with hand-held EC tester. **Frequency:** Annually, or more frequently if there are high salt levels in the irrigation water
pH (potential Hydrogen) test Measures the acidity or alkalinity of a solution: PH below 7 is acidic. pH of 7 is neutral pH above 7 is alkaline	To check levels of pH in the soil. High or low levels can affect the availability of many nutrients to the plant. High pH irrigation water may raise the pH levels in the soil.	Tests can be performed for soil and water. Testing is done with the 5-1 soil water mix. On-job sampling can be done with paste and color chart testing kit. **Frequency:** Annually, until a database is collected

Nutrition – soil analysis Measures the nutrient status within the soil.	**Soil analysis.** To aid in the detection of nutrient deficiency or toxicity. test for the amounts of: calcium (Ca) potassium (K) sulphur (S) magnesium (Mg) phosphorus (P), **Note:** Nitrogen (N) cannot be accurately determined by soil analysis as nitrogen is mobile.	Off-site. Soil samples should be taken and sent to a chemical analysis laboratory. **Frequency:** Annually until a sufficient database is compiled. If there is no change, reduce testing to every second year
Nutrition – tissue analysis Measures the nutrient status within the plant.	**Tissue analysis.** Indicates the nutrient status of the plant and can be valuable to determine which nutrients the plant has taken up in sufficient amounts. Micronutrients such as: manganese (Mn) iron (Fe) molybdenum (Mo) zinc (Zn) copper (Cu) chlorine (Cl) Boron (Bo).	Off-site. Tissue samples to be taken and sent to laboratory for analysis and recommendations. **Frequency:** Annually

Self-Check – 2	**Written test**

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

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

Test I: Short Answer Questions

1. Why do you measure EC? (3pts)
2. What is the importance is of tissue analysis? (3pts)
3. What does moisture have in relation to nutrient deficiency? (3pts)
4. What bulk density? (3pts)
5. What is the importance of knowing percolation rate? (3pts)

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

Note: **Satisfactory rating – 15 points** **Unsatisfactory - below 15 points**

3.1 Selecting and Use of Soil Ameliorants or Soil amendments

Soil Ameliorants are defined as materials added to soil to improve fertility.

Soil amendments /Soil ameliorants are the substance used for correcting the acidity or alkalinity of the soil. In high rainfall areas, due to the leaching of bases, acidic soils are formed. While in low rainfall regions in arid and semi-arid conditions, saline and alkaline soils occur.

Soil amelioration is a term used to describe an improvement in soil structure through mechanical inputs with the primary aim of improving air and water balance within the soil. Of the many types of problem soils, acid and alkali soils are mentioned here as Examples. Amelioration of problem soils is a precondition for optimizing plant

Nutrition this is because such soils cannot make the best use of the nutrients

Applied in the absence of suitable amendments. In fact, soil amendments should

Precede nutrient application. Once the soils have been amended, the crops grown

on them can make efficient use of the nutrients applied and high yields can be Obtained on a sustained basis. Soil amendment is any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. Amending a soil is not the same thing as mulching, although many mulches also are used as amendments. A mulch is left on the soil surface

Soil Fertility is the ability of a soil to sustain agricultural plant growth, i.e. to provide plant habitat, and result in sustained and consistent yields of high quality

A fertile soil has the following properties:

The ability to supply essential plant nutrients and water in adequate amounts and proportions for plant growth and reproduction

- The absence of toxic substances which may inhibit plant growth.
- Sufficient soil depth for adequate root growth and water retention;
- Good internal drainage, allowing sufficient aeration for optimal root growth (although some plants, such as rice, tolerate waterlogging);
- Topsoil with sufficient soil organic matter for healthy soil structure and soil moisture retention;
- Soil pH in the range 5.5 to 7.0 (suitable for most plants but some prefer or tolerate more acid or alkaline conditions);
- Adequate concentrations of essential plant nutrients in plant-available forms;
- Presence of a range of microorganisms that support plant growth.

Repeated use of land for crop production can result in loss of soil fertility due to:

- Nutrient depletion (Insufficient fertiliser application)
- Soil compaction (poor cultivation practices ….ploughing in wet conditions and always at the same depth)
- Increasing soil salinity (poor quality water used for irrigation and failure to take measure to reduce surface evaporation)
- Incorrect fertiliser selection (Repeated use of acidifying fertiliser e.g. Urea)
- Loss of organic matter from the soil (Removal of crop and crop residue)

Therefore repeated use of land for Agricultural production requires that attention is given to maintaining soil fertility and this will require implementation of Good Agricultural Practices including the appropriate use of Soil Ameliorants.

Types of soil ameliorant include:

- Green manure (Cover Crops)
- Animal manure
- Compost
- Lime
- Gypsum
- Organic and inorganic fertiliser

The types and properties of Soil Ameliorants.

- **Green manure (Cover Crops)**

The principle of using Green Manure (Cover) Crops is that the Green Manure crop is planted at a time in the crop rotation when the soil would lie fallow (no crop in place) or in intensive cropping systems can actually be inter planted or under-planted in crops such as Maize, Sorghum or Millet. Then after the green manure crop has grown, the crop is ploughed into the soil to increase the soil organic matter or is harvested and fed to livestock with the residue being directly returned to the soil.

Crops selected for Green Manure production must fit the local climate and cropping system and should ideally be nitrogen fixing. Crops that have been used successfully in Eastern Africa include; Sun Hemp, Pigeon Peas, cow Peas, Lablab and Alfalfa (Lucerne). Informal weed growth can also provide some of the advantages of a Cover Crop but it is essential to cut and or incorporate the weed growth before the weeds set seed!

The advantages of using a Cover crop are many and include:

- Suppression of weed growth and protection of the soil surface from leaching and erosion
- Nutrient enrichment (when Legumes are used) and nutrient recycling
- Provision of food for human consumption, food for livestock and organic matter for the soil
- Support for the soil micro flora and fauna and increases water holding capacity of the soil.

The disadvantages of using cover crops are few but need to be addressed:

- ✓ Farmers will undoubtedly focus on the extra cost of seed and land preparation which can be offset by the human and livestock feed produced, reduced fertiliser cost in the next crop if Legumes were used
- ✓ **'**Temporary Lock Up' of Nitrogen may occur if crops are planted immediately after the Green manure has been incorporated.

Animal manure

Application of Animal manure prior to planting is also a valuable way of enriching the soil with nutrients and organic matter. However in Ethiopia the availability of good Animal manure is limited to farmers operating near to livestock farms. Within the rural community, most animal manure is removed from the farming nitrogen cycle and used for fuel or building.

When selecting and using Animal manures, several factors need to be considered:

- ✓ The manure should be allowed to rot for several months before use ….fresh manure will scorch the crop roots
- ✓ The nutritional value of the manure will depend on the type of animal, the diet of the animal and whether animal bedding in included in the sample. In most cases it is probably best to consider manure as a useful ameliorant but not as the main nutrient source. Where manure is to be the main nutrient source, the farmer needs an analysis of the product and to calculate the application rate needed based on the soil and manure analysis and the crop requirements.

Weed seed may be an issue. Many types of weed seed survive passage through an animal.Transport of the manure to the field site may be an added cost.

Compost

Long-term solution for acidic soil is to keep adding good quality compost to the area. While these used have an initial impact on the soil pH, it will help improve it overtime and provide any plants in the area with vital nutrients while you're getting the soils acidity level under control. Add at least 2-3 inches of compost per year, either to the surface of the soil or dig into the soil. If it's a new planting area, or one replant every year, such as vegetable garden, then dig it into the top few inches of soil at or before planting time, or at the end of the season **.**Composting is the process that occurs when plant material rots.

The end product (when the compost is well made), is useful for soil amelioration; increasing soil organic matter, increasing water holding capacity, reducing leaching of mineral nutrients, supporting soil micro flora and fauna and increasing soil friability, (crumbliness).

Production of good compost needs a management and commitment. In brief:

- You need a mix of green and dry materials to give a C : N ratio of about 30:1.
- Heavily infected material and weed seed should be excluded
- Addition of animal manure is useful but not essential
- The process is aerobic so production above ground is preferred (this is contrary to common practice in Ethiopia where material is just dumped in a hole in the ground). Green and dry material should be layered, compacted and gently compacted
- Turning is necessary to ensure that all the material is 'cooked' and watering in the dry season will be necessary.
- Organisation of the site and management of the materials is necessary to reduce time spent on double handling to make heaps.

On most farms compost preparation fails due to lack of materials and lack of management of the composting process.

Lime Adding pulverized limestone or dolomite limestone is one of the fastest ways to increase your soil ph. The general recommendation for adding lime to your soil is to add 5-10 lbs. per 100 sq. ft. Of garden soil to increase your soils pH by one level

The primary reason for adding lime to soil is to raise the pH, see LO 2 but in Heavy Clay soil Lime can also be used to improve drainage and soil friability. The Calcium ions provided by the Lime are divalent, Ca^{2+} so one calcium ion can hold two clay particles together. This process is called flocculation and the larger particle units created in the soil contribute to increases in porosity, drainage and aeration.

The limitation to using lime in this way is that the Soil pH should be kept within the acceptable range for the crops to be grown.

Gypsum (Calcium sulphate)

Gypsum is used in the reclamation of Sodic soil (soil where the concentration of Sodium ions will inhibit crop growth).

The treatment works on the basis that the Calcium ions from the Gypsum displace the Sodium ions held on the soil clay particles (by the process of Cation Exchange). The beneficial effect of this is that the Calcium ions help to flocculate the clay, see above, and the sodium ion are now free in the soil water so can be leached.

Organic and inorganic fertilisers

Organic and inorganic fertilisers are sometimes included in the definition of soil ameliorants. These products may be used to raise the nutritional content of the soil where the natural fertility is low or nutrients have been removed by cropping or leaching. LO 4-6 following give more details about the use of Organic and inorganic fertilisers.

Table 1 Quick scan of the properties soil ameliorants

Quick scan of the properties of soil ameliorants in common use					
Properties	**Cover crops**	**Manure**	**Compost**	**Lime**	**Gypsum**
Benefits					
Soil Organic Matter increased	X	X	X		
Water Holding Capacity increased	X	X	X		
Soil microflora & fauna increased	X	X	X		
Aeration increased	X	X	X	x	X
Nutrients added to soil	x*	X	X		
Leaching of mineral nutrient reduced	X	X	X		
Removal of toxic ions facilitated					x
Problems					
Cost involved	X	x		x	x
Management & Labour required	X		X	x	x
Weed seeds		x	X		
Minor OHS Microbe concern		x**	x***		

* If Nitrogen fixing crops (Legumes) are used ** E coli *** Aspergillus fun

Self-Check – 2	**Written test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Explain the terms (5pts)

a. Soil fertility

b. Soil ameliorant

2. List 4 soil ameliorants(5pts)
3. Select one type of organic soil ameliorant and:(5pts)

a. Explain when and why it should be used

b. The advantages and disadvantages of the ameliorant selected

***Note:* Satisfactory rating – 15 points** **Unsatisfactory - below 15 points**

Operations Sheet 1 Nutritional problems in plants

Examine the Crops and or pictures provided by your Instructors and:

- ✓ Describe the symptoms presented by the plants
- ✓ Identify the probable nutrient deficiencies or toxicities presented
- ✓ Explain what additional information is needed to help to confirm your identification
- ✓ Collect and present a plant sample for formal identification by a specialist
- ✓ Review the practices used in the student plots or similar intensive field cropping system and:
- ✓ Identify practices that could lead to a reduction in soil fertility
- ✓ Identify soil ameliorants that are available or could be available
- ✓ Select suitable ameliorants and make a plan Showing when and how these ameliorants should be used

Justify your selection of ameliorants and explain what you hope to achieve by using the selected ameliorants.

LAP TEST	**Performance Test**

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

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **1** hour. The project is expected from each student to do it.

Task 1:- To identify nutrient deficiencies and toxicities from the visual symptoms shown by the plant

Task 2. To prepare a plant sample and collect the support information needed for a Specialist to confirm the type and cause of the nutrient problem present in the crop

Task 3. To select suitable soil ameliorants to help to maintain or improve soil fertility in a defined farming situation

LG #37	LO # 4 Prepare materials and equipment to apply fertilizers

Instruction sheet
This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics: • Selecting the fertilizer to be used with environmental implications. • Assessing fertilizer application methods • Selecting tools, equipment and machinery • Carrying out pre-operational and safety checks • Calibrating and adjusting tools, equipment and machinery • Applying fertilizers • Handling and storing fertilizers safely This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, **upon completion of this learning guide, you will be able to**: • Selecting the fertilizer to be used with environmental implications. • Assessing fertilizer application methods • Selecting tools, equipment and machinery • Carrying out pre-operational and safety checks • Calibrating and adjusting tools, equipment and machinery • Applying fertilizers • Handling and storing fertilizers safely

Learning Instructions:
1. Read the specific objectives of this Learning Guide. 2. Follow the instructions described below. 3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them. 4. Accomplish the "Self-checks" which are placed following all information sheets. 5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks). 6. If you earned a satisfactory evaluation proceed to "Operation sheets 7. Perform "the Learning activity performance test" which is placed following "Operation sheets" , 8. If your performance is satisfactory proceed to the next learning guide, 9. If your performance is unsatisfactory, see your trainer for further instructions or go back to "Operation sheets".

Information Sheet 1- Selecting the fertilizer to be used with environmental implications

1.1 Selection of type of fertilisers

Fertilisers can be categorised into various types based on origin of the material, nutrient composition and formulation:

- Origin of materials …..Organic or Inorganic
- Nutrient content ………Straight, Compound or Blended
- Formulation ……………..Powder, Prills, Granules or Chelates

Note that a fertiliser product may fall into more than one category, e.g. Ammonium Nitrate is an Inorganic, straight fertiliser, suitable for both soil and foliar application and available in powder or prilled formulation.

Which types of fertiliser are selected by an enterprise will be affected by the philosophy of the Farmer, the soil type on the farm, the methods of application to be used and the possible impact on the environment:

- Philosophy /Ideal …………………..Integrated or Organic Farming
- Soil type ……………………..…. Clay or Sandy soil
- Application method ……. Manual or mechanical, pre-planting or top dressing, soil or foliar application, etc

Fertilizers

Fertilizers are substances applied to soil to increase crop yields by providing one or more of the elements that are essential plant nutrients

Types of fertilizers

Organic manures are bulky which are applied in large quantities and contain low amount of plant nutrients. E.g. farm yard manure, compost, night soil

- ✓ Chemical /commercial/Artificial
    - Urea, DAP, TSP

An overview of which types of fertilisers are suitable for use on these various situations is provided below.

Organic Fertilisers

Manure and compost can be considered as fertiliser when high levels of application are used and incorporated pre-planting but these products are more usually considered as soil ameliorant

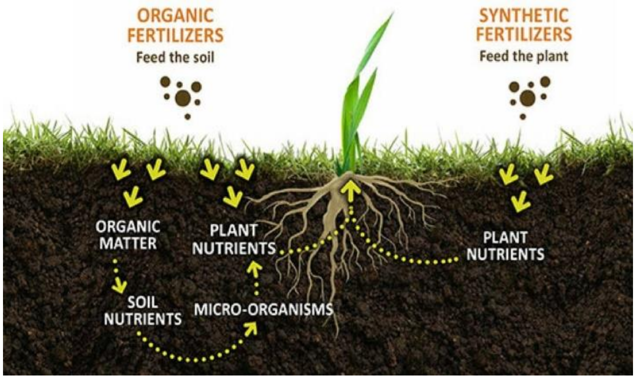
- **Natural /organic manure**

  - ✓ Farm yard manure
  - ✓ Green manure
  - ✓ Compost
  - ✓ Vermicompost

Liquid organic fertiliser can be made on the farm by soaking selected plant types or sacks of manure then diluting and applying the leachate to the soil or as a foliar spray. The nutrient value of these preparations is however dependant on the quality of material used to make the fertiliser so unless the farm is committed to 'Organic Production', there may be a need to supplement the fertiliser programme with some inorganic fertiliser.

Commercially prepared preparations are also available and these preparations do have a stated nutrient content for major nutrients.

Application of liquid organic fertiliser is possible using spraying equipment or drip irrigation systems but the turbidity of the produce can create problems with blocked filters and nozzles.

Organic fertilisers have the advantage of providing a wide range of nutrients and growth enhancing compounds and nutrients supplied in organic form are less easily leached, particularly in sandy soil than those provided in inorganic form. Organic fertilisers also support and enhance the soil microflora and fauna and make useful contribution to the soil organic matter content.	

Organic nutrients are generally seen as being ‘Environmentally friendly’ but the concentrated leachate from manure and compost heaps is very rich in nutrients and will do serious damage if it leaks into water sources.

Inorganic fertiliser

Inorganic fertiliser provides nutrients in mineral form. This means that these products are readily soluble in water so provide a rapid response in plant growth but are also easily leached from the soil. Inorganic fertilisers are suitable for all types of application and give reliability and flexibility to the fertiliser programme for a crop.The nutrient value is known, application can be made at different stages of crop growth and the wide variety of product available means the desired balance of nutrients for each stage of crop growth can be provided.

Straight, Compound or Blended

These terms describe the nutrient mix in the product and are usually only applied to inorganic fertilisers:

Straight fertilisers contain only one nutrient, e.g. Ammonium Nitrate supplies only Nitrogen.

Compound fertilisers contain two or more nutrients within the same molecule, e.g. Potassium Nitrate which contains Potassium and Nitrogen. The term Compound fertiliser is also used to describe granular fertilisers where each granule contains two or more nutrients and the nutrient ratio in each granule is the same.

Blended fertilisers are produced by mixing different types of fertiliser to produce the nutrient content and nutrient ratio required. When Blended fertiliser is supplied as a mixture, the farmer needs to check that the different types of granules are evenly mixed before application. If the granules are of different sizes or weights, mechanical application will not be possible as the mixture will separate during the application process. Where the Blend is manufactured so that all the nutrients are represented in the correct ratio in each granule or the granules are of equal size and weight, this is not a problem.

Powder is finely ground fertiliser. Small particle size means that the product will dissolve quickly and very even application is possible, increasing the chance of the fertiliser being placed near to roots.

Prills are small evenly sized balls of fertiliser coated with a material that will prevent uptake of water from the atmosphere. This facilitates mechanical application and prevents the fertiliser deliquescing and then caking on drying.Ammonium Nitrate is prepared in this way and is coated with Magnesium Sulphate.

Granules are small lumps of fertiliser. Granulation facilitates accurate mechanical application provided that the granules are small enough for even application and are free flowing

Chelation is usually used for Trace elements which are easily locked up at high or low pH. In Chelation a large molecule e.g. EDTA or EDDHA is attached to the trace element in its available form and the Trace element is protected from the effect of pH by the attached molecule, (Ligand). Different chelating molecules are used for different pH situation.

In Small Farms, the selection of fertiliser type to use is made by the Farmer in consultation with the DA and local suppliers.

In large commercial enterprises the selection of fertiliser type to use will be made by the Manager in consultation with the farm consultant and suppliers.

Self-Check – 1	**Written test**

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

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

1. How do you select fertilizer? (3pts)
2. What are the factors that influence fertilizer selection? (3pts)
3. What are the choices of fertilizer? (3pts)
4. Why do you send the soil sample to the laboratory? (3pts)

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

***Note:* Satisfactory rating - 12 points** **Unsatisfactory - below 12 points**

Information Sheet 2- Assessing fertilizer application methods

2.1 Applying Fertilizer Using Appropriate Method

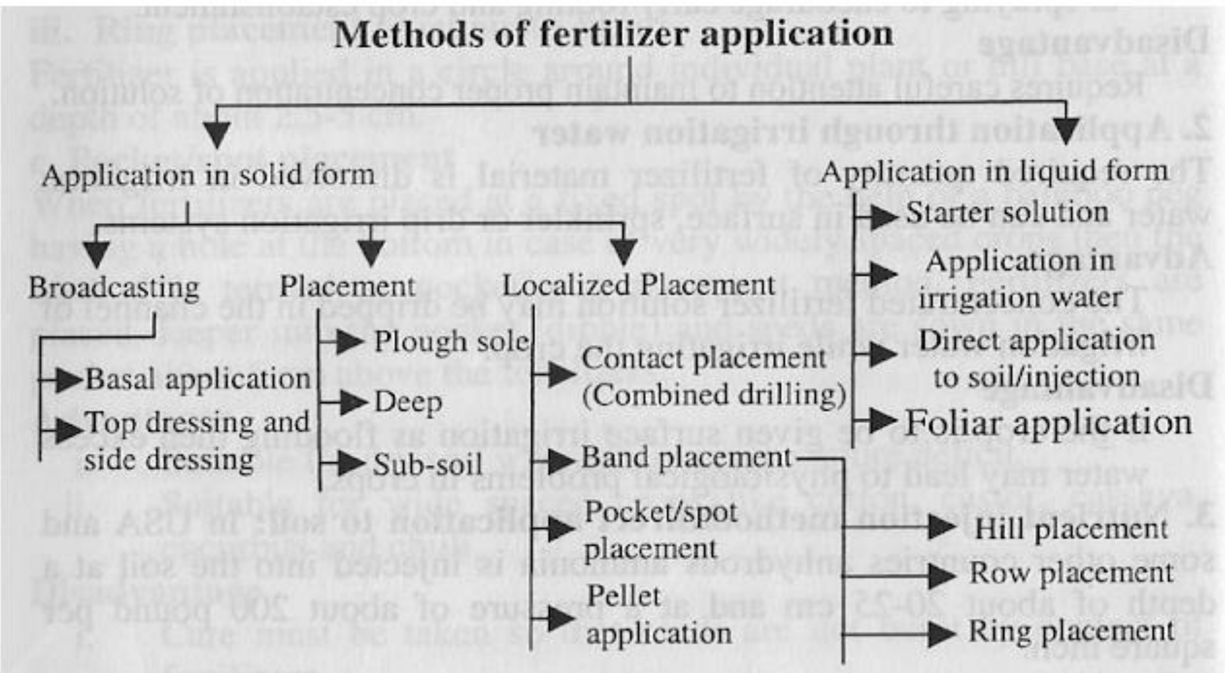
Factors which affect the choice of application method and fertiliser placement include:

- Cropping system (full field coverage e.g. cereals or discrete rows in beds, e.g tomato)
- Stage of crop growth
- Scale of production and value of the crop
- Rain fed or irrigated and if irrigated, what Irrigation system is in use
- Manual or mechanical application and if mechanical, what Equipment is available

Application methods available include:

New Update Methods of Fertilizer Application

January 14, 2019



Broadcast, banded or placed per plant suitable for Solid fertiliser

Fertigation or foliar spray Used for Fertiliser dissolved in water

Gas injection is also possible for Nitrogen application but the Equipment is very expensive so this method is not widely used.

The aims of fertiliser application are to place the correct amount of fertiliser close to the plant root so that uptake of nutrients is facilitated. In practice this is achieved by:

2.2. Method of application of solid fertilizer materials

2.2.1 Broadcast application

Even and uniform spreading of dry solid fertilizers by hand or spreader over the entire field before or after sowing of the crop is termed as broadcasting. Well decomposed FYM, compost, oil cake, bone meal, urea, superphosphate and lime are applied by this method. Broadcast application can be used for both Base Dressing and Top dressing and can be done manually or mechanically using hand held or tractor mounted equipment.

Bulky organic materials are usually broadcast over the whole cropping area pre planting and incorporated during field cultivations. Inorganic fertilizers can similarly be applied either to the whole field or to the bed pre planting and incorporated into the top 15 cm of the soil, (Root Zone).

Advantages

This method is easy, less time taking, cheap and more convenient to the farmers. This method proves effective-

- When the crops have a dense stand
- When the plant roots absorb nutrient from whole volume of soil
- When soil is rich in fertility
- When large amount of material is to be use

Disadvantages

- It is not advantageous because it encourages weed growth all over the field.
- Most of the material remains on the soil surface and does not reach to the root zone for uptake by plants.
- There is greater loss of fertilizer nutrients due to washing, run-off, volatilization, etc. Hence the recovery (extent of fertilizer used by plants) ranges between 25 to 45 per cent or even less.

Inorganic fertilisers can also be broadcast over a growing crop as Top Dressing.

Please ensure that the foliage is dry to prevent leaf scorch and note that these nutrients will only reach the plant roots in rain fed crops or crops where overhead sprinkler irrigation is used.

Note also that the method is only recommended where there is full crop cover of the field.

Fig 1 broadcast method

Broadcast application is particularly suitable for densely planted crops where the roots will grow into the whole area treated. In bed or row crops fertiliser that lands outside the cropped area in paths will be wasted; either leached or used to support weed growth!

Broadcasting may be done in following ways:

a. Basal application

Spreading of fertilizers before sowing or planting of the crops and mixing them by cultivating the soil during seed bed preparation is termed as basal application through broadcasting

Advantages

- Controlled/slow release fertilizers are applied in this inctliod
- Bulky manures are applied in this method.

Disadvantage

- Encourages early weed growth

b. Top dressing and side dressing

Spreading of fertilizer in standing crops without considering the crop rows is termed as top dressing. But when the crop rows are taken into account and the material is dropped on the ground surface near the crop rows then it is called as side dressing.

Advantages

- Highly mobile fertilizers are top dressed by split application.
- Side dressing reduces misuse of fertilizers in row crops

✓ **Disadvantage**

- Top dressing is not suitable for bulky manures.

2. 2.2 Placement

This refers to applying fertilizers into the soil from where the crop roots can take them easily.

Advantages

- Maximum portion of the material can be used by plants
- Losses through uptake by weeds, washing, run-off, volatilization etc. could be eliminated to the greatest extent.

Disadvantage

- Is not suitable for bulky manures.

Placement could be done in following ways:

a. Plough sole placement

When the fertilizers are applied in open furrows at plough sole level while ploughing then it is termed as plough sole placement. Such furrows are covered immediately during the next run of the plough

Advantages

- This method is suitable when-
- In dry soil where there is a moisture only in the plough sole layer
- In problem soils where there is the problem of fixation

Disadvantage

- Is not suitable for bulky manures.

b. Deep placement

The method is adopted in dry land condition where the fertilizers are placed deeper than plough sole level then it is called as deep placement.

Advantages

- Suitable for dry soil where there is a moisture deficit.
- Helps in root elongation.
- Eliminates various losses of nutrients from the soil.
- In wet land rice a reduced form of N fertilizer (ammonium sulphate) is placed deep in the reduced layer to avoid denitrification.

Disadvantage

Laborious and time consuming.

c. Sub-soil placement

When fertilizers are placed still deeper than the seeding or planting depth and also deeper than the previous two methods the method is termed as sub-soil placement.

Advantages

- Suitable for dry soil where there is a moisture deficit.
- Helps in maximum root elongation.
- In strongly acidic soils P and K fertilizers .are placed in deeper layers by heavy machinery to avoid fixation.

Disadvantage

- Laborious and time consuming.

2.2.3. Localized placement

There is distinction between placement and localized placement. The former refers to applying fertilizer into the soil without special reference to the location of seed or plant while the latter implies the application of fertilizer into the soil close to the seed or plant.

Advantages

Localized placement of fertilizers have many advantages over broadcasting method of application such as-

- Relatively lesser quantity is required for production of an ideal crop
- Weed growth is suppressed
- Fertilizer losses are reduced
- Fertilizers are placed in moist zone where they remain available to plants for longer period of time
- Fertilizers come in easy reach of crop roots
- Fertilizer recovery and response of crops to applied doses is increased.

Disadvantages

- The method is very technical and needs special precaution.
- Besides, it is very expensive.

The method could be adopted in following ways:

a. Contact placement/combine drilling

When fertilizer is placed along with seed then it is called as contact placement. This is done by using seed-cum-fertilizer drill. Sometimes fertilizer is drilled by implement and seed is sown in the same furrow.

Advantage

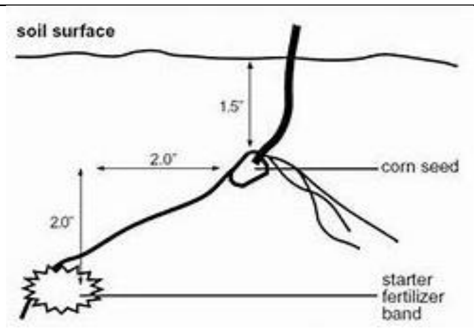
Well decomposed manures, ashes and P and K fertilizers in small quantities are used along with seeds during sowing.

Disadvantage

Care must be taken so that seeds are not burnt by contact of fertilizers.

b. Band placement

This is a localized placement of fertilizers by the side of plants or seeds (about 5 cm apart). This may be of two types as the bands may be continuous or discontinuous:

Banded application, where the fertiliser is placed under to or to the side of the seed drill can be used for Base Dressing for crops grown in rows.	

Note that the fertiliser is separated from and below the seed by at least 2 inches (5cm) of soil to protect the seed during the germination phase, (remember fertiliser will inhibit germination)	
Banded application, where the fertiliser is placed to the side of the established crop for Top dressing is also possible. The fertiliser may be spread along the side of the row and incorporated with a small rake or more usually a drill is opened to the side of the row and the fertiliser is placed along the drill. Take care to minimise root damage and remember that fertiliser in direct contact with the roots will burn the roots Note: this method can be adapted for treatment of individual plants, e.g. in conservation farming of maize or in fruit tree production	

i. Hill placement (discontinuous band)

In the hill for widely spaced plants like cotton, castor and cucurbits fertilizers are placed on either of both sides of plants along or across the row but not along the entire row. This method is also termed as discontinuous band application.

ii. Row placement (continuous band)

Along the entire rows of closely spaced crops like cereals, minor millets, potato and tobacco fertilizers are applied continuously at 2-2.5 cm depth. This method has a definite relationship of fertilizers with seedlings or seed as the fertilizer is placed to the side of seedlings or seeds some distance away from them or at the level of the seed, above or below or by the side of the seed level. When the soil surface is dry, this method gives very promising results.

iii. **Ring placement (continuous band)**

Fertilizer is applied in a circle around individual plant or hill base at a depth of about 2.5-5 cm.

c. Pocket/spot placement

When fertilizers are placed at a fixed spot by the help of a bamboo peg having a hole at the bottom in case of very widely spaced crops then the method is termed as pocket/spot placement method. Fertilizers are placed deeper into the pocket (dibble) and seeds are sown in the same pocket about 5 cm above the fertilizers.

Advantages

Suitable for dry soil where there is a moisture deficit.

Suitable for wide spaced crops like cotton, castor, cassava, cucurbits and chilli.

Disadvantage

Care must be taken so that seeds are not burnt by contact of fertilizers.

Laborious and time consuming.

d. Pellet placement

This method is adopted specially in case of deep water rice cultivation where it is difficult to apply fertilizers in normal methods as the fertilizer granules get dissolved in water before reaching to the ground level. In this method fertilizers (specially nitrogenous ones) are mixed with clay soil in the ratio of one part of fertilizer into 10-15 parts of soil. The fertilizer is well mixed with soil after slight moistening then filled in gunny bags and stored for two-three days. Now small mud bolls are prepared and these boll or pellets are dropped near the crop rows in rice Jr jute under deep water conditions.

2.3. Method of application of liquid fertilizers

Use of liquid fertilizers is not very common practice but in advanced countries this is the most common method. It is the most suitable method under dry land agriculture and in the areas which are prone to erosion problems. Liquid fertilizers may be applied in following ways:

1. **1.Starter Solution**

Starter solutions usually contain N, P, and K in 1: 2: 1 or 1: 1: 2. This method is used for transplanted crops where in place of irrigation water this solution is applied just to wet the field so that the seedlings may establish quickly.

A fertiliser solution of NPS (1-3 kg /200 litres) is made in a barrel and 200 – 250 ml of this solution is added to each planting hole immediately prior to transplanting.

This helps the soil to bind around the roots of the transplant and provides an immediate nutrient source

Advantages

- ✓ Thus it serves as irrigation water as well as nutrient solution for the crops.
- ✓ This is also used for dipping the seedling roots and soaking of seeds or spraying to encourage early rooting and crop establishment

- **Disadvantage**

- ✓ Extra labour is required, and
- ✓ The fixation of phosphate **is higher**
- ✓ Requires careful attention to maintain proper concentration of solution.

2. Application through irrigation water

The required quantity of fertilizer material is dissolved in irrigation water and can be used in surface, sprinkler or drip irrigation systems.

Advantage

The concentrated fertilizer solution may be dripped in the channel of irrigation water while irrigating the crop.

Disadvantage

If the crop is to be given surface irrigation as flooding then excess water may lead to physiological problems in crops.

3. Nutrient injection method/direct application to soil

In USA and some other countries anhydrous ammonia is injected into the soil at a depth of about 20-25 cm and at a pressure of about 200 pound per square inch.

Advantages

The anhydrous ammonia is the cheapest source of nitrogen because of its lower unit value.

Injecting hormonal solution and some micro nutrient solutions in the phloem region of the fruit trees is also becoming a distinct possibility in correcting the nutrient deficiency.

Disadvantage

For this method the soil should have fine tilth, enough moisture etc. so that loss of nitrogen in the form of ammonia does null take place.

4. Foliar spraying of nutrient solutions

In this method of fertilizer application urea, micro nutrients and other required materials are dissolved in water, filtered and sprayed over the crop foliage by the help of a suitable sprayer.

1. It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants.

2. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them.

3. The concentration of the spray solution has to be controlled, otherwise serious damage may result due to scorching of the leaves.

4.Foliar application is effective for the application of minor nutrients like iron, copper, boron, zinc and manganese. Sometimes insecticides are also applied along with fertilizers.

Fig 2 foliar application

Advantages

This method is preferred over other methods because it needs very little quantity of materials.

- The crop plants respond within 24 hours of application.
- Soil reaction, topography and soil textures have no adverse effect on the nutrient availability and fertility status of the soil.
- Almost all nutrients can be applied by this method.

Disadvantage

- ✓ Non-uniform spraying and improper concentration of the solution may lead to hazardous effect over the crop and entire plant population may get devastated.
- ✓ High concentration of solution may cause burning of foliage

5. **Fertigation**

Fertigation is the application of organic or inorganic fertiliser dissolved in water, usually as part of the irrigation process. In this process a small amount of fertiliser is applied regularly (watered on), with no damage caused to the plant root system. This gives the Farmer good control of crop growth and minimises losses due to leaching.

Manual fertigation using a knapsack sprayer is however quite time consuming due to the need for regular treatment and is usually only practices on a very small scale.

In commercial greenhouse and intensive field vegetable production it is usual for the fertigation unit to be installed as part of the irrigation system.

Application through irrigation water (Fertigation)

1. It refers to the application of water soluble fertilizers through irrigation water.
2. The nutrients are thus carried into the soil in solution.

Generally nitrogenous fertilizers are applies

There are several methods of achieving fertigation in practice

a). Fertigation using a 'Family Drip' system

This is suitable for small farmers. Fertiliser solution at the concentration to be applied is mixed in the tank and applied through the drip lines.

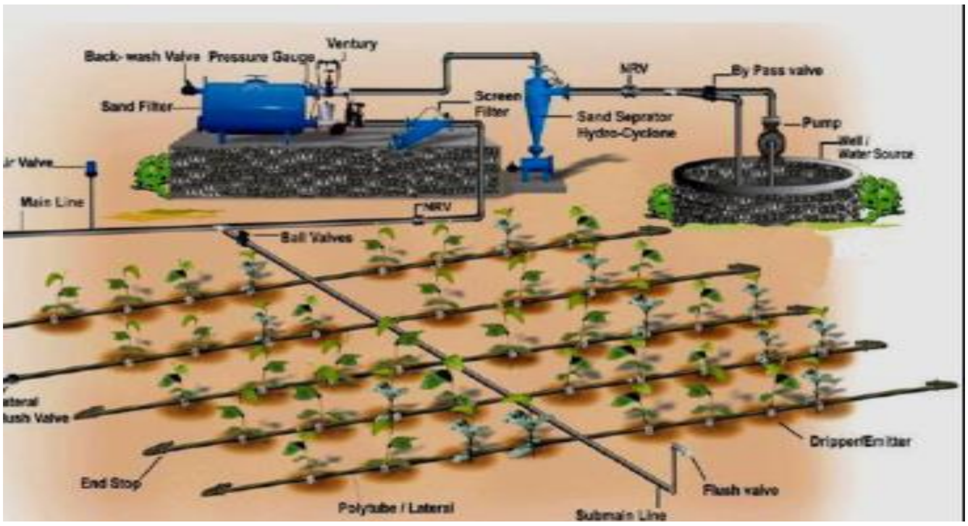


Fig 3 fertigation by family drip system

b).Fertigation using a water powered volumetric dosing unit (Injector)

Liquid fertilizers for injection into the soil may be of either pressure or non-pressure types.Non-pressure solutions may be applied either on the surface or in furrows without appreciable loss of plant nutrients under most conditions. Anhydrous ammonia must be placed in narrow furrows at a depth of 12-15 cm and covered immediately to prevent loss of ammonia.

In this system a water powered volumetric proportioning device (Injector / Diluter), e.g. Dosatron, is linked inline to the water supply to the irrigation distribution lines. Dosing is independent of flow rate and water pressure and the system does not require electrical power.These systems are widely used in non-intensive greenhouse production in some countries but are not yet in common use in Ethiopia.

c).Fully automated Fertigation

These systems are used in intensive commercial greenhouse and some intensive field vegetable production in Ethiopia. Fertiliser application is controlled by the composition of the stock solution which is injected automatically into the water supply in accordance with pre-set pH and EC targets. Irrigation cycles are controlled by a Timer and linkage to the Environmental Management computer is possible. This type of equipment gives very precise control of the fertigation process but is very expensive and requires a back-up generator for electrical power during outages

6. Aerial application.

In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest lands, in grass lands or in sugarcane fields etc

Note: The environmental impact of fertiliser application is minimised when:

- Fertiliser is applied in the amount needed for crop growth
- Split application and placement is in the root zone ensures that uptake by the crop is quick and easy and losses due to leaching are minimised
- The area where fertiliser is applied is separated from water sources by a buffer zone of natural vegetation (guideline; at least 5m separation)
- Compost and manure sites are sited at least 50m from water sources .

Self-Check – 2	**Written test**

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

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

I**. choice the best answer**

___1. Which Factor affect the choice of application method and fertiliser placement?

A. Cropping system
B. Stage of crop growth
C. Scale of production and value of the crop
D. Rain fed or irrigated E. All

___2.one is not the Method of application of solid fertilizer materials

A. Broadcast application B. Placement
C. Starter Solution D. Localized placement.

___3.which one is not methods of fertigation Application

A. Fertigation using a 'Family Drip' system
B. Broadcast application
C. Fully automated Fertigation D.All

___4. The fertilizer solutions are applied by aircraft particularly in hilly areas, in forest lands, in grass lands or in sugarcane fields etc

A. Placement B. Starter Solution,
C. Localized placement D. Aerial application

___5. Which one is fertilizer in standing crops without considering the crop rows is?

A. Top dressing B. side dressing
B. A and B D. All

6.---------is the application of organic or inorganic fertiliser dissolved in water, as part of the irrigation process

A. Fertigation B. Aerial application C. Placement D. Topdressing

3.1 Selection of tools, equipment and machinery

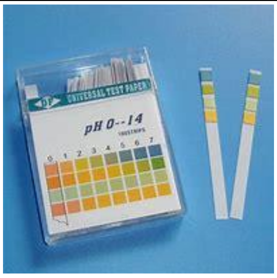
Selection of tools and equipment is based on:

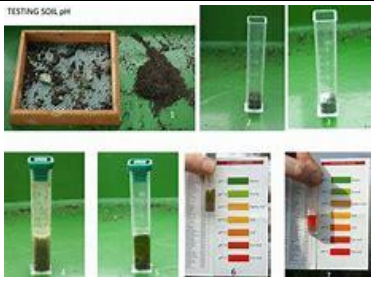
- Tools and equipment needed for measuring, calibration and mixing
- Tasks (Application) to be carried out
- Scale of operation and cropping system used
- Fertiliser type
- Stage of crop growth
- Equipment available

Precisely which tools and equipment are to be used for each task will be specified in or known from the established Enterprise Work Procedures prepared by management.

Equipment that is in common use in Ethiopia includes:

Process	Equipment needed
Checking **pH and EC** in Soil and Fertigation Solutions	Sampling equipment: **Soil:** Soil auger, sample bags, markers and tape for labelling **Solution**: Syringe, sample bottles, markers and tape for labelling **Measurement:** pH & EC metres, Beakers, Calibration solutions, stirrer & distilled water **Note**: pH may also be measured using pH sensitive dye or paper strips





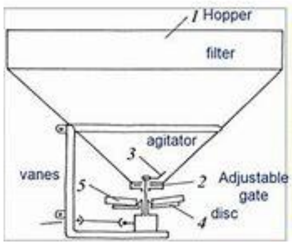
Application of bulky organic materials

By Hand: Hand forks and bags or baskets (Small farms)

Mechanically: Tractor mounted spreader (Larger farms)

Incorporate by ploughing: Oxen or Tractor and Plough

Process	Equipment needed
Broadcasting Fertiliser Base dressing & Top Dressing	By Hand: Weighing scales and fertiliser cups, bowls or bags. Hand held distributer may also be used Mechanically: Tractor mounted fertiliser distributer; oscillating spout or spinning disc plus weighing scale and tape measure for calibration

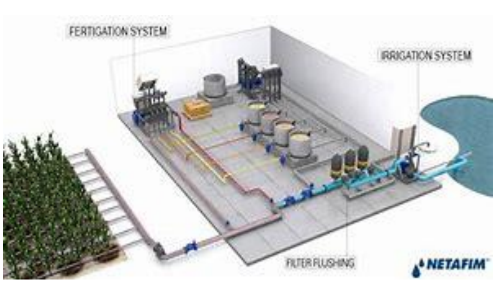


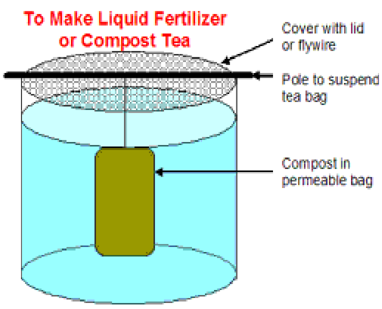
Process	Equipment needed
Banded Placements Base dressing & Top Dressing	By Hand: Weighing scales and fertiliser cups, bowls or bags and hand tools to open the drill

	Mechanically: Tractor mounted Drill (Hopper, tine & delivery spout) plus weighing scale and tape measure for calibration



Starter solution	Weighing scales, mixing barrel & stirrer, buckets and liquid scoops
Foliar feeding	Small scale: Weighing scales or graduated jugs, mixing bucket & stirrer, Knapsack sprayer fitted with appropriate nozzle Large Scale: Weighing scales or graduated jugs, mixing bucket & stirrer, Tractor mounted sprayer fitted with appropriate nozzles plus weighing scale and tape measure for calibration
Fertigation	Small scale: Weighing scales or graduated jugs, mixing bucket & stirrer, Knapsack sprayer fitted with appropriate nozzle or Family drip Larger Scale: Weighing scales, Fertigation Unit (Tanks, inline injectors, sand filters, pH & EC control unit, pump. This is a permanent unit that forms part of the irrigation system)





Self-Check – 3	**Written test**

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

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

1. List down Broadcasting Fertilizer material or equipment (5pts)
2. List of material /equipment need for Starter solution(5pts)
3. List of material /equipment need Foliar feeding(5pts)
4. List of material /equipment need Fertigation(5pts)

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

Note: **Satisfactory rating – 25 points   Unsatisfactory - below 25 points**

Information Sheet 4- Carrying out pre-operational and safety checks

4.1 Carrying out pre-operational and safety checks

Before starting work, it is important to check that the equipment that you are to use is in good working order and is safe to use.

Specific details of what is required for each piece of equipment will be included in the Manufacturers Handbook for the Equipment. Where this document is available; Pleas Read it before starting work. However this document is often not readily available on the farm so it is necessary to consult with your Line manager and apply the general rules of good practice and check:

Items	General pre-start checks
pH Meters	The electrodes are clean Glass electrodes are not dried out and are not leaking The battery is charged The calibration date and calibrate if necessary
Weighing scales	The battery is charged The calibration date and calibrate if necessary
Tractor mounted Fertiliser distributers	Look for obviously loose parts Safety guards are in place Inflation of wheels Mounting is horizontal The Hopper is empty and clean and the mechanism for adjustment of delivery moves freely Turn on and check the On /Off switches work and observe that moving parts do actually move freely

Manual Fertiliser distributers	Look for obviously loose parts The Hopper is empty and clean and the mechanism for adjustment of delivery moves freely Turn the handle or push and observe that moving parts move freely
Fertigation Unit	Electrical wiring Oil level in motors Mixing tank is empty and clean Look for visible leaks A and B Tank have emptied at the same rate Filters according to enterprise schedule
Tractor mounted sprayer	Look for obviously loose parts Safety guards are in place Inflation of wheels Mounting is horizontal The tank is empty and clean; filters are clean and nozzles not blocked Turn on and check the On /Off switches work, Put some water in the tank, turn on, open valves and check for leaks
Knapsack	Straps The tank is empty and clean; filters are clean and nozzles not blocked Put some water in the tank, pump and check for pressure and leaks

NOTE

- Do Not attempt to adjust, repair or work out how a piece of equipment works until you have read the manufacturers handbook or consulted your Line Manager and have been authorised to use the equipment.
- Do Not put your hands onto moving equipment. Turn the Equipment Off before trying to fix a problem or make adjustments and if you're not sure what to do ask your Line Manager.
- If you can't fix the problem report the problem to your Line Manager.

Self-Check – 4	**Written test**

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

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

1. What is the importance of pH meter (3pts)

2. Discus the Tractor mounted sprayer? (3pts

3. Discus the Manual Fertilizer distributers (3pts)

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

***Note:* Satisfactory rating - 9 points** **Unsatisfactory - below 9points**

5.1 Calibration of tools, machinery and equipment used for application

Calibration is essential for accurate operations.

Here we need to consider Calibration Method and the Frequency of Calibration required:

- Equipment for weighing and measuring fertiliser
- Equipment for measuring pH and EC
- Organisation and supervision of workers applying fertiliser by hand
- Equipment used for solid fertiliser distribution
- Equipment (Knapsack sprayer) for liquid fertiliser application

Procedures for calibration of equipment are described in the manufacturer's handbook for the equipment concerned. These procedures, the frequency of calibration required and the person responsible may then be documented by the Enterprise Management Team as 'Enterprise work Procedures'. The real situation on many farms is however that these documents are not readily available and members of the management team need to understand the basic principles of Calibration.

5.2 Calibration of Equipment for weighing and measuring fertiliser

Weighing scales and weights should be calibrated at least once a year.

Calibration can be done formally by the standards authority in Addis Ababa but on the farm it is easy to check the scales yourself. 1 Litre of water weighs 1 Kg.

If your scales indicate otherwise consult the Manufacturers Handbook to find out how to make the adjustment needed.

5.3 Calibration of Equipment for measuring pH and EC

Meters for measuring pH and EC should be calibrated at least every month.It's possible to prepare solutions for calibration in house, recipes available on the internet, but mostly Farms buy pre-prepared solutions to use for calibration. Solutions for calibration should be used once then discarded. Pre-prepared solutions have a life of several months and new solutions should be purchased at least annually. **T**o calibrate a pH meter you will need buffer solutions at pH 4, pH 7 and pH 9. For acidic samples calibrate using pH7 & pH4 and for alkaline samples, calibrate using pH 7 and pH 9.

The Procedure to use for calibration is:

1. You will need clean beakers, deionised or distilled water and the buffer solutions
2. Check and clean the electrode
3. Place the electrode in distilled water, turn on the metre and allow the metre and the calibration solutions all to equilibrate with room temperature.
4. Put the pH7 buffer solution into a small beaker, insert the pH probe and allow the reading to settle then set the pH reading on the metre to 7.0.
5. Clean the electrode and repeat the exercise using either pH 4 or pH 9.

The Procedure to use for calibration is:

1. You will need clean beakers, deionised or distilled water and the calibration solution.
2. Check and clean the electrode
3. Place the electrode in distilled water, turn on the metre and allow the metre and the calibration solutions all to equilibrate with room temperature ….. about 1 hour
4. Put the calibration solution into a small beaker, insert the probe, allow the reading to settle and set the reading to the EC of the calibration solution.
5. Clean the electrode before use.

5.4. Organisation and supervision (Calibration) of workers applying fertiliser by hand

Ensuring that the fertiliser is applied evenly and at the correct rate by teams of workers in the field is the responsibility of the Supervisor.

1. The Field should be divided into small units and the Fertiliser divided into the amount to be applied to each unit.
2. All Workers should be checked to see that the fertiliser is being spread evenly and corrective action taken as necessary

5.5. Calibration of Equipment used for solid fertiliser distribution

5.5.1 Calibration of Tractor mounted spinning disc or oscillating spout distributors

Calibration is an annual operation and is usually carried out by the Farm Manager working with the Crop supervisor.Equipment needs to be calibrated for each application rate and fertiliser type to be applied and results should be recorded for reference throughout the year.

- Tractor and fertiliser distributor.
- Remember to carry out pre-start checks before beginning calibration
- Several Kg of each type of fertiliser to be used
- Collection trays for measuring Swath width
- Weighing scales, distributor collection tray for spinning disc or bag for oscillating spout equipment and bucket for weighing
- Tape measure, note book and pen.

Procedure:

1. Adjust the distributor to the release rate that matches the type of fertiliser and application rate required for the crop to be treated. Details of how to do this are included in the Manufacturer's handbook.
2. Measure the output of the distributor at the operating RPM and application speed to be used in the field.

a. Close the outlet and put a weighed amount of fertiliser into the hopper

b. Select a site where the tractor is able to drive at operating speed for at least 50m and measure out a 50m or 100m distance. Fit a collection bag or collection tray over the outlet if possible.
c. Drive the tractor over the test site; start before the first marker to ensure that you are moving at application speed and required RPM before entering the measured area, open the outlet as you enter the measured area and close the outlet as you leave the measured area.
d. Measure the weight of fertiliser that you have delivered or have remaining in the hopper.
e. Record:
i. Forward speed and RPM used
ii. Outlet setting
iii. Distance
iv. Type of fertiliser
v. Fertiliser output

3. Measure the swath width:
4. Calculate the Area treated

   Effective Swath width x distance (50m or 100m according to distance measured in Step 2)
5. Then calculate the application rate achieved in kg / ha using the formula:

   Application Rate Kg/ha = $\frac{\text{Measure output x 10,000}}{\text{Area Treated}}$
6. Compare the application rate achieved with the desired application rate:
   a. If the rates are very similar make a record of your Calibration data; speed, RPM, equipment setting and effective swath width and use this in the field
   b. If the application rate calculated is too low, open the outlet a little more or reduce the speed and repeat the calibration exercise.
   c. If the application rate calculated is too high, close the outlet a little more or increase the speed and repeat the calibration exercise.

5.5.2 Calibration of Hand held spinning disc or oscillating spout distributors

This is essentially the same process as for the tractor mounted operation but substitute walk speed for tractor speed and number of Hand turns /min for RPM.

5.5.3 Equipment (Knapsack sprayer) for Foliar feed application

Here the process is similar to that used for Pesticide application:

1. Read the product label or the instructions from the Manager and note the Dilution rate required: Kg product per litre of application.
2. Carry out the pre-start checks on your knapsack and when the equipment is ready for use, fit an appropriate nozzle (usually a medium cone) that will give good leaf coverage and minimum run-off.
3. Put some water in the tank and spray the crop for 1 minute**.**
4. Measure the output of the sprayer (litres/minute) by spraying into a measuring jug or bucket.
5. Measure the area of crop to be Treated in m^2
6. Calculate the volume of spray (Foliar Feed), needed to treat the Crop area:

   Amount of spray needed = Sprayer output in litres/min x area to be sprayed m^2

   Area sprayed / minute m^2

7. **Amount of product needed** = Recommended Amount /Litre x Number of litres

$$Q = \frac{(V1-V2) * A}{a}$$

Where

Q = Quantity of water required (L/ha)

V1 = volume of water (L) in the sprayer before spray.

V2 = Volume of water (L) in the sprayer after spray

A = one hectare ($10000m^2$)

a = measured area of spray (m^2)

Self-Check – 5	**Written test**

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

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

Part I. Choose the letter with the correct answer

1. Fertigation through_________ is more efficient liquid fertilizer application

   A. Sprinkler B. Trickle C. Drip D. Furrow

2. Mixing of water and fertilizer takes place in:-

A. riser B Sub-line C. Laterals D. Tank

3. Application of fertilizers using equipments can not be operated:-

   A. Manually B. Mechanically C. Hydraulically D. Electrically E. none

4. Which one precedes the others?

   A. Calibration B. Wear PPE C. Spraying D. Check the equipments

5. Variation in walking speed and swath width resulted in uniform application of liquid fertilizers A. True B. False

Part 2 short answers

1. Why do you calibrate? (4 pts)
2. Discuss the steps in calibration? (2 pts)
3. What is the importance of the kalibottle? (5 pts)

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

***Note:* Satisfactory rating - 16points** **Unsatisfactory - below 116points**

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Information Sheet 6- Applying fertilizers

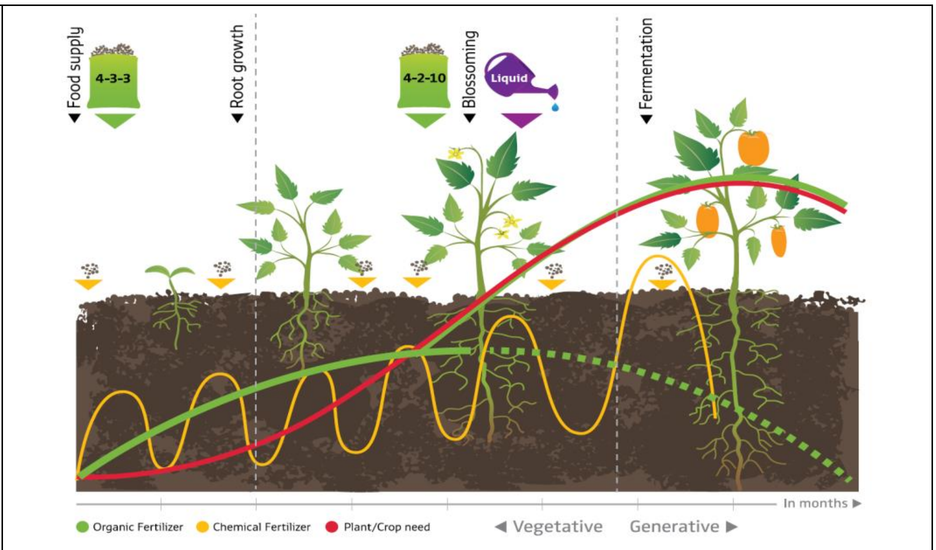
6.1 Timing of fertiliser Application

Crop plants have different requirements for nutrients at different stages of growth.

In principle the germinating seed or transplant needs a small amount of fertiliser with emphasis given to Nitrogen and phosphorous. As the crop grows, the requirement for nutrients increases. To accommodate this, Farmers usually split the fertiliser application into Base dressing and top dressing to reduce the risk of leaching when the crop is young.

If the Crop is to flower and fruit, then the balance of nitrogen and Potassium also becomes important at the start of the flowering period. Here the ratio of Nitrogen relative to Potassium applied changes from 1 : 1 to 1 : 2 or in some cases even 1 : 3.

Nutrient ratios and relative amounts required at the different stages of growth is shown diagrammatically below.

NPK ratio Amount of Nutrient required ↑ Time →	

An Example of a fertiliser schedule used in shown below:

Tomato: Target: 20,000 plants/ha and Harvest 800 qt / ha

Seed bed per 5 m^2: 50g Urea + 50g NPS + 60g KCl

Plot application per $200m^2$:

- ✓ Pre-Planting: 4 Kg NPS + 3Kg KCl
- ✓ Starter Solution: (2 barrels x 200 litres water containing 2 Kg NPS)
- ✓ 2 weeks after transplanting: 2.5 Kg Urea
- ✓ At flowering: 4 Kg NPS + 3 Kg Urea + 3 Kg KCl
- ✓ 2 weeks before harvest: 3 Kg Urea + 5.5 Kg KCl
- ✓ Harvest starts: 4.5 Kg Urea + 6 Kg KCl

Fertiliser schedules planned should be reviewed regularly throughout the crop and adjusted according to the findings:

Possible findings	**Recommended Action**
Luxurious growth or High pest or disease infestation	Reduce nitrogen and increase potassium
Slow growth after high rainfall	Apply additional Top Dressing
Lower than expected plant stand	Review economic return on fertiliser application and adjust application amount according to evaluation
Nutrient deficiency	Apply appropriate treatment to correct deficiencies identified **if** these deficiencies will respond to treatment

Self-Check – 6	**Written test**

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

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

1. Which nutrient should be applied at sowing? Why? (4 points)
2. When is the best time for phosphorus application? (3 points)
3. Why apply rock phosphate 3 weeks before sawing? (5 points

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

***Note:* Satisfactory rating – 11 points** **Unsatisfactory - below 11**

7.1 Fertiliser storage

The complexity of storage facility needed depends on the amount of fertiliser to be stored and the types of fertiliser to be stored.

To minimise the risk to the Environment, fertiliser storage facilities should not be sited close to water; drainage ditches, bore holes, lakes and rivers. For large stores, a minimum of 50m separation is recommended.

Minimum requirements for a small Farming enterprise using the typical range of mineral fertilisers required for field crop production in Ethiopia are:

- The Store must be dry and structurally sound
- Ideally the floor should be non-permeable (Cement)
- The store should be secure (Locked to prevent theft)

For more complex and large commercial farms, the facility will need extra features:

- The Store must be dry and structurally sound
- The floor should be non-permeable (Cement)
- The store should be secure (Locked to prevent theft)
- The size should be adequate for the maximum amount of fertiliser to be stored with sufficient space remaining for access and safe working
- Equipment to clean up spillage (Brush, bucket & Waste sacks), a fire extinguisher, eye wash and PPE must be provided.
- **Where concentrated Acids** are used the area for Acid storage must be physically separate (minimum 2 m) from the fertilisers and the area must be secures and bunded to contain spillage or leakage

7.2 Arrangement of Fertiliser stock in store

Details for storage requirements can be found either on the Label or in the MSDS. The general principles for good practice are:

- The fertiliser should be stored off the ground on pallets …. This is an extra precaution to keep the fertiliser dry
- Fertilisers should be segregated according to type
- Fertiliser should be stacked in accordance with label recommendations where these are provided
- Fertiliser stacks must be stable (worker safety) and safe access to must be possible
- All fertiliser stock should be handled carefully to avoid damage to containers and spillage

7.3 Fertiliser Store Management Procedures

Management procedures for Fertiliser storage should be developed by the Farm Management team, explained to workers and posted for reference.

Procedures should include:

- Access restricted to authorised / named personnel …..
- PPE to be used when necessary for tasks to be carried out
- Careful handling and safe lifting is to be practiced
- Measuring and mixing to be carried out only in the designated area
- Spillage is to be brushed up promptly and bagged for disposal
- Trashes are to be removed
- Stocks of individual fertilisers are to be managed on a first in first out basis
- Deliveries (Receipt of Goods) must be recorded
- Issue is made in response to written authorised instructions and is recorded and signed for
- Person to contact in the event of an accident or emergency is ……
- Access to the Door and Fire extinguisher must not be obstructed at any time

7.4 Stock Records

Stock records, **bin cards and stock inventory**, must be maintained.

Bin cards, one for each type of fertiliser is store, **show the diary records of movement of each fertiliser** into and out of the store. Records will show at least:

- Date
- Balance in store
- Fertiliser received
- Fertiliser Issued
- Signature of Store man for each transaction

The stock inventory is usually updated at least monthly by Management and shows the global picture of what is in store; **Fertiliser Type and Balance in store**

Then the Physical balance and the Office Inventory will be checked at least once per year in the annual 'stock Take'. (Note: This is done monthly in farms with a large monthly usage of fertiliser).

Self-Check 7	**Written Test**

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

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

1. What is the use of monitoring plant response? (4 points)
2. What points are considered when monitoring plant response? (3 points)

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

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

Operations Sheet Prepare to apply Fertilisers

Task	Activity
1	**For the site, crop, scale of production and season outlined by your instructor:** Select and describe the types of fertiliser that should be used and justify your selection Select and describe appropriate methods of application for the fertilisers selected
2	**Select the tools and equipment to be used for the following activities in a scenario described by your Instructor**: Calibration and measurement of the pH and EC of a soil sample Application of fertiliser with a team of people Broadcast fertiliser application Banded fertiliser application
3	**Carry out pre-operational and safety checks on the equipment provide by your instructor** Prepare a check sheet Examine the equipment Report your findings **List the OHS Risk associated with using this equipment and explain how to minimise these risks**
4	**Calibrate the equipment provided** Knapsack sprayer Hand held or tractor mounted fertiliser distributor
5	Describe the application schedule to be used for a named crop and season of production.
6	**The Farm is expecting delivery of:** 1 Tonne of Ammonium Nitrate in 25 Kg bags 0.5 Tonne DAP in 25 Kg bags 500 litres conc. Nitric Acid in 20 litre jerry cans Explain how to handle and store these products safely Prepare a stock record/Bin Card for the DAP Prepare operating procedures for the Fertiliser store

LAP TEST

1. For a given situation that is familiar:

To perform the appropriate application methods

To perform Apply fertiliser according to the enterprise application schedule

LG #38	LO # 5 Operate the fertigation process

Instruction sheet

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

- Preparing materials to meet fertigation requirements.
- Connecting and calibrating injection or fertigation equipment
- Implementing start-up sequence
- Calculating fertilizer concentration and solution
- Operating and monitoring fertigation process
- Monitoring fertigation equipment
- Implementing corrections

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

- Preparing materials to meet fertigation requirements.
- Connecting and calibrating injection or fertigation equipment
- Implementing start-up sequence
- Calculating fertilizer concentration and solution
- Operating and monitoring fertigation process
- Monitoring fertigation equipment
- Implementing corrections

Learning Instructions

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the "Self-checks" which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets
7. Perform "the Learning activity performance test" which is placed following "Operation sheets" ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to "Operation sheets".

Information Sheet 1- Preparing materials to meet fertigation requirements

1.1 Introduction

Fertigation is a recent innovative cultural method, by which fertilizers are applied along with irrigation water through irrigation system like drip to get higher fertilizer use efficiency as well as increasing the crop yields. Nutrient solutions are injected in the irrigation water using an appropriate injection device. Fertigation provides essential elements directly to the active root zone, thus minimizing losses of expensive nutrients, which ultimately helps in improving productivity and quality of farm produce and reduce the risk of environmental pollution.

Fertigation involves specific equipment's according to the crop type and irrigation system and precise selection of suitable fertilizer and its combination. The present article is an attempt to make understanding on various aspects of fertigation technology

- **Fertigation using a 'Family Drip' system**

This system can be operated by small farmers working with Family drip units usually with tanks of 200 – 500 litres capacity irrigating one plot/ tank fill.

The system works on the basis that fertiliser is mixed to the correct concentration for application in the header tank prior to use so no mechanism for dilution before application is needed.

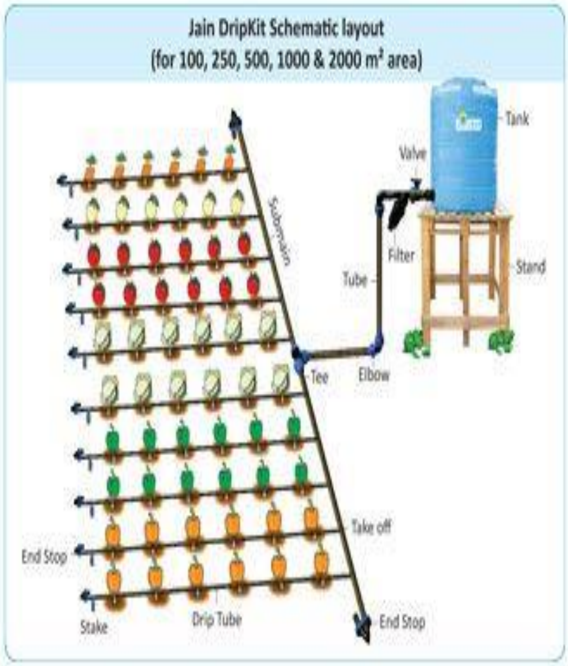
Step 1: Close the water inlet and Use the system to moisten the soil then close the outlet.

Step 2: Dissolve the correct amount of fertiliser for the crop area to be treated in a bucket then pour into the tank. (Remember that the EC of the solution applied must be <2.0 to avoid root damage)

Step 3: Fill the tank to the correct volume for the irrigation cycle for the area to be treated, turn off the water inlet and open the water outlet to fertigate the crop

Step 4: Flush a small amount of clean water through the system to remove fertiliser deposit from the drip emitters.

Note: To use this idea in the small farm will require the use of a Supplementary Tank (200 litres) for preparation of the fertiliser solution

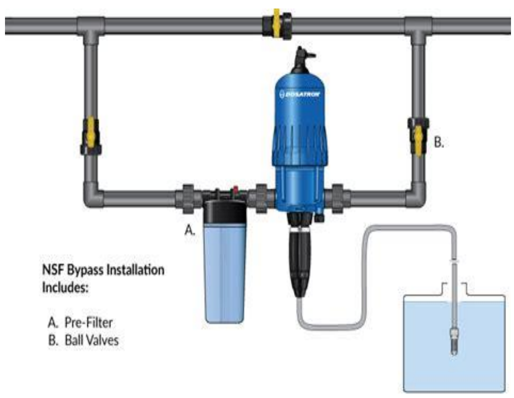


Fertigation using a water powered dosing unit (Injector)

Here the fertiliser is mixed to make a stock solution which is diluted as needed and usually applied in each irrigation cycle.

A 'water powered volumetric proportioning device (Injector)', e.g. Dosatron, is fitted inline to the water supply leading to the irrigation distribution lines.

The desired fertiliser is mixed in a stock tank, the dilution rate is set in the injector, the injector intake tube is inserted into the tank, the water is turned on and dilute feed is distributed through the irrigation. Dosing is independent of flow rate and water pressure and the system does not require electrical power. These systems are widely used in non-intensive

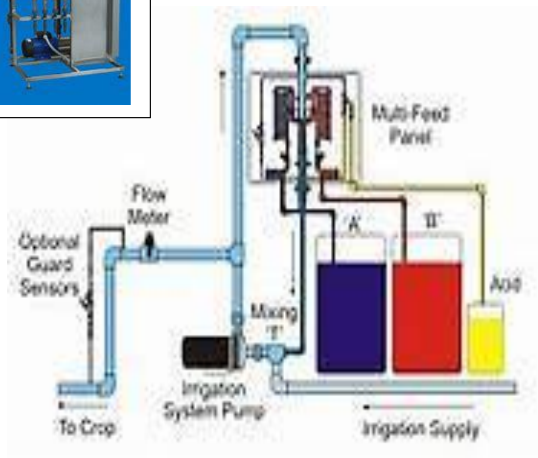


greenhouse production in some countries but are not yet in common use in Ethiopia.	

- **Fertigation using a fully automatic 3 tank in line dosing system**

This system is typical of the fertigation units found in Ethiopia in the commercial greenhouse and some intensive vegetable far

Here there are 2 fertiliser stock Tanks, the A Tank and B Tanks containing Fertilisers (dissolved in water and separated to avoid precipitation)



and an acid Tank.

The unit is powered by electricity and can be linked to the climate control computer for full automation.

The balance of the nutrients supplied is controlled by the contents of the stock tanks and the Fertiliser and acid are injected 'in line'. Dosing is controlled by automatic monitoring of the pH and EC of the mixture before the mixture is pumped to the crop areas. Fertigation is usually applied at each irrigation cycle.

This type of unit is often used for crops grown in intensive production systems where all nutrients need to be supplied. Fertigation is usually applied in each irrigation cycle. Irrigation needs are based on solar gain or evaporation then the total requirement is divided into a number of applications; in soil grown crops, two or three applications per day will be applied whilst in hydroponic systems 10 – 15 cycles per day is more usual.ThepH and EC in the root zone is closely monitored and in hydroponic systems the volume of run off is also measured

1.2 .Materials needed for Fertigation

Where crops are grown intensively using fertigation, the range of fertilisers used is much larger than for crops in the field and fertigation programmes may include as relevant

- **Selection of fertilisers will be affected by**:
  - ✓ Crop needs
  - ✓ Media analysis (pH and nutrients)
  - ✓ Solubility
  - ✓ Ion composition
  - ✓ Cost and availability

In a single tank fertigation system used for crops grown in soil, the Fertiliser programme will normally supply only Nitrogen and Potassium, with Ammonium nitrate and Potassium Nitrate being the fertilisers of choice.

For Tomato crops, magnesium sulphate, Epsom salts may also be added during the period immediately prior to first harvest.

In a 3 tank system as is used in Ethiopia for crops grown in hydroponic systems using inert media or for roses grown in soil, a much bigger range of nutrients are necessary and typical tank mixes may include:

ATank Water , Ammonium Sulphate ,Mono ammonium Phosphate ,Potassium Nitrate

Borax ,Fe EDTA ,Sodium Molybdate

B Tank Water ,Calcium Nitrate ,Magnesium Nitrate Zn EDTA

Acid Water Sulphuric Acid Nitric Acid

Note:

- Calcium and Phosphate Fertilisers are kept separate to prevent precipitation
- Nitrate and Ammonium sources of Nitrogen are used
- Phosphate fertiliser may not be needed in soil grown crops
- The amounts of fertiliser needed and the balance of the nutrients required will vary according to crop type, stage of growth, weather conditions, time of year ref market, pH and media analysis.

Self-Check – 2	**Written test**

Name_____________________________Date: ___________________________

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List and discuss fertilizer injection equipments. 9 points
2. What are the basic components of fertigation equipments? 8 points
3. Discuss the differences of central injection point and multi in field injection points.

Note: **Satisfactory rating – 25 points** **Unsatisfactory - below 25 points**

2.1 Connect and calibrate fertigation equipment

2.2.1 Connection

2.2.1.1. Family Drip Unit

No additional connections are needed to use this equipment for fertigation

2.2.1.2 Single tank system using a hydraulic injector connected in line

Follow the instructions provided (Read the Manual or consult your line manager)

In principle the following guidelines apply:

- Connect the filter and the injection equipment into the water line making sure that the water flow is in line with the arrow on the equipment
- Ensure that the equipment is adequately supported
- Ensure that the suction tube hangs freely with the inlet just above the bottom of the fertiliser Stock Tank

2.2.1.3 Automated 3 Tank system

These systems are installed by specialist contractors and are 'permanent fixtures' so no additional connections are needed to use this equipment for fertigation

2.2.2 Calibration

2.2.2.1 Family Drip Unit

No calibration is needed. Fertiliser content of the fertigation solution applied is controlled only by the amount of fertiliser and water that is put into the Tank.

2.2.2.2 Single tank system using a hydraulic injector connected in line

Follow the instructions provided (Read the Manual or consult your line manager)

In principle the following guidelines apply;

- Fit the metering device or set the control valve for the required dilution

- Calculate the fertiliser requirement for the stock mix (see 5.4 below) and prepare the stock solution. Put the injector inlet into the stock mix
- Turn on the water and allow the injector to run for a few minutes
- Collect a sample X and measure the EC

2.2.2.3 Automated 3 Tank system

These systems are installed by specialist contractors and are calibrated at installation. Thereafter, the calibration is checked weekly by comparison of the pH and EC of the fertigation at point of delivery with that of a reference sample prepared annually.

Self-Check – 2	**Written test**

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

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

1. Define the Automated 3 Tank system 2pts
2. Define Calibration 2pts
3. Define Family Drip Unit 2pts

Note: **Satisfactory rating - 6 points** **Unsatisfactory - below6 points**

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

Information Sheet 3- Implementing start-up sequence

Start-up procedures for each piece of equipment are described in the operators handbook provided by the manufacturer supplied with the equipment. Copies of these manuals are now often also available on the internet and may be available in the farm as ‘Work Instructions. Please do not attempt to operate fertigation equipment unless you are authorised to do so and have received instruction.

Pay close attention to the order of operations and remember to open and close valves slowly. Sudden changes in water pressure in the system puts pressure on the joints and leads to leaks.

Self-Check – 3	**Written test**

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

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

1. Define the Implementing start-up sequence 2pts
2. Define Calibration 2pts
3. Define Family Drip Unit 2pts

Information Sheet 4- Calculating fertilizer concentration and solution

4.1 Calculation of Fertiliser concentration and preparation of fertiliser solutions

4.4.1 Calculation of fertiliser requirements

Basic calculations for fertigation:-Basic fertigation calculations involve determining the velocity of a water-soluble chemical, which is directly related to the velocity of irrigation water in the application system. Fertigation time is therefore related to the time needed by irrigation water to travel from the point of injection of the material to the furthest emitter, e.g., of a drip line. Travel time is calculated as T = D/v, where Dis the distance traveled by the dissolved nutrient, or the length of pipe through which the irrigation water flows, and v is the velocity of the irrigation water. Fertilizer solution travel time is used to calculate fertilizer injection rate (IR) for a particular irrigation system.

For a micro sprinkler system, IR can be calculated based on the following relationship. IR= (A*Q/F*T*P)*100where A is the area to be irrigated (hectares), Q (kg/ha) is the quantity of chemical to be applied per hectare, F is the chemical fraction (fertilizer per liter of fluid injected, %), and ρ (kg/L) is the chemical solution density. Using the above relationship, a quantity of 3 kg/ha of N is applied to a 25-ha orchard with a 10-0-10 5-kg/L dense fertilizer solution that is injected for 1 hour at the rate of 150 L/ hr. Because micro sprinkler irrigation systems do not irrigate the entire soil surface, the fertilizer applied using these systems is delivered only to the irrigated portion of the soil surface. For a simple case of 50% irrigated soil surface, the N application rate in the irrigated zone (i.e., A/2 = 25/2 = 13.5), using the above revised relationship and the above information, will be slightly less than 6 kg/ha, as follows:

Q=IR*F*T*P/A*100=150*10*1*5/13.5*100=5.56 kg/ha

Because micro-irrigation systems do not apply water and chemicals to the entire soil surface, chemical applications to micro-irrigated crops are often made on an individual plant or tree basis, rather than on a gross-area basis. The above relationship for IR on the number of trees on an area basis becomes: IR= (A ÷Qp÷n/ F *T*P)*100 where Qp (kg/tree) is the quantity of fertilizer to be applied per tree, n is the number of trees per ha, and all other variables are same as previously defined. In a 10-ha grove of young trees, e.g., citrus trees, the quantity of 0.05 kg of N from a 5 kg/L dense 8-0-8 solution, at 1 hr fertigation time for a 100 trees/ha grove will require 125 L/hr IR, calculated as follows:

IR = (10*.05*100/8*1*5)*100=125L/hr

It is recommended that the duration of injection should be greater than the time the chemical needs to travel from the point of supply tank to the most distant emitter of dripper or sprinkler in the field. Flushing time is also an important consideration, to completely clean the system, and it should also be half of the time of duration of fertilizer injection; nonetheless, excessive flushing time may lead to leaching loss of nutrients.

Fertilizer Calculations and Practice Questions

Fertilizer injectors (proportioners) take a concentrated fertilizer solution from the stock tank and add it to the irrigation water. If we have an injector ratio of 1:100, this means 1 gallon of fertilizer concentrate is added to 99 gallons of water. For a 1:100 injector, the fertilizer in the stock tank P is 100 times more concentrated than the water that the plants will receive. This means that if a plant receives fertilizer at 200 ppm nitrogen, in the stock tank this will be mixed at20, 000 ppm nitrogen.

Part 1 – Calculations using the fertilizer label

The bags of commercial fertilizer that we use contain a label which specifies how much to use to achieve a given fertilizer concentration. On the table, simply find the column that corresponds to your injector ratio; and the row that corresponds to your target fertilizer concentration.

Ounces of Peters Professional 20-10-20 General Purpose Per Gallon of Concentrate						
Nitrogen	Injector Ratios*					E.C.**
ppm N	1:15	1:100	1:128	1:200	1:300	mmhos/cm
25	0.35	1.69	2.16	3.38	5.06	0.16
50	0.5	3.38	4.32	6.75	10.13	0.33
75	0.75	5.06	6.48	10.13	15.19	0.49
100	1.0	6.75	8.64	13.50	20.25	0.65
150	1.5	10.13	12.96	20.25	30.38	0.98
200	2.0	13.50	17.28	27.00	40.50	1.30
300	3.0	20.25	25.92	40.50	60.75	1.95
400	4.0	27.00	34.56	54.00	***	2.60

Question 1a: You wish to apply Peter's 20-10-20 fertilizer at a rate of 150 ppm N. You have a 1:200 injector. How many ounces / gallon of fertilizer concentrate will you need for the stock tank?

From the chart above find the row for 150 ppm N and the column for 1:200 – this shows us that 20.25 ounces per gallon of fertilizer is needed in the stock tank.

Question 1b: Your stock tank holds 5 gallons. So how many ounces of 20-10-20 will you need from question 1a to mix up 5 gallons of concentrated fertilizer?

Since 20.25 ounces per gallon of concentrate are required; and our stock tank holds 5 gallons we will need:

20.25 (oz/gal) × 5 gal = 101.25 oz

Question 1c: Given the ounces of fertilizer needed from question 1b. Convert the answer from ounces to grams.

If you are using a scale to weigh in grams, the conversion factor is:

1 ounce = 28.3 grams **Equation 1** So we simply multiply our answer from 1b by 28.3 to get the answer:101.25 oz × 28.3 (g/oz) = 2,865.4 g

The fertilizer table also lists the EC (salt reading) that should result from this fertilizer. We can use this to calculate the EC of the water that will reach our plants. By checking this water coming off the end of the hose we can make sure that our stock tank was mixed correctly and our injector is functioning correctly.

Remember that the tap water you are using also has some level of salts dissolved in it (for example the salt reading from Cornell water is 0.4 mmhos/cm). You can calculate what the final EC should be of the water hitting your plants from the equation below. final EC = EC of tap water + EC of fertilizer **Equation 2**

Question 1d: What should be the EC of the water hitting your plants using the fertilizer mix described in questions 1a-c?You can see from the fertilizer label (above) that our fertilizer EC should be 0.98,so fill this into equation 2 final EC = 0.4 (EC of Cornell tap water) + 0.98 (EC of fertilizerfinal EC = 1.38 mmhos/cm (note that: mmhos/cm = dS/m)

Part 2 – Calculations using the percentage of a nutrient in the fertilizer

Now let's look at the case where we need to mix a fertilizer that does not have a table to give use the mixing values. When we mix fertilizers we typically have a target in mind in terms of ppm (parts per million) of a particular nutrient.

However, fertilizers are usually weighed in ounces and then mixed in stock tanks measured in gallons. Because we are converting from ppm (parts per million) to ounces per gallon we need to use a conversion factor:

1 ounce E / 100 gal water = 75 ppm **Equation 3**

(Where E is any soluble element)

In the fertilizers we use, any given element (such as nitrogen or calcium) is only 1 part of the

Fertilizer, therefore we need to know the percentage it makes up of the fertilizer. In the case of N this is usually quite easy as the fertilizer bag lists the percentage of N-P2O5-K2O (so we know that our bag of 20-10-20 contains 20% nitrogen), for other fertilizers we may need to look up the values from a table, for example: epsom salts (magnesium sulfate or $MgSO_4 \cdot 7H_2O$) contains 9.9% Mg and 13% S). Note that the percentage can be represented as a decimal fraction (df), ex: 9.9% _ 0.099 and 13% _ 0.13. Once we have the decimal fraction we can easily calculate the ounces of fertilizer needed to achieve a target ppm using the following equation:

ozfert per gal irrigation water = target ppm / (75 × 100 × df) **Equation 4**

where df = the decimal fraction of the element of interest

Note: the equation calculates ounces per gallon of final irrigation water; to account for the injector we must multiply by the correct proportion (ex: multiply by 100 for a 1:100 injector)

Question 2a: We wish to make up a solution of 30 ppm magnesium using Epsom salts

($MgSO_4 \cdot 7H_2O$); how many ounces per gallon of final irrigation water are required; and assuming we are using a 1:200 injector; how many ounces are required per gallon of concentrate in the stock tank.

Using a lookup table we found that Epsom salts contains 9.9% magnesium, so the decimal fraction is 0.099, plug this and the target concentration (30 ppm) into equation 4 and solve:

Ozfert per gal irrigation water = 30 ppm / (75 × 100 × 0.099)= 30 / (742.5)

= 0.04 ounces per gallon irrigation water

Now account for the 1:200 injectors:

0.04 oz per gal × 200 (injector proportion) = 8 oz per gal stock concentrate

Now let's say we wanted to know how much sulfur was provided by adding 30 ppm magnesium with Epsom salts, we can use a related equation to calculate this, but in this case use the df for sulfur, because that is the nutrient of interest:

ppm = ounces fert per gal irrigation water × 75 × 100 × df **Equation 5**

Self-Check – 4	**Written test**

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

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. You wish to apply Peter's 20-10-20 fertilizer at a rate of 150 ppm N. You have a 1:200 injectors. How many ounces / gallon of fertilizer concentrate will you need for the stock tank? 15 points

***Note:* Satisfactory rating – 15 points** **Unsatisfactory - below 15 points**

Information Sheet 5 Operating and monitoring fertigation process

5.1. Operation and monitoring the Fertigation process

Details of the monitoring activities for fertigation required will vary according to the type of system in use and should be detailed in the Enterprise Work Procedures.

Responsibility for monitoring and reporting findings in a commercial farm is with the Crop Nutrition supervisor who will report to the Production manager.

In a Small Farm, the Farmer is responsible and may need advice

General requirements that apply to all systems are:

- Check the system; water supply, mixing and dilution and delivery system, for leaks and repair or arrange for repair to be carried out as necessary.
- Check the operation of the injection equipment (observe injection action and fall of level in the stock barrels). Report observed problems to the Production Manager
- Check that drip emitter are dripping (look for drip action and investigate areas of poor growth and obvious dryness). Unblock as necessary and discuss arrangements for acid treatment and flushing with the Manager when the incidence of blocked emitters is high.
- Check soil moisture to ensure that field Capacity is not exceeded and fertigation is leaching into the ground water (thereby causing Pollution and unnecessary expense)
- Check all filters and clean as necessary

Farms using automated systems in greenhouses will also check regularly:

- The pH and EC of the fertigation at point of delivery. (Deviation from the desired pH and EC must be reported promptly so that the manager can make the necessary

.

Self-Check – 5	Written test

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

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

1. mention General requirements that apply to all systems
2. Explain Enterprise Work Procedures

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

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

Information Sheet 6- Monitoring fertigation equipment

6..1 Adjust equipment as necessary

In commercial farms any adjustment to automated fertigation units must be discussed with the manager prior to implementation.

For small holder farmers, problems relating to application of fertigation by fertigation are most likely to show in the growth of the crop. Where problems are observed, the expertise should discuss the programme being used with the Farmer and advise accordingly.

Fertigation enables producers and growers to dose additional nutrients and fertilizers to plants, or to correct nutrient deficiencies. Better understanding starts with testing. Soil and water testing takes analysis one step further, increasing understanding of naturally occurring nutrients in the soil and the uptake of nutrients added through fertigation. Together, plant tissue, soil, water solution and water analyses empower growers to take decisive action to improve the health and productivity of their plants as well as reduce their costs

Services To get the most benefits from fertigation monitoring services, it is recommended to perform frequent testing and the following irrigation systems should be used:

• Drop-by-drop.

• Sprinkling.

• Micro-sprinkling.

• Exudation. Using suction lysimeters, our experts quantify the actual chemical composition of the plant available for metabolic processes and their interaction with the tissue of the leaves and fruit. This process includes analysis of various parameters:

Self-Check – 6	**Written test**

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

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

Test I: Short answer questions (4 points

1. What are the Fertigation solution, soil solution
2. What are the Fertigation enables producers and growers to dose additional nutrients and fertilizers?

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

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

Information Sheet 7- Implementing corrections

7.1 Minimising the environmental impact of fertigation

Fertilisers applied via fertigation are all very soluble and therefore easily leached

Some of these impacts include algae blooms causing the depletion of oxygen in surface waters, pathogens and nitrates in drinking water, and the emission of odors and gases into the air. Simply put, fertigation is a process that combines fertilization and irrigation. Fertilizer is added to an irrigation system. It is most commonly used by commercial growers. ... It also reduces soil erosion and water consumption, reduces the amount of fertilizer utilized, and controls the time and rate it is released from the root zone. Farms using Fertigation should therefore monitor the operation of the Fertigation system as described above

Key issues for the environment are:

- Detection and prompt repair of leakages
- Monitoring of root zone moisture levels and minimisation of run-off
- Monitoring of pH and EC so that the need for flushing of the media or release of collected run off solution to reduce Salinity in the root zone is minimised or avoided Minimisation and management of fertiliser waste

Self-Check – 7	**Written test**

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

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

1. Explain the term fertigation
2. Explain Key issues for the environment are
3. Describe how to handle and mix concentrated acid safely
4. a. Calculate the fertiliser needed to mix 750 litres of stock for Tank given the recommendations:

Calcium Nitrate	65Kg / 1000 litres
Magnesium Nitrate	42Kg / 1000 litres
ZnEDTA	500g / 1000 litres

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

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

Operations Sheet 1	Operate Fertigation Equipment

Prepare stock solution according to the recipe provided by your Instructor.

- Dilute a sample of your stock Solution 1 : 200

  Measure the pH and EC

- Select fertilisers to supply Nitrogen and Potassium to a crop via fertigation using a Family Drip System
- Calculate the fertiliser needed to mix 200 litres of solution containing 200 ppm N and 200 ppm K

Prepare work Instructions for a Small Farmer who is required to apply this fertiliser by fertigation using a Family Drip system

Check the output from a drip irrigation system and flush the lines after fertigation

Lap test	Performance Test

1. To prepare a reference stock solution, dilute the stock as instructed and measure the pH and EC
2. Apply fertigation using a family drip system
3. Check output from a drip irrigation system and flush the lines after fertigation or for end of season cleaning

LG #39	LO # 6 Apply specific products at appropriate rates& shut down the fertigation process

Instruction sheet

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

- Selecting specific products based on their analysis
- Calculating Product application rates
- Applying specific products at the correct rate, timing and method
- Recording product applications
- Monitoring, documenting and reporting target plant response
- Flushing out Injection equipment
- Cleaning equipment
- Managing waste generated

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

- Selecting specific products based on their analysis
- Calculating Product application rates
- Applying specific products at the correct rate, timing and method
- Recording product applications
- Monitoring, documenting and reporting target plant response
- Flushing out Injection equipment
- Cleaning equipment
- Managing waste generated

Reporting and recording fertigation activities

Learning Instructions

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
    - If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”

Information Sheet 1- Selecting specific products based on their analysis

1.1 Selection of products to apply based on product analysis

To be able to select fertiliser products based on analysis we first have to consider how the analytical data is presented on the product label and how fertiliser recommendations are expressed.

Fertiliser recommendations for solid fertiliser to be applied as Base Dressing or Top Dressing are quoted in **Kg / ha N, P_2O_5 and K_2O (**Nitrogen, Phosphate and Potash**)**

Fertiliser recommendations for application by fertigation are quoted **in ppm N P K (**Nitrogen, Phosphorus and Potassium**)** and **(**PPM being Parts per million by weight based on atomic weights**)**

Therefore it is necessary to be clear about how the analysis information for the fertiliser is presented.

Fertiliser analysis on commercial fertilisers are shown as % N, P_2O_5 and K_2O

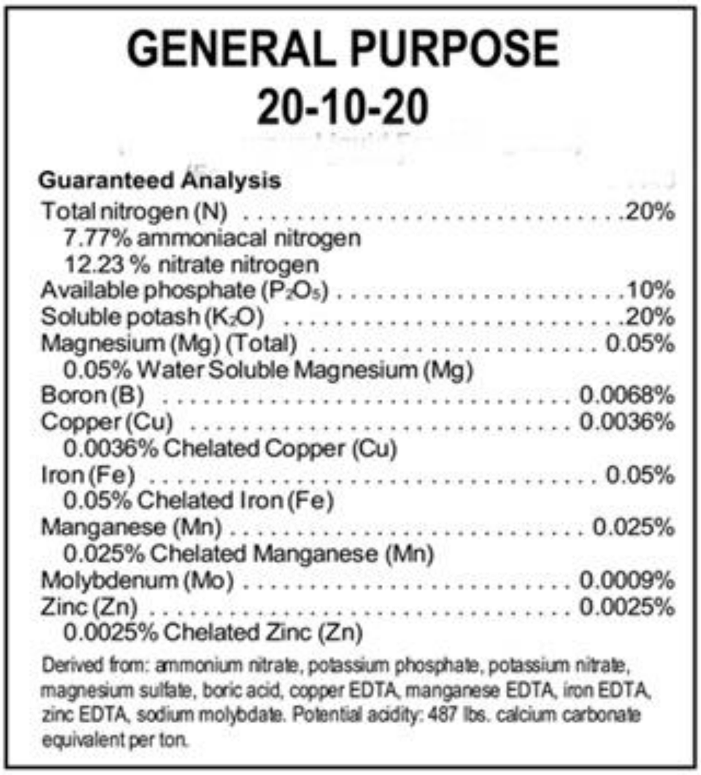
P_2O_5 and K_2O can be converted to their elemental analysis by multiplying by conversion factors. To convert from the Oxide content to the Elemental content of fertiliser requires the use of conversion factors:

% P_2O_5 x 0.44 = % P	**% P x 2.29 = % P_2O_5**
% K_2O x 0.83 = % K	**% K x 1.2 = % K_2O**

Table 1 Therefore in the example shown below

	**Kemapco** is the name of the Manufacturer **Potassium Nitrate** is the name of the fertiliser **13-0-46** is the analysis The net weight of the bag is **25Kg**	**13-0-46** means 13% N 0% P_2O_5 and 46% K_2O This is therefore: 13% N 0% P and 38% K The net weight of the bag is **25Kg** Therefore the bag contains 3.25 Kg N 0% P and 11.5Kg K_2O 3.25 Kg N 0% P and 9.5 Kg K

A comprehensive label for a proprietary compound blended fertiliser is shown overleaf.

This label is from a general purpose proprietary **Blended Fertiliser** and gives a full analysis of the contents: % N total and divided into N supplied in the Nitrate and Ammonium form (Plants prefer to have N supplied as both types of ion) % P_2O_5 and K_2O (available and soluble) % Mg, B, Cu, Fe, Mn, Mo and Zn	

GENERAL PURPOSE
20-10-20

Guaranteed Analysis
Total nitrogen (N) 20%
7.77% ammoniacal nitrogen
12.23 % nitrate nitrogen
Available phosphate (P_2O_5) 10%
Soluble potash (K_2O) 20%
Magnesium (Mg) (Total) 0.05%
0.05% Water Soluble Magnesium (Mg)
Boron (B) 0.0068%
Copper (Cu) 0.0036%
0.0036% Chelated Copper (Cu)
Iron (Fe) 0.05%
0.05% Chelated Iron (Fe)
Manganese (Mn) 0.025%
0.025% Chelated Manganese (Mn)
Molybdenum (Mo) 0.0009%
Zinc (Zn) 0.0025%
0.0025% Chelated Zinc (Zn)

Derived from: ammonium nitrate, potassium phosphate, potassium nitrate, magnesium sulfate, boric acid, copper EDTA, manganese EDTA, iron EDTA, zinc EDTA, sodium molybdate. Potential acidity: 487 lbs. calcium carbonate equivalent per ton.

all quoted as % element Cu, Fe, Mn and Zn are all chelated with EDTA The components of the Blend are stated at the base of the label. Potential acidity means that 487 lb of this product has the same effect on Soil pH as one Ton (2240 lb) of calcium carbonate i.e. very small effect	

Fertilisers in common use in field crop production Ethiopia:

Traditionally:

Urea 46 % N and **DAP**(Di-Ammonium Phosphate) 18% N 46% P_2O_5 (20.2%P) 1.5% S have formed the basis of all fertiliser recommendations. However recent soil surveys carried out by the Ethiopian ATA have shown that this limited range of fertilisers is not the most suitable for all Regions in Ethiopia and a new range of Blended fertilisers shown here, is being developed and introduced by the Ministry of Agriculture.

Please consult your Instructors and the local Agriculture Bureau to find out which is the most appropriate Blend for your area.

Formula 1: NPS	19 N – 38 P_2O_5 +7S
Formula 2 : NPSB	18. 1 N – 36.1 P_2O_5 + 6.7S + 0.71B
Formula 3 : NPKSB	13.7 N – 27.4 P_2O_5 – 14.4 K_2O + 5.1S + 0.54B
Formula 4 : NPSZnB	16.9 N – 33.8 P_2O_5 + 7.3S + 2.23Zn + 0.67B
Formula 5 : NPKSZnB	13.0 N – 26.1 P_2O_5 – 13.7 K_2O + 5.6S+ 1.72Zn + 0.51B
Formula 6 : NPSZn	17.7 N – 35.3 P_2O_5 + 6.5S + 2.5 Zn
Formula 7: NPSZn	15 N –31 P_2O_5 –8 K_2O + 7 S+ 2.2 Zn
Formula 8 : NPSFeZn	17 N –35 P_2O_5 +8 S+ 0.3 Fe+ 2.2Zn
Formula 9 : NPSFeZnB	17 N –33 P_2O_5 –0 K_2O + 7 S+ 2.2 Zn+ 0.3 Fe+0.5 B
Formula 10: NPSFeZn	15 N –30 P_2O_5–8 K_2O +7.0 S+ 0.3 Fe-chelate+ 2.2Zn
Formula 11: NPKSFeZn	17 N –20 P_2O_5 –8 K_2O + 11 S+ 2.2 Zn+ 0.3 Fe + 0.5 B
Formula 12: NPKS	15 N –29 P_2O_5–8 K_2O +10S

- ✓ **In practice, the selection of products to use is based on several considerations:**
  - The nutrient analysis of the product
  - The effect on soil and media pH

- The types of nitrogen
- Solubility
- Purity and freedom from toxic contaminants
- Availability and Cost of the actual nutrient

The cost of the actual nutrient

It is easy for farmer to compare the cost of fertilisers based on the cost per Kg of product. It is however more meaningful to compare fertilisers based on the cost per Kg of Nutrient; e.g. If Potassium Chloride, (KCl), cost 12 Birr per kilo and Potassium Sulphate, (K_2SO_4), also costs 11 Birr per kilo. Which is the best buy?

	Potassium Chloride KCl		Potassium Sulphate K_2SO_4	
Analysis	59% K_2O		50% K_2O	
Actual Cost per Kg K_2O	$\frac{12 \times 100}{59}$	= 20.334 Birr	$\frac{11 \times 100}{50}$	= 22.0 Birr

This example shows clearly that the 'Cheapest Fertiliser' may not actually be 'cheapest'!

Availability and Cost

Unfortunately these are still two major limiting factors

Self-Check – 1	**Written test**

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

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

Test I: Short answer questions (4 points)

1. What are the Fertilisers in common use in field crop production Ethiopia
2. What are The solubility nutrient ?

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

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

Information Sheet 2- Calculating Product application rates

2.1 Calculate application rates

Average crop needs for fertiliser have been established experimentally over many years for different crops, seasons and target yields. Fertiliser recommendations are designed to satisfy the plant needs for nutrients and maintain soil fertility without causing either excessive leaching or an increase in soil salinity. The Ministry of Agriculture in Ethiopia produces fertiliser recommendations for common crops grown in the various Regions by Small holder farmers and these have been adapted for use in large scale and intensive farming systems by Farm Managers and consultants working with these Enterprises.

Recommendation vary for each Crop type, the Crop Yield expectation and the soil characteristics and nutritional status prevailing.

In practice, most Farmers use fertiliser recommendation provided by the Government or by private consultants and make adjustment year on year based on experience and soil analysis

Table 1 Fertilizer recommendations

Crop Tomatoes: Fertiliser recommendations are:			
Yield expectation → / Nutrients ↓	Target yield 600 – 700 Qt/ha	Target yield 850 Qt/ha	Target yield 1,000 Qt/ha
N	82	127	336
P_2O_5	92	92	152
K_2O	0	238	554

Fertilisers selected:

Urea (46%N)

Potassium Chloride (60% KCl)

ATA Formula 1 (19%N – 38% P_2O_5 – 0% K_2O – 7%S)

Calculation:

To calculate the amount of fertiliser needed per ha use the formula:

$$\text{Amount of fertiliser needed Kg / ha} = \frac{\text{Amount of Nutrient needed} \times 100}{\text{\% Nutrient in the Fertiliser}}$$

To calculate how much nutrient an amount of fertiliser provides use the formula

$$\text{Amount of Nutrient in … Kg Fertiliser} = \frac{\text{\% Nutrient in the Fertiliser}}{100}$$

Target yield 600 – 700 Qt/ha

Start with NPS as this is the only fertiliser containing P_2O_5

Amount of NPS needed /ha = $\frac{92 \times 100}{38}$ = 242 Kg

Then calculate how much Nitrogen the fertiliser provides

Amount of N in 242 Kg NPS = $\frac{242 \times 19}{100}$ = 46 Kg N

The total amount of Nitrogen needed is 82 Kg /ha

Use Urea to supply the balance of Nitrogen required (82 – 46) 36 Kg N

Amount of Urea needed /ha = $\frac{36 \times 100}{46}$ = 78 Kg

Crop Tomatoes: Calculated Total Fertiliser requirements in Kg/ha are:			
Yield expectation → Fertiliser ↓	Target yield 600 – 700 Qt/ha	Target yield 850 Qt/ha	Target yield 1,000 Qt/ha
NPS	242		
Urea	78		
Potassium Chloride	0		

Please complete the calculations for Expected Yield 850 and 1,000 Qt/ha

Self-Check – 2	**Written test**

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

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

Part II. Show your calculations clearly in steps

1. What quantity of urea, SSP and MUP(Muriate of potash) will be required for applying N,P_2O_5,K_2O at a rate of 92,32, &30 kg/ha respectively(5pts)
2. Calculate the amount of $NaNO_3$,SSP,and K_2SO_4 for N,P_2O_5,K_2O at a rate of 32,16 and 24 kg/has respectively(5pts)
3. It is recommended to apply 92 kg N, 32 kg P_2O_5 and 60 kg K_2O/ha. Calculate the amount of urea, SSP and MUP for an area of 4000m^2? (5pts)
4. How much of calcium ammonium nitrate(CAN) can supply the same plant nutrient as contain in 25 kg Na NO_3(5pts)
5. Calculate the amount of DAP, urea and MUP for supplying 80 kg N, 92 kg P_2O_5 and 60 kg K_2O(5pts)

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

Note: **Satisfactory rating - 25 points** **Unsatisfactory - below 25 points**

Information Sheet 3- Applying specific products at the correct rate, timing and method

When working in a commercial farm where you are working under the guidance of a production manager and have responsibility for implementation of the Plant Nutrition programme, you may be required to supervise workers applying fertiliser in the field, procedure shown below), or working with the fertigation system When Supervising workers applying fertiliser in the field; key points are:

Ensure that the materials and equipment needed are available in the field

Explain the work instructions and check understanding

Divide the area to be treated into convenient units and mark out the units

Allocate workers to units

Measure the correct amount fertiliser accurately for each unit

Supervise the workers applying fertiliser to check rate of application, uniformity of application and placement

Provide guidance and coaching for workers who do not work to a satisfactory standard

Ensure that all distribution equipment is emptied and cleaned at the end of the task.

Selection and correct application of specific products through nutrient analysis

Self-Check – 3	**Written test**

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

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

Test I: Short answer questions (4 points)

1. What are the m Nutrient Analysis. ?
2. What are The fertilizer analysis?

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

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

Information Sheet 4- Recording product applications

4.1 Record application

Records of fertiliser application are required by all farms.

As with all Farm records, the data must be complete, accurate, recorded at the time of operation, legible and stored in such a way that useful information is readily available when required.

- Details required are as a minimum:
- ✓ Field number, crop and area treated
- ✓ Date of application
- ✓ Product used and nutrient analysis
- ✓ Method of application

This data can be used to calculate the total cost of Fertiliser used and the cost of fertiliser used per kilo or per tonne of produce harvested.Farmers growing 'Certified' (MPS, Global GAP, Fair Trade, etc.) crops for export may also be required to record:

- The source and batch number of fertiliser to demonstrate traceability
- The name of the operator responsible for the application and
- The type and number of the application used when more than one type of piece of equipment is available on the farm
- Monitor and maintain records of soil fertility
- Keep records of waste disposa

Self-Check – 4	**Written test**

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

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

Test I: Short answer questions (3points)

1.list the Farmers growing 'Certified' ?

2. mention Records of fertiliser application?

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

Information Sheet 5- Monitoring, documenting and reporting target plant response

5.1 Monitor and document the impact of Application on the crop and the environment

- **All farmers need to monitor**:

- ✓ The Status of Crop growth
- ✓ Incidence of pests and diseases
- ✓ Signs of nutrient deficiency and soil salinity
- ✓ Potential and actual return on investment in fertiliser
- ✓ Implementation of responsible fertiliser use to minimise the impact of use on the environment and sustainable land use.

In the Small Farmer sector, it is the responsibility of the Farmer to monitor the performance of crops on the farm and to plan and make decisions relating to observations of crop performance. How to monitor the crop responses to fertiliser application should be included in trainings provided at the Farmer Training Centre and Lead Farmers should be coached so that they are able to guide the Farmers in their network group.

In the commercial farming sector, the Crop Scout, the Crop Supervisor and the Production Manager will all observe application practices and crop growth. Based on observations and reports, this group will meet regularly to discuss progress and agree actions to be taken.

5.1.1 How actual crop growth affects the Fertiliser programme planned

At the start of each season a Farmer or Farm Production Manager will make a cropping plan and fertiliser application schedule. Then during the growing season it is essential to monitor crop growth so that adjustment can be made to this plan as necessary, e.g.

- ✓ Heavy rainfall may have caused significant leaching of nutrient leaving the crop looking 'hungry' so additional Top Dressing may be justified
- ✓ Lower than expected temperatures may have resulted in slow crop growth so the application of Top Dressing / change of nutrient balance in the feed may need to be delayed
  - ✓ Where conditions for crop establishment and growth have been difficult and the crop stand in poor then the crop yield potential needs to be considered as additional application of fertiliser may not be justified.

5.1.2 Impact of Fertiliser application on the incidence of Pests and Diseases

This part of the monitoring process will be done during the routine Crop Scout inspection.

Crop Scouts will note when growth is very soft and examination of week on week reports will show when the incidence of pests and diseases in increasing. Where problems are attributed to soft growth and nitrogen application or nitrogen release from organic matter incorporated prior to planting, it may be appropriate to lower future Nitrogen feeds and increase the level of potash (K) in the feed.

5.1.3 Symptoms of deficiency

Symptoms of nutrient deficiency and soil salinity should also be noted and reported during the crop scout process and action to be taken is decided by the production Manager. Some nutrient disorders can be treated whilst the crop is in place provided that prompt action is taken. Other disorders will require remedial action to be taken before the next crop is planted

Farmers growing crops in greenhouses will record the pH and EC of fertigation solution and run off so that appropriate changes to pH, EC and feed composition and the volume of irrigation supplied can be made before the pH and conductivity of the root zone moves outside the target range.

5.1.4 Impact on the Environment

The impact of fertiliser application on the Environment is difficult for a Farmer to monitor. However the operational practices that cause a negative impact are easier to see and should be monitored and controlled by the Farmer or Farm Management as part of routine management. This allows for action to be taken by the team before significant damage to the environment occurs.

Key issues to monitor in the field are; run off from manure and compost heaps entering water courses, over application of fertiliser or irrigation leading to leaching and application of fertiliser close to surface water sources.

Key issues for fertigation in soil grown crops are: excessive leaching resulting from over application or flushing excess salts from the root zone which can be minimised by matching application with the plant actual needs for water and careful selection of fertilisers to minimise the build-up of salts in the root zone.

Key issues for fertigation in crops grown in pots or troughs are: collection and use of the run-off. In most systems this is recycled into the crop or used for other crops grown in soil. Disposal of the collected run-off into or near water courses is not allowed until the water has been treated (in a constructed wetland) to remove the nutrients

Self-Check – 5	**Written test**

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

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

Test I: Short answer questions (4 points)

1. Explain Symptoms of deficiency
2. Define the Impact fertilizer on the Environment?

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

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

Information Sheet 6- Flushing out Injection equipment

6.1 Flushed out Injection equipment according to enterprise standards prior to shut down

Flush out **injected equipment** or flush out valves should be placed at the ends of all irrigation or fertigation operation. There must be a means of flushing debris from the pipe to reduce emitter clogging. Flush out and flush valve installations should be designed and installed in a way that allows quick location and easy access for maintenance. Installation of the flush device in a valve box is preferred.

Folded over and clamped pipe is unsightly and can leak. A manual shut-down valve should be installed between the potable water supply and the backflow prevention unit. A ball valve is recommended.

A manual shut-down allows installation and repair without interrupting flow to the house.

A manual shut-down allows for winterizing the downstream components of the point of connection.

Ball valves must be opened and closed slowly.

Prior to starting the first irrigation season (and at any time system pressure or flow rate is reset)

1. Filter system adjustment

- Media cleaning
- Backflush flow adjustment

• Backflush frequency adjustment

• Backflush duration adjustment

• Backflush dwelling-time adjustment (the time between flushing of each two consecutive tanks)

2. System evaluation – test flow rate, operating pressure and distribution (emission) uniformity

Annually before the beginning of irrigation season

1. Undertake system evaluation – test flow rate, operating pressure and distribution (emission) uniformity

2. Inspect pumping station and pump/motor maintenance

3. Test bore and pump

4. Inspect all system components and replace defective ones

1. Inspect media and screen filters
2. Flush system

During the irrigation season

▪ Daily observations

- Walk the field and repair any system irregularities
- Check screen/media filter performance
- Check and record system pressure and flow rate

▪ Weekly observations

- Ckeck for emitters clogging
- Clean screens and strain

Self-Check – 6	**Written test**

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

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Discuss the importance of flushing out injection equipment's before shutdown fertigation equipment's. 8 points
2. Explain the advantages of manual shutdown of fertigation equipment. 4 points

Note: **Satisfactory rating - 12 points** **Unsatisfactory - below 12 points**

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Information Sheet 7- Cleaning equipment

7.1 Clean Application Equipment according to enterprise procedures

The system need to be flushed at least once a month. The frequency can be increased or reduced depending on the amount of impurities in the irrigation water. When the irrigation is complete, all the equipments and their component should be cleaned and stored safely in a safe place.

The procedure for the network is as follows:

• Flush mains, sub mains, manifolds and laterals.

• Inspect for possible damage to the network and repair it.

• Open fully and drain completely all valves.

• Remove dirt, corrosion and other foreign material from the component parts.

• Check emitters for possible clogging, damage, wear and signs of deterioration, and replace where necessary.

• Store all emitters in a dry clean place on shelves away from fertilizers, chemicals, oil, grease and lubricants.

• Examine the condition of air and check valves.

• Flush and drain filtration and fertilizer injection equipment.

• Clean all filter elements.

• Check condition of gaskets and seals; remove, clean and store in a dry place.

• Retrieve all portable plastic tubes by rolling them up in coils; store properly.
• Inspect all portable metal pipes for any kind of damage and consult suppliers for repair; store properly away from power lines and wiring.

• Drain completely all pipes left in the open

1) The job site shall be kept in a neat, clean, and orderly condition at all times during the installation process.

2) All scrap and excess materials are to be regularly removed from the site and not buried in trenches.

3) Trenching, laying pipe and backfilling shall be continuous so that the amount of open trench at the end of each work day is minimized. Any open trench or other excavations shall be barricaded and marked with high visibility flagging tape.

Next to tidiness, cleanliness is one of the most essential elements in maintaining a healthy and safe work environment. Not only does a clean workplace reflect the professionalism of a business or facility and help motivate employees, it also promotes a healthy workforce as a clean environment prevents accidents and the spread of germs.

Many office managers strive to maintain a clear work site policy, few succeed. However, each employee should be responsible for keeping their individual work area tidy and clean. It takes very little time to adopt a "clean and tidy as you go" policy and it needn't hinder work performance. Furthermore, there is no reason why employees shouldn't contribute to keeping the common work areas clean and tidy. Simple acts such as putting rubbish in the correct bin, placing cups in the dish-washer or washing them up and putting them away would contribute greatly to achieving a better working environment.

Like Health & Safety, maintaining a clean work environment is the responsibility of everyone.. However, there is only so much cleaning the team can do during each shift and in such cost conscious times it makes sense for employees to adopt some simple good housekeeping practices and allow the cleaning team to concentrate on hygiene and deep cleaning tasks.

Preventing mess as well as clearing up as you go along helps create a healthy workplace and provides the professional cleaning teams with a good platform to make effective use of their time on-site, allowing them to concentrate on hygiene, germ containment, recycling and deep cleaning. Working together we can all contribute to creating a safe and healthy workplace and a professional looking facility for employees, visitors and customers

Self-Check – 7	**Written test**

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

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What are the advantages of cleaning fertigation equipments at the completion of work? 7 points
2. List steps/techniques of cleaning fertigation equipment. 10 points

Note: **Satisfactory rating – 17 points** **Unsatisfactory - below 17 points**

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

Information Sheet 8- Managing waste generated

8.1 Manage waste generated by the use of fertiliser on the farm

In fertigation management, fertilizer choice and irrigation water quality are the two most important considerations. The water characteristics influencing the fertigation operation are ion composition, water salinity level, pH, bicarbonate concentration and redox potential.

Two main aspects are of importance when water quality is considered in fertigation:

1. The effect of water quality on plant nutrition;
2. The fertilizer-water interactions in the irrigation system.

Fertility Management Native soils are generally used as the growing medium in most high tunnel systems and therefore the first step in managing fertility in a high tunnel is to obtain a routine soil test. Soil pH, P, K, Ca, Mg, and micronutrients should be monitored every two to three years or more often if problems are occurring. In addition, a soluble salts test (also known as an electrical conductivity test) is recommended to ensure that salts are not building up. For most situations, adjustment of pH, phosphorus fertility, and micronutrients should be done before planting.

Fertilizers are an important resource input in conventional agriculture, however the over-application of nutrients can cause a host of environmental problems including polluting water resources and emitting nitrous oxide (a potent greenhouse gas) into the atmosphere.

Environment protection

- Is aware of relevant catchment management plans and ensures fertilizer use is consistent with those plans and with the soil's present fertility status.

- Knows and understands the relevant environmental values of local water bodies
- Is aware of the priority pollutants of local water bodies.

- Recognizes the indicators of eutrophication in water bodies.
- Is aware of whom to contact and the procedures to follow should a fertilizer spill occur in a farm dam or waterway.
- Understands the main pathways for nitrogen and phosphorus fertilizer loss from farms, specifically.

Fertigation is another management tool for growers to use in production of selected vegetable crops. It is an extremely effective and efficient method of applying fertilizers and other chemicals via the drip irrigation system. However, it does require more management and attention to details than other methods of fertilizer application. Success in using this system will depend on a sound fertility program based on soil testing and a drip irrigation system that is designed and operated properly.

Self-Check – 8	**Written test**

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

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Why need of managing waste materials generated by fertigation process and cleaning process? 6 points
2. Discuss the impact of wastes management in environmental protection. 6 points

***Note:* Satisfactory rating – 12 points** **Unsatisfactory - below 12 points**

Information Sheet 9- Reporting and recording fertigation activities

9.1 **Record keeping and monitoring fertilizer response**

The first time that a Nutrient Management Plan is done, the quality of the plan may be less than ideal because many of the calculations are based on assumptions that are not necessarily backed up with solid information. However, as the farmer begins a process of keeping thorough organized records on nutrient management practices, the plan can be adjusted each year based on these records. Over time, the quality of the plan will improve substantially.

One of the best sources of information in planning a major overhaul should be the maintenance records for the unit or units involved. These records should provide details on the history, present condition, and any unusual maintenance problems of the fertigation unit. This can help identify specific items that may need attention during the overhaul. Reports of previous overhauls can prevent the same mistake from being made twice and may provide tips that can expedite the overhaul procedure. The maintenance files may also provide names of sources for parts and materials and fertigation equipmen

The most important data to record includes:

1. Crop grown
2. Date, rate and method of all manure applications
3. Date, rate and method of all chemical fertilizer applications including formulations
4. Harvest (and planting/seeding) date
5. Yield
6. Crop quality information (or vigour assessment for berries)

Self-Check – 9	**Written test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Explain the importance of recording and reporting of fertigation activities at the completion of activities. 7 points
2. What are the fertigation activities should be recorded and reported. 8 points

Note: **Satisfactory rating - 15 points** **Unsatisfactory - below 15 points**

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

Operation sheet 1– Apply Products

For the Crop Production provided by your instructor:

1. Select the fertilisers to use
2. Calculate the amounts of fertiliser needed
3. Prepare an application plan

a. Timing of applications

b. Method of application

4. Supervise a team of people applying fertiliser
5. Record the application

Clean the fertiliser application equipment provided by your Instructor:

- Flush out drip lines

Clean the fertiliser distributor

Dispose of fertiliser wastes in accordance with the College Waste Management procedures

Operation Sheet -2	Cleaning fertigation equipments

Steps/ techniques to clean fertigation equipment are:-

1. Flush mains, sub mains, manifolds and laterals.
2. Inspect for possible damage to the network and repair it.
3. Open fully and drain completely all valves.
4. Remove dirt, corrosion and other foreign material from the component parts.
5. Check emitters for possible clogging, damage, wear and signs of deterioration, and replace where necessary.
6. Store all emitters in a dry clean place on shelves away from fertilizers, chemicals, oil, grease and lubricants.
7. Examine the condition of air and check valves.
8. Flush and drain filtration and fertilizer injection equipment.
9. Clean all filter elements.
10. Check condition of gaskets and seals; remove, clean and store in a dry place.
11. Retrieve all portable plastic tubes by rolling them up in coils; store properly.
12. Inspect all portable metal pipes for any kind of damage and consult suppliers for repair; store properly away from power lines and wiring.
13. Drain completely all pipes left in the open

Lap Test	**Demonstration**

Name………………………………. ID……………………………..

Date…………………………………….

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **1** hour. The project is expected from each student to do it.

1. Task 1 to perform Prepare an application plan
2. Task 1. Clean ferigation equipments

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