THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

GUIDELINES FOR PREPARING THE LABORATORY FOR PRACTICAL EXAMINATIONS IN SECONDARY SCHOOLS

AGRICULTURE

Prepared by:
The National Examinations Council of Tanzania,
P.O. Box 2624,
Dar es Salaam, Tanzania.

October 2021

THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

GUIDELINES FOR PREPARING THE LABORATORY FOR PRACTICAL EXAMINATIONS IN SECONDARY SCHOOLS

AGRICULTURE

Prepared by:
The National Examinations Council of Tanzania,
P.O. Box 2624,
Dar es Salaam, Tanzania.

October 2021

Issued by:

The National Examinations Council of Tanzania,
P. O. Box 2624,
Dar es Salaam, Tanzania.

First Edition, 2021

Table of Contents

FOREWORD

The National Examinations Council of Tanzania (NECTA) administers Agriculture practical examinations in the Certificate of Secondary Education Examination (CSEE) and the Advanced Certificate of Secondary Education Examination (ACSEE). The examinations aim at assessing skills and competencies that the candidates have acquired and testing facts practically under a controlled environment. Through conducting practical examinations, the council can evaluate strengths and weaknesses of the candidates. However, for a good candidate to demonstrate the acquired skills and competences, adequate preparation of the laboratory is mandatory.

These guidelines have been prepared to assist Agriculture subject teachers and laboratory technicians who are involved with preparation for practicals in performing the task effectively and efficiently. The guidelines consist of important instructions on how to organise the laboratory for examinations. It provides step by step guideline notes to assist teachers and laboratory technicians in preparing and administering practical examinations.

These guidelines can also be used as a tool for promoting the teaching and learning process as those concerned with laboratory preparation will learn the skills and procedures for conducting different Agriculture practicals. In view of this, a thorough analysis of the Agriculture syllabuses was done to determine areas that require practical assessment. Therefore, the guidelines comprise the area of assessment, practical activities, objectives of the practical, materials, apparatuses, equipment, specimens and chemicals to be used in the practical. They also comprise important note to teachers and laboratory technicians in practical preparations. These guidelines aim to ensure harmonised, smooth and fair conduct of examinations among examination centres.

The Council expects that teachers and laboratory technicians will use these guidelines to improve their practice in preparing practical examinations and enabling practical examinations to be conducted per the set guidelines and procedures.

The Council appreciates the valuable contributions of all who participated in the preparation of these guidelines.

Dr Charles E. Msonde

EXECUTIVE SECRETARY

1.0 INTRODUCTION

These practical guidelines aim to improve the preparation of laboratory for practical examinations and candidates' performance. They will enhance the teaching and learning process. They will also promote fair assessment since the candidates will be assessed on the same content taught.

The National Examinations Council of Tanzania (NECTA) has prepared these guidelines to provide teachers with the necessary skills in preparing practical examinations. Agriculture subject teachers and laboratory technicians cannot prepare their practical examinations effectively if they are not familiar with the laboratory techniques that will lead to learning the required skills. The Agriculture subject teachers and laboratory technicians with the required skills will be able to prepare the laboratory for practical examinations effectively. This will improve the administration of examinations. These guidelines will also help teachers to efficiently and effectively teach their students laboratory practicals.

Practicals in these guidelines are categorised in four subject fields, namely Soil Science, Crop Production, Livestock Production and Agro-mechanics. The practicals are on specific topics and subtopics in each field. They involve actual activities such as observation and practice that build competences to improve the knowledge and skills of agriculture students. The competences learnt are important since they prepare the candidates to be agricultural experts who can meet the emerging demands of agricultural development.

To prepare and conduct Agriculture subject practical examinations, schools offering agriculture subject should have laboratories with the necessary infrastructures. Such laboratories should be well managed and organised. They should also adhere to safety precautions.

2.0 AGRICULTURE LABORATORY ORGANISATION, MANAGEMENT AND SAFETY

A laboratory is a room or building designed for scientific experiments. It is a place where practical examinations are also conducted. To prepare laboratory practicals effectively, one needs to have knowledge and skills in doing agriculture practicals. Preparations for practical examinations start immediately after receiving a checklist. This is a set of instructions for the items that should be available for agriculture practicals. The items to be used for Agriculture laboratory practicals are taken from the syllabus. Preparations end up when preparing the items to be used in the examination as instructed in the 3 hours advance instructions. The laboratory has to be properly organised and managed so as to be utilized effectively and efficiently during the preparation and conduct of practical examinations. Teachers and laboratory technicians must observe safety precautions when preparing and conducting practical examinations.

2.1 Laboratory Organisation

Organisation is a basic and essential function in the science laboratory. Laboratory organisation includes the arrangement of the laboratory for examinations. Teachers and laboratory technicians must perform the following tasks:

(i) Keeping the laboratory and workplace clean and free from items that will not be used in the examination;
(ii) Making sure that all the items required are present in the specified quantities, and the specimens are labelled accordingly;
(iii) Arranging all items on the checklist according to the subject fields (Soil Science, Crop Production, Livestock Production and Agro-mechanics) for easy distribution;
(iv) Thoroughly cleaning of the apparatuses and equipment before and after use;
(v) Allocating candidates positions according to the laboratory capacity while maintaining distance from one candidate to another;
(vi) Placing the items to be used close to the candidate;
(vii) Keeping windows open to allow air circulation during the examination; and
(viii) Ensuring the availability of protective gear (safety gloves, safety glasses, laboratory coat) and safety equipment (fire extinguisher and first aid kit).

2.2 Laboratory Management

Laboratory management entails the role of the teacher and laboratory technician in handling the laboratory. Managerial skills and strategies during the preparation and conduct of practical examinations should be applied. These include the following:

(i) Keeping the laboratory out of bound during the preparation and conduct of examinations;
(ii) Observing confidentiality during the preparations and conduct examination of examinations;
(iii) Making sure that apparatuses and equipment are in good working condition, and chemicals have not expired;
(iv) Preserving animal specimens while keeping plant specimens fresh;
(v) Providing real object specimens and not otherwise;
(vi) Improvising apparatuses and equipment which are in short supply or not available where possible;
(vii) Ensuring all the electric, gas and water systems are functioning properly;
(viii) Regular inspecting the items in the laboratory to see what is available or lacking; and
(ix) Repair and maintaining items where applicable.

2.3 Laboratory Safety

A teacher and laboratory technician must observe safety precautions in the laboratory to protect users, equipment, apparatuses and the buildings. The following are the precautions to adhere to in preparing and conducting practical examinations:

(i) Know the position and operation of safety equipment such as the first aid kit and fire extinguishers;
(ii) Know what to do in case an accident occurs in the laboratory;
(iii) Check for gas leakage before use;
(iv) Wear protective gear like coats, gloves, safety goggles and boots where necessary;
(v) Dispose of wastes after preparing the laboratory and conducting practical examinations;
(vi) Washing hands with soap and water after preparing the laboratory and conducting practical examinations;
(vii) Clean the apparatuses, equipment and the work place after the examination;
(viii) Store the apparatuses, equipment, chemicals and materials safely after the examination; and
(ix) Close water taps and switch off the electric and gas systems after use.

3.0 AREAS OF ASSESSMENT

The areas for practical assessment are Soil Science, Crop Production, Livestock Production and Agro-mechanics. The practicals to be conducted are indicated in a specific topic and subtopic.

3.1 FIELD: SOIL SCIENCE

3.1.1 Topic: Introduction to soil science

3.1.1.1 Sub-topic: The concept of soil

Selected practicals

Practical Activity 1: Determination of air in the soil

This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable candidates to verify that soil contain air.

Overview

Air is one of the basic components of soil. Air is held between the pore spaces in the soil. Since water is also held in the pore spaces, the amount of air present in the soil depends on the amount of water in the same soil. Wet soil contains more water while dry soil contains more air. Plant roots and soil microorganisms require oxygen for respiration.

Apparatuses and materials

Prepare a 500 cm^3 measuring cylinder, water, 250 cm^3 beaker and a dry soil sample.

Important note to the teacher and laboratory technician

(a) Prepare apparatuses and materials for every candidate.
(b) Prepare a fresh dry soil sample for every candidate.
(c) The apparatuses and work place should be cleaned thoroughly.

Procedures for the practical activity

(i) Put 100 cm^3 of the soil sample into the 250 cm^3 beaker.
(ii) Pour 200 cm^3 of water into a 500 cm^3 measuring cylinder.
(iii) Put 100 cm^3 of the soil sample into the measuring cylinder containing water and record the volume of the mixture.
(iv) Place your hand over the mouth of the cylinder and shake the mixture thoroughly.
(v) Leave the mixture until all the air bubbles have escaped and record the volume of the mixture.

Sample questions

1. Why did the air bubbles escape from the mixture?
2. Calculate the percentage of air in the soil sample if
   (a) The volume of water poured in the cylinder = 200 cm^3
   (b) The volume of water + soil in the cylinder before shaking = Z cm^3.
   (c) The volume of water + soil in the cylinder after shaking = Y cm^3.

Practical activity 2

Determining water in the soil: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to verify that soil contains water.

Overview

Soil contains water as one of its major constituents. Water is usually held between soil particles. The amount of water in the soil varies with the soil type, particle size, organic matter content and time. Water is essential for plant growth and production.

Apparatuses and materials

Evaporating dish, tripod stand, weighing balance, stirring rod, garden soil, water bath and bunsen burner

Note to the teacher and laboratory technician

(a) Prepare the apparatuses and materials for every candidate.

(b) The weighing balance should be well-calibrated before use.

(c) The apparatuses and work place should be thoroughly cleaned. A fresh soil sample should be given to every candidate and used as instructed.

(d) If gas is to be used as a source of heat, ensure that the gas system and bunsen burners work properly.

Procedure for the practical activity

(i) Weigh the evaporating dish and put about 10 g of garden soil in it.

(ii) Place the dish over the bunsen burner and gently heat it.

(iii) Cool the dish in a water bath and weigh it.

(iv) Repeat the process until a constant weight is obtained.

(v) Record the results as follows:

- Weight of garden soil = 10 g
- Weight of soil after cooling = X g
- Loss in weight = (10 – X) g

Sample questions

1. Why is there loss in weight?
2. Calculate the percentage loss in weight.
3. What does this percentage loss in weight represent?

Practical Activity 3

Determining organic matter in the soil: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to verify that soil contains organic matter.

Overview

Organic matter consists of various products of decayed plant and animal residue. Organic matter undergoes microbial decomposition to release plant nutrients and humus. It also influences the physical properties of soil such as water-holding capacity, aeration and drainage.

Apparatuses and materials

Evaporating dish, tripod stand, weighing balance, stirring rod, garden soil, water bath and Bunsen burner.

Important note to the teacher and laboratory technician

(a) Prepare the apparatuses and materials for every candidate.
(b) The weighing balance should be well-calibrated before use.
(c) The apparatuses and work place should be thoroughly cleaned. A fresh soil sample should be given to every candidate and used as instructed.
(d) If gas is to be used as a source of heat, ensure that the gas system and bunsen burners work properly.

Procedure for the practical activity

(i) Weigh the evaporating dish and put about 10 g of garden soil in it.
(ii) Place the dish over the bunsen burner and gently heat it.
(iii) Cool the dish in a water bath and weigh it.
(iv) Repeat the process until a constant weight is obtained.
(v) Place the dish over the bunsen burner and heat strongly until you notice colour change on the soil sample. Keep the soil well stirred during heating.
(vi) Cool the dish with soil in a water bath and weigh it.
(vii) Repeat the process until a constant weight is obtained.
(viii) Record the results as follows:
- Weight of dry soil = X g
- Weight of strongly heated soil = Y g
- Loss in weight = (X-Y) g

Sample questions

1. Find out why there was a colour change and loss in weight after strong heating.
2. Calculate the percentage loss in weight.
3. Name the substance that was lost after strong heating.

3.1.1.2 Sub-topic: Soil texture, structure and porosity

Selected practicals

Practical Activity 1

Determining soil texture by the feel method: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to determine the texture of the soil by the feel method.

Overview

Soil texture refers to the relative proportions of different soil particles in a soil sample. Soil texture affects the physical properties of the soil such as permeability, capillarity and water holding capacity. Once soil texture is determined in the field, general characteristics of soil can be predicted with reasonable accuracy, which helps to identify the proper management practices of a particular soil. The texture of sand soil, clay soil and silt soil can be easily determined by the feel method.

Specimens and materials

Sand soil, clay soil, silt soil, 3-petri dishes and water

Important note to the teacher and laboratory technician

(a) Prepare and place the three soil samples into 3 separate petri-dishes and label them A, B and C.
(b) These specimens and materials must be for every candidate.
(c) The work place should be thoroughly cleaned.
(d) Fresh soil samples should be given to each candidate.
(e) Prepare the soil samples to be used as directed on the checklist.

Procedures for the practical activity

(i) In each soil sample add a few drops of water to make them wet.
(ii) Put a small amount of one of the wet soil samples between the thumb and fore finger and rub to feel it.
(iii) Repeat the same procedure for each of the soil samples.

Note

Sand soil has a gritty feel when wet. Clay soil is sticky when wet, and silt soil has a soapy feel when wet.

Sample questions

1. Why is it important to make the soil sample wet before rubbing it using a thumb and forefingers?
2. Name three types of soil samples.
3. Determine the texture of the three soil samples.

Practical Activity 2

Determining soil texture by textural triangle: This practical can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to determine the textural class of the soil sample using the textural triangle method.

Overview

The soil textural triangle is used to convert particle size distribution into a recognised textural class based on the relative percentage of sand, silt and clay.

Apparatuses, equipment and materials

Soil sample, mortar and pestle, soil sieves, weighing balance and textural triangle

Important note to the teacher and laboratory technician

(a) Prepare apparatuses, equipment and materials for every candidate.
(b) In case of a shortage of some apparatuses and equipment, allow candidates to share as directed on the checklist.
(c) The weighing balance should be well calibrated before being used.
(d) The textural triangles provided should be visible and meshes in the soil sieves intact.
(e) The apparatuses, equipment and work place should be thoroughly cleaned and a fresh soil sample should be given to each candidate.
(f) Prepare the soil sample to be used as directed on the checklist.

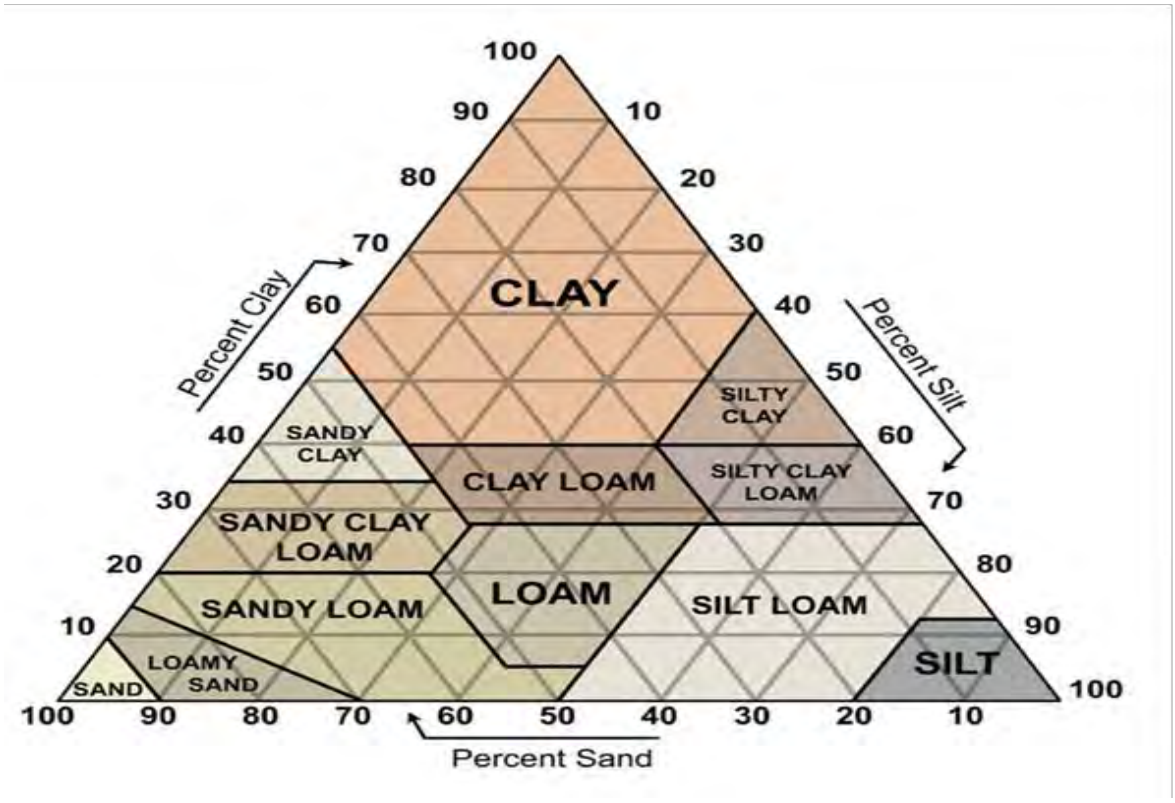
Procedure for the practical activity

(i) Put the required amount of soil in a mortar.
(ii) Use the mortar and pestle to break the soil lumps (clods) without breaking the particles.
(iii) Put the soil in a sieve with the largest mesh diameter of 2.0 mm and shake vigorously.
(iv) Weigh the soil remaining on the sieve and record.
(v) Repeat the process using other sieves with mesh diameters of 0.2 mm, 0.02 mm and 0.002 mm.
(vi) Calculate the percentage composition of sand, clay and silt based on the original soil sample.
(vii) Use the percentage composition of sand, silt and clay to determine the textural class of the soil sample in the textural triangle.

Note

A certain amount of soil particles remains in each sieve. The soil with the largest particles remains on the first sieve which has a mesh diameter of 2.00 mm (gravel). Small sized particles remain on the second sieve which is 0.20 mm (coarse sand) in diameter. Fine-sized particles remain on the third sieve which is 0.02 mm (fine sand) in diameter. Finally, the finest particles pass through the fourth sieve with a diameter of 0.002 mm (clay) in which silt particles remain. The percentage of gravel is not used to determine the soil texture. The

following figure represents a textural triangle that is used to determine the textural classes of the soil samples.



Sample questions

Use the textural triangle to determine the textural classes of soil samples with the following composition:

1. Sand 80 %, silt 5% and clay 15%
2. Sand 50%, silt 30% and clay 20%

Practical Activity 3

Comparing water holding capacity of clay and sand soil: This practical can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare the practical activity to enable the candidates to verify that different soils have different capacities of retaining water.

Overview

Soil structure and texture greatly influence the water retaining capacity of the soil. Fine particles and well aggregated soils tend to hold more water than soil with large particles and less compacted structure. The water retaining capacity of the soil also depends on the proportion of clay and humus available.

Apparatuses and materials

Funnels, weighing balance, beaker, measuring cylinders, filter papers, tap water, clay soil, sand soil and a stop watch

Important note to the teacher and laboratory technician

(a) Prepare the apparatuses, equipment and materials for every candidate.
(b) In case of a shortage of some apparatuses, allow the students to share as directed on the checklist.
(c) Make sure the weighing balance is well-calibrated before use, and stop watches are functioning well.
(d) The apparatuses and work place should be thoroughly cleaned.
(e) Fresh soil samples should be given to each candidate.
(f) Prepare the soil sample to be used as directed on the checklist.

Procedure for the practical activity

(i) Place filter papers into the funnels and label them G and S.
(ii) Put 150 g of dry clay soil in funnel G and 150 g of dry sand in funnel S.
(iii) Place each funnel in a graduated measuring cylinder.
(iv) Measure 100 cm^3 of tap water and put it into the beaker.
(v) Pour water from the beaker into funnel G and start the stop watch.
(vi) After two minutes, remove the funnel and record the volume of water collected in the measuring cylinder.
(vii) Repeat procedure iv, v and vi with funnel S.

Sample questions

1. Which soil retains more water? Give a reason.
2. Which soil retains less water? Give a reason.
3. Calculate the infiltration rate of the two types of soil.

Practical Activity 4

Mechanical soil analysis by the simple sedimentation method: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to verify that soil has particles of different sizes.

Overview

Soil has particles of different sizes. The distribution of these particles influences the physical and chemical properties of soil such as water holding capacity, workability, the amount of nutrients available and aeration.

Apparatuses and materials

Sample of garden soil, mortar and pestle, 250 cm^3 measuring cylinder, water, barium sulphate, weighing balance and stirring rod

Important note to the teacher and laboratory technician

(a) Prepare apparatuses and materials for every candidate.
(b) In case of a shortage of some apparatuses, allow the students to share as directed on the check list.
(c) The weighing balance should be well-calibrated before being used.
(d) Check for expiry date of the chemical (barium sulphate) before use to ensure that it does not affect the results of the experiment.
(e) Apparatuses and work place should be thoroughly cleaned.
(f) A fresh soil sample should be given to each candidate.
(g) Prepare the soil sample to be used as directed on the checklist.

Procedure for the practical activity

(i) Break the dry soil sample provided and mix it thoroughly with a recommended amount of barium sulphate powder.
(ii) Weigh 10 g of garden soil and put it into the measuring cylinder.
(iii) Add 30 cm^3 of water.
(iv) Cover the mouth of the cylinder and shake the mixture thoroughly.
(v) Leave the mixture to settle until you notice layers of soil particles.
(vi) Note and record your observations.

Note

The soil will settle in different layers after some time. Heavy and large particles are seen to settle at the bottom, followed by medium-sized particles, and the fine particles will settle at the top. Organic matter will float on the water together with suspended soil particles.

Sample questions

1. Why was barium sulphate added to the garden soil?
2. Draw a well labelled diagram of the distribution of soil particle sizes in the measuring cylinder.

Practical activity 5

Comparing water permeability in clay and sand soil: This practical can be done by both CSEE and ACSEE candidates.

Objectives

The teacher should prepare a practical activity to enable the candidates to verify that different soil types have different permeability.

Overview

Soil permeability is the ability of water to pass through the soil particles. Soil permeability describes how quickly water can pass through the dry soil pore space. Therefore, the large the pore space, the high the permeability and viceversa.

Materials

Wooden box with four holes on one side, four plastic tubes, watering can, clay and sand soil

Important note to the teacher and laboratory technician

(a) The teacher should prepare the materials to be shared among the students as indicated on a checklist.
(b) Work place and materials should be thoroughly cleaned.
(c) Fresh soil samples should be given to each candidate.
(d) The tubes should be tightly fixed into the holes of the wooden box to prevent water leakage.
(e) Prepare the soil sample to be used as indicated on the checklist.

Procedure for the practical activity

(i) Prepare a wooden box with four plastic tubes at the sides and label the tubes 1-4 from the top to the bottom of the box (diameters of the holes and tubes should be the same).
(ii) Fill the lower part of the box with wet clay soil and spread it evenly.
(iii) Fill the rest of the box with a layer of sand soil up to the top.
(iv) Fix a plastic tube in each hole in one corner of the box.
(v) Using the watering can, pour water uniformly on the layer of the sand soil.
(vi) Make observations.

Sample questions

1. What happens to water when it is poured on the layer of sand soil?
2. What happens to water when poured on the layer of clay soil?
3. Which of the two soil type is more permeable and why?

Note

Sand soil is more permeable than clay soil because water passes through it faster than through clay soil.

3.1.2 Topic: Soil productivity

3.1.2.1 Sub-topic: Soil fertility

Selected practicals

Practical Activity 1

Identification of deficient plant nutrients based on their deficiency symptoms: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to identify observable symptoms of plant nutrient deficiency.

Overview

Proper growth and development of plants among other things require adequate supply of plant nutrients. A careful inspection of the growing plant can help identify a specific nutrient stress. If a plant lacks a particular nutrient, characteristic symptoms may appear. The deficiency of a nutrient does not directly produce symptoms. Rather, the normal plant processes are thrown out of balance due to the accumulation of certain intermediate organic compounds and a shortage of others. This leads to the abnormal growth conditions recognised as symptoms. Visual evaluation of lack of nutrients should be used only in addition to other diagnostic techniques. Nutrient deficiency symptoms may be classified as follows:

(a) complete crop failure at the seedling stage;
(b) severe stunting of plants;
(c) specific leaf symptoms appearing at varying times during the season;
(d) internal abnormalities such as clogged conductive tissues;
(e) delayed or abnormal maturity;
(f) obvious yield differences with or without leaf symptoms;
(g) poor quality of crops, including differences in protein, oil or starch content and storage quality; and
(h) yield differences detected only by careful experimental work.

Each symptom must be related to certain functions of the nutrient in the plant. A given nutrient may have several functions. This makes it difficult to explain the physiological reason for a particular deficiency symptom.

Specimen and materials

Hand lenses and plants suffering from nutrient deficiency

Important note to the teacher and laboratory technician

(a) Prepare the specimens and materials for every candidate.
(b) In case of a shortage of specimens and materials, allow the candidates to share as directed on the checklist.
(c) The plant specimens provided should be fresh for the deficient symptoms to be visible.

Procedure for the practical activity

With the aid of a hand lens, make careful observations of the observable symptoms of nutrient deficiency.

Note

Shortage of different plant nutrients in the soil results into different deficiency symptoms in plants. Therefore, teachers should enable students to identify deficiency symptoms of the following plant nutrients: nitrogen, phosphorus, potassium, magnesium and Iron.

Sample questions

1. Which symptoms have been observed?
2. Which plant nutrient is associated with the observed symptoms?
3. Outline the functions of the plant nutrients in part (b).

Practical Activity 2

Determining soil pH using colour indicator dyes: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to determine the pH of soil.

Overview

Soil pH indicates the acidity or alkalinity of soil, and is measured in pH units. Soil pH is defined as the negative logarithm of the hydrogen ion concentration in the soil solution. The pH scale ranges from 0 to 14 with pH 7 as the neutral point. As the amount of hydrogen ions in the soil increases, the soil pH decreases, thus becoming more acidic. From pH 7 to 0, the soil is increasingly more acidic, and from pH 7 to 14, the soil is increasingly more alkalinity.

Soil pH influences the availability of various nutrients in the soil for the plant by either fixing the nutrients or increasing their solubility to an injurious level. It also influences the activities of micro-organisms, the type of crops to be grown, and the amendment to be done to the soil.

Chemicals, apparatuses, equipment and materials

Air dried soil sample, test tubes, distilled water, pH colour indicator dyes, pH colour chart, barium sulphate powder, cork, weighing balance, spatula, test tube rack and wall clock

Important note to the teacher and laboratory technician

(a) Prepare the apparatuses, chemicals and materials for every candidate.
(b) In case of a shortage of apparatuses, allow the candidates to share as directed on the checklist.
(c) The weighing balance should be well calibrated before use, and wall clocks should function well.
(d) Check for expiry date of chemicals (colour indicator dyes and barium sulphate).
(e) Soil pH colour charts should be visible and coloured.
(f) The apparatuses and work place should be cleaned thoroughly.
(g) A fresh soil sample should be given to each candidate.
(h) Prepare the soil samples to be used as directed on the checklist.

Procedure for the practical activity

(i) Take the air dried soil sample and mix it thoroughly before testing it.
(ii) Measure 5 g of soil and put it into the test tube.
(iii) Add barium sulphate powder and mix it well with the soil. Barium sulphate is chemically inactive; hence, it will not interfere with the chemical composition of the soil.
(iv) Add distilled water and a few drops of colour indicator dye to the mixture.
(v) Ensure the cork of the test tube is well fitted and then shake the mixture vigorously to ensure thorough mixing.
(vi) Allow the content to stand for 45-60 minutes.
(vii) Observe the clear area formed in the middle of the test tube.
(viii) Match the colour of the soil solution with that of the colour chart and record the corresponding pH value.

Note

The following table indicates various Soil pH values and their corresponding colours.

Table 1: pH values and their corresponding colours

Soil pH value	Colour
1-2	Red
3-4	Reddish orange
5	Orange
6	Yellow
7	Yellow green
8	Green

Soil pH value	Colour
9	Blue green
10	Blue

Sample questions

1. Give the pH value of the soil sample.
2. Give the interpretation of the pH value obtained and its implication to crop production.
3. Why were barium sulphate and the pH colour indicator dye added to the soil sample during the experiment?

3.1.2.2 Subtopic: Maintenance of soil fertility

Selected practical

Practical Activity 3

Identification of inorganic fertilizers: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to identify different type of inorganic fertilizers.

Overview

Soil fertility is the ability of the soil to supply all the plant nutrients and air in a sufficient and balanced quantity. Soil fertility can be maintained by adding materials containing plant nutrients in a concentrated form, materials containing organic matter and using good agronomic practices. Chemical substances that contain one or more plant nutrients in a concentrated form are called inorganic fertilizers. Inorganic fertilizers supply pure nutrients. In addition to pure nutrients, they contain other substances which are called filler substances or secondary substance. Example of such substances are chlorides, sulphates and trace elements. These also favour plant growth. Inorganic fertilizers which contain only one of the three major elements are called straight fertilizers, whereas those which contain all the three major elements (N.P.K) are called complete or mixed fertilizers. Complete fertilizers are prepared by chemical change in a factory, whereas mixed fertilizers are obtained by mixing two or more fertilizers. The table below indicates the colour, formulation and Soil pH of different fertilizers.

Table 2: Colour, Formulation and pH

S/N	Fertiliser name	Colour	Formulation	pH
1	Sulphate of Ammonia (SA)	White	Crystalline	Acidic
2	Urea	White	Granular	Very acidic
3	Calcium Ammonium Nitrate	Creamy white	Granular	Neutral

S/N	Fertiliser name	Colour	Formulation	pH
	(CAN)			
4	Di-ammonium Phosphate (DAP)	Grey	Granular	Acidic

Specimens, apparatuses and materials

Sulphate of Ammonium (S.A), Urea, Calcium Ammonium Nitrate (C.A.N), and Di-Ammonium Phosphate (DAP) fertilisers, test tubes, petri-dishes, litmus papers (red and blue), and distilled water

Important note to the teacher and laboratory technician

(a) Prepare specimens, apparatuses and materials for every student.
(b) Provide the students with specimens which are in good order.
(c) The apparatuses and work place should be cleaned thoroughly.
(d) New fertilizer samples should be given to the next group if more than one session is involved.

Procedures for the practical activity

(i) Place small amounts of fertilisers in a clearly labelled petri-dish.
(ii) Record the colour of the fertilisers.
(iii) Record the shape of the fertiliser particles.
(iv) Place a small quantity of each fertilizer, one at a time, in a test-tube; add distilled water; and shake vigorously. Record your observations.
(v) Place a strip of red and blue litmus paper in the solution made by dissolving the fertilisers in water. Record your observations and find out the pH of the fertilisers.

Sample questions

1. Give the experimental observations for each of the fertiliser provided.
2. What have you observed in step (iv) of the procedure above?
3. What have you noticed in step (v) of the procedure above? Based on your observation, what do you conclude?
4. What is the pH of the four fertiliser solutions?
5. Identify the types of fertilisers from your observation.

3.1.3 Topic: Introduction to soil chemistry

3.1.3.1 Sub-topic: Chemical properties of soil

Selected practical

Practical activity

Correction of soil reactions by liming: This practical activity can be done by ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to raise the pH of the soil sample.

Overview

To correct soil acidity to a certain level, lime materials are applied. Most agricultural crops prefer a soil reaction of pH of about 6.5. Soils which have low pH values (acidic) require the addition of lime to raise their pH values. The amount of lime required to modify soil pH depends on the soil type, the degree of acidity and the type of the liming material to be used.

Specimens, apparatuses and materials

Air dried acidic soil sample, air dried alkaline soil sample, $CaCO_3$ powder, distilled water, pH meter, 250cm^3 beakers, weighing balance, stop watch/wall clock and stirring rods

Important note to the teacher and laboratory technician

(a) Prepare soil samples as instructed on the checklist.

(b) Make sure the pH meter, weighing balance and stop watch/wall clock are functioning well.

(c) Provide specimens, apparatuses and materials for every candidate.

Procedures for the practical activity

(i) Take two 250 cm^3 capacity beakers and label them A and B.

(ii) Pour 50 cm^3 of distilled water into each beaker.

(iii) Add 50 g of air dried acidic soil in beaker A and 50 g of air dried alkaline soil in beaker B.

(iv) Stir the mixture for 3-5 minutes and leave it to settle for 5 minutes.

(v) Insert the pH meter rods in each beaker A and B for 5 minutes and record the pH readings of each mixture in a beaker as initial readings.

(vi) Add 20 g of $CaCO_3$ powder in each beaker: A and B.

(vii) Rinse a stirring rod with distilled water, stir again the mixture for 3-5 minutes, and leave the mixture to settle for 5 minutes.

(viii) Rinse the pH meter rods with distilled water, insert them again in beaker A and B for 5 minutes, and record the pH readings of each mixture as final readings.

Sample questions

1. Tabulate initial and final readings of the pH meter in each beaker, as shown in the table below:

Beaker	**pH meter readings**	
	Initial readings	Final readings
A		
B		

2. Comment on the change of pH readings in each beaker.
3. Suggest the probable land reclamation method tested above.

3.2 FIELD: CROP PRODUCTION

3.2.1 Topic: Crop husbandry

3.2.1.1 Sub-topic: Production of cereal crops

Selected practicals

Practical Activity 1

Identification of plant diseases based on their symptoms: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable candidates to identify different plant diseases based on their observable symptoms.

Overview

Generally, a plant becomes diseased when it is continuously disturbed by causal agents that result in an abnormal physiological and biochemical processes that disrupt the plant's normal structure, growth and other functions. This interference with one or more of a plant's essential physiological or biochemical systems elicits characteristic pathological conditions or symptoms as a response to the cause.

Plant diseases can be broadly classified according to the nature of their primary causal agents, either biotic or abiotic agents. Biotic diseases are caused by pathogenic organisms such as a fungus, bacterium, mycoplasma, virus, viroid, nematode, or parasitic flowering plant. The pathogens are capable of reproducing within, or on their host, and spreading from one susceptible host to another. Abiotic plant diseases are caused by unfavourable growing conditions, including extreme temperature, disadvantageous relationships between moisture and oxygen, toxic substances in the soil or atmosphere and an excess or deficiency of an essential mineral. Abiotic causes of plant diseases are non-infectious and not capable of reproducing within the host. They are not transmissible. For these guidelines, only pathogenic diseases shall be dealt with. Plant diseases can be diagnosed by studying

symptoms, signs and microscopic investigations. Symptoms and signs provide the most important evidence about the causal agent. Signs can point directly to causal agents. Each disease is characterized by certain symptoms; they may change in nature and intensity in the course of a disease: and they may be modified by environmental conditions

Specimen and materials

Hand lenses and maize plants affected by maize streak viral disease.

Important note to teacher and laboratory technician

(a) Prepare the specimens and materials for every student.
(b) In case of shortage of the specimens and materials, allow the students to share as directed in the checklist.
(c) Plant specimens provided should be fresh for the symptoms to be visible.

Procedure for the practical activity

With the aid of hand lens, carefully observe the symptoms of the plant disease in the specimen.

Note

Different crops are affected by different diseases; therefore, teachers should teach their students about the symptoms of the following diseases: Maize streak virus, blast in paddy, bean anthracnose, fusarium wilt in beans, bean rust, tomato blight, tomato leaf curl virus, bacterial wilt in tomato, blossom end rot of tomato, dumping off in tomato, groundnuts rosette, cassava mosaic, potato blight, Coffee Berry Disease (CBD) and coffee leaf rust based on their visible symptoms

Sample questions

1. Identify the disease symptoms observed in the specimen.
2. Name the disease affecting the specimen.
3. What are the control measures of the identified disease?

Practical Activity 2

Identification of modes of feeding of insect pests: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable candidates to identify the modes of feeding of different insect pests by observing their mouth parts.

Overview

A crop pest is any animal or plant which damages crop plants. The major pests of crops are insects, pathogens and weeds. Other pests are rodents, birds and nematodes. Rodents are

small mammals which attack food mainly in stores. Rats are the most common rodents in food stores. Birds are animals with feathers. Some types of birds are serious pests of crops in the fields. Birds eat grains such as sorghum, millet, wheat and maize in the fields. A good example is *Quelea quelea*. Nematodes are small worms that infest the roots of a plant. Insect pests are classified according to their mode of feeding (nature of their mouth parts), namely biting and chewing insects, piercing and sucking, and boring insect pests.

(a) Biting and chewing insect pests are those whose mouthparts are well adapted to biting and chewing plant tissues and organs. These insects physically damage crops by eating up the leaf tissues, apical meristem and organs. They are categorized as defoliators or skeletonizers, leaf miners, leaf webbers, leaf folders, gall makers, and seed feeders. Examples of insects in this group are grasshoppers, beetles, locusts and caterpillars.

(b) Piercing and sucking insects pierce plant tissues and organs and suck their sap. The damage caused includes sucking of the cell sap and weakening the plant stem. They also inject toxic or poisonous saliva into the host plant since they are vectors of some disease-causing organisms. This creates openings for secondary infections in the plants. Examples of such insects in this group include cotton stainer, white flies, mealy bugs, butterflies, aphids, leafhoppers, thrips, bugs and scales.

(c) Boring insects have mouthparts that bore into plant tissues and seeds. The damage caused includes eating up the grain contents, reducing them to powdery form; destroying the seed embryo; and reducing seed viability. This also reduces grain quality and market value. Examples of insects in this group include weevils and stem borers, pod/ capsule borers/boll worms, fruit borers and bark borers.

Specimen, apparatuses and materials

Grasshopper, hand lens, forceps and petri-dish

Important note to the teacher and laboratory technician

(a) Prepare the specimens, apparatuses, and materials for every student.
(b) In case of a shortage of these specimens, apparatuses and materials, allow the students to share as indicated on the checklist.
(c) Provide the students with the specimens that have been preserved in formalin.

Procedure for the practical activity

With the aid of a hand lens and forceps, make a careful observation of the mouth parts of the specimen.

Note

Insect pests have mouthparts which are adapted to their modes of feeding. Different insects have different modes of feeding hence the different of mouthparts. Therefore, teachers should let students know the mouthparts of the following insects: maize stalk borer, maize weevils, leaf hoppers, large grain borer, cut worms, bean leaf beetle, bean aphids, bees, american bollworms, moth and strainers, fruit flies and bean bruchids.

Sample questions

1. Draw a large well labelled diagram of the observed specimen's mouthparts.
2. How are the mouthparts in (a) adapted to their functions?

3.2.1.2 Sub topic: Control of crop pests

Practical activity

Identification, collection and preservation of crop pests: This practical can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable students to identify, collect and preserve different crop pests.

Overview

A pest is any living organism that destroys crops, either directly or indirectly. Pests and diseases cause great damage to crops, both in the field and in the store. Heavy infestation by pests and infection due to diseases greatly lowers the crop growth rates, leading to reduced yield and poor quality products. It also increases the cost of production. Accordingly proper control of crop pests is very crucial.

Specimens, apparatus and materials

Crop pests, glass bottles or specimen bottles, formaldehyde or ethanol, several pairs of forceps and a sweep net

Important note to the teacher and laboratory technician

(a) Organize a visit to a crop field where students can observe and identify different pests on the growing crops.
(b) Organise a visit to a food store or to a nearby cereal store or warehouse to observe and identify different pests in the store.
(c) Assist the candidates to identify the pests.

Procedures for the practical activity

(i) Collect any crop pests found in the field and in the store using a sweep net and forceps.

(ii) Put the pets in specimen bottles and preserve them with formalin.
(iii) Label the bottle as follows: common name, scientific name, the crop and part of the crop attacked, damage caused, control measures and date of collection.

Note
The teacher should prepare a practical activity to enable the candidates to identify, collect and preserve the following crop pests from the growing crops in the field and from the produce in the store: maize stalk borer, maize weevils, leaf hoppers, large grain borer, cut worms, bean leaf beetle, bean aphids, american bollworms, moth, armyworms, locusts, bean bruchids and stainers.

Sample question
Why do we collect and preserve pests?

3.2.2 Topic: Principles of crop production

3.2.2.1 Sub-topic: Planting

Selected practical

Practical Activity 1
Estimating the amount of planting materials required in an area: This practical can be done by both CSEE and ACSEE candidates.

Objective
The teacher should prepare a practical activity to enable the candidates to estimate the amount of planting materials required in an area.

Overview
Planting is the act of setting seeds, seedlings and any other planting materials into the ground to grow. During planting, it is important to use proper spacing. Crop spacing is the number of crops planted in a unit area. It is the distance between one plant and another. If crops are planted too close to one another, it may be hard for the farmer to walk in the farm during crop inspection, weed and spray pesticides. Furthermore, their roots can tangle and compete for the same resources of water and nutrients in the soil. It can also limit the growth potential and often threatens plant health. Spacing between plants in the same row is referred to as intra-row spacing (within) and spacing between rows of plants is known as inter row spacing (between). Once crop spacing is known, one can estimate the amount of planting materials to be used in an area.

Materials
Wooden box (100 cm x 100 cm x 20 cm), loam soil, 30 cm ruler and 4 cassava cuttings

Important note to the teacher and laboratory technician
(a) Provide the candidates with a wooden box filled with loam soil half of its height with planted cassava stem cuttings with the spacing of 90 cm x 75 cm.
(b) Make sure that the cuttings are planted in the proper spacing as instructed.

Procedure for the practical activity
Using a ruler, measure the spacing of the cassava cuttings and record the results.

Note
Plant population can be calculated using the following formula:

$$\text{Plant population} = \frac{\text{Farm area } \left(\text{m}^2\right)}{\text{Spacing } \left(\text{m}^2\right)}$$

Sample questions
1. What is the spacing for the planting cassava cuttings?
2. How many cassava cuttings are needed to plant in one hectare (1 ha = 10,000 m^2)?

3.2.2.2 Sub topic: Weeding and weed control

Practical Activity 1

Weed identification, collection and preservation: This practical activity can be done by both CSEE and ACSEE candidates.

Objective
The teacher should prepare a practical activity to enable the candidates to identify, collect, and preserve different types of weeds.

Overview
A weed is a plant growing where it is not required. Weeds pose a serious threat to crop and livestock production. Weed outbreak is one of the main limiting factors in farming. To understand the harmful effects of weeds and apply effective control measures, we should correctly identify the weed.

Specimen and materials
Weeds, A4 plain paper, a folder, cello tape, old newspapers, a heavy weight and secateurs or sharp knife

Important note to the teacher and laboratory technician

Conduct a visit to the school or neighbouring farm and help the students to identify and collect weeds.

Procedures for the practical activity

(i) Using secateurs or a sharp knife, collect weeds which include leaves, roots, flowers and fruits, if any.
(ii) Remove soil from the roots of the weeds.
(iii) Place each weed separately in the middle pages of newspaper. The newspaper will absorb moisture from the weed as they dry.
(iv) Place the newspaper with weeds under a heavy thing such as a stone.
(v) Air the weeds daily by exposing them. Leave them in the same position for two to three weeks. If this is done properly, the weeds will retain their original colour.
(vi) Remove the dry weed from the newspaper and place them on A4 plain paper using cello tape to form a book herbarium folder.
(vii) For each weed, write the following: common name, scientific or botanical name of the weed, its economic importance and control measures.

Note

Teacher should prepare a practical activity to enable candidates to identify, collect and preserve the following weeds: pig weeds, nut grass**,** blackjack, black nightshade**,** double thorn, witch weed**,** thorn apple, lantana/tick berry, couch grass, water hyacinth**,** star grass, wild finger millet**,** wandering jew, kikuyu grass, sodom apple, goat weed**,** P. W. D weed and striga weed. If kept properly and well handled the book herbarium can be used as a reference to identify weeds when they are not available.

Sample questions

1. Why did place each weed between the middle pages of the newspaper?
2. Why do we collect and preserve weeds?

3.2.3 Topic: Agro-forestry

3.2.3.1 Sub-topic: Bee-keeping

Selected practical

Practical Activity 1

Honey purity test: This practical activity can be done by CSEE candidates.

Objective

The teacher should prepare a practical activity to enable candidates to test for honey purity.

Overview

Honey is a natural sweet substance, produced by honeybees from the nectar of plants or from secretions of living parts of plants. It is the excretion of plant-sucking insects. Bees collect and transform it by combining with specific substances of their own, depositing, dehydrating, storing, and leaving in one honeycomb to ripen and mature.

Honey can be used as human food since it is rich in carbohydrates. It usually contains a diversity of minor constituents such as minerals, proteins, vitamins and others. Some people use honey as medicine or tonic for treatment of various diseases. Honey can also be used as a source of industrial raw materials. For example, in beverage industry, honey is used for making wines and beers. Likewise it is used in manufacturing many secondary products such as breakfast cereals and bakery goods.

There is a clear difference in the number of buyers of pure raw honey in today's world compared to the available quantity of products in the markets. This difference leads to the practice of honey adulteration. To address the huge demand, most of the honey in the market is adulterated to match the viscosity and taste of raw honey. This poses many health issues. This calls for honey purity tests. It's not always that the honey purchased is impure. If one gets the honey directly from the producer in its raw and unprocessed form, then then it is pure.

Important note to teacher and laboratory technician

(a) Prepare specimens, apparatuses and materials for every candidate as directed.
(b) Test for honey purity before allowing it to be used as a pure honey specimen for the examination.
(c) Perform the following experiments to test for honey purity.

Experiment 1: The Water Test

Specimens, apparatuses and materials

250 cm^3 beaker, tablespoon, pure honey, impure honey and tap water.

Procedures for the practical activity

(i) Put 200 cm^3 of water into the beaker.
(ii) Add one tablespoon of pure honey into the water and observe the behaviour of the honey.
(iii) Repeat the same procedure for impure honey.

Note

Impure honey will dissolve in the water right away, but honey in its pure form will settle down undissolved.

Experiment 2: Thumb test

Specimens, apparatuses and materials
250 cm^3 beaker, tablespoon, pure honey and impure honey

Procedures for the practical activity
(i) Take a small amount of pure honey from the beaker
(ii) Pour it on your thumb using a tablespoon.
(iii) Observe carefully if it spills or spreads around.
(iv) Repeat the same procedure for impure honey.

Note
Pure honey will stay intact on your thumb and will not spread.

Experiment 3: Blotting Paper or Paper Towel Test

Specimens and materials
Blotting Paper or Paper Towel, pure and impure honey

Procedures for the practical activity
(i) Take a piece of blotting paper or paper towel.
(ii) Drop two to three drops of pure honey on it.
(iii) Check if it leaves any wet traces on the blotting paper.
(iv) Repeat the same procedure for impure honey.

Note
Honey in its pure form will not be absorbed; neither will it be diluted with sugar syrups.

Experiment 4: Fire Test

Specimens and materials
Matchbox with matchsticks, pure and impure honey

Procedures for the practical activity
(i) Take a dry matchstick.
(ii) Dip the tip of the matchstick into pure honey.
(iii) Strike the same stick against the rough surface of the matchbox.
(iv) Observe if and how it lights.
(v) Repeat the same procedure for impure honey.

Note
If the honey is pure, the match stick will light up quickly and will keep on burning with ease. If the honey is impure, it will not light up due to the moisture present in the honey.

Experiment 5: Heat Test

Specimens, apparatuses and materials
Pyrex beaker, source of heat, tripod stand, pure honey, impure honey and wire gauze.

Procedures for the practical activity
(i) Put pure honey in a pyrex beaker and heat it.
(ii) Observe if the honey caramelises or bubbles up.
(iii) Repeat the same procedure for impure honey.

Note
When pure honey is heated, it caramelises quickly and does not get foamy.

Experiment 6: Tablespoon Test

Specimens and materials
Tablespoon, pure honey and impure honey

Procedures for the practical activity
(i) Take a small amount of pure honey on a tablespoon.
(ii) Hold the tablespoon up with the side of the spoon containing honey pointing downward and see whether the honey stays on the spoon.
(iii) Repeat the same procedure for impure honey.

Note
The pure honey will stay glued to the spoon; if it falls off, the honey is impure.

Experiment 7: Iodine Test

Specimens, apparatuses and materials
Table spoon, tap water, dropper, iodine solution, pure honey, impure honey and beaker.

Procedures for the Practical Activity
(i) Put a tablespoon full of pure honey in the beaker, add some water and a few drops of iodine.
(ii) Mix it well.
(iii) Observe if the colour changes to blue.
(iv) Repeat the same procedures for impure honey.

Note
If the honey turns blue, it is impure. It is mixed with some other things like starch or flour in it. Otherwise, honey will retain its original colour.

Sample questions
1. What have you observed in the experiments?
2. Interpret of your observations.

Practical Activity 2: Extraction of bees wax
This practical activity can be done by the CSEE candidates.

Objective
The teacher should prepare a practical activity to enable candidates to extract bees wax.

Overview
Bees wax is another important apiary product after honey. It has great demand in its different forms due to various uses. The extraction of wax requires skills.

Important note to the teacher and laboratory technician
(a) Prepare equipment and materials for each candidate.
(b) If Bunsen burners are to be used as a source of heat, check if the gas system and the Bunsen burners are working.
(c) Thermometers should be in good working condition.
(d) Honey combs should be collected from the beehives with all precautions.

(a) Extraction of bees wax by the hot bath method

Equipment and materials
Stainless steel cooking pot, muslin cloth or sackcloth or a sack (preferably jute made), jute or plastic string (2-3 m long), a stick, a large stainless steel spoon, a mould, bee combs, source of heat, thermometer and water

Procedures for the practical activity
(i) Put water (amount depends on the quantity of bee combs) in the cooking pot and heat.
(ii) Make pieces of bee combs, wash them thoroughly to remove dirt and honey, and place the pieces in the muslin cloth or sack.
(iii) Make a good packet by tightening the opening of the sack or muslin cloth with a string.
(iv) Put the packet into the pot and use the stick to push it down to the bottom of hot water.

(v) Insert the thermometer into the hot water. When the water temperature reaches 59°C, the wax begins to melt and a waxy scum begins to form on top of the water.
(vi) Use the stick to press the packet further. More wax will float on the top of water.
(vii) Use the spoon to skim off the melted wax and pour it into the mould. Continue this process until the wax no longer rises to the surface. Keep pressing the bag until all the wax has melted. It will be much smaller in size.
(viii) Let the mould cool down. Remove the wax from the mould.

(b) Extraction of bees wax by the solar method

Equipment and Materials

Aluminium foil sheet, thermometer, cleaned comb, knife (stainless steel) and a stainless steel container

Procedures for the practical activity

(i) Wash the crushed /pieced combs until they are free of dirt and honey.
(ii) Put the properly cleaned comb pieces in the aluminium foil sheet. Wrap these properly and make a drain point in the foil.
(iii) Place the container below the drain point of the foil.
(iv) Keep all these in the sun.
(v) Monitor the surrounding temperature. Once the temperature goes above 61°C, the wax starts melting. seeping into the container through the drain point.
(vi) Collect all the wax by repeating the process for few days.

Note

(a) Do not subject bees wax to high temperature. Prevent the water from boiling by reducing heat.
(b) Bees wax should never come into contact with direct heat.
(c) Bees wax should not be heated above 85°C.
(d) All utensils should be cleaned quickly while the wax is in liquid form.
(e) Bees wax cleaned in a solar wax extractor can sometimes be less aromatic and will be whiter, almost the pale white colour of paraffin wax.

Sample questions

1. Why is it not advised to subject wax to higher temperatures?
2. Give uses of bees wax.

3.2.4 Topic: Introduction to Crop production

3.2.5 Sub-topic: Classification of Crop plants

Selected practical

Practical Activity

Morphological classification of crop plants: This practical activity can be done by CSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to classify crops on the basis of their morphology.

Overview

Crops are grouped or classified based on agronomy, use, life cycle and morphological classification. There are two groups of plants in morphological classification, namely monocotyledons or monocots and dicotyledons or dicots. The difference between monocot and dicot seeds is that monocots have one cotyledon, while dicots have two. Cotyledon is the part of the embryo within the seed that acts as an initial energy source for the plant. The cotyledon of a monocot seed is rather thin and does not contain sufficient food material, while the cotyledons in dicots are fleshy and contain the required nutrients. The other differences between monocot and dicot seeds lies in their leaves, flowers, stem and roots. Examples of monocots include maize, wheat, rice, sugarcane and banana plants. Example of dicot plants are mango, orange, tomato, beans and peas.

Specimens and materials

Maize plant, bean plant and hand lens.

Important note to the teacher and laboratory technician

(a) Prepare these specimens and materials for every candidate.

(b) Provide the candidates with fresh specimens so that the parameters demanded can be easily seen.

(c) The lenses should be clean for clear observation.

Procedure for the practical activity

With the aid of a hand lens, carefully observe the venation, root system, seeds and flower of the specimens. Record your observations.

Table 3: Morphological differences between monocots and dicots

Parameters	Monocots	Dicots
Leaves	The veins of the leaf of a monocot seed plant are parallel.	The veins of the leaf of a dicot seed plant are reticulate.
Roots	Tap root-like structure	Fibrous root-like structure.
Seed	One cotyledon	Two cotyledons
Flower	Multiples of 3	Multiples of 4 or 5

Sample questions

1. What have you observed?
2. Classify the plant specimens based on the root system, leaves venation, flowers and seeds.
3. Based on your classification in (b), what criteria guided you to the conclusion?

3.3 FIELD: LIVESTOCK PRODUCTION

3.3.1 Topic: Animal husbandry

3.3.1.1 Subtopic: Dairy animal farming

Selected practicals

Practical Activity 1

Testing for mastitis in cow milk: This practical activity can be done by both CSEE and ACSEE candidates

Objectives

The teacher should prepare a practical activity to enable the candidates to test for mastitis in cow milk.

Overview

Inflammation of the mammary gland or udder is called mastitis. The disease is recognised by physical, chemical and bacteriological changes in the milk and pathological changes in the milk-producing glandular tissue. It is a primary endemic disease of dairy cattle and milk-secreting tissues. Ducts of the udder may be temporarily damaged or sometimes permanently damaged. The disease can be treated with antibiotics and supportive measures. Mastitis can be prevented by taking adequate measures like maintaining udder hygiene, sanitation of the cow barn, clean food and water supplements and maintaining a milking schedule.

Specimens, apparatuses and equipment
Beaker, healthy fresh milk, milk affected by mastitis and a strip cup (teat cup)

Important note to teacher and laboratory technician
(a) Provide milk specimens to each candidate.
(b) If actual strip cups cannot be found, a normal cup with black plastic tied on the top can be used instead.
(c) Strip cups should be washed thoroughly before use by other students.
(d) The milk should be tested to ensure that there are samples of healthy fresh milk and one that is affected by mastitis.
(e) Preserve the milk samples so that they remain fresh before use.

Procedure for the practical activity
(a) Pour 25 cm^3 of healthy fresh milk into the beaker.
(b) Squirt few streams of the milk onto the strip cup.
(c) Clean the strip cup and repeat the procedure for the milk affected with mastitis.

Note
A strip cup is an instrument normally made of plastic materials, stainless steel or aluminium to test mastitis. Milking the first few strips into a strip cup then a black surface will show if there are any lumps (clots). Change in colour and watery appearance indicates beginning or advanced stage of mastitis, which should be controlled immediately. It is a tool that should be used in the milking parlour of a dairy cattle farmer. The main thing to observe is the quality of the first milk streaks when starting to milk.

Sample questions
1. What are your observations?
2. What is the conclusion of your observations?

Practical Activity 2: Detection of adulterants in milk
This practical activity can be done by both CSEE and ACSEE candidates.

Objective
The teacher should prepare a practical activity to enable the candidates to detect the presence of adulterants in milk.

Overview
Milk is a common drink in our daily diet. It contains water in large amounts and other nutrients like carbohydrates, lipids, protein, minerals, and vitamins in a balanced form used for building and maintaining the human and animal body. Water is the most common adulterant in milk. It reduces the nutritional value of milk. If contaminated, water poses a health risk to consumers. Adulteration is the addition of another substance to milk to

increase its quantity in raw form or prepared form, which may result in the loss of the actual quality of milk.

Milk adulteration is done for financial gain. It can also be adulterated due to different unhygienic conditions such as milking parlour, processing, packaging, transportation and distribution. Water is the most common adulterant used which decreases the nutritional value of milk and lowers the quality of milk. The following are simple laboratory tests which detect the presence of adulterants in milk: milk slip (water) test, detection of starch, detection for synthetic milk (formalin in milk) and detection of urea in milk.

Important note to the teacher and laboratory technician

(a) If the experiments for testing milk quality involve heating using gas, the gas system and bunsen burners should be working properly.

(b) Testing for the adulteration of milk requires the teacher to have samples of pure and impure milk. In preparing samples of pure milk, the teacher should test for the presence of different adulterants in the following experiments:

Experiment 1: Milk slip (water) test

Specimens and materials

Pure milk, milk adulterated with water and a small polished vertical surface of a wooden blocked.

Procedure for the practical activity

Put a drop of milk on a polished vertical surface and observe.

Note

Pure milk will stop or flow slowly, leaving a white trail behind. Milk mixed with water or other agents will flow down immediately without a trace.

Experiment 2: Detection of starch

Specimens, apparatuses and materials

Pure milk, milk adulterated with starch, test tube, tongs, test tube rack, dropper and source of heat, 1% iodine solution.

Procedures for the practical activity

(i) Pour 3 ml of milk in a test tube and boil it thoroughly.

(ii) Cool the milk to room temperature.

(iii) Add 2 to 3 drops of iodine solution and make observations.

Note

Change of colour to blue indicates that the milk is adulterated with starch. The addition of starch increases the Solid-Not-Fat (SNF) content of milk. Wheat flour and rice flour can also be added to increase the SNF content.

Experiment 3: Detection for synthetic milk (formalin in milk)

Specimens, apparatuses and materials

Pure milk, milk adulterated with formalin, test tubes, tongs, measuring cylinder and source of heat

Procedures for the practical activity

(i) Put a few drops of milk on the thumb and forefingers and rub to detect the feel.

(ii) Put 3 ml of milk in the test tube and heat it. Take the observations.

Note

Synthetic milk is created by combining chemicals and things like soap in natural milk. Synthetic milk is known for bad taste. It feels soapy when rubbed and turns yellowish when heated. Formalin is used for preservation purposes.

Experiment 4: Detection of urea in milk

Specimens, apparatuses and materials

Pure milk, milk adulterated with urea, tablespoon, measuring cylinder, test tube, soya bean powder and red litmus paper

Procedures for the practical activity

(i) Mix half a tablespoon of milk with soya bean powder in the test tube and shake well.

(ii) After five minutes, dip litmus paper for thirty seconds and take the observations.

Note

If there is a colour change from red to blue it means that the milk has urea in it. Urea does not change the taste of milk.

Sample questions

1. What have you observed in the experiments?
2. What is your conclusion based on the observations?

3.3.1.2 Sub-topic: Poultry farming

Selected practical

Practical activity

Selection of eggs for incubation: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to select desirable eggs for incubation.

Overview

Chicken farmers use candling to select which of their chicken's eggs are fertile and will hatch into baby chicks. Candling can also be used to detect if a fertilised egg has stopped developing. The candling process works by illuminating the interior of an egg thus enabling to see what is inside the shell.

Specimens and materials

Carton box, 2 battery capacity torch, fertilized and unfertilized eggs and a dark environment.

Important note the to teacher and laboratory technician

(a) Prepare specimens and materials for every candidate.
(b) The teacher should test the torches to ensure that they function well and have enough light.
(c) A dark room should be created using a black curtain so that no light passes through.
(d) Fertile eggs selected should have at least five days after being laid to see the developing embryo while unfertile eggs are to be selected any time after being laid.
(e) Eggs should be tested before being used as specimens.
(f) The candidates should be provided with the carton boxes that have been prepared by cutting a hole the size of an average sized egg on one side of the carton box.

Procedures for the practical activity

(i) Hold the fertilized egg between the thumb and fore finger.
(ii) Using a torch, light a spotlight inside the carton box in the direction of the hole.
(iii) Candle the egg by placing it at the end of the hole outside the carton box.
(iv) Tilt the egg slightly on one side and rotate it until you get the best view of looking in using the light.
(v) Repeat the same procedure for the unfertilized eggs.

Note
A fertile egg shows a network of blood vessels and a dark spot at the centre, indicating the presence of a developing embryo. An unfertile egg has a clear inside indicating absence of blood vessels or blood rings and embryo.

Sample questions
1. What is have you observed in the specimens?
2. Comment on the status of the specimens based on your observations.

3.3.2 Topic: Introduction to livestock production

3.3.2.1 Sub-topic: The concept of livestock production

Selected practical

Practical activity
Identification of chicken breeds: This practical activity can be done by CSEE candidates.

Objective
Teachers should prepare a practical activity to enable the candidates to identify breeds of chicken based on their physical traits.

Overview
Hundreds of chicken breeds are in existence. Domesticated for thousands of years, distinguishable breeds of chicken have been present since the combined factors of geographical isolation. Selection of desired characteristics created regional types with distinct physical and behavioural traits passed on to their offspring.

The physical traits used to distinguish chicken breeds are size, plumage colour, comb type, skin colour, number of toes, feathering, egg colour and place of origin. They are also divided by primary use, whether for eggs, meat or ornamental purposes; some are consided to be dual-purpose. Examples of common chicken breeds are Plymouth Rock, Cochin, Leghorn, Australorp, Rhode Island Red and New Hampshire Red. In this practical, only physical traits will be used to distinguish chicken breeds. Emphasis will also be on locally available breeds such as Kuchi, Ching'wekwe, Umbo la kati, Kishingo and Kibwenzi. The following table indicates various parameters of Australorp and Hampshire breeds.

Parameter	**Australorp Breed**	**New Hampshire Red**
Size	Large	Deep, broad body
Plumage colour	Black, white, or blue colour	Red
Comb type	Single red	Single and medium to large
Skin colour	White	Yellow

Parameter	Australorp Breed	New Hampshire Red
Number of toes	4	4

Specimens and materials
1 Australorp, 1 New Hampshire Red and Wire cage

Important note to the teacher and laboratory technician
The chicken breeds to be used should be well kept before the time of the examination. They should be put into wire cages so that they can be easily observed during the examination.

Procedure for the practical activity
Do careful observations on the specimens of the following physical traits: size, plumage colour, comb type, skin colour and the number of toes.

Sample questions
1. What were your observations of the specimens based on the given physical traits?
2. Identify the chicken breeds of the specimens based on your observations.

3.3.3 Topic: Principles of livestock production

3.3.3.1 Sub-topic: Management of livestock health

Selected practicals

Practical Activity 1
Identification of external parasites in livestock. This practical activity can be done by both CSEE and ACSEE candidates.

Objective
The teacher should prepare a practical activity to enable the candidates to identify different external parasites in livestock based on their external structures.

Overview
Parasites are the biological agents which affect the livestock industry in Tanzania. A parasite is defined as an animal or plant that lives on, with or in another organism or host. It gets its food at the expense of the host. Parasites may either be external or internal. Most external parasites belong to Phylum arthropoda. These include ticks, tsetse flies, lice, fleas and mites.

Specimens and materials
Tsetse fly, office pin, piece of soft board, hand lens and forceps.

Important note to the teacher and laboratory technician

(a) Provide the specimens and materials to each candidate.
(b) The tsetse flies should be collected and preserved in formalin to retain their natural conditions.
(c) The lenses should be clean for clear observation.

Procedures for the practical activity

(i) Pin the tsetse fly on a piece of a soft board using an office pin.
(ii) With the aid of a hand lens and forceps, do a careful observation of the external appearance of the tsetse fly.

Note

The external structure of a tsetse fly: The body is divided into head, thorax and abdomen. The wings and legs are attached to the thorax. The head contains compound eyes and two antennae. The cuticle is the hard outer cover of the body which is elastic on the ventral side (underneath) to allow the expansion of the abdomen so as to put blood meal after the fly has fed. The mouthparts are attached to the head by a bulb-like swelling at the end of the labium, called the thecal bulb. The bulb contains muscles to manipulate the mouthparts. The thorax has two pairs of openings, called spiracles. The legs have four segments called the coxae, trochanter, femur and tibia. It has two wings with a butcher cleaver knife-like structure called the hatchet cell. The abdomen has seven segments each with a pair of spiracles. The teacher should also prepare practical activities to enable the candidates to identify blue and brown ear ticks their external structures.

Sample questions

1. Briefly describe the external structures that you have observed.
2. Identify the organism based on the external structures that you have observed.

Practical Activity 2

Identification of the internal parasites of livestock. This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to identify different internal parasites in livestock based on their external structures.

Overview

The internal parasites hindering livestock production in Tanzania are mainly worms from the phylum Platyhelminthes such as tape worms, liver flukes and nematoda such as ascarids and hookworms. Tape worms deprive the animal food while hook worms, ascarids and flukes directly damage tissues.

Specimen and materials

Tapeworm, hand lens and forceps

Important note to the teacher and laboratory technician

(a) Prepare tape worms and materials to be used for every candidate.
(b) Tape worms should be well preserved in formalin.
(c) The lenses should be clean for clear observation.

Procedures for the practical activity

With the aid of a hand lens and forceps, observe the external appearance of the tape worm.

Note

Structure of a tape worm

It has an elongated segmented body. It is divided into head or scolex which has the organs of attachment, a neck that is the region of proliferation and a chain of proglottids, called the strobila. The teacher should also prepare practical activities to enable the candidates to identify roundworms and liver flukes based on their external structures.

Sample question

1. Briefly describe the external structures that you have observed.
2. Identify the organism based on the external structures that you have observed.

3.3.3.2 Sub-topic: Feeding of Livestock

Selected practicals

Practical Activity 1

Identification of the functions of ruminant stomach chambers based on their features: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to identify functions of ruminant stomach chambers based on their features.

Overview

Ruminant livestock include cattle, sheep and goats. Ruminants are hoofed mammals that have a unique digestive system that allows them to use energy from fibrous plant material better than other herbivores. Unlike monogastric animals such as swine and poultry, ruminants have a digestive system designed to ferment feedstuffs and provide precursors for energy for the animal to use. The anatomy of the ruminant digestive system includes the mouth, tongue, salivary glands (producing saliva for buffering rumen pH), esophagus, four-compartment stomach (rumen, reticulum, omasum and abomasum), pancreas, gall bladder,

small intestine (duodenum, jejunum and ileum), and a large intestine (cecum, colon and rectum).

Specimen and materials
Ruminant stomach chambers cut open, forceps, gloves and hand lens

Important note to teacher and laboratory technician
(a) Provide the candidates with the preserved ruminant stomach chambers which have been cut open to expose the features.
(b) Label the four stomach chambers.

Procedure for the practical activity
With the aid of gloves, forceps and a hand lens, careful observe of the features of the four stomach chambers.

Note
The rumen is the largest chamber and has regular contractions to move food around for digestion; it removes gases through eructation and send food particles back to the mouth for re-mastication. The rumen is the muscular chamber which breaks down food particles through mechanical digestion and fermentation with the help of symbiotic microbes.

The reticulum is called the "honeycomb" because of the honeycomb appearance of its lining. The main function of the reticulum is to collect smaller digesta particles and move them into the omasum, while the larger particles remain in the rumen for further digestion.

The omasum is spherical, and it is called the "many piles" or the "butcher's bible" due to reference to the many folds or leaves that resemble pages of a book. These folds increase the surface area which increases the area that absorbs nutrients from feed and water. Water absorption occurs in the omasum.

The abomasum is the "true stomach" of the ruminant. This compartment is most similar to the stomach in a non-ruminant. The abomasum produces hydrochloric acid and digestive enzymes, such as pepsin, that break down proteins and receive digestive enzymes secreted from the pancreas, such as pancreatic lipase that breaks down fats. These secretions help prepare proteins for absorption in the intestines.

Sample question
1. Briefly describe the internal features of each compartment from your observations.
2. Based on the internal features of each compartment, state the function of each compartment.
3.

Practical activity 2

Computation and preparation of a livestock ration for milking a cow: This practical can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to compute and prepare a livestock ration for milking a cow.

Overview

Feeding plays a major role in the productivity of livestock. Good quality feed increases feed efficiency and high performance. The importance of proper feeding includes good productive ability, growth, health and high production. The purpose of mixing a livestock ration is to obtain a standard feed using the feed material available in the farm.

Equipment and materials

Maize grain, powder fish meal, feeding standard tables, feed containers and weighing scale

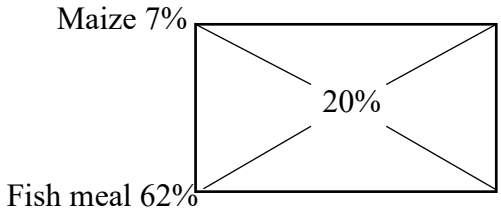
Important note to the teacher and laboratory technician

(a) Feed composition table should be in good condition.
(b) Weighing scale must be functioning well.
(c) Provide the feedstuff in the stated form.

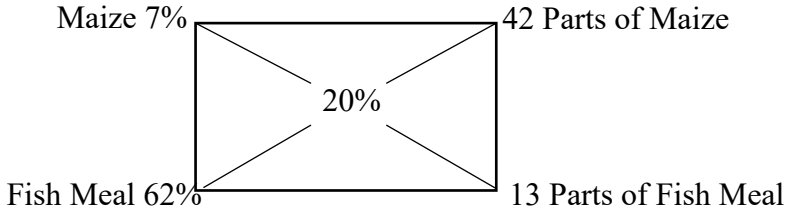
Procedures

(i) Identify the feed materials provided and classify them according to their feed value.
(ii) Using the feed composition table provided, find out the approximate composition of starch equivalent (SE), digestible crude protein (DCP) and the mineral percentage on the feedstuffs provided.
(iii) Find out the animal's feed requirements according to its body weight and production level.
(iv) Use Person's square method to calculate the amount of maize and fish meal required to make 100 kg of a feedstuff containing 20% DCP.
(v) From the feedstuff composition table, whole maize grains contain 7% DCP and the fish meal contain 62% DCP.
(vi) Draw Person's square and place the protein percentage of feed required in the centre of the square. In this case, it is 20%.

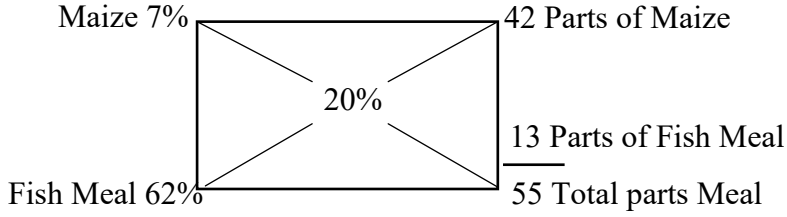
(vii) Draw the diagonals of the square, and write down on the left hand side corners of the square the protein value of the whole maize grains and the fish meal, which are the feedstuffs you are going to use.



(viii) Subtract diagonally across the square the small number from the large number for both the maize and fish meal disregarding the sign.



(ix) The resulting figures represent the parts of maize and fishmeal which will make the ration. Now add the parts together to obtain a base which will be used to calculate the amount of maize and fish meal in 100 kg of the feed.



(x) From this last square, calculate the amount of maize and fish meal in kilograms as follows:

$$\text{Maize} = \frac{42}{55} \times 100 = 76 \text{ kg}$$

$$\text{Fish meal} = \frac{13}{55} \times 100 = 24 \text{ kg}$$

(xi) After obtaining the amount of maize and fish meal required for 100kg ration, mix the ingredients thoroughly.

Note

Pearson's square method is the easiest and ideal method for balancing a few ingredients at a time such as energy, proteins and minerals.

Sample question

Using Pearson's square method, formulate 50 kg for dairy cow to feed 15% CP using maize bran having 10% CP and sunflower seed cake with 40% CP.

3.4 FIELD: AGRO-MECHANICS

3.4.1 Topic: Farm power

3.4.1.1 Sub-topic: Engine systems

Selected practicals

Practical activity 1

Determination of best engine coolants based on their properties: This practical activity can be done by ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to determine the best engine coolants based on their properties.

Overview

The engine coolant plays a vital part in keeping the engine running and in prolonging the life of the engine and its components. The coolant draws heat from the engine. The liquid is circulated in the engine through a hose in the gaps or 'passages' in the engine block. Once the coolant becomes too hot to effectively cool the engine, it is drawn back out through a separate hose before passing through the intercooler. As the liquid flows through the intercooler, it is cooled by air as the vehicle travels on the road. This circulation process continues while the car's thermostat works to regulate the temperature of the coolant and the engine.

Apparatuses and materials

Pyrex beaker, water, ethanol, source of heat, tripod stand, wire gauze, stop watch and thermometer

Important note to the teacher and laboratory technician

(a) Prepare the apparatuses and materials for each candidate.
(b) Gas systems and Bunsen burners should be working properly.
(c) Thermometers should be checked if they are functioning properly before use.

Procedures for the practical activity

(i) Measure 100 cm^3 of water and ethanol in two separate 250 cm^3 beakers.
(ii) Immerse thermometers in each of the separate beakers containing water and ethanol.

(iii) Place the two separate beakers containing water and ethanol on separate bunsen burners and heat them for two minutes. Record the temperatures of water and ethanol after 2 minutes of heating.

(iv) Switch off the Bunsen burners and remove the beakers from the source of heat and let water and ethanol cool. Record the temperatures of water and ethanol after 5 minutes of cooling.

Note

Water absorbs a large amount of heat without much increase in temperature compared to ethanol which, when it absorbs heat, it raises much its temperature. Water also absorbs a lot of thermal energy and releases it reasonably faster compared to ethanol, which releases heat slowly after absorbing much thermal energy.

Sample questions

1. Record the results of the experiment, as shown in the following table.

Specimen (s)	Temperature of the specimens after 2 minutes of heating (^{0}C)	Temperature of the specimens after 5 minutes of cooling (^{0}C)
Water		
Ethanol		

2. From the results of the experiments, suggest the specimen that can be used as a coolant in a tractor engine. Give reasons for your suggestion.

Practical activity 2

Determining of a good engine lubricant. This practical activity can be done by ACSEE candidates.

Objectives

The teacher should prepare a practical activity to enable the candidates to determine a good engine lubricant.

Overview

Motor oil, engine oil or engine lubricant is one of the substances that consists of base oils enhanced with various additives, particularly anti-wear additives, detergents and dispersants. For multi-grade oils, the viscosity index improver is added. Motor oil is used for lubricating of internal combustion engines. The main function of motor oil is to reduce friction and wear of moving parts and to clean the engine from sludge (one of the functions of dispersants) and varnish (detergents). It also neutralises acids that originate from fuel and from oxidation of the lubricant (detergents), improves the sealing of piston rings and cools the engine by carrying away heat from moving parts.

Materials and apparatuses
Watch glass, fresh engine oil and used engine oil.

Important note to the teacher and laboratory technician
Provide oil according to the stated requirements.

Procedures for the practical activity
(i) Pour used engine oil and fresh engine oil on separate watch glasses.
(ii) Take the sample of used engine oil from the watch glass using your thumb and fore finger and have a feel of it.
(iii) Repeat the same procedure for fresh engine oil.

Note
The fresh engine oil seems to be more viscous than the used engine oil which has lost viscosity as it is circulating in the engine.

Sample question
Identify the suitable specimen to be used as an engine lubricant from the results of the experiment.

Practical activity 3
Testing a thermostat for accuracy. This practical activity can be done by ACSEE candidates.

Objective
The teacher should prepare a practical activity to enable the candidates to test the accuracy of the thermostat as a component of the cooling system.

Overview
The tractor engine works best at a certain optimum temperature. When the engine is cold, components wear out easily, emit more pollutants and becomes less efficient. Thus, another important task of the cooling system is to allow the engine to warm up as quickly as possible and to maintain constant engine temperature. The main function of the cooling system is to ensure that the engine runs at its optimum operating temperature. If the cooling system or any part of it fails, it will overheat the engine, which can seriously damage it. One of the important components of the cooling system is a thermostat which is responsible for maintaining constant engine temperature.

Specimen, apparatuses and materials

Thermostat, thermometer, 1000mls pyrex beaker, manila string, a flat wooden bar (medium size to fit the top of the pyrex beaker), source of heat and a reliable source of water.

Important note to the teacher and laboratory technician

(a) Provide the items for each candidate.

(b) Make sure that the thermostat and thermometer are in good working condition.

Procedures for the practical activity

(i) Take 800 mls of water and pour it in a pyrex beaker.

(ii) Using a manila string, tie one side of the string to the thermostat and another side of the string to the flat wooden bar.

(iii) Dip the thermostat in a pyrex beaker containing water and place it horizontally on a flat wooden bar on top of the pyrex beaker.

(iv) Ensure sufficient tension of the manila string by allowing the thermostat to float within a pyrex beaker.

(v) Place a thermometer in the pyrex beaker and place the beaker on the source of heat.

(vi) Record the temperature at which the thermostat valve opens.

Note

The observation should be within degrees of temperature stamped on the body of the thermostat. For example, a 165 ^{0}F thermostat should open when the water reaches that temperature, but may not be fully open until the water has been heated to several degrees (10^0-15^0F) above that temperature.

Sample questions

1. Comment on the accuracy of the thermostat.
2. What is the implication of the opening of the thermostat valve?

3.4.2 Topic: Mechanisation in Agriculture

3.4.2.1 Sub-topic: Farm workshop

Selected practical

Practical activity 1

Determining the appropriate use of wood saws. This practical activity can be done by both CSEE and ACSEE candidates.

Objectives

The teacher should prepare a practical activity to enable the candidates to determine the appropriate use of different wood saws.

Overview

Different forms of saws have different properties, following different traditions. Each saw is meant for specific task. One saw cannot be used to perform the task of another one. Each of the saws does its own job.

Materials

30 cm long piece of dry wood (2 x 2 inches), rip saw and cross-cut saw.

Important note to teacher and laboratory technician

(a) The saws should be sharpened for easy cutting of wood.
(b) The saws to be used should have good handles.
(c) The pieces of wood should be dry.
(d) Labelling of the specimens should be done appropriately.

Procedures for the practical activity

(i) Hold a piece of wood on the bench using one hand.
(ii) Use another hand to hold a rip saw to cut along the grain of the wood and check for the smoothness and speed of the cut.
(iii) Repeat cutting using the rip saw across the grain of the wood and check for the smoothness and speed of the cut.
(iv) Repeat procedure (ii) and (iii) using a cross cut saw.

Note

A rip saw cuts along the grain typically means cutting a long piece of wood down its length. It goes faster and cuts cleaner if you use a ripsaw blade designed for cutting down the grain as opposed to a cross cut saw which cuts across the grain. The teeth spacing and size are optimised for a rip saw or cross cut saw for the different types of cuts.

The teeth in a cross cut saw are designed for cutting across the grain of the wood. This is generally considered a more difficult task, so crosscut saw teeth are ideal for it. Rip saw teeth do not have angled edges, which means they work more like little chisels, scraping the wood away rather than slicing through it. Rip saw teeth are designed for cutting along or with the grain. This is generally considered an easier task.

Sample question

Which saw is better when cutting across and along the grain? Give reasons for your answer.

Practical activity 2

Determining the appropriate use of wood saws through observation: This practical activity can be done by both CSEE and ACSEE candidates.

Objectives

The teacher should prepare a practical activity to enable the candidates to determine the appropriate use of different wood saws.

Materials

Rip saw, cross-cut saw and 30 cm ruler

Important note to teacher and laboratory technician

Labelling of the specimens should be done appropriately.

Procedures for the practical activity

(a) Count and record the number of teeth in the 10 cm of both rip saw and cross-cut saw.

(b) Observe and record the shape and size of teeth of both the rip saw and cross-cut saw.

Sample questions

Briefly describe the structural set-up of the teeth as observed in rip and cross cut teeth saw that relate to their functions.

Note

A rip saw has a smaller number of teeth with a large size which takes large wood bites or chips out of wood making fast cuts, while a crosscut saw has a large number of teeth with a small size which takes small bites and produces smaller chips, making a slow cut through the grain of the wood.

3.4.2.2 Sub-topic: Basic farm tools

Practical activity 1

Using of a knapsack sprayer: This practical activity can be done by both CSEE and ACSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to demonstrate the use of a knapsack sprayer.

Overview

A knapsack sprayer is a spraying piece of equipment that consists of a knapsack tank together with a pressurizing device, line, sprayer nozzle used mainly in spraying fungicides,

acaricides, herbicides or insecticides. The knapsack sprayer is mostly used by peasants because of its accessibility and affordability.

Equipment and materials

15 litre capacity knapsack sprayer, 1000 cm^3 measuring cylinder, a reliable source of water and a wall clock

Important note to the teacher and laboratory technician

Provide the candidates with knapsack sprayers which are in good working condition.

Procedure for the practical activity

(i) Take a knapsack sprayer and check all its parts to ensure that itr is in good working condition.
(ii) Open the cap of knapsack tank and pour into it 5 litre (5000cm^3) of water.
(iii) Close tightly the cap of the tank.
(iv) Carry a knapsack sprayer on your back and adjust the sprayer straps until you feel comfortable.
(v) Operate the sprayer handle until you notice a difference.
(vi) After noticing the difference, stop operating the handle and direct the sprayer lance to the laboratory water sink.
(vii) Press the on-off lever for about 30 seconds to allow an outlet of water and observe the outlet mist pattern of water.
(viii) Remove the knapsack sprayer from your back.

Sample questions

1. What difference have you noticed during operating the sprayer handle?
2. What do you think is the possible cause of the difference you have noticed in (1)?
3. Why is the operation of the sprayer handle and pressing of the on-off lever not simultaneously?

Practical activity 2

Determining of desirable qualities of a sprayer. This practical activity can be done by CSEE candidates.

Objective

The teacher should prepare a practical activity to enable the candidates to determine desirable qualities of the sprayer.

Overview

A sprayer is a machine used to apply liquid chemicals on plants to control pests and diseases. It can also be used to apply herbicides to control weeds and to spray micronutrients to enhance plant growth. The main functions of a the sprayer are breaking

the chemical solution into fine droplets of effective size, distributing the droplets uniformly over the plants, applying the chemicals with sufficient pressure to reach the plants and regulating the amount of liquid applied on plants to avoid excessive application.

Sprayers are available in variety of sizes and specifications, depending on the requirement of the plant or crop. The following are the main types of sprayers used for insecticide or pesticide sprays: low pressure sprayer, tractor mounted, high clearance sprayer, trailer-mounted sprayer, truck mounted sprayers, high pressure sprayer, air carrier sprayer, fogger (mist blower) and hand operated sprayer.

Equipment and Materials

Hand sprayer, wall clock and water

Important note to the teacher and laboratory technician

Check for workability of hand sprayers before being used.

Procedures for the practical activity

(i) Open the lid/cap of the sprayer tank.
(ii) Fill the tank with water in place of a chemical and close the lid/cap of the sprayer tank.
(iii) Use one hand to hold the boom and direct the nozzle opening of the sprayer to the water sinks.
(iv) Use another hand to pump the sprayer handle until the pressure is built and the liquid starts to flow out.
(v) Keep on pumping the liquid for 30 seconds and observe the flow of the liquid out of the sprayer.

Note

A good sprayer should possess the following qualities:

(a) it should produce a steady stream of spray material in desired droplets sizes so that the plants to be treated may be covered uniformly;
(b) it should deliver the liquid at a sufficient pressure so that the spray solution reaches all the foliage and spreads uniformly on the plant body; and
(c) It should be light in weight yet sufficiently strong, easily workable and repairable.

Sample question

From your observations, what makes the sprayer suitable for its purpose?

4.0 IMPORTANT CONSIDERATIONS

4.1 Calibration of weighing Balance

Procedures

(a) Take the known mass value and place it on a balance. Then, compare it to the balance reading.

(b) If the reading of the balance is the same as that of known mass value, the balance is accurate.

(c) If the reading of the balance is different from that of the known mass, adjust the balance until you get balance reading similar to the known mass.

4.2 Preparation of preservatives

4.2.1 Procedure for preparing 70% Ethanol (Ethyl alcohol)

(a) Measure 70 cm^3 of ethanol using a measuring cylinder and put it in a beaker.

(b) Measure 30 cm^3 of distilled water and mix it with the ethanol in the beaker.

(c) Label the solution as 70% ethanol. It is ready to be used as a preservative for insects.

4.2.2 Procedure for preparing 10% formalin (Formaldehyde)

(a) Measure 10 cm^3 of formalin using the measuring cylinder and pour it in a beaker.

(b) Measure 90 cm^3 of distilled water and mix it with the formalin in the beaker.

(c) Label the solution as 10% formalin. It is ready for preserving chordates e.g rodents and birds.

Note

Precaution has to be taken when preparing formalin (formaldehyde).The chemical is potentially carcinogenic. Therefore, people working with it should avoid skin contact with the chemical and inhalation of its fumes. Hence wearing of a laboratory coat, gas mask and gloves is crucial.

4.2.3 Checking for the working of Bunsen burners

Procedures

(a) Ensure that the hose fits securely on the gas valve and the burner.

(b) Open the needle valve at 1/2 turn.

(c) Use the spark/lighter to light the flame.

(d) Adjust the flame by turning the collar to regulate air flow and produce an appropriate flame (typically a medium blue flame).

4.2.4 Checking for the working of a gas system

(a) Know the location of the laboratory's main gas.

(b) Make sure the gas cylinders are full of gas.

(c) Use correct tubing (butyl rubber hose). Inspect hose for cracks, holes, pinch points, or any defect and replace, if necessary. Ensure that the hose fits securely on the gas valve.

(d) Secure and light the Bunsen burners.

4.3 How to use a textural triangle to determine soil textural class

(a) First, look at the orientation of the percentages on the sides of the triangle.

(b) The numbers are arranged symmetrically around the perimeter. On the left, the numbers correspond to the percentage of clay, and, on the right, the numbers correspond to the percentage of silt. At the bottom of the triangle chart are the percentages of sand.

(c) To classify a soil sample, find the intersection of the three lines that correspond to the three proportions. On the chart, all percentage values will add up to 100%.

4.4 Checking for working of stop watches

Procedures

(a) Make sure the stop watch reads zero by pressing the second button.

(b) Press the top button to start the timer running.

(c) Press the button a second time to stop it, leaving the elapsed time displayed.

(d) Press the second button to reset the stopwatch to zero. The second button is also used to record split times or lap times.

4.5 Checking for working of a thermometer

4.5.1 Ice method

Procedures

(a) Fill a long glass with ice.

(b) Pour cold water into the glass and make sure the water is cold so that it does not melt the ice.

(c) Stir the ice and water for 15 seconds.

(d) Insert the thermometer in the glass that is 5.1 cm deep.

(e) Hold the thermometer inside the glass for 30 seconds.

(f) Confirm that the thermometer reads 0^0C.

4.5.2 The Boiling Water Method

Procedures

(a) At sea level, fill a pot with water.

(b) Boil the water.

(c) Insert the thermometer 5.1 cm deep into the boiling water and hold it for 30 seconds.

(d) Confirm that the thermometer reads 100 ^{0}C at boiling point.

4.6 Maintenance of Saws

(a) Keep saws dry.

(b) Lubricate the blade after use.

(c) Oil the handle.

(d) Sharpen the saw

4.7 Maintenance of sprayers

(a) Regular cleaning of the sprayer.

(b) Check for blockage.

(c) Regular inspection of the spray tank, pump, hoses and nozzle tips.

(d) Lubricate the moving parts.

4.8 Soil sampling

Soil sampling for agricultural purposes provides a means to obtain a representative soil sample for making inference of various soil characteristics in the particular land area. A soil sample represents a particular soil type with unique characteristics. The validity and quality of the soil data obtained from soil sample testing or observation depends on the quality of the soil sample. In the Agricultural Science subject, soil sampling is a necessary activity for obtaining quality soil samples that can be used for various soil science practical activities in learning or assessing soil physical, chemical and biological properties.

Types of soil samples

There are different types of soil samples, depending on the desired soil characteristic(s). For example, undisturbed top soil samples (core samples) are used to measure soil bulk density, while disturbed top soil samples are commonly used for assessing several physical, chemical and biological soil characteristics. The latter are also commonly used for practical purposes in the Agricultural Science subject for O-level and A-level secondary schools in Tanzania.

Important tools and equipment for soil sampling

- Auger, hand hoe and or spade for taking soil sample from the ground.
- A bucket for mixing of soil subsamples before packaging.
- A pencil, its sharpener and rubber for labeling sample on paper ID.
- A paper sample ID and note book.
- A permanent marker pen for labeling on the sampling bag.
- Rope.
- Polythene sampling bags (1 kg capacity).
- 50 kg bags for storage of soil samples.

Top soil sampling procedure for soil science practical

(i) Identify a suitable location with the required soil type e.g. instructed soil colour and texture.

(ii) Conduct a reconnaissance field survey and identify soil variations based on slope, vegetation cover, soil colour, soil texture and or current or previous cropping history. Identify the most dominant factor(s) contributing to soil variation and proceed with step (iii).

(iii) Divide the land area into different **soil sampling units** based on the observed dominant soil variations. Each unit represents a particular soil type based on (ii) above.

(iv) Decide on the sampling pattern to be used for collecting soil samples from each sampling unit. The sampling pattern can be random or systematic.

(v) For each sampling unit, use the selected soil sampling pattern to collect the top soil composite soil sample at a depth of 0 – 30 cm. The composite soil sample is the most representative sample that can be obtained as follows:

- at each point in the particular soil sampling unit, remove the surface debris and organic materials at about 2 – 3 cm depth before digging;
- collect a soil subsample using auger, hand hoe or spade at 0 – 30 cm and put it in the bucket;
- move to the next point within the particular sampling unit and repeat the above activity for several points to make 5 up to 20 soil subsamples;
- mix the subsamples thoroughly and remove any none soil materials like rocks, worms and roots;

- quarter the soil to obtain up to 1 kg composite soil sample and pack in the polythene bag; and
- use a pencil to record the sample information in the ID including the location. use a permanent marker pen to label information on the sampling bag and close it.

Note that: For practical purposes, sometimes you may be required to prepare a uniform soil sample type for all students. In this case, after dividing the land into different sampling units, you may be required to select and collect enough soil samples from only one of the sampling units that bear the required characteristic(s) or feature(s) for practical purposes. Therefore, you may only concentrate on one unit and ignore other units that do not bear features or the characteristics of interest for practical purposes. However, when different soil types are required for any purpose, you may proceed to step (vi).

(vi) Repeat step (v) for each of the identified soil sampling unit of the land.

(vii) Take the soil samples to the school agricultural laboratory or selected room and air dry the soil samples at room temperature for 2 to 3 days. The drying room should be free from sample contaminating factors.

(viii) When the soil samples are air dried, they can be ground and passed through a 2 mm sieve for laboratory analysis.

Note: The above procedure does not apply for soil profile samples and for examination of some soil morphological characteristics like structure and colour which would need a special procedure to obtain fresh in-situ samples. Consult literature for a suitable procedure when such types of samples are required.

4.9 Preparations of impure honey

Add the following foreign substances such as glucose, dextrose, molasses, corn syrup, sugar syrup, flour and paraffin into the pure honey.

4.10 Preparations of adulterated milk

Pure milk can be adulterated by adding substances like water, starch, urea, salt, skim milk powder and formalin.

5.0 CONCLUSION

These guidelines provide important tips for subject teachers and laboratory technicians on how to prepare the laboratory for practical examinations. These tips will facilitate timely and effective preparation and smooth conduct of practical examinations. Effective preparation of practical examinations requires those concerned to be knowledgeable and skilled in Agriculture practicals. These guidelines give various selected Agriculture practicals from which subject teachers and laboratory technicians can acquire appropriate knowledge and skills in the subject and thus improve their formative assessments.