TVET CERTIFICATE III in CROP PRODUCTION

FERTILIZER APPLICATION

CRPFA302

Apply fertilizer

Competence

Learning

Credits: 5

hours:50

Sector: Agriculture and food processing

Sub-sector: Crop production

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Purpose statement

This module describes the skills, knowledge and attitude required to apply fertilizer. it is designed for trainees who have successfully completed 9 years basic education or its equivalent and pursuing TVET certificate III in crop production or any other related qualifications. At the end of this module, trainees will be able to prepare for fertilizer application operations, prepare tools, materials and equipment, and use fertilizers. qualified trainees deemed competent may work in various places including Site/field, Office, Nursery and Vegetable garden performing a range of tasks related to crop growing he can work alone or with others under supervision.

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Learning Unit 1 – Plan for fertilizer application operations

LO 1.1 – interpret the instruction provided by the supervisor

Content/Topic 1 : Instruction on task to be done in fertilizer application

- Keep chemicals out of reach of children, pets and livestock and away from food cupboards;
- Store chemicals in their original container or in clearly labelled containers only;
- Empty containers should be disposed off promptly and safely;
- Do not use an empty chemical container for any other purpose;
- Read all labels carefully before using chemicals;
- Use the recommended rates and methods of application;
- Keep appropriate records for chemical application;
- Do not taste or inhale their vapour as they very dangerous;
- Never eat, drink or smoke when using chemicals;
- Wear protective clothing when applying chemicals;
- Do not wear leather gloves or boots as leather can absorb chemicals;
- Wash your hands thoroughly after using chemicals;
- Avoid applying chemicals on windy or rainy days;
- Avoid chemicals spillage as this can pollute water sources;
- Do not spray chemicals immediately before harvesting;
- Do not harvest the crop until the safety period is passed. (The safety period is the length of time one should wait after spraying before harvesting the crop).

Guidelines for fertilizer application

- ***Guideline objectives***

The guidelines are aimed at decision-makers, managers, field supervisors and spray operatives. However, it must be emphasized that in some countries legislation is already in place to control safe and efficient pesticide use and application.

- **Basic aspects of fertilizer application**

The objective is to apply a fertilizer in such a way that the nutrients in it contribute as much as possible towards crop production. This can be accomplished by ensuring that fertilizers remain in the active root zone, improve the soil fertility and produce minimum negative effects on the environment.

A prerequisite of correct fertilizer application is its uniform distribution over all the treated area whether it is surface broadcast or applied in a restricted manner.

- **Multi-nutrient fertilizers vs single-nutrient fertilizers**

Farmers want fertilization to be effective, simple and cheap. This can be achieved through the use of straight fertilizers or suitable complexes. In the case of straight(single-nutrient) fertilizers, a separate fertilizer has to be purchased for each nutrient to be applied (urea for N, TSP for P, MOP for K, ZnSO4 for Zn, etc). Where a suitable multi-nutrient product is available in which the ratio of nutrients is close to or similar to the ratio of nutrients recommended, then one fertilizer can do the job. For example, where agronomical suitable, a 15–15–15 complex can provide any amount of NPK if these are to be applied in a 1:1:1 ratio, or a product of the grade 20–20–0 can deliver N and P if recommended in equal (1:1) amounts.

A multi-nutrient fertilizer that matches the exact nutrient needs of a field is very often not available.

- **Size of fertilizer particles**

Theoretically, fine, powdery material mixed thoroughly into the topsoil layer would result in the most uniform distribution within the root zone. However, this is not always so and it is often too costly. The use of granular, water-soluble fertilizers represents a compromise between uniformity of distribution and ease of application.

- **Fertilizer distribution on the soil surface**

The application of granulated fertilizers on the soil surface is the easiest and most common procedure. The fertilizer granules should be distributed as uniformly as possible in order to supply each plant with nutrients in more or less equal amounts. This is not an easy task. Experienced farmers are able to spread fertilizers by hand with considerable accuracy but mechanical distribution is superior in most cases.

- **Penetration of surface-applied nutrients into the rootzone**

Fertilizers spread on the soil surface, whether bare soil or with plant cover, will penetrate slowly into the top layer if they are water soluble and if there is sufficient moisture. Dryness after fertilization results in a delay in fertilizer nutrient uptake because the applied nutrient cannot be transported to the roots owing to inadequate moisture.

Precision fertilization

Variability and uncertainty are dominant features of field crop production. There are differences between nutrients in the type of variation encountered in field situations. For P and K, the variation is mainly spatial and location-related, but for N there is an additional large temporal (time-related) variation. These are difficult to account for with traditional fertilizer application methods.

Placement of fertilizers

Placement usually means positioning the fertilizer in a desired region or depth at sowing, either at the side or below the seed. It is normally done where the entire field is not to be treated or where restricted soil fertilizer contact is desired, as in the case of highly water-soluble but relatively immobile nutrients such as water-soluble phosphates. Placement is also the preferred method of fertilizer application for crops planted in widely spaced furrows, e.g. maize, potato, sorghum, sugar cane and pineapple (except for bushes and tree crops).

Fertilizer placement is generally made at sowing time or soon after in a number of ways:

- In a band a few centimetres to the side and below the seed;
- In a band directly below the seed, although this may hinder growth of the tap-root;
- In immediate contact with the seed, termed combine drilling (only in moist soils and mainly with phosphate as close contact within may damage the seed);
- In one or two bands on one or both sides of plant rows;
- By spot application between plants as in the case of usgs between rice hills or as in the case of ring placement around trees.

✓ Application equipment for solid fertilizers

The main problem with fertilizer application is non-uniform distribution in the field. Compared with the widely used and tedious spreading of fertilizer by hand, mechanical distribution is labour-saving and more precise. However, it should also be cost-effective. Precise and more expensive spreading procedures may be worthwhile for expensive fertilizers used to produce high yields on medium–large farms.

The requirements for suitable mechanical distributors are:

- Delivery of exact rates;
- Uniform distribution of the fertilizer with a deviation of less than 10 percent;

- Distribution to be independent of slope and speed;
- Ease of handling, operation and maintenance;
- Resistance to corrosion;
- Energy efficient.

✓ **Application of liquid and gaseous fertilizers**

Some of these require special application techniques while others can be sprayed on the leaves with conventional sprayers.

Application of liquid fertilizers

Liquid fertilizers serve two different purposes, either to supply nutrients to the soil or to provide direct nutrient supply to plants through foliar sprays. Fertilizer solutions provide for better soil transport and distribution of nutrients compared with granular fertilizers. Suspensions, which are concentrated solutions with small suspended solid particles, usually have higher nutrient concentrations than do liquid solutions. Both require solid and corrosion-resistant tanks or silos for storage and transport, good safety measures and special application equipment.

Liquid fertilizers that can be applied on bare soil or on soils covered with plants include: fertilizer solutions, fertilizer suspensions and organic materials such as animal slurry. These can be materials containing one or more nutrients including macronutrients and micronutrients.

The application of liquid fertilizers to soils has advantages and disadvantages:

Advantages:

- application of dissolved and, thus, immediately available nutrients,
- simple filling procedure of containers by pumps (labour-saving),
- very precise fertilizer distribution (superior to spreading of solids),
- large area can be fertilized in a short time (5–10 ha/hour),
- fertilization can be combined with compatible crop protection sprays;

Disadvantages:

- Nutrients in soluble forms (liquids) are generally more expensive than those in solid forms,
- Large amount of water must be transported,
- Complete fertilization is rarely possible, hence, application of solids is also needed,
- Transportation and storage requires expensive tanks and safety measures,

- Nozzles must be corrosion-resistant,
- Handling is generally more expensive than with solid fertilizers.

Application of gaseous fertilizers

In practice, fertilization with gases is restricted to anhydrous ammonia. It is a widespread practice in countries with large farms, a low ammonia price and high cost of solid N fertilizers (e.g. the United States of America). Anhydrous ammonia is applied from pressurized tanks. It leaves the distributing device as a gas after the pressure has been released and enters the soil as a gas.

✓ **GUIDELINES FOR THE APPLICATION OF ORGANIC MANURES**

Application of solid manures

Bulky organic manures such as composts and FYM can be applied to all soils and almost all crops, as can oilcakes, recycled wastes and animal meals. In order to make best use of the slowly acting N, these should be applied a few weeks before sowing, spread uniformly over the field and immediately ploughed into the soil in order to avoid ammonia losses. Common application rates are about 20 tonnes/ha but range from 10 to 40 tonnes/ha.

Application of slurries

Slurry can be obtained from farm animals raised in organized dairy farms. Animal slurry is the major manure in many developed countries where cattle are raised on
a large scale. Other forms of slurries are obtained from the treatment of sewage and from biogas plants.

Application of animal slurry

The common practice of spreading animal slurry on the soil surface results in substantial losses of ammonia where the slurry is not mixed immediately into the soil. N losses are reduced by modern drilling machines that place slurry a few centimeters into the, preferably, moist soil. In this respect, it is similar to suspension fertilizers.

Application of sewage (wastewater) and sewage sludge

In many countries, sewage sludge is rarely used directly as a nutrient source by applying it on bare soil. Because this procedure has health risks, wet sewage sludge is converted into a moist or dry solid product and possibly processed into sludge compost.

✓ **Application of green manure**

Green manure can be either grown in situ and incorporated in the main field or grown elsewhere and brought in for incorporation in the field to be manured. Not all plants can be used as a green manure in practical farming.

✓ **GUIDELINES FOR THE APPLICATION OF BIOFERTILIZERS**

Bio-fertilizers can be applied to the seed, to the soil or to the roots of seedlings before these are transplanted in the main field. It is most important to know that not all bio-fertilizers are suitable for all soils and crops.

Application of Rhizobium inoculant

Rhizobium inoculant is the most commonly used bio-fertilizer. It is specifically intended for application to legumes. It is very important to select the correct Rhizobium inoculant.

Application of soil amendments

Problem soils often require amendment before they can be cropped successfully and optimal use made of the plant nutrients applied. Liming of acid soils and reclamation of alkali soils are given here as examples.

LO 1.2 – select tools and equipment referring on fertilizer type

- ***Content/Topic 1 :*** **Criteria for tools, and equipment selection for fertilizer application**

The criteria for selection of tools, and equipment are:

a. Soil type

Some of tools and equipment may be damaged due to soil conditions during land preparation before or during fertilizer application.

b. Types of fertilizer

When choosing different tools and equipment for fertilizers applications types of fertilizer (example organic and inorganic) has to be taken into consideration as well as their physical properties (example: granular, powder or liquid).

c. Weather conditions

When choosing different tools and equipment for fertilizers applications weather conditions should be taken into consideration mainly the rainfall.

d. Cost

In fertilizer application, you should choose tools, materials and equipment which are cheap rather than those which are expensive.

e. **Fertilizer application methods**

Tools used vary according to the methods of fertilizer application. example sprayer are used in foliar method

f. **Availability**

Used the tools available in store which facilitate you to achieve your goals.

LO 1.3 – Assess occupational health and safety (OHS) hazards and risks for reporting to the supervisor

- Content/Topic 1 : Types of hazards associated with fertilizer application

A hazard is something that can cause harm, e.g. chemicals, dust, etc…..

1. Chemical hazards

A chemical hazard is a type of occupational hazard caused by exposure to chemicals in the workplace. e.g. fertilizers

2. Physical hazards

Physical hazard is agent, factor or circumstance that can harm without contact.

e.g. dust, machinery, computer equipment, etc……

3. **Biological hazards**

Biological hazards include viruses, bacteria, insects, animals, etc., that can cause adverse health impacts.

Content/Topic 2 : Hazards risks

Environmental problems associated with fertilizer use

Problem	**Cause mechanism**	**Risks associated**
Groundwater contamination	Leaching of weakly held nutrient forms such as nitrate (most important), chloride, sulphate and boric acid.	Chemical
Eutrophication	Nutrients carried away from soils with erosion, surface runoff or groundwater discharge	Chemical
Methemoglobinemia	Consumption of high nitrate through drinking-water and food.	Biological
Acid rain and ammonia redeposition	Nitric acid formed by the reaction of N oxides with moisture in the air, ammonia	Chemical

	volatilization and sulphur dioxide emissions.	
Stratospheric ozone depletion and global warming	Nitrous oxide emission from soil as a result of denitrification.	Chemical
Itai-itai (ouch-ouch) disease	Eating rice and drinking water contaminated with Cd	Biological
Fluorosis in animals	Ingestion of soil or fertilizer treated with high fluoride PR	Biological

LO 1.3 – Identify environmental implication of fertilizer application for discussion with supervisor

Content /Topic 1 : Environmental impact assessment

Environmental impact assessment (EIA): is a process of evaluating the likely environment impact of a proposed project or development, taking into account inter-related socio-economic, cultural and human health impact, both beneficial and adverse.

Environment Impact Assessment (EIA)

Methods of EIA

Listed below are the important methodologies for assessing the impacts of any developmental activity on the environment:

1. Adhoc method
2. Checklist method
3. Matrix method
4. Network method
5. Overlay method
6. Environmental index using factor analysis
7. Cost/Benefit analysis
8. Predictive or Simulation methods

These methods might vary from:

Simple to Complex

Static piece-meal approach to Dynamic nature of the environment

1. **Ad hoc methods**

Ad hoc methods indicate broad areas of possible impacts by listing composite environmental parameters (Ex: flora and fauna) likely to be affected by the proposed activity.

These methods involve assembling a team of specialists who identify impacts in their area of expertise. Here, each parameter is considered separately and the nature of impacts (long term or short term, reversible or irreversible) are considered. These methods give a rough assessment of total impact while giving the broad areas and the general nature of possible impacts. In this method, the assessor relies on an intuitive approach and makes a broad-based qualitative assessment. This method serves as a preliminary assessment and helps in identification of important areas like:

- ✓ Wildlife
- ✓ Endangered species
- ✓ Natural vegetation
- ✓ Exotic vegetation
- ✓ Grazing
- ✓ Social characteristics
- ✓ Natural drainage
- ✓ Groundwater
- ✓ Noise
- ✓ Air quality
- ✓ Visual description and services
- ✓ Open space
- ✓ Recreation
- ✓ Health and safety
- ✓ Economic values and
- ✓ Public facilities

2. Checklist method

In this method, environmental factors are listed in a structured format by giving importance weightings for factors and application of scaling techniques for impacts of each alternative. Checklists are strong indicators of impact identification. They effectively garner the attention and awareness of their audience. Impact identification is a fundamental function of an EIA.

Checklists may be:

1. Simple
2. Descriptive
3. Scaling or
4. weighting type

Simple checklists are a list of parameters without guidelines regarding either interpretation or measurement of environmental parameters or specific data needs or impact prediction and assessment.

Descriptive checklists include list of environmental factors along with information on measurement, impact prediction and assessment.

Scaling and weighting checklists facilitate decision making. Such checklists are strong in impact identification. While including the function of impact identification, they include a certain degree of interpretation and evaluation. The aforementined factors make these methods attractive to decision-making analysis.
advantages of this methods

1. It is simple to understand and use
2. It is good for site selection and priority setting

Disadvantages of this method are:

1. It does not distinguish between direct and indirect impacts
2. It does not link action and impact
3. It is cumbersome at times

3. Matrix Method

This methodology provides a framework of interaction of different activities of a project with potential environmental impacts caused by them. A simple interaction matrix is formed

when project actions are listed on one axis (usually vertical) and environmental impacts are listed along the other axis.

The **advantage** of the matrix method is that it links action to impact

This is a very good method for displaying EIA results

The **disadvantages** of this method are listed below:

- ✓ It is difficult to distinguish between direct and indirect impacts using this method
- ✓ There is potential for double-counting of impacts
- ✓ It is qualitative in nature and does not refer to quantity of impact

4. Network method:

- ✓ This method uses the matrix approach and extends it to include both the primary as well as the secondary impacts
- ✓ It is shown in the form of a tree called impact tree. This diagram is also called as reference or sequence diagram
- ✓ Identification of direct, indirect along with short, long term impact is a crucial and basic step of making an impact tree
- ✓ The impact tree is used to identify cause-effect linkages
- ✓ The impact tree is a visual description of linkages

The diagram below shows the example of a network analysis:

The advantages of the network method are:

- It links action to impact
- It is useful to check second order impacts in a simplified form
- It handles direct and indirect impacts

The disadvantages of this method are:

- It becomes overly complex if used beyond simplified version
- It is completely qualitative in nature

5. Overlays

- This method depends on a set of maps of a project area's environmental characteristics covering physical, social, ecological and aesthetic aspects

- It enables separate mapping of critical environmental features at the same scale as project's site plan (Ex: wetlands, steep slopes, soils, floodplains, bedrock outcrops, wildlife habitats, vegetative communities, cultural resources, etc)
- In the old technique, environmental features were mappped on transparent plastic in different colours
- Modern technique of the same activity is done using computer software, hardware, data and skilled people. It is called GIS (Geographic Information Systems)

The advantages of this method are:

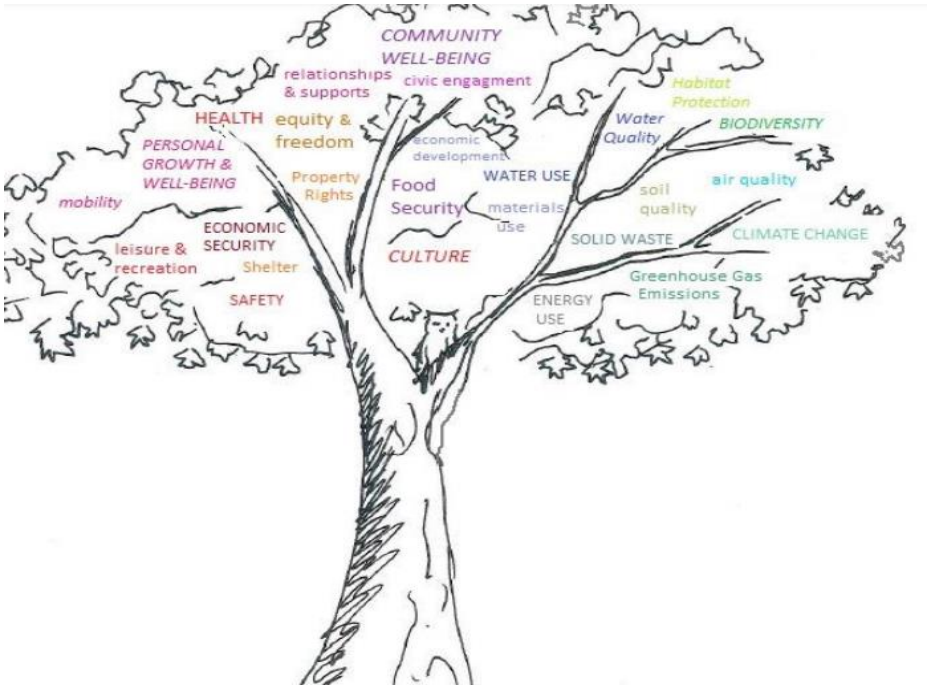
- It is easy to understand and use
- It has a good display and
- It is good for setting site selection

The disadvantages of this method are:

- It addresses only direct impacts
- It does not address impact duration or probability

The Impact Tree

The impact tree can help you identify your full range of social and environmental impacts, beyond what you might obviously think of.



Impact Area	Impact Dimensions
Air Quality	- Decrease in air pollutants, smog, acid rain - Improvements in air quality
Biodiversity/ Habitat protection	- Health of biological systems - Diversity and viability of species - Use of native vegetation - Reduction of invasive species, - Habitat protection
Civic engagement	-Level of citizen involvement in civic life - political and non-political.
Climate Change	- Reducing the possibility of significant, long-lasting changes in the climate of our planet. - Adapting to changes in the climate
Community Well-being	- Encompass all other parts of the tree relating to the healthy functioning of individuals, communities and the natural world.
Culture	-Shared traditions and values -Heritage and place -The arts -Diversity and social history -Cultural identity and preservation.
Economic Development	-Investment -Job creation -Infrastructure development
Economic security	Financial resources necessary to participate fully and with dignity in community activities
Energy use	-Reduction in the amount of energy used -Change in the type of energy used -Increase in energy from more environmental benign sources
Equity and freedom	-Diversity -Equal rights and opportunities -Non-discrimination

	-Freedom of association -Social justice
Food security	-Quality and sustainability of the food supply -People's access to a healthy diet -Food safety
Greenhouse gas emissions	--Reduction in GHG gases by cutting emissions or improving sinks.
Health	-physical and mental health -Health conditions -Activity limitations
Leisure and Recreation	-Free time -Opportunities to express creativity -Opportunities to satisfy spiritual, physical and community needs
Materials use	-Decrease in the amount of materials used (per good/ absolute) -Decrease persistent and synthetic (toxic) materials and increase in more benign materials (organic and biodegradable) -Use of recycled materials, and those from well managed eco-systems
Mobility	-The ability to move in the community -Barrier-free transportation -Environmentally responsible transportation
Personal Growth and Well-being	-Emotional well being -Strength to overcome helplessness -Meaning and connection in life -Resilience
Property rights	-Individual or community ownership and possession of land -Cultural and intellectual property -Indigenous entitlements

Relationships and Supports	-Personal relationships -Family -Community supports
Safety	-Incidence of crime -Consumer protection -Freedom from harm -Life without fear and violence
Shelter	Access to secure and affordable housing
Soil quality	- Improvements in soil quality - Limiting damage to soil
Waste	Reduction in solid waste to landfill through recycling, and reuse.
Water quality	-Limiting water pollution - Improvement in water quality
Water Use	-Decrease in water use for human consumption and manufacturing -Using water in a way that doesn't compromise ecosystem functioning of the water system

- **Content/Topic 2 : The impact of fertilizers on environment**

1. Negative impact

a) Water pollution

The most critical issue in using chemical fertilizers is groundwater contamination. Groundwater is being utilized for drinking water. Nitrogen fertilizers break down into nitrates and travel easily through the soil.

b) Air pollution

The increase in nitrogen in the fertilization of crops may cause greenhouse gases like nitrous oxide and CO_2 into the atmosphere.

c) **Loss of wild biodiversity**

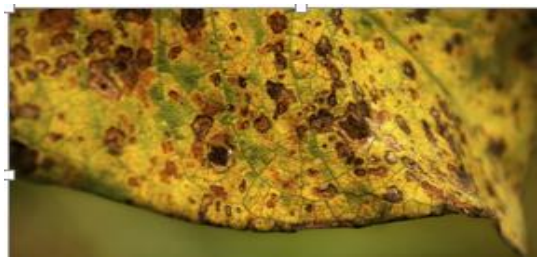
Water polluted by chemical fertilizers.

Chemical run-off has excess fertilizers causing adverse effects on waterways. It creates an imbalance between oxygen and nutrients in the waters. Oxygen depletion causes fishes to die.

d) **Loss of genetic diversity**

Wild strains of agricultural plants are disappearing as development destroys their habitat.

e) **Outbreak of new pests and diseases**



Chemical leaf scorch can cause the plant to wither and die.

It's ironic how these chemical fertilizers negatively affect the plants. Over-application of chemical fertilizer to plants can damage the plants and decrease the crop yield. The condition is known as chemical leaf scorch. It initially causes the leaves to wilt and eventually kills the plant.

2. Positive impact

a) Recycling of waste

The residues are collected in environment are converted into the fertilizer used as nutrient of plant or crops.

b) Soil erosion control

Organic fertilizer increase ability soil to hold water and nutrients.

c) Soil structure improvement

Organic fertilizers break down, they improve the structure of the soil.

d) Feeding soil fauna and flora

Organic fertilizers, like manure, improve the fertility of soil by feeding microorganisms in the soil

LO 1.4 – Select PPE according to the desired operation

- **Content /Topic 1:Types/categories of PPE use in fertilizer application**

✓ **Eye and Face Protection**

Eye protection is achieved by wearing eyewear specifically designed to reduce the risk of exposure to chemical splashes, laser radiation and/or flying debris.

Type	Use
Face shields	• Required when splashes from chemicals that can cause immediate skin damage are handled (e.g. working with concentrated acids, dispensing liquid nitrogen, sonicating tissue samples, etc.). • Shall be worn in conjunction with chemical splash goggles. Respiratory protective equipment might be required, depending on the task; contact EH&S if you have any questions regarding face shield use.
Impact goggles	• Offer protection from flying debris only. • Often have ventilation holes on the sides that render the user susceptible to chemical splashes and dust or small debris. • EH&S does not offer impact goggles, but chemical splash goggles can often be used in substitution. Feel free to contact EH&S with any questions regarding this substitution
Chemical splash	• Are recommended any time a splash of chemicals or infectious substances could reach the eyes. • Can act as impact goggles to prevent flying debris from reaching the eyes.

goggles	• May be purchased from the campus bookstore or obtained from EH&S in accordance with LHAT recommendations
Laser safety glasses	• Selection is based on the laser wavelength and power. • Protective properties can be found printed on the eyewear. • Are not as effective as laser safety goggles at filtering all light entering the eyes. • EH&S does not provide laser safety glasses or goggles for use in the laboratory, but will assist in selecting the correct laser safety goggles or glasses for your application, which can be purchased by the PI as needed
General safety glasses	• Must have side shields, or a one-piece lens that wraps around the temple. • Are the minimum level of eye protection that must be worn in the laboratory. • Are not effective in protecting the eyes from splashes, and are only recommended for use with solutions that are not likely to damage the eye, such as some buffers and salts.

✓ **Hearing Protection**

When an employee's noise exposure cannot be reduced to safe levels, then hearing protection must be worn. There are several options for hearing protection available that include ear plugs, ear muffs, and hearing bands, which are also known as canal caps. Each should be carefully considered for the noise reduction they will provide, as well as for comfort and fit.

✓ **Hand Protection**

Appropriate selection of gloves is essential to protecting hands. Chemically protective gloves are one of the most important tools to minimize dermal exposures to chemicals in research laboratories. Gloves should only be used under the specific conditions for which they are designed, as no glove is impervious to all chemicals

Type		Use
Light latex, vinyl or nitrile gloves	Disposable latex (powdered or unpowdered)	Working with biological hazards (human blood, body fluids, tissues, bloodborne pathogens, specimens), BSL1, BSL2, BSL2+, BSL3
	Disposable nitrile (puncture and abrasion resistant, protection from splash hazards)	Working with biological hazards and chemical splash hazards
	Disposable vinyl (economical, durable, similar to latex)	Working with biological hazards, BSL1, BSL2, BSL2+, BSL3
Light chemical resistant gloves	Natural rubber latex (chemical resistant, liquid-proof)	Working with small volumes of corrosive liquids, organic solvents, flammable compounds
Light to heavy chemical resistant gloves	Nitrile (chemical resistant, good puncture, cut and abrasion resistance)	Using apparatus under pressure, air or water reactive chemicals
Heavy chemical resistant gloves	Butyl (high permeation resistance to most chemicals)	Working with large volumes of organic solvents; small to large volumes of dangerous solvents, acutely toxic or hazardous materials
	Viton® II (high permeation resistance to most chemicals)	Same as butyl gloves, plus hazardous material spills
	Silver shield (extra chemical and mechanical protection)	Same as butyl and Viton® II gloves, added mechanical protection, hazardous material spills

Insulated gloves	Terrycloth autoclave (heat resistant)	Working with hot liquids and equipment, open flames, water bath, oil bath
	Cryogen (water resistant or water proof, protection against ultra-cold temperatures)	Handling cryogenic liquids
Wire mesh gloves	Wire mesh (cut resistant)	Working with live animals and exposed to potential cuts

✓ **Body Protection**

Lab coats are required for all wet labs. Cotton or cotton/poly blends are sufficient for labs without risk of fire.

Type	**Use**
Traditional (cotton/cotton-polyester blend - protects skin and clothing from dirt, inks, non-hazardous chemicals	General use; chemical, biological, radiation and physical hazards
Flame resistant (e.g. Nomex or other flame-resistant cotton — resists ignition)	Working with water or air reactive chemicals, large volumes of organic solvents, and potentially explosive chemical
Barrier (predominantly polyester — offers splash protection, not flame resistant)	Working with infectious materials

✓ **Respiratory Protection**

Respiratory Protective Equipment (RPE) is a particular type of **Personal Protective Equipment** (PPE), used to **protect** the individual wearer against the inhalation of hazardous substances in the workplace air.

Type	**Use**
Surgical masks	Protect against large droplets and splashes (*does not require fit-testing*)

N-95 respirators	Protects against dusts, fumes, mists, microorganisms (*requires fit-testing*
Half-mask respirators	Purifies air: protects against variety of particulates, vapors, dust, mists, fumes; depends on filter cartridge used (*requires fit-testing*)
Full-face respirators	Same as half-mask, with greater protection factor; eye, mucus membranes and face protection; depends on filter cartridge used (*requires fit-testing*
Respirator cartridges	For use in half-mask respirators and full-face respirators

- **Content /Topic2: The criteria of PPE selection**

The criteria of PPE selection are the following:

a) Use
b) Potential hazards
c) Availability
d) Exposure to hazards
e) Level of protection
f) Fitness
g) Awareness
h) of limitation

Procedures for selection of PPE

The selection of appropriate PPE is based upon the hazard assessment. Procedures for selection of PPE include:

- Identifying the potential hazards.
- Determining the types of protective equipment available for the present hazards.
- Evaluating the effectiveness of the PPE.
- Selecting appropriate protective equipment.
- Providing a variety of sizes to properly fit all users.
- Selecting equipment that is compatible with other PPE.

Learning Unit 2 – Prepare tools, materials and equipment

LO 2.1 – Identification of site according to soil fertility status

- **Content/Topic 1: Indicators of soil fertility status**

Fertile (Good) soils are characterized by:

a) Black colour of the soils, surface and sub-surface soil layers
b) Low frequency of watering/irrigation
c) Visible cracks on the soils during the dry season
d) Good crop performance, like maize, millet etc without the use of fertilizers, manures and crop residues,
e) Presence / vigorous growth of a certain plants
f) Presence/growth of plants that survive during the dry season
g) Presence of green vegetation during the dry season
h) Presence of wild sisal and many ever-green trees/vegetation

Infertile (Poor/bad) soils are characterized by:

a) Poor crop performance even with the application of fertilizers or manures
b) Occurrence of red or light coloured sandy soils
c) Poor natural vegetation even where water is not limiting
d) Compacted soils
e) v) Presence of sandy soils
f) Prominence of coarse sand depositions on the landscape
g) Stunted plants even during the rainy season when water is adequate
h) Fast drying up of soils after rains or irrigation
i) Presence of white spots/patches on the soil surfaces
j) Presence of salts or salt patches on the soil surface.
k) Presence of very coarse sands, gravel and stones on the landscape.

a. **Type of vegetation**

The plants species indicate good fertile soil including solanum indicum (intobo karemba), urtica massaica (igisura) , comelina bangalensis (inteja), solanum nigrum (isogo),craccecophalum bumbero (igifaraninde) ,etc …….

The plants species indicate bad fertile soil including ferns (urushihe), Striga spp(kurisuka), eulesina sp (urumamfu), etc……..

b. **Nutrient deficiency symptoms**

Symptoms caused by **nutrient deficiencies** are generally grouped into five categories:

- ✓ Complete crop failure at the seedling stage.
- ✓ Severe stunting of plants.
- ✓ Specific leaf symptoms appearing at varying times during the season.
- ✓ Internal abnormalities such as clogged conductive tissues.
- ✓ Delayed or abnormal maturity.
- ✓ Obvious yield differences, with or without leaf symptoms.
- ✓ Poor quality of crops, including differences in protein, oil, or starch content, and storage quality

Stunting is a common **symptom** for many **deficient nutrients** due to their varied roles in the plant.

Ways Soil Loses Nutrients

Leaching – Plant nutrients are lost beyond the reach of plant roots. Usually caused by excessive rainfall washing nutrients deep down into sub-soil beyond new roots reach.

Soil erosion – Top soil is lost by the agent of erosion e.g. wind, water.

Monocropping – This utilizes only specific nutrients from a particular zone making it exhausted. -It also causes accumulation of certain pests and diseases.

Continuous cropping –This continuously exhaust the fertility of land unless the the land if fallowed.

Change of soil PH -Use of either acidic or basic fertilizers affect soil pH and Consequently the presence of micro-organisms hence soil fertility affected.

Burning of vegetations –Destroys organic matter and soil structure. Nutrients are lost and soil exposed to erosion.

Accumulation of salts – Common in waterlogged areas and semi-arid areas in which poor drainage causes evaporation during the dry periods, making the soil saline.

Content/Topic 2: Soil characteristics with regard to soil fertility

Physical indicators

(1) Soil texture,

(2) Depth of soils, topsoil or rooting,

(3) Infiltration,

(4) Soil bulk density,

(5) Water holding capacity.

Chemical indicators

(1) Soil organic matter (OM), or organic carbon and nitrogen,

(2) Soil pH,

(3) Electric conductivity (EC),

(4) Extractable N, P, and K.

Biological indicators

(1) Microbial carbon and nitrogen

(2) Potential mineralizable nitrogen (anaerobic incubation)

(3) Soil respiration, water content, and soil temperature

1. Soil color

Black/ dark soils

The black or dark colours of soils as indicators of good soils (fertile soils) are reflections of the high amounts of organic matter contents in the soils.

These red and light coloured soils have low soil; moisture/water and nutrient retention capacities, acidic soil reactions, low percent base saturation, hence their local categorization as bad soils.

However, all dark or black soils are not always good or fertile. Some soils are black due to the dispersed humus, which is common in sodic soils that are associated with semi-arid and arid areas.

Soil organic matters contribute to soil fertility as follows;

(i) Through the process of decomposition and mineralization of organic matter, the plant nutrients contained in its components are released into the soil to support plant growth;

(ii) Organic matter is a source of carbon and energy for the soil micro organisms which are involved in many natural biological processes in soils;

(iii) Organic matter increases the water retention and storage capacities of soils, hence increasing the magnitude and extent of plant available water /soil moisture;

(iv) During the process of decomposition, some of the decomposition products of soil organic matter are synthesized into humic compounds, which have high capcities to retain plant nutrients (ions) in exchangeable forms;

(v) Organic matter stabilizes soil reaction that is act as a buffer of soil pH and other chemical processes and reactions in soils.

(vi)Organic matter contributes to the formation and development of good soil structure and increases the stability of the soil aggregates so formed;

(vii) During the decomposition of soil organic matter, organic acids are produced which solubilize some soil minerals and compounds hence releasing the nutrients contained in them in forms available to plants;

(viii) Humus is capable of forming complex compounds with plant nutrient ions, hence preventing them from being lost from the soil through the process of leaching

2. Soil texture

Soil texture affects how well nutrients and water are retained in the soil; thus, clayey and organic soils hold nutrients and water much better than sandy soils, in which water drains and carries nutrients along with it. When nutrients leach into the soil, they are not available for plants to use.

3. Structure

Soil fertility is greatly influenced by soil structure. The term soil structure is used to describe the way soil particles (sand, silt and clay) are grouped into aggregates.

Soil aggregation is an important characteristics of soil fertility; the greater the degree of aggregation, the better the soil 'tilth' and the more the pore space, the more available will be the water and air to plant roots.

4. Water holding capacity

Water holding capacity refers to the quantity of water that the soil is capable of storing for use by plants.

Water holding capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems.

The ability of the soil to provide water for plants is an important fertility characteristic.

The capacity for water storage varies, depending on soil properties such as organic matter, soil texture, bulk density, and soil structure that affect the retention of water and the depth of the root zone

5. Soil permeability (bulk density)

Soils that are loose, porous, or well-aggregated (e.g. clay soil) will have lower bulk densities than soils that are not aggregated (sand). The bulk density of soil depends greatly on the mineral make up of soil and the degree of soil compaction.

If soil is too compact it will impede the movement of water down to the roots and also the penetration of the roots down in the soil.

LO 2.2 – Identification the fertilizer according to crop nutritional requirement

- Content/Topic 1: Essential crop nutrient and their functions

Classification		Elements
Macronutrients	(Available from air or water)	Carbon, Hydrogen, Oxygen
	Primary Nutrients	Nitrogen, Phosphorus, Potassium
	Secondary Nutrients	Calcium, Magnesium, Sulphur
Micronutrients		Boron, Cobalt, Chlorine, Copper, Iron, Manganese, Molybdenum, Zinc

Crops nutrient functions and their plant available from soil solution complex

Functions and available forms of nutrients			
Nutrient		Plant Available From Soil Solution Complex	
		Form(s)	Symbol(s)
Nitrogen	✓ Promotes rapid growth, ✓ chlorophyll formation ✓ protein synthesis.	Anion and Cation	NO^-_3 NH^+_4

Phosphorus	✓ Stimulates early root growth. ✓ Hastens maturity	Anion	$H\ PO^-$
Potassium	✓ Increases resistance to drought and disease. ✓ Increases stalk and straw	Cation	K^+
Calcium	✓ Improves root formation, ✓ stiffness of straw and vigor.	Cation	Ca^{++}
Magnesium	✓ Aids chlorophyll formation and phosphorus metabolism. ✓ Helps regulate uptake of other	Cation	Mg^{++}
Sulfur	✓ Amino acids, vitamins.	Anion	SO^{--}
Boron	✓ Aids carbohydrate transport	Anion	H BO
Iron	✓ Chlorophyll formation.	Cation*	Fe^{++} Fe^{+++}
Manganese	✓ Oxidation-reduction reactions. ✓ Hastens germination and	Cation*	Mn^{++}
Zinc	✓ Auxins, enzymes.	Cation*	
Molybdenum	✓ Aids nitrogen fixation and nitrate	Anion	MoO^{--}
Nickel	✓ Grain filling,	Cation	Ni^{++} Ni^{+++}
Chlorine	Water use.	Anion	Cl^-
Oxygen	Component of most plant compounds.		

Carbon	Component of most plant compounds.	

1. Primary nutrients

Classification, Characteristics and Deficiency Symptoms of Essential Nutrients

Nutrient	Characteristics	Deficiency Symptom
Primary		
Nitrogen (N)	All converts to nitrate. Nitrate can leach from soil. Ammonium held to soil. Plants use mostly nitrate, some ammonium (e.g. rice)	1. Slow growth, stunted plants 2. Yellow-green colour 3. Firing of older leaf tips
Phosphorous (P)	Easily tied up by soil and made unavailable to plants. Availability reduced at high or low pH and soil temperature below 50°F. Form for plant use varies with soil pH.	1. Slow, stunted growth 2. Purplish color to leaves/stems 3. Delayed maturity 4. Dark green, dead leaf tips 5. Poor fruit/seed development
Potassium (K)	Increases size and quality of fruit	1. Tip and marginal burn on older leaves 2. Weak stems, lodging 3. Small fruit, shriveled seeds 4. Slow growth

2. Secondary nutrients

Classification, Characteristics and Deficiency Symptoms of Essential Nutrients

Secondary		
Calcium (Ca)	Major component of cell wall. Does not move within plant. Deficiency related to blossom end rot of tomato and others. Can be deficient in acid soils, but corrected by liming.	1. Death to growing points of top and root 2. Unusually dark green foliage, which fails to unfurl 3. Premature blossom/bud shed 4. Weak stems
Magnesium (Mg)	Deficiency may show on sandy, acid soils. Can be corrected with dolomitic limestone during pH adjustment.	1. Yellowing between older leaf veins. 2. Leaves curl up along margins 3. Marginal yellowing with 'Christmas tree' shape along midrib.
Sulfur (S)	Can be deficient in acid soils.	1. Pale green/yellow color to young leaves initially. 2. Small week plants 3. Retarded growth, slow maturity. 4. Yellow between veins of corn leaves.

3. Minor nutrient

Classification, Characteristics and Deficiency Symptoms of Essential Nutrients

Micronutrients (Trace elements)		
Zinc (Zn)	Terminal growth areas affected first. Deficiency can be caused by excess phosphorous.	1. Decreased stem length, rosetting terminals. 2. Reduced fruit bud formation 3. Mottled leaves 4. Stripping or banding of corn leaves
Iron (Fe)	Deficiency can be induced by high manganese at low pH. Usually associated with high pH soil or excess training.	1. Yellowing between dark green veins of young leaves.
Manganese (Mn)	Excess may induce iron deficiency at low pH.	1. Yellowing between veins of young leaves. Not as distinct as with iron.
Copper (Cu)	Not usually deficient. May be linked to fruit cracking to tomato.	1. Stunted growth 2. Poor color 3. Wilting and death of leaf tips.
Boron (B)	Does not move within plant. Deficient occasionally on cole crops.	1. Soft, dead spots on fruit or tubers. 2. Reduced flowering and pollination 3. Thick, curled, wilted, yellow leaves. 4. Stunted, unvigorous plants 5. 'Whiptail' of cauliflower 6. Cupping or rolling of leaves
Molybdenum (Mo)	Essential for N fixation by legumes. May be applied with seed inoculation. Deficiency often corrected with liming.	
Cobalt (Co)	Important in N fixation in legumes	General yellowing is legumes.

- **Content/Topic 2 :Basis /criteria of fertilizers classification**

1. Classification of fertilizer based on complexity of fertilizers

a. Straight fertilizer

Straight fertilizers: Straight fertilizers are those which supply only one primary plant nutrient, namely nitrogen or phosphorus or potassium.

eg. Urea, ammonium sulphate, potassium chloride and potassium sulphate.

Nitrogen	**%N**
Urea	45
Ammonium sulphate	21
Prilled ammonium nitrate	34
Ammonium nitrate/calcium carbonate	21-26
Anhydrous ammonia	81
Liquid fertilisers containing ammonium nitrate, ammonia and urea	20-40
Phosphorus	**%P_2O_5**
Superphosphate	18-21
Triple superphosphate	45-47
Ground mineral phosphate	29-33
Basic slag	8-22
Potassium	**%k_2O**
Potassium chloride (Muriate of potash)	60
Potassium sulphate	50

b. **Compound fertilizer**

- **Complex fertilizers**: Complex fertilizers contain two or three primary plant nutrients of which two primary nutrients are in chemical combination. These fertilizers are usually produced in granular form.
  eg. Diammonium phosphate, nitrophosphates and ammonium phosphate.

- **Binary (NP, NK, PK) fertilizers**

Major two-component fertilizers provide both nitrogen and phosphorus to the plants. These are called NP fertilizers.

A 50 kg bag of fertilizer labeled 16-4-8 contains 8 kg of nitrogen (16% of the 50 kg) an amount of phosphorus and potassium equivalent to that in 2 kg of P_2O_5 (4% of 50 kg) and 4 kg of K_2O (8% of 50 kg).

-Mixed fertilizers: are physical mixtures of straight fertilizers. They contain two or three primary plant nutrients. Mixed fertilizers are made by thoroughly mixing the ingredients either mechanically or manually.

NPK fertilizers

NPK fertilizers are three-component fertilizers providing nitrogen, phosphorus, and potassium.

Table . Some complete and mixed fertilizer materials

Mixed	Percent (%)		
	N	P_2O5	K_2O
5-10-15	5	10	15
11-37-0*	11	37	0

2. Classification of fertilizer based on physical form

Fertilizers can also be classified based on physical form:

a. Solid
b. Liquid fertilizers

a. Solid fertilizers are in several forms *viz*.

- ❖ Powder (single superphosphate),
- ❖ Crystals (ammonium sulphate),
- ❖ Prills (urea, diammonium phosphate, superphosphate),
- ❖ Granules (Holland granules),
- ❖ Supergranules (urea supergranules) and
- ❖ Briquettes (urea briquettes).

Urea prills

Granulated urea

Ammonium sulphate

b. Liquid fertilizers

- ❖ Liquid form fertilizers are applied with irrigation water or for direct application.
- ❖ Ease of handling, less labour requirement and possibility of mixing with herbicides have made the liquid fertilisers more acceptable to farmers.

4. Classification of fertilizer based on sources/origin

a. **Organic fertilizers**

Organic fertilizers are fertilizers derived from crop residues and animal manures.They supply nutrients in low amount and organic matter in high amount.

- **Characteristics of organic fertilizers:**
  - ✓ Nitrogen is usually the predominating nutrient with lesser quantities of phosphorus and potassium. One exception is bone meal in which phosphorus predominates and N is a minor ingredient.

- ✓ Nutrients are only made available to plants as the material decays in the soil, so they are slow acting and long lasting.
- ✓ Organic materials alone are not balanced sources of plant nutrients, and their analysis in terms of the three major nutrients is generally low. They contribute to the organic matter content in the soil.
- ✓ The material is bulky and the exact amount of fertilizer applied is difficult to measure.

1. Farmyard manure

This type of manure is got from animal dung, urine and beddings collected form animal houses.

Advantages

- ✓ It usually has a high content of nitrogen and phosphorus
- ✓ It supplies high amount of organic matter to the soil
- ✓ Improves soil physical properties such as soil structure
- ✓ Improves on the quality of other manure, for example, compost
- ✓ It promotes microbial activity
- ✓ It supplies organic matter, even to the sub soil
- ✓ It loosens the sub soil naturally
- ✓ It acts as a protection against erosion

Disadvantages

- ✓ It is difficult to collect enough animal droppings if the animals are scattered
- ✓ Urine is only collected when the floor is cemented and if the animals are kept indoors
- ✓ Requires a lot of labour to collect the excreta
- ✓ Has a bad smell

Figure 1: Farm yard manure

2. Compost

Compost means a collection of items from different sources. Compost is manure made from kitchen waste and rubbish that can rot easily.

Advantages

- ✓ It improves soil physical properties such as soil structure, water holding capacity, permeability;
- ✓ It supplies nutrients essential to the crop growth;
- ✓ It reduces chemical pesticides since it contains beneficial microorganisms that may protect plants from disease and pests;
- ✓ It promote microbial activity;
- ✓ It supplies organic matter, even to the sub soil;
- ✓ It loosen the sub soil naturally;
- ✓ It acts as a protection against erosion

Disadvantages

- ✓ Requires a lot of labour to prepare
- ✓ It is expensive to apply since it is bulky
- ✓ May be a source of pests and disease
- ✓ It takes a long time to prepare
- ✓ May pose a health risk to a farmer
- ✓ Has a bad smell

Figure 2: Compost

- ✓ **The kinds of compost**

- **Aerobic Decomposition**

  Aerobic process is most common in nature. In aerobic composting, aerobic organisms utilize considerable amounts of oxygen in decomposing organic matter to a relatively stable humus under suitable environmental conditions.

- **Anaerobic Decomposition**

  In anaerobic decomposition, oxygen does not have access. Organic compounds break

down by the action of living organisms that do not require air, and develop intermediate compounds including methane, organic acids, hydrogen sulphide and other substances, many of which have strong odours and some present phytotoxicity.

- **Vermicompost**

Vermicompost (vermi-compost, vermiculture) is the product of the decomposition process using various species of worms, usually red wigglers, white worms, and other earthworms, to create a mixture of decomposing vegetable or food waste, bedding materials, and vermicast.

Vermicast is the end-product of the breakdown of organic matter by earthworms.

- ✓ **The methods of composting**

- **Indore Method**

The Indore Method is much used for composting in layers.

The advantages of this method

- The process can be kept under control and runs smoothly, because the heap is turned regularly;
- Compost is produced in a short time.

Disadvantages of this method

- It requires much water;
- It is very labour intensive.

- **Bangalore Method**

The Bangalore Method is another popular composting method. The heap is constructed in a similar way to the Indore Method. Here too, a compost heap of several layers is set up in a week's time.

It differs from the Indore Method as follows:

A few days after completion of the heap, it is completely covered with mud or grass sods, thus closing it off from outside air. Decomposition of organic material continues, but now other types of micro-organisms keep the process going. These micro-organisms decompose the material much more slowly. Therefore, it takes longer before compost is formed than in the Indore Method, although the quality of the compost is about the same.

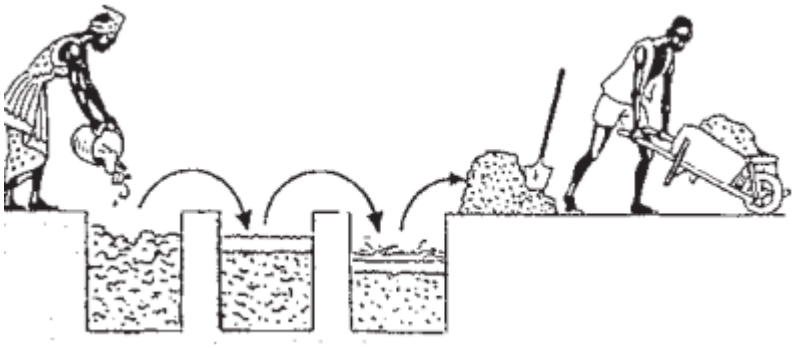
The major advantages of the Bangalore Method

- a saving of water;
- it requires less labour, because the heap is not turned over during the decomposition process.
- Disadvantages of the Bangalore Method are:
- more disease germs and weed seeds survive due to the temperature during decomposition;
- the decomposition process is more difficult to control because the heap has to be kept continually covered;
- it is a less suitable method for those with little or no experience in composting.

✓ **Heating Process or Block Method**

This method resembles the Bangalore Method. However the treatment is different and it can be used to compost large quantities of organic material.

✓ **Pit composting**



This method involves making compost in pits which have been dug in the ground. The best depth for a pit varies according to local soil conditions and the depth of the water table. A typical pit would measure 1.5 to 2m wide, 50cm deep and any length. The pit can be lined with a thin layer of clay to reduce water loss. Often, several trenches are dug next to each other, to allow turning from one pit into the next.

Material should be placed in the pit in layers as described below. For a larger pit measuring 2m wide, 2m long and 1 m high, 1 to 1.5 liters of water should be poured on before applying the layer of soil, which seals the pit.

Advantages:

Pit composting is quick, easy and cheap as it does not require investment in materials. It needs less water so it is useful for dry areas.

Disadvantage:

It is more difficult to follow of the decomposition process than with an above ground heap.

- ✓ **Trench composting**

Trench composting is similar to pit composting except that plants are grown directly onto the pit as opposed to taking the compost out of the pit and spreading it on land. A trench should first be dug. The size depends on how much material you have available and how many plants you are planting in the trench. The width can range from 50cm to several meters, the depth lm or less and it can be any length.

Advantages:

Trench composting is especially useful against termite attack as most species live above ground level.

- ✓ **Basket composting**

If materials for composting are in short supply, you can still make good use of them by using the basket method of composting. It is especially useful for food production in home gardens.

Advantages:

Basket composting makes good use of nutrients for a small kitchen garden.

This method is also good for using up small quantities of waste.

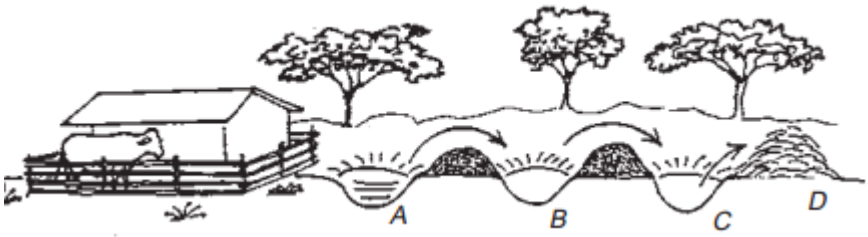
- ✓ **Boma composting**

When a farmer keeps animals, there is usually, a boma (enclosure where the animals are kept all the time or only at night) on the farm. In order to keep the animals clean, bedding is put in the boma.

It as advisable to add enough new bedding once a week, so that all urine is soaked up. Any type of dry organic material can be used as bedding. It can be maize stalks, weeds, dry grass or leaves, sawdust, etc.

A mixture of materials is best. Bedding soaks up urine and droppings, which are very rich plant food, and prevents losses through leaching or drying out of manure. The farmer who puts new bedding regularly will make plenty of high quality compost.

Well-mixed manure can be taken out either every day or once a week. If taken out daily, the mixture should be put in a pile and a small amount of soil spread on top each day. This can be continued until there is enough material to build a boma compost.



Note: If a boma has no roof the manure becomes wet during the rain. To avoid leaching, all manure should be taken out as often as possible and immediately composted and covered. Remember, compost should be moist, not wet.

3. Green manure

Green manure is prepared from fresh plants especially legumes like lucerne, mucuna and beans.

Advantages

- ✓ They speed up the biochemical activities in the soil
- ✓ They increases the organic matter content of the soil
- ✓ They promote microbial activity
- ✓ They supply organic matter, even to the sub soil
- ✓ They loosen the sub soil naturally
- ✓ They act as a protection against erosion

Disadvantages

- ✓ If the material is fibrous, a lot of N is used by microorganisms to decompose it. This means that a little N is left for crops.
- ✓ A lot of water is used in the decomposition process. This leaves a little water in the soil for the next crop.
- ✓ Crops like beans used to make green manure are food crop and it may be difficult for farmers to sacrifice their crops.
- ✓ It requires a lot of labour to make
- ✓ Delays the cropping programme
- ✓ Increases the cost of production through hiring machinery to plough back the crops into the soil

Figure 3: Green manures

4. Add mulch

You can apply granular fertilizer on top of the mulch. Water in. it will make it way to the plants roots. Or you can apply a liquid fertilizer on the foliage and the mulch..

- **Definition of mulch**

Mulch is any type of soil covering which is spread or laid on top of the soil.

- **Types of mulch**
  - **Organic mulch**

Organic mulch are those that break down over time and, therefore, gradually improve the condition over time, releasing nutrients into the soil as they biodegrade.

- **Inorganic mulch**

Inorganic mulch are those that do not break down over time. These can be either manmade products, such as rubber, or natural products like slate chippings.

b. **Inorganic**

Fertilizer is a material that contains at least one of the plant nutrients in chemical form that, when applied to the soil, is soluble in the soil solution phase and 'available' for plant roots.

Characteristics of inorganic fertilizers

- ✓ Inorganic fertilizers are those from a non-living source.
- ✓ Inorganic fertilizer is manufactured in dry, liquid, or gaseous forms.
- ✓ Nutrients are in a soluble form and are quickly available for plant use.
- ✓ The soluble nutrients make them caustic to growing plants and can cause injury.

Care must be taken in applying inorganic fertilizers to growing crops so as not to come in contact with the roots or remain on plant foliage for any length of time.

Example: NPK 17-17-17, DAP

Comparison between organic and inorganic fertilizers

Description	**Organic Fertilizers / Manures**	**In-Organic Fertilizers**
Physical Properties	Improves the **Soil** Structure	No effect on soil structure
	Improved Water Holding Capacity	No water holding capacity
	Soil becomes more permeable	No effect of fertilizer on Permeability
	Improves Drainage in the **Soil**	No effect
	Prevents Soil Erosion	No effect
	Decreases water Evaporation	No effect
Chemical Properties	Slow release of Nutrients	Fast release of nutrients
	Decreases leaching of nutrients from soil	No such effects
	Supplies micronutrients	No Micronutrients supply

	Doesn't produce acidity or alkalinity in the soil	Fertilizers like sodium products produce acidity and alkalinity in the soil
	organic fertilizers contain naturally degradable compounds	Inorganic fertilizers contain synthetic materials
	Upon Decomposition produces organic acids while helps to dissolve minerals	No such effects
Biological Activities	Increases the growth of microorganisms like earthworms	Slightly helps in the growth of microorganisms
Use	Usually applied 15-20 days before the crop is sown	Nitrogen fertilizer is applied immediately before sowing.
	Not used in liquid form	Used as foliar spray
	Used in huge quantity	Used in Small Quantity
	Organic manure is long lasting	Inorganic manure is short lasting
	Organic manures are incorporated in soil	It is also incorporated in soil but may be used as top dressing
Application	By hand	By hand or special equipment

Use of both chemical and organic fertilizers together gives more benefits than applying them separately which increase physical and microbiological properties of the soil. This will increase the availability of nutrients as well which cause increasing the production and productivity of land.

4. Classification of fertilizer based on nutrient present

i) Nitrogen fertilizers

It should be remembered that all N used by crops is ultimately derived from atmospheric N. whilst legume plants convert atmospheric N_2 into mineral N by biological fixation,

- ✓ N fertilizer is produced by converting atmospheric N_2 into ammonia (NH_3) using the Haber–Bosch industrial process which uses natural gas as an energy source.
- ✓ The most common nitrogen fertilizer is urea but compound NPKs are often used as a source of N for basal fertilizer application.

A list of commonly available fertilizer materials

Table 4. Nitrogen fertilizer materials

Anhydrous ammonia	82-0-0	Gas	---Extremely irritating to eyes and respiratory system in concentrations up to 0.07 % by volume; 0.17 % causes convulsive coughing; 0.5 to 1.0 % is rapidly fatal after short exposure;
Urea	46-0-0	solid (prills, granules, crystalline)	Good storage and handling properties
Ammonium nitrate	34-0-0	solid (prills or granules)	---Strong oxidizer; readily absorbs water;can be explosive when mixed with
UAN (urea ammonium nitrate)	(28-32)-0-0	liquid	--Normally 33 to 35 % is urea and 45 to 47 % is ammonium nitrate
Ammonium sulfate	21-0-0 + 24 S	solid (crystalline or granules)	-- Used primarily as an acidifying fertilizer or source

❖ **Nitrate Fertilizers**

Fertilizer	**Formula**	**Composition**
Sodium nitrate	$NaNO_3$	16%N
Calcium nitrate	$Ca(NO_3)_2$	15.5% N
Potassium nitrate	KNO_3	13.4% N and 44% K

Nitrate fertilizers are quickly dissociated in the soil, releasing the nitrate ion for plant absorption. As such they are readily absorbed and utilized by the plants

❖ **Ammonium Fertilizers**

In these fertilizers, nitrogen is combined in ammonium (NH_4^+) form with other elements examples of such fertilizers:

Fertilizer	**Formula**	**Composition**
Ammonium sulphate	$(NH_4)_2SO_4$	20% N
Ammonium phosphate	$NH_4H_2PO_4$	20% N and 20% P or 16% N and 20% P
Ammonium chloride	NH_4Cl	24-26% N
Anhydrous ammonia		82% N

❖ **Nitrate and Ammonium Fertilizers**

These are fertilizers that contain nitrogen in both ammonium and nitrate forms. Examples of such fertilizers:

Fertilizer	**Formula**	**Composition**
Ammonium nitrate	NH_4NO_3	32.5% N
Ammonium sulphate nitrate (ASN)	$(NH_4)_2SO_4.NH_4NO_3$	26% N
Calcium ammonium nitrate (CAN)	$Ca(NH_4NO_3)_2$	25% N

❖ **Amide fertilizers**

These fertilizers are carbon compounds, and so are called organic fertilizers. Important fertilizers in this group are:

Fertilizer	**Formula**	**Composition**
Urea	H_2NCONH_2	46% N
Calcium cyanamide	$CaCN_2$	22% N

- ✓ Nitrate (NO_3^-) and ammonium (NH_4^+) are the major N sources released from N fertilizers and available for plant uptake.
- ✓ Nitrate anions are directly available for the plant, but are also easily leached out of the root zone.
- ✓ Ammonium may be taken up directly by the plant or first oxidized to nitrite in a process called nitrification and then transformed into nitrate by nitrifying microorganisms.
- ✓ Nitrification results in the release of hydrogen ions (H^+), which leads to soil acidification. If all nitrate ions produced through nitrification are absorbed by plant roots, excretion of OH^- by the plant neutralizes the hydrogen ions. In general, however, only a fraction of total nitrate produced is absorbed by the plant roots.

ii) Phosphorus fertilizers

All fertilizer phosphorus is derived from mined phosphate rocks.

❖ Phosphorus fertilizers containing water-soluble phosphoric acid or monocalcium phosphate [$Ca(H_2PO_4)_2$] such fertilizers are

Fertilizer	**Formula**	**composition**
Single super phosphate	$Ca(H_2OP_4)_2.H_2O$	16-18% P_2O_5
Triple super phosphate	$Ca(H_2PO_4)_2 \cdot H_2O$	46-48% P_2O_5
Ammonium phosphate	$(NH_4)_3PO_4$	20% N and 20% P_2O_5 or 16% N and 20% P_2O_5

- Fertilizers containing soluble phosphoric acid or dicalcium phosphate CaHPO4.2H20 such fertilizers are:

Fertilizer	Formula	Composition
Dicalciumphosphate	$CaHPO_4$	34-39% P_2O_5

- Fertilizers containing insoluble phosphoric group [$Ca_3(PO4)_2$] such as

Fertilizer	Formula	Composition
Rock phosphate		20-40% P_2O_5

iii) **Potassium fertilizers**

All fertilizer potassium is manufactured from very large deposits of water-soluble potassium minerals that have accumulated as a result of the evaporation of shallow seas or natural lakes over geological time. The most widely used K salts in agriculture to produce K fertilizers are double salts that also contain significant quantities of Mg and S.

Examples of potassium fertilizers:

Table 6. Potassium fertilizer materials

Material	Analysis	Formula	Physical Form	Handling Precautions
Potassium chloride	0-0-(60-63)	KCl	solid, granule	Avoid excess dust
Potassium sulfate	0-0-(50-53) + 18S	K_2SO_4	solid, granule	Avoid excess dust
Potassium nitrate	13-0-44	KNO_3	solid, granule,	Avoid excess dust
Potassium-magnesium sulphate	0-0-22	K_2SO_4.MgSO4		

LO 2.3 – Select tools and equipment according to fertilizer types and application

Content/Topic 1: Selection criteria of tools and equipment for fertilizer application

a. Soil type

Some of tools and equipment may be damaged due to soil conditions during land preparation before or during fertilizer application.

b. Types of fertilizer

When choosing different tools and equipment for fertilizers applications types of fertilizer (example organic and inorganic) has to be taken into consideration as well as their physical properties (example: granular, powder or liquid).

c. Weather conditions

When choosing different tools and equipment for fertilizers applications weather conditions should be taken into consideration mainly the rainfall.

d. Cost

In fertilizer application, you should choose tools, materials and equipment which are cheap rather than those which are expensive.

LO 2.4 – Prepare organic fertilizers referring to procedure

- **Content/Topic 1 : Criteria of raw material selection**

During the selection of raw material to be used in organic fertilizers making, the following point will be considered:

- ✓ **Plant species**: legumes are more preferred basing on their high decomposition rate and their nitrogen content, moreover the requested amount of legumes will be high compared to grasses for obtaining sufficient amount of organic fertilizers.
- ✓ **Harvesting time**: raw material plant could be harvested before reaching the flowering stage, when their tissues still soft.
- ✓ **Decomposition rate**: duration of decomposition is more important when selecting a good raw material.
- ✓ **Nutrient contents**: raw material could be rich in nutrients, based on this; legumes are more preferred than grasses.

- ✓ **Availability of raw material**: the most available plant species in the region will be used as raw material for making organic fertilizers.

Raw material by composition of N and C

Carbon-Rich Ingredients	**Nitrogen-Rich Ingredients**
Straw	Grass clippings
Dry corn stalks	Fruit and vegetable scraps
Shredded paper	Weeds that haven't gone to seed
Small twigs	Deadheads/trimmings from garden plants
Dry fall leaves	Coffee grounds and tea bags
	Farm animal manures

Material with N are recommended for organic fertilizer preparation.

- **Content/Topic 2 : Types of organic fertilizers**

1. **Farm yard manure**

Farm yard manure, Source: http://www.brsgardengroup.co.uk

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

Factors affecting the quality of farmyard manure

- ✓ **Type of animals kept**: excreta from non-ruminant animals provide good quality manure than ruminant animals
- ✓ **Types of beddings used**: straw beddings absorb more urine than wood shavings
- ✓ **Type of food given to the animals**: concentrates provide excellent manure than starchy.
- ✓ **Method of storage**: Manure which is stored under shelter has more plant nutrients than manure exposed to rain and sunshine

- ✓ **Time**: manure should be given enough time to fully decompose. This should be about one and half month

2. Compost

Is organic matter that has been decomposed and recycled as a fertilizer and soil amendment.

When making compost manure, care should be taken to avoid the following:

- ✓ Polythene materials
- ✓ Plastic pieces
- ✓ Broken glass
- ✓ Metals

Composting means breaking down organic material.

To make the best possible compost, the micro-organisms must be able to work optimally. This can be achieved if the following four factors are combined to the best advantage:

- ➢ Type of organic material
- ➢ Air
- ➢ Moisture
- ➢ Temperature

The acidity (pH) is also considered by some to be an important factor.

The composting process will be optimal when:

- ➢ Various materials of different decomposition rates are combined;
- ➢ The different materials are well mixed;
- ➢ the size of the heap varies from 1 x 1 meters to 3 x 3 meters. This makes it possible for the temperature to stay constant within the heap.

b. The stages of composting

A good composting process passes through 3 consecutive stages, these are as follows:

➢ a heating phase (fermentation)

➢ a cooling down phase

➢ a maturation phase

(i). Heating Phase

During the first stage of composting, the compost heap starts to heat up considerably. This effect is known as fermentation and is the result of the breaking down of the complex and tough fibrous material of the organic matter. This fermentation process (decomposition) is strongest in the centre of the heap.

To get the fermentation going quickly and effectively, a number of factors are important.

- ✓ All sorts of organic materials
- ✓ The right micro-organisms have to be present.
- ✓ Adequate oxygen and water.

(ii). Temperature test

A simple way to see if the fermentation process has started is as follows:

Put a stick in the centre of the heap about 5 days after completing the compost heap or after the final turning over. Leave it there for about 5 to10 minutes.

After taking it out, feel it immediately. It should be considerably warmer

(60 - 70 oC) than body temperature. If not, then this is an indication that something is wrong, perhaps the material used or aeration is at fault.

(iii). Cooling down phase

The fermentation phase gradually changes into a cooling down phase.

Decomposition occurs without much generation of heat and the temperature drops slowly.

During this period new types of micro-organisms convert the organic components into humus. The heap remains clammy and hot inside and the temperature drops from 50 oC to

30o C. By regulating the temperature, air and water supply, the process can be accelerated or slowed down.

How long this cooling down stage takes, depends on

(i). The type of heap,
(ii). The material,
(iii). The attention given to it,
(iv). The climate etc.

The cooling down period usually takes a few months, but in unfavorable conditions may require up to a year.

(iv). Maturation phase

In this end phase of decomposition, the temperature drops to soil temperature, depending on the climate, 15-25 oC.

Apart from the micro-organisms mentioned, the large soil fauna are active at this stage too. In temperate regions, earthworms in particular, feed on the strongly decomposed organic material, and in this way contribute to decomposition.

1. Green manure

Figure 4: Example of green manure crops **Source: newsteadgarden.wordpress.com**

Green manure is a term used to describe specific plant or crop varieties that are grown and turned into the soil to improve its overall quality.

Plants to be used in the making of green manures should have the following characteristics:

✓ They should have a fast growth rate

- ✓ They should be able to decompose quickly
- ✓ They should have high content of nutrients, especially nitrogen
- ✓ They should be free from pest and diseases
- ✓ They should be easy to plough into the soil
- ✓ They should be leafy or highly vegetative
- ✓ They should be able to grow on relatively poor soils

Green manure crops include alfalfa, cowpea, fava beans, fenugreek, lupin, mustard, radish, sesbania, soybean, Sudan grass etc……

- **Content/Topic 3 : Procedure to make compost fertilizers**

1. **Identification of raw material**

Identification of criteria of raw material are discussed in 2.4.1

2. **Choose the compost location**

Where to place your compost pile or bin. Any pile of organic matter will eventually rot, but a well-chosen site can speed up the process. Look for a level, well-drained area. if you plan to add kitchen scraps, keep it accessible to the back door.

Unsuitable Area/ locations for composting

- **Under trees –** Locate your compost under trees with caution, because, after heavy rains and the tree's shade, the compost may dry out too slow. The trees roots may send roots into the bottom of the compost searching for nutrients and water.

- **Against permanent wooden structures** – Compost will rot any wood in contact with it. It's fine to use wood for the compost pile or to fence it in, as long as you know that you may need to replace it every three to four years.

- **Under house eves or against the house** – If the compost is placed under roof eves, the compost may not get enough rainfall or it may get to wet due to excessive rain run-off. Try to place your compost at least 6m away from the house.

- **In sight of your neighbors** – If you live in a densely populated housing area, be respectful of your neighbors. You may think that your compost is a beautiful thing, but if it's in plain site, your neighbors may not appreciate it. Try to keep the compost out of site.

3**. Alternate layers**

i. **Start your compost pile on bare earth:** This allows worms and other beneficial organisms to aerate the compost and be transported to your garden beds.

ii. **Lay twigs or straw first**: This aids drainage and helps aerate the pile.

iii. **Add compost materials in layers**, alternating moist and dry. Moist ingredients are food scraps, tea bags, seaweed, etc. Dry materials are straw, leaves, sawdust pellets and wood ashes. If you have wood ashes, sprinkle in thin layers, or they will clump together and be slow to break down.

iv. **Add manure**: green manure (clover, buckwheat, wheatgrass, grass clippings) or any nitrogen source. This activates the compost pile and speeds the process along.

v. **Keep compost moist**: Water occasionally, or let rain do the job.

vi. **Cover** with anything you have – wood, plastic sheeting, carpet scraps. Covering helps retain moisture and heat, two essentials for compost. Covering also prevents the compost from being over-watered by rain.

Turn. Every few weeks give the pile a quick turn with a pitchfork or shovel. This aerates the pile. Oxygen is required for the process to work, and turning "adds" oxygen. You can skip this step if you have a ready supply of coarse material like straw. Once you've established your compost pile, add new materials by mixing them in, rather than by adding them in layers. Mixing, or turning, the compost pile is key to aerating the composting materials and speeding the process to completion

4. Spray water

The compost should be moist, but not soaked and sodden.

5. **Maintain the compost**

a. water spray

It's important that your compost stays moist not dry – keep it moist but not saturated. It's best to think of keeping it as moist as a wrung-out sponge.

b. turn the pile

Turn compost depends on a number of factors including size of the pile, green to brown ratio and amount of moisture in the pile.

Many things can create an anaerobic (no oxygen) environment in a compost pile. All of these problems can be reduced or eliminated by turning your compost. These can include:

- ✓ **Compaction** – This is the most obvious way that turning can aerate a compost pile. When the particles in your compost get too close to each other, there is no room for air. Turning compost will fluff your compost heap and create pockets where oxygen can get inside the pile and supply the microbes.
- ✓ **Too much moisture** – In a compost pile that is too wet, the pockets in between the particles will be filled with water rather than air. Turning helps to drain away the water and reopen the pockets to air instead.
- ✓ **Over consumption by microbes** – When microbes in your compost pile are happy, they will do their job well — sometimes too well. The microbe near the center of the pile may use up the nutrients and oxygen they need to survive and then they will die off. When you turn the compost, you mix the pile up. Healthy microbes and undepleted material will be
- ✓ **Overheating in the compost pile** – This is closely related to over consumption as when microbes do their jobs well, they also produce heat. Unfortunately, this same heat can kill off the microbes if the temperatures get too high. Mixing the compost up will redistribute the hot compost in the center into the cooler outer compost, which will help keep the overall temperature of the compost pile in the ideal range for decomposition.

c. Harvest the compost

One can tell that manure is ready when the following signs are noticed:

- The materials reduce in volume
- Temperature of the heap reduces
- Materials develop a sharp smell
- Materials can easily break to pieces
- Fungi grow on the manure

The pile will compost in 4 – 6 months, with the material being dark and crumbly. Leaf compost is best used as an organic soil amendment and conditioner; it is not normally used as a **fertilizer** because it is low in nutrients.

Precautions for preparing quality compost

In order to prepare good manure, the following have to be done:

- Ensure constant turning and mixing of manure to enable uniform decaying
- Sprinkle water during dry period to speed up the process of rotting
- Add old compost to provide microorganisms to speed up rotting
- Cover the pit to reduce loss of nutrients through volatilisation
- Remove materials that cannot rot such as polythene, glass and metal.

- **Content/Topic 4 : Procedure to make farmyard manure fertilizers**

Material required

✓ Animal excreta: Cow dung, urine

✓ Bedding materials: Straw, peat soil, sawdust, dry leaves etc

1. Select the location for FYM

The **manure** pile should be **located** in a dry, flat area as far away from downspouts, ditches, streams, rivers, wetlands, ponds, and the property line as possible. Water plus **manure** makes a muddy mess for you, and can be a source of water pollution.

2. Mark area

After measurement, mark every corner before digging.

3. **Dig a shallow pit**

For single cattle, the size of the pit or heap where materials are to be stored is 4.5 m in length, 2m in breadth and 1 m in depth. Sometimes, the pit or heap is divided into 3 chambers.

4. Alternate layer

a. Spreading of litter

The litter is the bedding material, which is spread on the floor of the cattle shed, straw, peat soil, sawdust, dry leaves etc.

b. **Collection of urine**

The cattle excreta urine which soaks the litter cattle urine contains considerable quantities of nitrogen and potash and for that reason litters are used to absorbed the urine

c. **Collection of dung**

All the dung voided by cattle is collected with urine soaked litter every day.

5. Maintain the pit of farmyard manure

The collected urine soaked litters along cow dung are stored in manure pit or heap where farmer is better when a manure pit/heap has been filled to its capacity. Then it is covered with a thin layer of soil 3 to 5 cm thick.

6. **Harvest the farmyard manure**

Within about 3-4months these manuring materials becomes ready for using as an organic fertilizer.

Preservation of farmyard manure

Certain chemical changes/ loses take place in the farmyard manure during preparation and storage some losses are inevitable and considerable the losses are due to-

- ✓ A large urine soaked surface is expected to the atmosphere and the urine is converted to ammonia and later to ammonium carbonate. The loss of ammonia can be reduced by providing suitable litter.
- ✓ The pit should have impervious floor and sides to prevent the nitrogen and potassium from leaching. For that it should be made by concrete or clay soil.
- ✓ The manure pit requires some protection against sun and rain.
- ✓ If the upper surface of the manure becomes dry, then pit /heap should be wetted by water or urine to prevent the loss of N by high temperature as well as to make the manure easily mixable to soil.
- ✓ The chemical substances like super phosphate, phosphoric acid etc, can be used in the manure easily mixable to soil pit to prevent the N from loosing

- **Content/Topic 5: Steps to make green manure fertilizers**

1. Plant the seeds

There are two types of Green manures you can choose from. There are legumes and non-legumes. Legumes generally are plans that will release nitrogen into the air.

You can use alfalfa, clover and soybeans as additional alternatives to legume green manure. Non-legumes, on the other hand, are things such as ryegrass, oat and buckwheat.

Plant your green manure seeds. Make sure you use the most popular choice for your physical location.

2. Apply fertilizers and let grow

Apply a fertilizer, rich in nitrogen. Using fertilizer in your pre-developed and pre-seeded garden generally will help the germination to begin quicker. The green manure crop will begin to grow after the first application of fertilizer. The green manure must remain on your crop or garden area until it fully matures. At maturity, the green manure will control existing weeds in your garden beds.

3. Chopping

A plant is cutting into a piece of a plant and put in soil

4. Turn over the bed

Use a rototiller or a spade to re-till the land or the garden area. The plants and the root systems of your green manure should be turned over right into the soil.

5. Add mulch

Add a layer of mulch over your garden. The mulch should remain on your bed or garden area until you are ready to plant a new crop. The mulch will maintain the moisture in your garden area, promote worms and other creatures that are responsible for helping release nitrogen into your crop area.

LO 2.5 – Record keeping

Content/Topic 2 : content of record form/Template

1) Type of organic fertilizer

   :…….

a) FYM……

   ……..

b) Compost……

   ……

c) Green manure

   :……

2) Date

   :……

   ……

3) Activity:……

   ……

4) Site selection

:……

…

5) Ingredient

:……

……

6) Size of the pile

:……

7) Corresponding quantity of well decomposed organic fertilizer:……

8) Tentative date of harvesting:……

Record Keeping

Record keeping is good practice for agricultural operations. For nutrient management, crop yield records, by field, support yield goals used to develop nutrient recommendations. In addition, records of equipment calibration and organic applications confirm proper application rates and that nitrogen credits are assigned to the appropriate fields.

- **Methods of record keeping**

✓ **Written recording**

Written record: a written document preserving knowledge of facts or events.

✓ **Soft record on electronic device**

Keeping written document preserving knowledge of facts or events in electronic device as a soft.

Learning Unit 3 – use fertilizers

LO 3.1 – Identify of fertilizer application methods according to the cropping system

- **Content/Topic 1: The different methods of solid fertilizer application**

It is very important to choose the right method of fertilizer application. Choice of method of fertilizer and its application mainly depends on:

1. Kind of soil we are ploughing
2. Type of crop we are taking
3. Nature of nutrient we are applying
4. Irrigation facility in the area i.e. the land is irrigated or rain fed.

Nutrients to be used by plant must be placed in such a manner that they can be dissolved by the moisture in the soil. The rates and distance that plant food element can move within the soil depend on the chemical nature of the material that furnishes the nutrients and character of soil.

Fertilizers are applied by different methods mainly for 3 purposes:

a) To make the nutrients easily available to crops
b) To reduce fertilizer loss
c) For ease of application

The aspects that require consideration in fertilizer application are listed below

1) Availability of nutrient in manures and fertilizers
2) Nutrient requirements of crop at different stages of crop growth
3) Time of application
4) Methods of application, placement of fertilizers
5) Foliar application
6) Crop response to fertilizers application and interaction of N,P and K
7) Residual effect of manures and fertilizers
8) Unit cost of nutrient and economics of manuring

1. The different methods of solid fertilizer application

The different methods of solid fertilizer application are shown through the following classification

1. Broadcasting

The broadcasting refers to spreading fertilizers uniformly all over the field. It is suitable to crops with dense stand, the plant roots permeate the whole volume of the soil. Normally broadcasting increases application of high doses.

a) Broadcasting at sowing or planting (Basal application)

The main objectives of broadcasting the fertilizers at sowing time are to uniformly distribute the fertilizer over the entire field and to mix it with soil.

b) Top dressing

It is the broadcasting of fertilizers particularly nitrogenous fertilizers in closely sown crops like paddy and wheat, with the objective of supplying nitrogen in readily available form to growing plants.

Disadvantages of broadcasting

The main disadvantages of application of fertilizers through broadcasting are:

i) Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.

ii) The weed growth is stimulated all over the field.

iii) Nutrients are fixed in the soil as they come in contact with a large mass of soil.

2. Placement

1) It refers to the placement of fertilizers in soil at a specific place with or without reference to the position of the seed.
2) Placement of fertilizers is normally recommended in small quantity of fertilizers application. Due to poor root development and low soil fertility and Phosphatic and Potassic fertilizer requirements, this method is preferred.

The most common methods of placement are as follows:

a) Plough sole placement

1. In this method, fertilizer is placed at the bottom of the plough furrow in a continuous band during the process of ploughing.
2. Every band is covered as the next furrow is turned.
3. This method is suitable for areas where soil becomes quite dry upto few centimeters below the soil surface and soils having a heavy clay pan just below the plough sole layer.

b. deep placement or sub-surface placement

In this method, fertilizers like ammonium sulphate and urea, is placed in the reduction zone as in paddy fields where it remains in ammonia form and is available to the crop during the active vegetative period. It ensures better distribution in the root zone, and prevents any loss by surface runoff. It is followed in different ways, depending upon local cultivation practices such as:

Irrigated tracts: the fertilizer is applied under the plough furrow in the dry soil before flooding the land and making it ready for transplanting.

Less water condition: fertilizer is broadcasted before puddling which places it deep into the reduction zone.

Sub-soil placement: this refers to the placement of fertilizers in sub-soil with the help of heavy power machinery.

c. localized placement or spot application

It refers to the application of fertilizer into the soil close to the seed or plant. It is usually employed when relatively small quantities of fertilizers are to be applied.

Advantages :

- ✓ The roots of the young plant are assured of an adequate supply of nutrients,
- ✓ Promotes a rapid early growth
- ✓ Make early intercultivation possible for better weed control
- ✓ Reduces fixation of phosphorus and potassium

Localized placement or spot application includes different methods like

(i). Contact placement or combined drilling or drill placement
(ii). Band placement
(iii). Pellet application
(iv). Side dressing
(v). Circular placement
(vi). Pocket placement
(vii). Pellet placement

- **Contact placement or combined drilling or drill placement**

it refers to the drilling of seed and fertilizer together while sowing. It places the seed and small quantities of fertilizers in the same row. This is found useful in cereal crop, cotton and grasses but not for pulses and legumes.

- **Band placement**

In this, fertilizer is placed in bands which may be continuous or discontinuous to the side of seedling, some distances away from it and either at level with the seed, above the seed level or below the seed level. There are two types of band placement: it includes hill and row placement.

Hill placement: when the plants are spaced 90cm or more on the both sides, fertilizers are placed close to the plant in bands on one or both sides of the plants. The length and depth of the band and its distance from plant varies with the crop and amount of fertilizer.

Row placement: when the seeds or plants are sown close together in a row, the fertilizer is put in continuous band on one or both sides of the one or both sides of the row by hand or a seed drill. It is practiced for sugarcane, potato, maize, cereals and vegetables crops.

- **Pellet application**

In this method, fertilizer (nitrogenous fertilizers)is applied in the form of pellets 2.5-5cm. deep between the rows of paddy crop.

- **Side dressing**

Fertilizers are spread in between the rows or around the plants.

- Circular placement

Application of manures and fertilizers around the hill or the trunk of fruit trees crops in the active root zone.

- Pocket placement

Applications of fertilizers deep in soil to increase its efficiency especially for sugarcane pocket placement is done. Fertilizers are put in 2to 3 pockets opened around every hillby means of a sharp stick.

Generally placement of fertilizer is done for three reasons

(i). Efficient use of plant nutrients from plant emergence to maturity

(ii). To avoid the fixation of phosphate in acid soils

(iii). Convenience to the grower

Advantages of placement of fertilizers

The Main advantages are as follows**:**

(i). When the fertilizer is placed, there is minimum contact between the soil and the fertilizer, and thus fixation of nutrients is greatly reduced

(ii). The weeds all over the field cannot make use of the fertilizers

(iii). Residual response of fertilizers is usually higher

(iv). Utilization of fertilizers by the plants is higher

(v). Loss of nitrogen by leaching is reduced

(vi). Being immobile, phosphate are better utilized when placed

2. The different methods of liquid fertilizer application

The different methods of liquid fertilizer application are shown through the following classification

a) Starter solutions

It refers to application of solution of N, P_2O_5 and K_2O in the ratio of 1:2:1 and 1:1:2 to young plants at the time of transplanting, particularly for vegetables.

Starter solution helps in rapid establishment and quick growth of seedlings.

The disadvantages of starter solutions are:

- ✓ Extra labor is required
- ✓ The fixation of phosphate is higher

b) Foliar application

(i). It refers to the spraying of fertilizers solutions containing one or more nutrients on the foliage of growing plants

(ii). Several nutrients elements are readily absorbed by leaves when they are dissolved in water and sprayed on them

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

(iv). 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

c) Application through irrigation water (fertigation)

(i). It refers to the application of water soluble fertilizers through irrigation water

(ii). The nutrients are thus carried into the soil in solutions

(iii). Generally nitrogenous fertilizers are applied through irrigation water

d) Injection into soil

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

e) 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.

3. Application of fertilizers in gaseous form

Anhydrous ammonia, which supplies nitrogen, is the only gaseous fertilizer used. It is typically stored in a liquid form, most commonly under pressure, and to a lesser degree, under refrigeration. Anhydrous liquefied ammonia is applied by subsurface injection.

The properties of fertilizers

The properties of good fertilizers are:

a) They should be easily soluble in soil water to give a quick response

b) They should contain the required nutrients in the correct proportions

c) They should be easy to handle and apply

d) They should be easily to store

Factors affecting responses of crop to fertilizers

The ability of a crop to benefit from fertilizers applied depends on the following factors.

(1) Amount of fertilizer applied

(2) Fertility level of the soil

(3) Moisture content of the soil

(4) Soil temperature

(5) Soil pH

(6) Permeability of the soil

(7) Method of placement

(8) Pests and diseases

(9) Stage of crop growth

(10) Nature of fertilizer

(11) Plant population

(12) Weed infestations

The properties of fertilizers

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(iii). They should be easy to handle and apply

(iv). They should be easily to store

- **Content/Topic 2 : . Factor of selecting fertilizers application methods**

Factor of selecting fertilizers application methods are the following:

(i). Crop type

(ii). Crop growth stage

(iii). Cropping system

(iv). Soil moisture

(v). Soil type

(vi). Type of fertilizer

(vii). Row spacing

(viii). Spread of seed and fertilizer

LO 3.2 – Appraisal of prevailing weather conditions according to the site location

- **Content/Topic 1: Weather conditions for fertilizers planning**

Weather conditions for fertilizers planning, you should consider the following

(i). Drought

(ii). Rainfall

(iii). Floods

(iv). Wind

(v). Temperature

Content/Topic 2: Effects of Weather conditions on soil fertility and soil quality

1. Losses of Nutrients from Soil

Leaching – Plant nutrients are lost beyond the reach of plant roots. Usually caused by excessive rainfall washing nutrients deep down into sub-soil beyond new roots reach.

Soil erosion – Top soil is lost by the agent of erosion e.g. wind, water.

Monocropping – This utilizes only specific nutrients from a particular zone making it exhausted. -It also causes accumulation of certain pests and diseases.

Continuous cropping –This continuously exhaust the fertility of land unless the the land if fallowed.

Change of soil PH -Use of either acidic or basic fertilizers affect soil pH and Consequently the presence of micro-organisms hence soil fertility affected.

Burning of vegetations –Destroys organic matter and soil structure. Nutrients are lost and soil exposed to erosion.

Accumulation of salts – Common in waterlogged areas and semi-arid areas in which poor drainage causes evaporation during the dry periods, making the soil saline.

2. Loss of soil fertility

Negative effects

- The pressures of constantly increasing agricultural production have in turn resulted in a persistent decline in soil fertility.
- This could possibly be a major challenge agriculture is currently facing.

Loss of soil fertility with soil health

- Soil **degradation** and **loss of fertility** is affecting the productive capacity of the soil.
- The current status of **nutrient-use efficiency** remains quite low for most nutrients.
- The demand for food grain is expected to increase, but with the current soil health status, meeting the targets would be a huge challenge.

The causes of loss of soil fertility

- Inappropriate **agricultural practices** include,

1. Overuse of chemical fertilisers and pesticides on soil.
2. Excessive tillage.
3. Moving away from age-old organic soil revival practices.
4. Unscientific rotation of crops.
5. Poor irrigation and water management practices.

LO 3.3 – Apply fertilizers according to the recommendation

- Content/Topic 1: **Selection criteria of fertilizers**

Selection criteria of fertilizers are summarize below

(i). Physical properties of fertilizer
(ii). Chemical properties of fertilizer
(iii). Soil types
(iv). Crop (species, growth stages)
(v). Soil pH
(vi). Temperature
(vii). Moisture

- **Content/Topic 2: Fertilizer application rates**

Different types of fertilizers, rates, application time and methods applied to major crops grown in Rwanda are described below.

Table 1: Types of fertilizers applied to major crops grown in Rwanda and their methods of application

Crop	Fertilizers	Kg/are	Application time	Application methods
Roots and tubers				
Irish Potatoes	NPK	3kg	At planting and during weeding(45 day after planting)	In each seed holes
Sweet potatoes	NPK	3kg	When first sprouts appear	In a shallow trench made along the row where seedlings were planted

Cassava	NPK	3kg	When first shoots appear on planted cuttings	In a circle around cutting
Cereals				
Wheat 2types	NPK + Urea	2.5kg of NPK and 1kg of Urea	At sowing time: when the seedlings sprouts	In a shallow trench made along the row where wheat seeds have been sown
	DAP +Urea	1kg of DAP and 1kg of Urea	At sowing time: 45 days after sowing	In a shallow trench made along the row where wheat seeds have been sown
Sorghum (2 types)	NPK + Urea	2.5kg of NPK and 1kg of Urea	At sowing time: 45 days after sowing	In a shallow trench made along the row where seeds have been sown
	DAP +Urea	1kg of DAP and 1kg of Urea	At sowing time: 45 days after sowing	In a shallow trench made along the row where seeds have been sown
Maize (2types)	NPK + Urea	2.5kg of NPK and 1kg of Urea	At sowing time: 45 days after sowing	In a shallow trench made along the row where seeds have been planted
	DAP +Urea	1kg of DAP and 1kg of Urea	At sowing time: 45 days after sowing	In a shallow trench made along the row where seeds have been planted
Rice (2types)	NPK + Urea	2.5kg of NPK and 0.6kg of Urea	At transplanting time: 30 days after transplanting	Fertilizers spreading and mixed up with the soil
	DAP +Urea	1kg of DAP and 1kg of Urea	At transplanting time: 30 days after transplanting	Fertilizers spreading and mixed up with the soil
Legumes				

Bush beans	NPK	2kg	At sowing time	In seeds holes
	DAP	1kg	At sowing time	In seeds holes
Climbing beans	NPK	2kg	At sowing time	In seeds holes
Soybeans treated with rhizobium	DAP	1kg	At sowing time	In seeds holes
Banana	Urea + KCL or K2SO4 or NKK or Urea	200g/plant +KCL or K2S04 400g/plant 125g/plant 125g/plant	½ of mixture at planting time, ½ of mixture 3 months after planting	Around banana tree
Vegetables				
Tomatoes	NPK	3-4kg	After tomatoes seedlings take roots	All around tomatoes plant
Industrial crops				
Coffee (2types of fertilization)	$NPK_{22-6-12+}S$	200gr	½ in November1/2 of March	Apply around coffee tree
	NPK20 1010	400gr at separate times		
Tea	NPK 20 -10-10	60gr for each tea plant	When the first shoots appear	Around the plant
Sugarcane	Urea	3kg	Application period	
	NPK 10 6 15	1kg of N2+0.60kg of P2O5 +1.5kg of K2O	On the first canes which are not yet harvested	

	NPK 130 70 150 to boost the growth of the canes	1.3kg of N2+0.70kg of P2O5 +1.5kg of K2O	On canes and shoots	

Source: Farmer's dairy, 2008-2009

FERTILIZER RECOMMENDATION

Recommendations are always made in terms of nutrients and not in terms of fertilizers. It is because various fertilizers contain nutrient in different amounts.

Selection of fertilizers

Selection of fertilizers depends on many factors but the relative price of a nutrient in various fertilizers is usually the basic fertilizers.

Unit value

Unit value is the price of one unit (e.g:100kg) of a nutrient in a fertilizer.

Unit cost of nutrient =$\frac{cost\ of\ 100kg\ straight\ fertilizer}{percentage\ of\ nutrient}$

Example:

Urea and DAP available in the market. Which fertilizer should be selected for growing nitrogen to wheat crop. Cost of urea (46%N) IS 25000RWF/bag of 50kgand that of DAP (18%N) IS 30000RWF/bag of 50kg.

Solution

Unit cost of N in urea=$\frac{25000*2}{46(\%\ of\ \ N)} = 1087RWF$

(2=Number of bag i.e.100kg of urea)

Unit cost of N in DAP=$\frac{30000*2}{18(\%N)} = 3333RWF$

It is clear that we have to spend only 1087RWF to supply 1kg N though urea as compared to 3333 RWF through DAP. we should , therefore prefer urea to DAP for wheat crop.

Dose of fertilizers

There are three method by which doses of fertilizers can be calculated:

a) Direct method
b) Conversion method

c) Formula method

Example:

A farmer wants to grow a high yielding variety of irrigated wheat, how much urea (46%N) , single superphosphate(SSP 16% P_2O_5) and muriate of potash (MP 60%K_2O) will be required? Irrigated wheat required 120kg of N, 50kg of P_2O_5 and 5Okg of K_2O

Solution

1. Direct method

46kg N can be supplied by 100kg of urea

1 kg of N can be supplied by 100kg/46 of urea

120kg of N→$\frac{100*120}{46} = 260.8\ kg\ of\ urea$

16kg P_2O_5 is supplied by 100kg of SSP

1kg of P_2O_5 is supplied 100kg/16 of SSP

50kg of P_2O_5→$\frac{50*100}{16} = 312.5\ kg\ of\ SSP$

60kg of K supplied by 100kg of MP

1kg of K supplied by 100kg/60 of MP

50 kg of K supplied $\frac{50*100kg}{60} = 83.3kg\ of\ MP$

2. **Conversion factor (CF) method**

N	4.854	Ammonium sulphate
N	2.174	Urea
N	3.846	Ammonium sulphate nitrate
N	4.000	Ammonium chloride
N	3.030	Ammonium nitrate
P_2O_5	6.250	Single superphosphate(SSP)
P_2O_5	3.125	Double superphosphate
P_2O_5	2.083	Triple superphosphate(TSP)
P_2O_5	2.174	Di:ammonium phosphate (DAP)
P_2O_5	2.500	Rock phosphate (40% P_2O_5)
K_2O	1.666	Murate of potash(MP)
K_2O	2.000	Sulphate of potash

:Recommended dose of N in (kg/ha)*2.174(CF)=urea(kg)

i.e 120x2.174=260.4kg of urea

: Recommended dose of P_2O_5(kg/ha) *6.25(CF)=SSP(kg)

i.e 50*6.25=312.5kg of SSP

: Recommended dose of K_2O(kg/ha) *1.666(CF)=Muriate of potash(kg)

i.e 50*1.666=83.3kg of MP

3. Formula method

Quantity of fertilizer required(kg)=$\frac{\boldsymbol{recommmendation\left(\frac{kg}{ha}\right)*100}}{\boldsymbol{\%\ of\ nutrient}}$

Quantity of urea required to supply 120kg of N=$\frac{100*120}{46} = 260.86kg$

Quantity of SSP required to supply 50kg of P_2O_5 =$\frac{50*100}{16} = 312.5kg$

Quantity of MP required to supply 50kg of K_2O=$\frac{50*100}{60} = 83.3kg$

In case of compound fertilizer, calculation should be done according to the following example

Example:

A farmer wants to apply 80kg of N,40kg of P_2O_5 and 40kg of K_2O. hence has the following fertilizer:

1.urea

2.diammmonium phosphate (DAP) 18%of N ,46% of P_2O_5

3.sulphate of potash 50% of K_2O

Find out the quantities of these fertilizers

Solution

The DAP contains two nutrients. The whole of P_2O_5 , is to be applied through DAP

46kg of P_2O_5 can be supplied by 100kg of DAP

1kg of P_2O_5→100kg/46 of DAP

40kg of P_2O_5→$\frac{40*100}{46} = \boldsymbol{87kg\ of\ DAP}$

Now, let us see how much nitrogen 87kg DAP contains:

100kg DAP contain 18kg of N

1kg DAP contain 18kgof N/100

87kg of DAP→$\frac{87*18}{100} = \boldsymbol{15.66kg\ of\ N}$

We should deduct 15.66kg of N from recommended dose of nitrogen and apply rest of nitrogen through urea **80:15.66=64.34kg of N to be supplied by urea**

46kg of N can be supplied by 100kgof urea

1kg of N →100kgkg of urea/46

64.34kg N →$\frac{64.34*100}{46} = \mathbf{139.86}\boldsymbol{kg\ of\ urea}$

50kg of K_2O is supplied by 100kg of sulphate of potash

1kg of K_2O is supplied by 100kg/50 of sulphate of potash

40kg of k2o→$\frac{40*100}{50} = \mathbf{80}\boldsymbol{kg\ of\ sulphate\ of\ potash}$

ESTIMATION OF DOSE FOR DIFFERENT PLOT SIZE

Amount of fertilizer needed for plot(kg) $= \frac{recommended\ dose\ of\ nutrient\left(\frac{kg}{ha}\right)*plot\ area}{100*\%nutrient\ in\ fertilizer}$

Example:

Find out the amount of urea for wheat to be grown in a plot measuring 80mx60m in size. The recommended dose of N is 120kg /ha for wheat crop.

Solution:

Recommended dose of N=120kg/ha

Area of the plot=4800m^2

Urea needed (kg)=$\frac{120*4800}{100*46} = 125.22kg$

Care should be taken that the recommended dose is given in kg/ha and plot area in m^2. The amount of desired fertilizer will automatically come in kg.

Preparation of fertilizer mixtures

Fertilizer mixtures are prepared by mixing two or more straight or complex fertilizers.

Mixtures are prepared for improving the physical quality of fertilizers, ensuring greater uniformity in distribution of fertilizer and saving labor cost of fertilizer application .

To prepare fertilizer mixtures of different grades , quantities of fertilizers can be calculated.

To adjust the weight of mixture some inert materials like **gypsum, lime stone, fine soil, peat** etc are also mixed in the fertilizers mixtures. These materials are called **fillers**.

Fillers

Inactive ingredients added to fertilizer packaging may include products to keep the fertilizer from drying out, hardening and clumping, rendering it unusable. Sand and granular

limestone are popular fillers because they are inexpensive and make distribution of the fertilizer easier without adversely affecting your lawn or garden.

Example:

Prepare 100kg fertilizer mixture of grade 4:8:12 for ground nut crop using ammonium sulphate, SSP and muriate of potash. using gypsum as a filler.

Solution

20kg N will be supplied by 100kg of ammonium sulphate

1kg N →100kg/20 of ammonium sulphate

4kg N →$\frac{100*4}{20} = 20kg\ of\ ammomium\ sulphate$

16kg P_2O_5 will be supplied by 100kg SSP

1kg P_2O_5 will be supplied by 100/16 kg of SSP

8kg P_2O_5 →$\frac{8*100}{16} = 50kg\ SSP$

46kg K_2O will be supplied by 100kg of muriate of potash

1kg K_2O will be supplied by 100kg/46 of muriate of potash

12kg K_2O will be supplied by $\frac{12*100}{46} = 20kg$ of muriate of potash

Fertilizer required:

Ammonium sulphate =20kg

Single superphosphate =50kg

Muriate of potash =20kg

Total **90kg**

To make up the weight of mixture to 100kg use **10kg gypsum**

A hundred kg prepared fertilizer mixture will contain 4kg N, 8kg P_2O_5, 12kg K_2O

Calculating simple fertilizer mixtures

Example

Calculate the amount of ammonium nitrate (34:0:0) and treble superphosphate(TSP) (0:45:0) to make 1000kg of a 15:10:0 mixture.

Solution

Mixture 15:10:0

100kg of mixture contain 15kg of N

1000kg of mixture contain 150kg of N

100kg of mixture contain 10kg of P_2O_5

100kg of mixture contain 100kg of P_2O_5

34kg of N will be supplied by 100kg of ammonium sulphate

1kg of N will be supplied by 100kg/34 of ammonium sulphate

150kg of N will be supplied by $\frac{150*100}{34} = 441kg$ of ammonium sulphate

45kg P_2O_5 will be supplied by 100 of TSP

1kg P_2O_5 will be supplied by 100/45 of TSP

100 P_2O_5 will be supplied by $\frac{100*100}{45} = 222kg$ of TSP

Fertilizer required

TSP = 222kg

Ammonium sulphate =441kg

Total 663kg

Amounts of filler =1000:663=337kg

Calculations of percentage of nutrient

Example

Calculate the percentage of N,P and P_2O_5 in Diammonium phosphate if it were pure. formula is $(NH4)_2HPO_4$

Solution

%N=$\frac{2N}{(NH4)2HPO4} X100 = \frac{28*100}{132} = 21\%$

Most commercial $(NH4)_2HPO_4$ fertilizer is less pure and less fully ammoriated , so it will have percentage of N about 16 to 18%

%P=$\frac{P*100}{(NH4)2HPO4} = \frac{31*100}{132} = 23.5\%$

62g of P →23.5%

1g of P →$\frac{23.5}{62}$

142g of P_2O_5 →$\frac{142*23.5}{62} = 53.8\% \; of \; P_2O_5$

Impure diammonium phosphate fertilizer usually have about 46:48% P_2O_5.Some may reach nearly 50:53%

Calculations of complex fertilizer mixture

The steps to be followed in calculations

1. Calculate weights needed for each micronutrient that is derived form single source ,even though it might have other nutrient in it.

2. Calculate the weights needed for each of the remaining micronutrient which derived from several sources

3. Calculate the weights needed for secondary nutrient that are derived from a single source but which may contain some other secondary or primary nutrient.

4. calculate the weights needed of the remaining secondary nutrient

5.calculate the weights needed for major (NPK) nutrients that are derived from a single source but which contain other nutrients.

6. Calculate the required weights of the remaining primary nutrient.

Example

Calculate the weight of urea (46%), treble superphosphate (TSP) 45% P_2O_5 and KCl (60% K_2O) to make up 100kg of a mixture having a ratio of N:P_2O_5:K_2O of 4:2:1 . when the mixture is made, calculate its grade.

Solution

46kg of N →100kg of urea

1kg of N →100/46kg of urea

4kg of N →$\frac{4*100}{46} = 8.696kg\ of\ urea$

45kg of P_2O_5→100kg of TSP

1kg of P_2O_5→100/45 kg of TSP

2kg of P_2O_5→$\frac{100*2}{45} = 4.444kg\ of\ TSP$

- **Content/Topic 3: Fertilizer application frequency**

The factors which affect the optimum fertilizer dose are:

1. **Initial Soil Fertility.** Plants growing on soils high in available plant nutrients responds little to application of fertilizers. This soil requires little dose of fertilizers.

2. **Soil pH**. In neutral soil (pH 7.0) responses of fertilizers is maximum. In acidic, saline and alkaline soils availability of fertilizers is reduced, thus, higher application is needed.

3. **Soil Texture**. Sandy soil requires greater amount of fertilizer in comparison to a clayey soil.

4. Soil Erosion. Eroded soil requires heavier fertilizer dose.

5. **Rainfall**. There is high requirement of fertilizer in the areas of high rainfall.

6. **Previous Crop Raised**. If an exhaustive crop like maize is taken during the A season, the wheat crop to be sown during B season requires a higher dose of nitrogen.

7. **Intensity of Cropping.** Higher the cropping intensity, higher removal of nutrients.

8. **Sowing Period.** If the crop is sown late, dose should be increased.

9. **Irrigated Area.** Fertilizer dose should be more in comparison to un-irrigated areas.

Potash fertilizer like phosphate becomes available slowly. As such, it is always advisable to apply the entire quantity of potash at sowing time. Leaching of potash is greater in sandy soils. This means split application of potash is desirable in sandy soils.

- Content/Topic 4: Timing of fertilizers application

1. Basal application

a. Before preparatory tillage

Bulky organic manures, green manures, soil amendment and soil conditioners are applied before preparatory tillage for thorough mixing with the soil

b. Basal dressing

Application of manures and fertilizers before last ploughing /puddling or before sowing or planting.

c. At sowing or planting

Concentrated organic manures, readily soluble and higher mobile fertilizers, slow release fertilizers, starter dose of N fertilizer to legume crops and fertilizer for specific nutrient deficient soil are applied during this time.

2. Top dressing

it is the application of manures and fertilizers to the established crop with crop duration. Top dressing may be done to the soil or to the foliage. Split application of nitrogen and potassium is done throughout the cropping period to increase the fertilizer use efficiency.

The time and method of fertilizer application vary in relation to

1) The nature of fertilizer
2) Soil type
3) The differences in nutrient requirement
4) The nature of field crops

Proper timing increases yields, reduces nutrient losses, increases nutrient use efficiency and prevents damage to the environment.

Time, quantity and method of application have to be chosen to suit the particular nutrient, the crop, as well as the method of cultivation.

Fertilizers can be uniformly spread or placed in soil at a specific place. Depending on the density and type of cultivation, one solution or the other may be more appropriate.

Principles governing selection of proper time for application of fertilizers are:

1. **Nitrogen is required throughout the crop growth.** Nitrogen is taken up by the plant slowly in the beginning, rapidly during the grand growth period and again slowly as it nears maturity.

2. **Nitrogen is lost easily through leaching.** Therefore, it is better not to apply too much nitrogen fertilizer at one time, but to apply in split doses throughout the growth period.

3. Phosphorus is required during the early root development and early plant growth. As such, crop plants utilize 2/3rd of the total requirement of phosphorus when the plants accumulate l/3rd of their dry weight.

4. **All phosphatic fertilizers release phosphorus for plant growth slowly.** As such, it is always recommended that the entire quantity of phosphatic fertilizers should be applied before sowing or planting.

5. **Potash behaves partly like nitrogen and partly like phosphorus.** From the point of view of the rate of absorption, it is like nitrogen, being absorbed, up to the harvesting stage.

LO 3.4 – Keep record as required by supervisor

- **Content/Topic 1 :Tools used in record keeping**

✓ **Computer**
✓ **Internet**
✓ **Pencil**

✓ **Content of record form/Template**

- **Technical form of data recoding on fertilizer application**

Fertilizers application worksheet			
Name of grower			
Date			
Field			
Crop to be grown			
Previous crop			
Target yield			
Nutrient applied	Type	Quantity applied	Rate
Manure applied			
Other organic nutrient sources			
Pre-plant fertilizers			
Starter fertilizers			
Supplement fertilizers			
Total NPK applied per are			
Methods used			
Crop stage			
Emergence			
Flowering			
Maturity			
Notes: Comment on fertilizers application			

1. Written recording

Written record: a written document preserving knowledge of facts or events.

2. Soft record on electronic device

Keeping written document preserving knowledge of facts or events in electronic device as a soft.

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