

Krishi Production, Processing and Marketing

LABORATORY MANUAL



383KRISHIB3



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A Word with You

Dear learners!

We are delighted that you have chosen ‘Krishi: Production, Processing and Marketing’ as a subject at the Senior Secondary Stage, and we hope you are enjoying your studies. The purpose of teaching Agriculture/ Krishi is not just to provide you with theoretical knowledge of agricultural concepts, practices, and principles, but also to help you develop practical skills/capabilities essential for the field. To support this objective, we have developed this laboratory manual containing various hands-on practical exercises in agriculture, many of which you will be able to perform independently.

This manual begins with an introduction that indicates the importance of practical learning in agriculture. It provides detailed instructions on how to use the manual, safety measures to follow, tips on maintaining your record book and number distribution for your practical examination. The manual includes 18 practical exercises related to the concepts discussed in the lessons. Each exercise provides step-by-step instructions to guide you in conducting the activity and documenting your observations. Please read these instructions carefully before starting any practical work.

At the end of each exercise, you will find an ‘*Observation to be recorded*’ section to help you reflect and assess your understanding of the task. You are required to record your findings and responses in a separate record book, which holds significant weight in your practical examination. Additionally, you also need to prepare and submit a herbarium sheet from the given exercises in manual. Please note that there will be 5 PCP (Personal Contact Programme) practical classes in study centre (AIs) where your attendance will be mandatory.

We hope you will find these exercises engaging and beneficial in developing a deeper understanding of the course ‘Krishi: Production, Processing and Marketing’. If you face any challenges while performing these practicals, do not hesitate to reach out to your study centre for support or you can directly contact us in this email- aoagri@nios.ac.in.

Wishing you success in your learning journey!

Course Coordinator

Krishi: Production, Processing and Marketing

How to use the Study Material

Congratulation! You have accepted the challenge to be a self-learner. NIOS is with you at every step and has developed the material with the help of a team of experts, keeping you in mind. A format supporting independent learning has been followed. If you follow the instructions given, then you will be able to get the best out of this material. The relevant icons used in the material will guide you. These icons have been explained below for your convenience.



Title: will give a clear indication of the contents within. Do read it.



Introduction: This will introduce you to the lesson linking it to the previous one.



Objectives: These are statements that explain what you are expected to learn from the lesson. The objectives will also help you to check what you have learnt after you have gone through the lesson. Do read them.



Notes: Each page carries empty space in the side margins, for you to write important points or make notes.



Intext Questions: Very short answer self check questions are asked after every section, the answers to which are given at the end of the lesson. These will help you to check your progress. Do solve them. Successful completion will allow you to decide whether to proceed further or go back and learn again.



What You Have Learnt: This is the summary of the main points of the lesson. It will help in recapitulation and revision. You are welcome to add your own points to it also.



Terminal Exercises: These are long and short questions that provide an opportunity to practice for a clear understanding of the whole topic.



Do You Know: This box provides additional information. The text in boxes is important and must be given attention. It is not meant for evaluation, but only to improve your general knowledge.

Answers : These will help you to know how correctly you have answered the questions.

Activities: Certain activities have been suggested for better understanding of the concept.

Website: These websites provide extended learning. Necessary information has been included in the content and you may refer to these for more information.

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Bifurcation of Syllabus

Krishi Production, Processing and Marketing at Senior Secondary Level (383)

Total no. of lessons - 25

Modules (No. & Name)	TMA (40%) (No. of lessons - 10)	Public Examination (60%) (No. of lessons - 15)
		Objective question - 50% and Subjective question 50%
1. Scope and importance of agriculture	L-1: Evolution and development of agriculture L-2: Importance of agriculture in Indian economy	L-3: Characteristics of Indian agriculture L-4: New developments in agriculture
2. Crop production practices	L-10: Vegetable crops L-11: Flower crops	L-5: Soil health and plant nutrition L-6: Crops, cropping system and crop establishment L-7: Nutrient, water and weed management L-8: Plant protection and harvesting L-9: Fundamentals of horticulture and fruit production
3. Post harvest management	L-12: Need and importance of post-harvest management	L-13: Processes in postharvest management system L-14: Storage & warehousing
4. Food processing and value addition	L-15: Food processing sector: opportunities and challenges L-19: Food safety and quality control	L-16: Food groups and nutritional importance L-17: Types and methods of food processing L-18: Value added food products
5. Agricultural economics, marketing and policy	L-22: Agricultural finance and credit in India	L-20: Basics of agricultural economics L-21: Agricultural marketing and policy
6. Enterprises in agriculture	L-24: Importance of self-help groups in agriculture and village economy L-25: Career opportunities in the agriculture sector	L-23: Entrepreneurship: nature, types and levels

Note: The syllabus has been bifurcated into two sections-

(i) Lessons for the Tutor Marked Assignment (TMA)

(ii) Lessons for public examination question paper

The details of the different sections are on the next page.

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INTRODUCTION

Practicals hold significant importance in agriculture, much like in other science disciplines. The objective of teaching agriculture extends beyond imparting knowledge of terms, facts, concepts, and principles—it enables learners to grasp these concepts through hands-on activities and practical applications. Engaging in direct experiences not only dispels doubts and misconceptions but also cultivates a deeper interest in the subject. This laboratory manual is designed to integrate experiential learning as an indispensable part of the agriculture (Krishi: Production, Processing and Marketing) curriculum at the Senior Secondary level.



Notes

THE OBJECTIVES OF PRACTICALS

The objectives of practical exercises in agriculture are to:

- equip learners with hands-on skills in agricultural practices, including crop identification, soil collection & testing, pest control, and food processing;
- develop observational skills in the form of identifying and locating plants, plant parts and crop pests;
- demonstrate the operational skills to handle basic laboratory apparatus and instruments;
- analyze agricultural challenges, devise innovative solutions, and make informed decisions based on practical observations; and
- draw, label and record experimental results and interpret them.

THE FORMAT OF THIS MANUAL

The exercises presented in this manual are in the form of self-instructional material. Each exercise in the manual has the following format:

- ***Name of the exercise:*** This indicates the aim or focus of the exercise.
- ***Introduction:*** It describes the purpose of the experiment.
- ***Learning outcomes:*** The outcome of an exercise gives you an idea about the skills and knowledge to be developed after performing that experiment.
- ***What you should know:*** It highlights the concepts and background knowledge
- ***Materials required:*** List of various materials, apparatus etc. required to carry out the exercise.

Practical

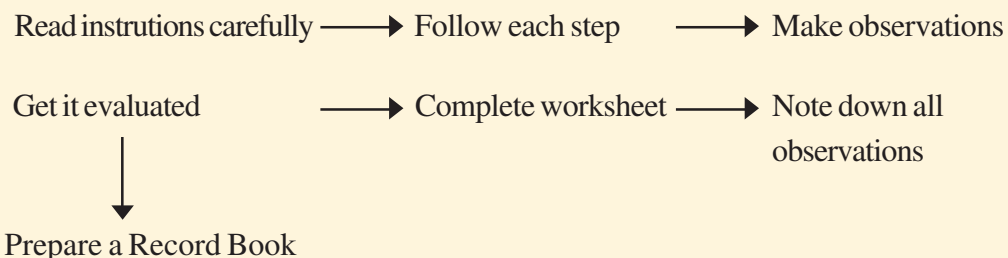


Notes

- **How to proceed:** It includes the steps to perform an experiment in a sequential manner.
- **Precautions:** It denotes the specific measures or steps taken to ensure the experiment is conducted safely, accurately, and effectively. Any specific precaution wherever necessary is also listed at the relevant step of the exercise.
- **Observation to be recorded/Results:** A detailed format of observations, step by step procedure and their recording is given in this section. An effort has been made to adopt a self-interactive method of recording these observations. Draw diagrams, wherever necessary.
- **Conclusion/Interpretation:** Justify the relationship between the principle of the exercise and results obtained.
- **For the teacher:** These are specific instructions to the teacher/mentor who will guide the learners to perform an experiment.

HOW TO USE THIS MANUAL

- Carefully read the *name*, *introduction* and *what you should know* part of the exercise to clearly understand its purpose and the tasks to be performed.
- Collect all the necessary materials and equipment required to carry out the practical.
- Go through the methodology/*how to proceed* and step-by-step instructions provided in the manual and follow them precisely.
- Record your observations as you perform the exercise. Draw diagrams as they appear during the observation or experiment. Keep your record book neat and complete, as it carries marks.
- Follow the general laboratory safety rules as well as specific precautions mentioned in each practical. These are essential for obtaining accurate results.
- Always have your manual with you during the practical session for guidance and reference.



GENERAL SAFETY PRECAUTIONS IN LABORATORY (DO'S AND DON'TS)

- Always listen carefully to your teacher's instructions and ask for guidance if unsure about any task.
- Always wear appropriate protective equipment such as gloves, aprons, and closed-toe shoes to protect yourself from dirt, chemicals, and injuries.
- Use agricultural tools and equipment properly to avoid any sudden accidents.
- If you are using fertilizers, pesticides, or other chemicals, always read and follow the instructions carefully.
- Keep your workspace clean and organized to avoid accidents and ensure easy access to materials and tools.
- After performing an exercise, wash your hands thoroughly to remove any dirt, chemicals, or other substances you may have come into contact with.
- Be aware of first aid procedures and location of emergency exits to manage any unexpected situations.

MAINTENANCE OF RECORD BOOK

We encourage you to follow the instructions provided in each exercise and record your observations in your notebook. It should be written in your own language. You may use the following format for writing your record book.

1. Aim of the exercise
2. Concept/principle of the experiment
3. Materials required
4. Procedure followed
5. Observations (present your work in the notebook as instructed in the exercise)
6. Draw diagrams wherever required
7. Conclusion/interpretation
8. Precautions taken

Practical



Notes

EXERCISE-1

Study of morphological character of field crops and their seeds

Practical

SCHEME OF PRACTICAL EXAMINATION

There will be a practical examination of three-hour duration carrying 20 marks. The distribution of marks is as follows:

Sl. No.	Criteria of Assessment	Marks	Remarks
1.	Regular Participation in PCP Classes	2	
2.	Activities Performed in PCP Classes	2	
3.	Maintenance of Practical Record	2	Practical record should be neat and clean with proper mentioning your name
4.	Submission of herbarium sheet	2	
5.	Participation in peer group interaction	2	
6.	Activities performed in final practical examination	2*3.5 = 7	Two activities to be done out of given three
7.	Viva-voce	3	
	Total	20	



Notes

STUDY OF MORPHOLOGICAL CHARACTER OF FIELD CROPS AND THEIR SEEDS



Notes

A crop and their seeds can be identified correctly by studying its botany. Field crops have been classified into different groups based on the botanical characters and uses. Members of a single group have similarities in morphological features and use of their economic parts. These crop groups are cereals, pulses, oilseed, fibre crops, fodder crops etc.



LEARNING OUTCOMES

After performing this exercise, the learner:

- classifies different crop groups according to their morphological characteristics and
- identifies the seeds of field crops by its morphological features.

WHAT YOU SHOULD KNOW

Morphological Features of Cereal Crops

- Monocot plants belong to grass family Poaceae. They are mainly grown as grain crop.
- Cereal crops are rice, wheat, maize, barley, oat, sorghum, pearl millet, finger millet etc.
- The leaves are narrow, long, alternate exhibit parallel venation and consist of two distinct parts, leaf sheath and lamina.
- Stem is erect, usually cylindrical, hollow except at nodes and possess intercalary meristem.

Practical



Notes

- Presence of ligule and auricle differentiates one cereal from other.
- The **ligule** is a membranous appendage located at the junction of the leaf-blade and leaf-sheath; **auricles** are the pair of claw-like appendages at the base of the leaf blade which clasp the sheath at the culm internode.
- The primary, secondary, tertiary and quaternary tillers arise from the subterranean nodes of primary, secondary or tertiary stems.
- Generally they are shallow rooted with fibrous root system.
- The inflorescence may be **spike of spikelets** as in case of wheat, barley, rye or **panicle of spikelets** in case of oats, rice and sorghum.

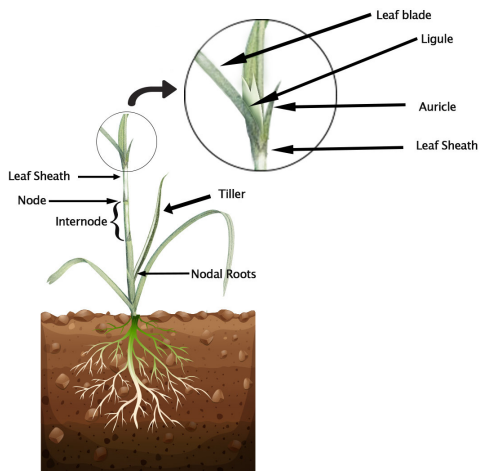


Fig. 1.1: Parts of a typical cereal crop plant



Fig. 1.2: Common cereal plants a) rice b) wheat c) maize and d) sorghum

Identification of Seeds of Cereals

Cereal grain is one seeded indehiscent fruit called caryopsis, composed of the endosperm, germ, and bran. The pericarp is fused with the seed coat of the grain. The endosperm forms the main part of the grain and consists of large cells packed with starch grains.

Practical



Fig. 1.3: Seeds of a) rice, b) wheat, c) maize (d) sorghum (e) pearl millet and (f) kodo millet

Features of Pulse Crops

- Pulses are dicot plants. They belong to legume family Fabaceae and are used for grain purpose.
- Their flowers are hermaphroditic containing both the stamen and pistil.
- The flowers have five petals and an ovary with one carpel, cavity and style.

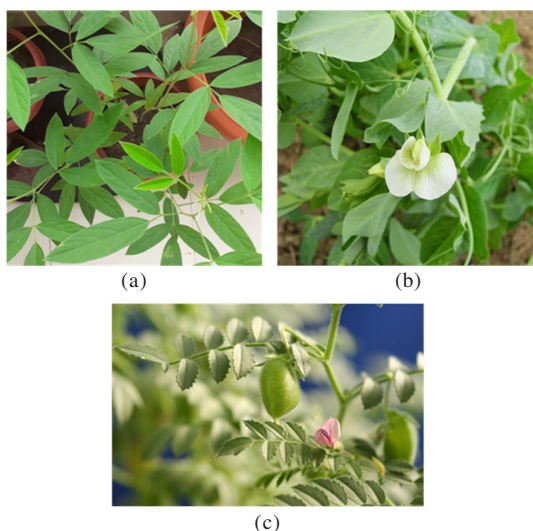


Fig. 1.4: Plants of a) pigeon pea/arhar b) pea and c) Bengal gram

Identification of Seeds of Pulses

Seeds vary greatly in size, shape and surface characters. Their fruit may be one seeded or several-seeded pods.



Fig. 1.5: Seeds of a) blackgram, b) green gram c) chickpea and d) field pea



Notes

Practical



Notes

Features of Oilseed Crops

Unlike cereals and pulses, oilseed crops do not belong a single family. When **soybean** and **groundnut** belong to Fabaceae, **Rape seed and mustard** is a Cruciferae species, while **sunflower**, **safflower** and **niger** belong to Asteraceae, **castor** a Euphorbiaceae member and **linseed** belong to Linaceae family.

Similarly, the seed features vary from crop to crop in respect of shape, size, colour and surface characters. In Compositae species, the seed unit is an achene which is an indehiscent one seeded fruit with the top of the achene is being depressed. In Cruciferae the seed unit may be a true seed, in indehiscent pod or a segment of a pod and seeds are mostly spherical. Distinctive feature of the seed in Euphorbiaceae family is the presence of prominent raphe (the ridge formed by union of funicle with the body of the ovule).



Fig. 1.6: Seeds of a) black mustard, b) sunflower c) safflower d) soybean and e) groundnut

MATERIAL REQUIRED

1. Sample of seeds and plants
2. Forcep
3. Petri dish
4. Magnifying glass
5. Notebook
6. Pen/pencil

HOW TO PROCEED

- Visit your nearest farmer's field and collect the desired plants or plant parts and seeds for the purpose of identification.
- Observe and study the morphological features of plants and its seeds.

Practical



Notes

- Try to compare multiple specimens from different locations or conditions to understand variation within species.
- Classify the crops into groups (cereal, pulse, oilseeds, fibre or any other)
- Note down their taxonomic details of the plants.
- Discuss their morphological features and taxonomic details with you parents/mentor.

PRECAUTIONS

- Handle plant specimens gently to prevent damage to delicate structures.
- Use forceps or gloves when necessary to minimize direct contact.
- Observe the specimen carefully in natural light or well-placed artificial lights that can help to reveal the minute features.

OBSERVATIONS TO BE RECORDED

Collect the following information by visiting the field and interacting with the farmers. You may take help of parents or any experts of this field. One example for how to fill up this table has given in first row.

Sl. No.	Local name of crop	English name	Category of crop	Botanical name	Family	Morphological features
1.	Dhan	Rice	Cereals	<i>Oryza sativa</i>	Poaceae	

Practical

Notes**FOR THE TEACHER**

- Make them aware of important terminologies related to plant morphology, such as vegetative structures (roots, stems, leaves) and reproductive structures (flowers, fruits). This foundational knowledge is crucial for students to accurately describe and identify plants.
- Provide learners with field guides, botanical books, and online tools that show detailed descriptions and pictures of different plants.
- Encourage peer discussions about plant morphology which can stimulate interest and facilitate knowledge sharing among students.

STUDY OF MORPHOLOGICAL CHARACTER OF SEEDS AND PLANTS OF COMMONLY CULTIVATED VEGETABLE CROPS



Notes

Vegetables are an integral part of our balance diet. To cultivate any crops, knowledge of morphological characters of seeds and plants are most necessary for successful cultivation.



LEARNING OUTCOMES

After performing this exercise, the learner:

- differentiates commonly cultivated vegetable crops based on morphological characteristics; and
- classifies the seeds and plants of major vegetable crops.

WHAT YOU SHOULD KNOW

Seeds are considered as the basic unit of agriculture. The quality seeds determine crop growth and also its yield potential. A healthy seed produces a better crop. Usually, vegetable seeds can be identified by their seed shape, size, color, texture, etc.

Many growers from urban and peri-urban areas prefer to grow their vegetables near the residential area. Some crops are very similar in their morphological characters, and it is difficult to identify them especially during early stages of their growth e.g., cole crops. With interest and continuous practice, identification of seeds and their crop plant will be easy. Some major morphological characters useful for identification of seeds are

- a) **Colour:** The seed colour varies from brown, dark brown, black, cream, reddish, reddish brown to yellowish, green or purple. The seed may be uniform or mottled in colour.

EXERCISE-2

Study of Morphological Character of Seeds and Plants of Commonly Cultivated Vegetable Crops

Practical



Notes

- b) **Shape:** Different plants have different shape of seeds. In general a seed may be round, oval, elliptical, rod like, flat elongated or kidney shaped. It is one the important criteria of seed identification.
- c) **Size:** Based on size, seeds are classified into small, medium or large (bold) sized seeds. Crops like turnip and cabbage have small sized seed while bold size seeds are found in pea, bottle gourd and bitter gourd.
- d) **Surface texture:** The surface texture of seed may be smooth or rough. Sometimes it may contain markings, spine or hooks.
- e) **Hilum:** It is a scar or mark on a seed coat that indicates where the seed was attached to the ovary wall or funiculus. Through hilum seed absorbs water from surroundings. Hilum is prominent in pea and bean seeds.

MATERIALS REQUIRED

- | | |
|-------------------------------|---------------------|
| 1. Sample of seeds and plants | 2. Forcep |
| 3. Petri dish/board | 4. Magnifying glass |
| 5. Notebook | 6. Pen/pencil |

HOW TO PROCEED

- I. Collect the seeds and plant parts from your surrounding area.
- II. Spread the seeds of different vegetable crops on a glass petri plate and observe them with magnifying glass.
- III. Note down the size, shape, colour, surface texture or any other identification marks (location of the hilum) on the seed.
- IV. Keep the plant samples under magnifying glass and carefully observe the leaves (particularly their shape, size and venation), stem, flowers and roots with help of a forcep.

Few morphological characters of different vegetables which are useful in identification are as given below:

Solanaceous Crops:

- a. **Potato:** Potato seeds are basically tubers that are irregular in shape having eyes (bud) on it. Plant has compound leaves which are spirally arranged leaflets and have terminal single leaf.

Practical



Notes

- b. **Tomato:** Seeds are flat, rusty brown/grey colour with hairy appendages. Leaves are long serrated with small leaflets at base.
- c. **Chilli:** Seeds are flat round in shape with dull yellow color. It has pointed portion called *hilum* (point of attachment with placenta). Leaves are uneven in shape with narrow apex.
- d. **Brinjal:** Seeds are flat kidney shaped with light brown in colour. Leaves are slightly lobed with oblong to oval shape and may have thorns.

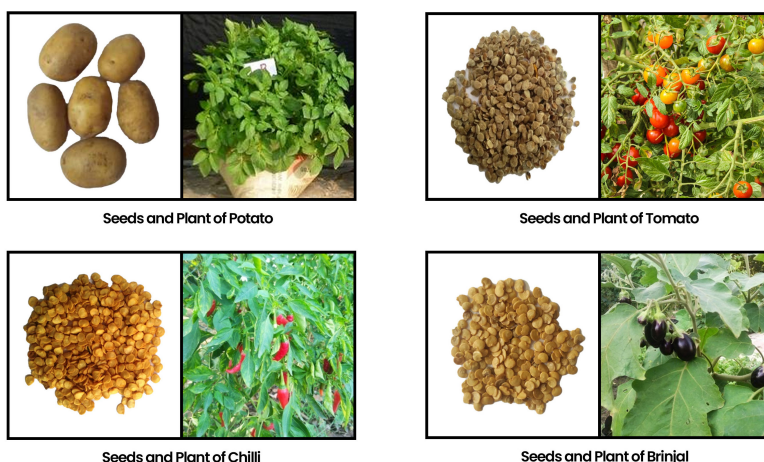


Fig. 2.1: Morphological characters of solanaceous crops

Pulse Crops:

- a. **Garden Pea:** Seeds are round, smooth or wrinkled surface having greenish yellow color. Plants are climbing annual with succulent stem and tendrils.
- b. **Cow Pea:** Seeds are mostly tan in color with black spot at the centre and have kidney shape. Leaves are trifoliate having oval leaflets and tap root system.
- c. **Dolichous Bean:** Seeds are black color and ovoid round shape, compressed with a conspicuous white color linear hilum. Leaves are alternate and trifoliate with white or purple flower.
- d. **Cluster Bean:** Seeds are flat greenish yellow in color. Plant stem is angled and leaves are trifoliate with tap root system.

Practical



Notes

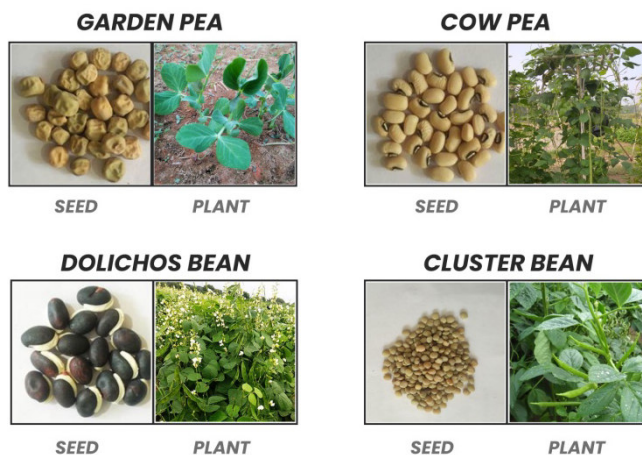


Fig. 2.2: Morphological character of pulse crops

Cucurbitaceous Crops

- a. **Cucumber:** Seeds of cucumber are whitish to pale tan in colour, long skinny flat in shape with smooth outer surface and tapering at both the ends. Leaves have 4-7 pointed lobes and rough hairs with bright yellow flowers.
- b. **Bottle Gourd:** Seeds are long (1.5-2 cm), compressed with two flat facial ridges on the surface and tan in color. The leaves are simple, lobed and one leaf per node with soft texture.
- c. **Pumpkin:** Seeds are large with flat body and uniform tan colored. Leaves are large, lobed and round often serrated edges.
- d. **Bitter Gourd:** Seeds are golden brown in colour, flat in shape and have indents on the surface, one has pointed distal end. Leaves are simple, veined with a lobed and crenate margin.
- e. **Muskmelon:** A long skinny seed (5 mm long), covered with a sticky gelatinous coating with a smooth light brown skin. Leaves are round to oval and wedge-shaped at bases.
- f. **Watermelon:** Seeds are long skinny with a shining black patch. Leaves have large oval shape with 3-5 lobes. It has hairy texture and underside veins.
- g. **Sponge Gourd:** Seeds are flat either black or white in color with smooth surface. Plants have 3 lobed leaves with bright yellow flowers.
- h. **Round Gourd:** Seeds are black-brown in color and have double inner lining on the surface of seed. Leaves are long with hairy stem and dorsally veined.

Practical



Notes

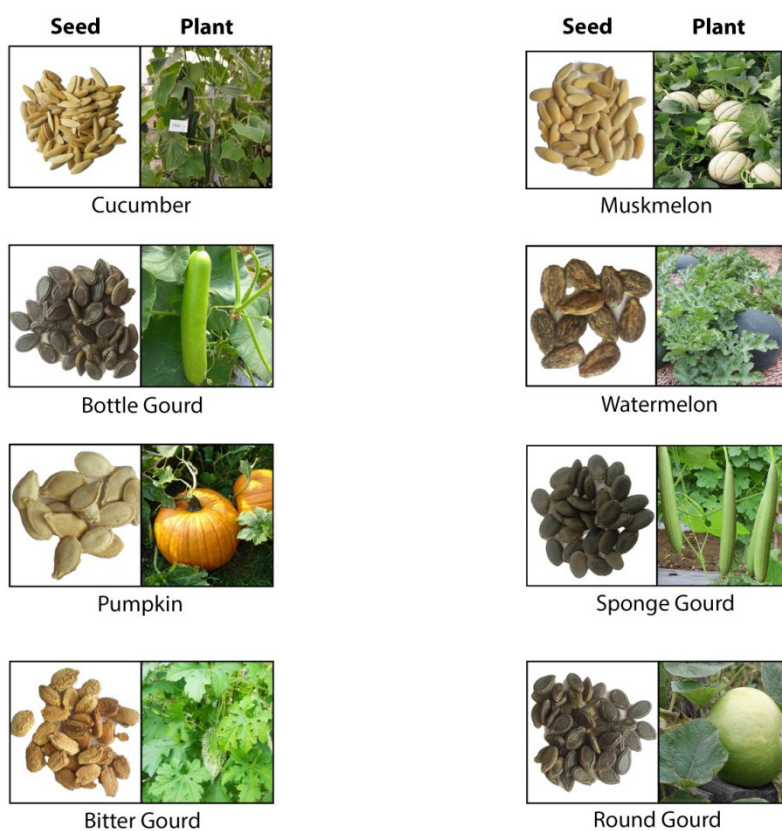


Fig. 2.3: Morphological features of cucurbitaceous crops

Root Crops

- Radish:** The seeds are oval-shaped, slightly flattened, and reddish brown in color. Plant has short hairy stem and oblong leaf shape.
- Carrot:** Seeds have light brown color with small rough hair bristle like surface. Plants have 8-15 feathery leaves and tap root system.
- Turnip:** Seeds are round in shape, blackish or reddish-brown in colour with 1.5–2 mm diameter. Leaves are green with succulent stems and rough hairs and roots have mostly purple coloration.

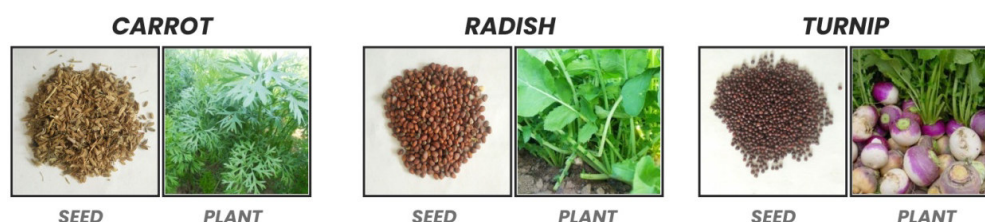


Fig. 2.4: Morphological features of root crops

Practical



Notes

Leafy Vegetables

- Spinach:** Seeds are tan in colored with round shape having pointed projections.
- Coriander:** Seeds are globular shape with tan color having longitudinal ridges on the surface.
- Fenugreek:** Seeds are brownish in color, small and stony, oblong having deep furrow. Seeds have a strong aroma and bitter taste. Leaves have three leaflets with small oblong shape.

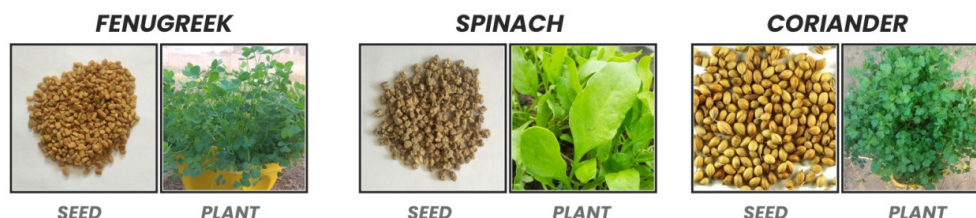


Fig. 2.5: Morphological features of some leafy vegetables

Cole Crops

- Cabbage:** Seeds are brown to deep red or black in colour. These are small round in shape. Leaves are succulent with no hairs and covered with a waxy coating and uniform edges.
- Cauliflower:** Cauliflower seeds are small, round, and smooth with brownish or dark reddish-brown colour. Leaves are large, thick, and leathery, typically exhibiting a dark green color. Outer leaves often protect the curd (the edible head) and are often tied up around it during growth to prevent sun exposure.



Fig. 2.6: Morphological character of cole crops

Others

- Onion:** Seeds are dark black and irregular in shape. Plants have 8-10 hollow leaves and contain bulb at the base.

Practical

- b. **Drumstick:** Seeds are triangular shaped with tapering end having grey color with or without papery wings. Plants are perennial and leaves are bi- or tripinnately compound and have oval-shape leaflets.
- c. **Curry leaf:** Seeds are round shape with shining black color. Plants are perennial and leaves are small in size with long, oval in shape.



Fig. 2.7: Morphological features of onion, drumstick and curry leaf

RECORDING OF OBSERVATION

OBSERVATION 1

1. Compare the morphological characteristics of pulse seeds and cucurbitaceous seeds.

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OBSERVATION 2

2. Explore your kitchen garden at home and write down the morphological characteristics of seeds and plants of important vegetable crops in the following table:

Sr. No.	Name of the crop	Seed traits			Plant traits		
		Size (small, medium and big)	Shape	Colour	Leaf	Stem	Flower



Notes

Practical



Notes

OBSERVATION 3

3. Identify and describe the root systems of common vegetable crops in your surrounding area.

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PRECAUTIONS

1. Wash your hands thoroughly before and after handling plants to minimize the risk of transferring allergens, irritants or harmful chemicals.
2. Never eat or drink in the laboratory or during fieldwork to prevent accidental ingestion of harmful substances.
3. Be aware that many plants have chemical and mechanical defense system, such as poisonous chemicals and thorns and spines, which can be dangerous to handle. Exercise caution when handling these kinds of plants.

FOR THE TEACHER

1. Encourage students to draw diagrams of seeds and plants, labeling parts with proper terminology.
2. Discuss how specific morphological characters help vegetable crops thrive in different climates and soils.
3. Facilitate a peer discussion where students exchange observations and findings so they can benefit from one another's perspectives.

IDENTIFICATION AND PREPARATION OF HERBARIUM OF COMMON WEEDS



Notes

Identification of weeds infesting any crop is the first step towards effective control. Selective herbicides control targeted weeds only, leaving others unaffected. Therefore, correct identification of the weed flora present in a crop field is necessary for taking appropriate control measures. Taxonomic research, biodiversity conservation, teaching, multidisciplinary studies, and cultural documentation are all aided by the identification and preparation of herbarium specimens. Students, scientists, educators, and environmentalists can benefit greatly from these collections.



LEARNING OUTCOMES

After performing this exercise, the learner:

- identifies different types of weeds found in major crop fields; and
- develops a weed herbarium as a reference manual for major local weeds.

WHAT YOU SHOULD KNOW

3.1 Weed Identification

Morphologically weeds are identified broadly as grasses, sedges and broad-leaved weeds even without knowing the species.

- **Grass:** Grasses are referred to weed species of Poaceae family which are characterized by narrow leaves with parallel venation, round and hollow stems containing nodes and internodes, and fibrous root system. Leaves sometime have ligule and auricles.
- **Sedge:** Sedges are monocots like grasses but stems are triangular in shape in most cases with solid internodes. Leaves are long, narrow and arranged in sets of three, and roots are fibrous.

Practical



Notes

- **Broad-leaf weed:** Unlike grasses, broad-leaved weeds have relatively wider leaves with reticulate venation and they are dicots with few exceptions. Stems are solid, rounded and sometimes angular. These plants have taproot systems which go deeper in to the soil.

3.2 Weed Herbarium

Weed herbarium is a guide book containing dried and pressed weed specimen labeled with plant characteristics, taxonomic and geographical information. It is used as a reference database for all those who are interested in identification of weeds. A well-documented herbarium will not only be useful for identification of weeds, but also the predominant weed species of the region can be known from the collected specimen.

MATERIALS REQUIRED

- | | |
|-----------------------|--------------------|
| 1. A gardener's knife | 2. A plant press |
| 3. Trowel | 4. Herbarium sheet |
| 5. Gum/tape | 6. Pen/Pencil |
| 7. Label | |

HOW TO PROCEED

First step: Collection of Weed Species

- i. Collect the weed samples of three groups (grass, sedge, broad leaf weed) and observe the differences in morphological characters in laboratory. Collection is preferably made during afternoon hours so as to avoid quick drying of plants.
- ii. Identify the weeds by their scientific names and make brief morphological description of leaves, stems, flowers, roots, rhizomes, stolons and other parts of the sample plants by drawing in note book.
- iii. For unidentified weed species refer a standard weed herbarium, weed flora books, reliable online reference manual on weed plates or seek the assistance of competent plant taxonomist.

Second step: Preparation of Herbarium of Common Weeds

- i. For preparation of herbarium, the whole plant of the targeted species should be selected and they must be free from damages by insect and disease pests. The specimen should have all parts of plant i.e., leaves, stem, flowers, fruits and root.

- ii. If specimen is large enough to be accommodated in herbarium sheet, then the plant may be cut part-wise in to small pieces which can be mounted in the sheet.
- iii. The specimen plants are collected and put in separate polythene bags. For each species 2-3 plants may be collected to select the best samples for mounting.
- iv. One identification number has to be assigned to each specimen during collection. The collector should record other information in field note book, such as date and place of collection, habitat, associated crop, local name, etc.

Third step: Pressing and Drying

Morphological features of the plants should remain intact in mounted specimen which can be ensured by pressing of live specimen. Drying is required to keep the samples for a long time without mould infection. Wash the collected specimen, wipe them and give pressing immediately. Pressing of specimens can be taken up between a pair of wooden presses by applying light pressure. Collected plants are put without folding them inside blotting papers or any absorbent papers and pile one over another. Gently press the pile between the presses and tie it putting an identification tag.

Proper drying of specimen is needed before mounting. The blotting papers are periodically replaced until the specimens are properly dried. Natural drying under sun takes little more time than artificial electric press but natural plant colour is achieved.

Fourth Step: Mounting of Specimens

1. Good quality papers of 42cm×29cm size are used to prepare the herbarium. Each specimen is placed in the centre of sheet with the help of glue or transparent adhesive tape.
2. The right bottom corner space of the page will be used for labelling. The label must contain the important information like local name, common name, scientific name, family, habitat, date and place of collection of the specimen, collector's name etc.
3. The specimens may be arranged family wise and under each family the member weeds to be placed alphabetically for making the herbarium user friendly.

OBSERVATIONS TO BE RECORDED

The label of a plant specimen should contain information in the following format

1. Local name of the plant
2. Common name of the plant

Practical



Notes

EXERCISE-3

Identification and Preparation of Herbarium of Common Weeds

Practical



Notes

3. Scientific name
4. Family
5. Type of habitat
6. Date of collection.....
7. Place of collection
8. Collector's name

PRECAUTIONS

1. Do not collect specimens during wet weather, as moisture can lead to mold and deterioration during pressing and storage.
2. Care should be taken during pressing of specimen so that plant parts may not get damaged.
3. Herbarium should be stored in a cool and dry place for their better longevity.
4. Periodically check specimens for signs of deterioration or pest infestation.

FOR THE TEACHER

- Encourage students to observe and note specific morphological traits of plants, which enhances their understanding of plant diversity and taxonomy.
- Demonstrate each step of the herbarium preparation process, including pressing, drying, and mounting specimens.
- During fieldwork, provide guidance on using tools like trowels and plant press effectively and supervise the learners to ensure that safe and ethical collection practices are followed. Respect for the environment and legal guidelines for plant collection should be promoted.



Common name: Crab grass
Local name: Kankada ghasa
Scientific name: *Digitaria sanguinalis*
Family: Poaceae
Habitat: Green gram crop field
Date of collection: 21.02.2024
Place of collection: Kendrapara

Fig. 3.1: Sample of a herbarium sheet

CALCULATION OF SEED RATE OF CROPS



Notes

The seed rate for crops varies depending on the type of crop, its variety, and the desired plant population per unit area. Seed rate is typically expressed in terms of weight (e.g., kilograms or pounds) or count (number of seeds) per unit area. Calculating the ideal seed rate helps farmers achieve higher yields, reduce costs, maintain crop health, and conserve resources. Therefore it is a critical practice in sustainable and profitable agriculture.



LEARNING OUTCOMES

After performing this exercise, the learner:

- explains importance of optimum seed rate for crop production; and
- calculates ideal seed rate for a given land area.

WHAT YOU SHOULD KNOW

Seed rate is defined as the quantity of seed required per unit land area for optimal crop stand and economically optimal yield. Higher seed rate increases the competition between crop plants while low seed rate reduces the plant population and hence the crop yield. Overcrowded crops are more prone to pests and diseases due to limited airflow and higher humidity around the plants. Crops sown at an ideal seed rate tend to be more uniform in size and maturity, making them easier to harvest and market. Therefore, an optimal amount of seed rate is required for higher crop production.

Practical

HOW TO PROCEED

Let us understand how the seed rate is calculated.

Step - 1: To find out final plant population per unit area (ha) from the given planting spacing

If the plant to plant and row to row spacing are P m and R m, then each plant or hill occupies an area of $P \times R \text{ m}^2$; if P and R are given in centimeter units, it can be converted into meter units. If we divide the total area to be cultivated by the area occupied by each plant, we get total number of plants or hills or plant population (say it is 'n'). Here number of plants will be same as number of seeds required to be sown.

$$n = \frac{10,000}{(P \times R)}$$

[Note: 1ha=10,000m² and P and R should be in meter unit]

Step - 2: To find out the number of seeds considering germination, purity and other variables.

If the germination and purity percentage is 100%, the above number of seeds would have been required for cultivation of one hectare land. But in reality, germination and purity percentage are always less than 100%, therefore, more seeds are required.

If germination % and purity % are G and P, then the required number of seeds (s) will be

Step - 3: To find out the weight of the seeds to be required

From the given test weight (t)(the weight of 1000 number of seeds), we can determine the total weight of calculated number of seeds in the following way. Test weight is expressed in g units.

$$\text{Seed Weight (kg)} = \frac{t \times s}{1000 \times 1000}$$



Notes

Example:

A rice crop has to be transplanted at a spacing of 25cm row to row and 10cm plant to plant distance with 3 seedlings per hill. The seeds to be used have germination and purity of 80% and 90%, respectively with the test weight of 25g. Find out the seed rate in kg/ha for this crop.

Solution

1. The place at which seedlings are transplanted is called a hill. First, the total number of hills to be accommodated in one hectare area has to be found out.

Number of hills	$= 10,000\text{m}^2 / (0.25\text{m} \times 0.10\text{m})$
	$= 10,000 / 0.025$
	$= 4,00,000$

2. The number of seedlings required (equal to the number of seeds) will be $4,00,000 \times 3 = 12,00,000$
3. Actual number of seeds required considering germination and purity will be $(12,00,000 \times 100 \times 100) / (80 \times 90) = 16,66,667$
4. Now, the weight of above number of seeds will be

Seed rate (kg/ha)	$= (\text{Test wt.} \times \text{Actual no. of seeds}) / 10,00,000$
	$= 25 \times 16,66,667 / 10,00,000$
	$= 41.67$

OBSERVATIONS TO BE RECORDED

1. Calculate the optimum seed rate of mungbean in kilogram per hectare (kg/ha) from the given data. Spacing = 30 cm × 10 cm, test weight = 36 g, germination percentage (%) = 92% and purity percentage = 85%.

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Practical*Notes*

Practical*Notes*

2. Determine the optimum seed rate for soybean in kg/ha if:

Spacing = 45 cm×10cm, Test Weight = 110g, Germination = 90%, Purity = 85%.

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STUDY ON METHODS OF NURSERY RAISING OF VEGETABLE CROPS AND THEIR PROTECTION



Notes

A vegetable nursery is a place or an establishment for raising or handling of young vegetable seedlings until they are ready for more permanent planting in crop field. For successful vegetable production, it is necessary to have disease free seeds and nursery. Farmers can prepare their main fields while seedlings are being raised separately in nurseries, saving the valuable time and money. As a result, efficient nursery management can significantly lower total production cost. Nurseries also contribute to biodiversity conservation by propagating a variety of plant species, including those that are rare or endangered.



LEARNING OUTCOMES

After performing this exercise, the learner:

- explains the benefits of growing vegetable crops in nursery;
- discusses the techniques of soil and pest management for nursery; and
- outlines the schematic steps needed to raise quality and disease-free seedlings of different vegetable crops.

WHAT YOU SHOULD KNOW

Vegetable crops are either sown directly in the field like pea, cowpea, spinach, coriander, fenugreek, garlic, potato, carrot, radish, etc. or are transplanted in the main field by raising the seedlings in nursery viz., tomato, chilli, brinjal, cabbage, cauliflower, onion. Availability of vegetable nursery is of paramount importance in enhancing the production of vegetable crops. Nursery raising is a technical and skilled venture which require proper planning, experience and efficient management.

Practical**Notes****Benefits of Nursery Raising:**

- Large number of seedlings can be grown from small unit area.
- Favorable growing conditions can be managed or created easily.
- Easy management of diseases and pest.
- Off-season cultivation of vegetables can be done.
- Ensures better utilization of resources viz., land, labour, water, nutrients and other inputs.
- Uniform plant growth can be maintained. It is the only way to obtain the desirable type of plants.
- Ensure easy and cheap availability of plants.
- It helps to achieve higher yield that response to transplanting.

MATERIALS REQUIRED

- | | |
|---------------------------------|-----------------|
| 1) Seed bed | 2) Spade |
| 3) Khurpi | 4) Seeds |
| 5) Well rotten farm yard manure | 6) Watering can |
| 7) Formaldehyde solution | 8) Sprayer |
| 9) Polythene sheet | 10) Pesticide |

HOW TO PROCEED

For raising healthy vegetable nursery, following steps should be followed sequentially:

- 1) Selection of ideal site and preparation of land for nursery raising
- 2) Treating the soil to make the nursery free from infestation of soil borne pathogen
- 3) Preparation of nursery beds and sowing of seeds
- 4) Management of seedlings in nursery
- 5) Hardening of nursery

a. Site Selection and Land Preparation:

- Site should preferably be located near the water source. It is advised not to locate the nursery area near the trees or tall building.
- The site should be protected against stray animals. Always locate the beds on the raised place as to avoid stagnation of water.
- It is preferred not to use the same land again and again because there are chances of frequent pathogen attack present in the soil.
- Soil should be light to medium, free from infestation of diseases and weed plant. Stones and weeds should be removed, and land should be loosen with 2-3 hoeing. If a soil is heavy, mix 2-3 kg sand and well rotten FYM.

b. Soil Treatment:

When a nursery is grown at a place year after year, it may become susceptible to the attack of pests. Therefore, it is necessary to make the nursery free from infestation of soil borne pathogen like fungi and nematode. For this purpose you may follow the following steps

- Sterilize the soil with the solution of formaldehyde. The 1.5-2% solution of formaldehyde is applied at the rate of two litre per square meter, so that it saturates upper 6 inches of the soil. The solution is applied on the prepared bed of 1.25 meter width.
- The soil is then covered with thin plastic sheet for 48-72 hours.
- After the required time period, remove the sheet and loosen the soil so that fumes of the chemical escape in to the air.
- Keep the soil open for 4-5 days. The sowing is done thereafter.

Soil Solarization:

Alternatively, soil solarization can also be used to sterilize the soil. Solarization is an easy, safe and cost-effective way to sterilize the soil and produce healthy seedlings. The period of May-June is most ideal for soil solarization as temperature rises up to 45°C. For this, land should be saturated with water and covered with transparent polyethylene sheet (200 gauges) for 5-6 weeks. The polyethylene margin should be covered by wet soil to check the entry of air (Fig. 5.1).

Practical*Notes*

Practical



Notes



Fig.5.1: Soil solarization of field using transparent polyethylene sheet

c. Nursery Bed Preparation and Method of Sowing:

Bed Preparation:

- On well prepared soil, the nursery beds of 1.25 meter width are prepared (Fig.5.2).
- The beds should be raised up to 15 cm. The length of the beds varies with the type of the crop and area of the commercial crop to be raised.
- An alley (narrow passage between crop rows) of 50 cm is kept in between the two beds so as to do agricultural operations such as weeding, watering, spraying etc.



Fig. 5.2: Raising of onion nursery over raised bed method with line sowing

Method of Sowing:

- Seed should be purchased from reliable source. Before sowing of seeds in the bed, it is essential to treat the seeds with 3g of captan/thiram fungicide for one kilogram of seed.
- The seed should always be sown in the rows as it will facilitate air circulation and also ease in intercultural operations.
- On the raised beds the rows are marked widthwise at a distance of 5 to 7.5 cm, about 1-2 cm deep.
- Adjust the planting depth according to the seed size.
- Cover the seed with mixture of soil and farmyard manure. Also, mulch the nursery beds with paddy straw or dry leaves immediately after sowing.

d. Seedling Management in Nursery:

- Sprinkler irrigation to the nursery beds can be twice in summer and once in winter. Beds are kept moist till germination.
- Remove the mulch immediately, as and when the white thread like structure is seen above the ground.
- The nursery of chilli, brinjal and spring season tomato is protected against cold during night in December-January.
- Drench the nursery plant with 0.4 % captan/ thiram (3g/litre of water after 7 days of germination. Repeat it again after 7-10 days.
- If the seedlings are densely planted in the beds, then thinning of the seedlings is an important operation to remove dense plants from the nursery beds keeping distance of about 0.5 to 1.0 cm from plant to plant.
- Remove weak, unhealthy, diseased, insect pests affected nursery plants. If there are some weeds in the seed bed, remove them manually.

e. Hardening of Nursery:

- Once the seedling has attained ideal stage of transplanting (after 4-6 weeks), water should be withhold for 3-4 days before transplanting.

Practical**Notes**

Sprinkler irrigation to t
and once in winter. Bed

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This will cause hardening of seedling and prevent mortality from transplanting shock and unfavourable environment like low and high temperature, water scarcity and hot dry wind, etc.

- Before uprooting the seedlings, the nursery area should be irrigated. The plants can be dug with *khurpi* or with hand. The seedlings roots are wrapped with a piece of paper and tied with thread or rubber band for distant market.

Other Nursery Raising Techniques:

Other than soil-based nursery technique, plug/pro tray nursery and poly bags nursery raising technique (Fig.5.3) are also followed.

- a) **Plug Tray Nursery:** In this method of nursery raising, plastic plug trays of uniform shape and size are used. Based on seed size, the cell size of plug need to be selected. For example, small seeded crops viz., tomato, chilli, brinjal, etc can be sown in small cell size while pumpkin, bottle gourd, sponge gourd, etc need to be sown in big cell size plug trays. The plug tray should be filled with growing media i.e. Cocopeat: Perlite: Vermiculite (3:1:1). Since soil is not used, diseases and weeds are not the problems. Single seed is placed in each cell so there is no competition between plants for space, water and nutrient. Such nursery is mostly used for raising nursery of F_1 hybrids.

An F_1 hybrid is the first-generation offspring of two different parent plants that have been carefully selected for their desirable traits. These hybrids usually have better growth, yield and disease resistance.

- b) **Poly Bags Nursery:** These type of nursery is followed to raise cucurbits (muskmelon, watermelon, etc). The size of polyethylene bags is 10 cm × 15 cm. Best growing media for poly bag nursery is soil + FYM (1:1). 2-3 seeds are sown in each bag. Once the seed germinates, thinning of young seedling is done to avoid competition. Before transplanting, hardening of seedling is done.

Practical



Notes



Fig.5.3: Plug tray and poly bag method of nursery raising

PRECAUTIONS

- Choose a site that is shielded from strong winds to prevent damage to seedlings.
- Avoid placing the nursery on slopes that could lead to soil erosion or in areas prone to waterlogging, which can harm seedling roots.
- Regularly inspect seedlings to ensure adequate spacing for air circulation, light penetration, and disease monitoring.

RECORDING OF OBSERVATION

OBSERVATION 1

1. Enlist vegetable crops that require nursery raising.

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OBSERVATION 2

2. Raise chilli seedlings by raised bed and cucurbit seedling by plug tray method. What difficulties did you face during the procedure. Describe your experience in own words.

EXERCISE-5

Study on Methods of Nursery Raising of Vegetable Crops and Their Protection

Practical



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OBSERVATION 3

3. Prepare a poly bag nursery and identify the challenges encountered while performing the experiment. Explain the necessary steps/solution that you have taken in order to mitigate the challenges.

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FOR THE TEACHER

- Demonstrate every crucial steps of nursery preparation and discuss their importance in successful raising of nursery.
- Encourage monitoring and record keeping of different seedlings growth stages to understand nursery timeline.

STUDY OF AGRICULTURAL/ HORTICULTURAL TOOLS AND IMPLEMENTS



Notes

To develop a garden, you may need the various tools to convert an open, dull space into a well decorated, visually appealing garden. Different equipments and implements are used for performing various gardening operations. In this exercise, we will discover some of the commonly used tools and implements in agricultural operations.



LEARNING OUTCOMES

After performing this exercise, the learner:

- identifies various agricultural as well as horticultural tools and implements;
- differentiates the utility of using different tools for different purposes; and
- chooses the appropriate tools for specific gardening operation.

WHAT YOU SHOULD KNOW

I. Tools Used for Digging and Lifting:

- a) **Spade** is used for breaking ground and chopping through tree roots and other tough stuff. Planting trees, excavating garden beds, removing grass, and cutting garden margins all need the use of a spade in the garden.
- b) **Shovel** helps with digging and transplanting soil, making shallow trenches, and in removing dirt or debris.
- c) **Fork** is used in loosening and turning over soil. Its tines allow it to be pushed more easily into the ground, and it can rake out stones and weeds and break up clods.

Practical



Notes

- d) **Crowbar** is used to punch holes in the ground for planting bean poles and for taking the temperature of a compost pile.

II. Tools Used for Intercultural Operations:

- a) **Dutch hoe** is used in severing the roots of weeds as it slides just under the surface of the soil. It is also used for chopping out big weeds, hilling of potatoes, removing chunks of sod for new beds and breaking up clods of soil.
- b) **Trench hoe:** In soft soil it is generally used for tilling (mixing) the soil. In firm soil it can be used to break the ground for creating a new garden, or to loosen and drag soil away for activities like planting trees or installing sidewalks.
- c) **Garden rakes** are designed to pick up leaves and other garden debris without damaging the lawn and the soil beneath.
- d) **Hand rake** is ideal for cleaning up dead leaves, plant materials and other debris in garden beds.
- e) **Hand cultivator** is used to turn the soil where you plan for planting and removing weeds. In small flower or vegetable gardens, it can also be used like a small plow to dig the planting rows.
- f) **Hand Hoe/Khurpi** is used to loosen the soil and remove weeds. It can also be used as sowing implements, for filling pots with potting mix, placing fertilizer, spreading compost and many other uses. It's an ancient tool that predates the plow.
- g) **“V” Blade Hand Hoe** is used for weeding of the vegetable crops, breaking of the soil crust and aeration of the soil.
- h) **Axe** is used for cutting hard woody branches, tree trunk or dry wooden poles.
- i) **Bill hook** is used for cutting shrubby branches, soft to medium soft branches.
- j) **Secateur:** Secateur is a gardening tool that looks like a pair of strong, heavy scissors. These are used for cutting the stems of plants. Use secateurs cautiously to avoid damaging the leaves.
- k) **Sickle:** Sickles are utilized for weeding, helping to manage unwanted

Practical



Notes

- vegetation that competes with crops for nutrients and water.
- l) **Grass shear** is used to cut grass from a standing position. Two kinds of grass shear are available: with horizontal blades and with vertical blades. Horizontal blades are used to remove grass which has not been cut by the lawn mower, while vertical blades are used for trimming the edges of a lawn.
 - m) **Hedge shear**: Hedge shears are perfect for maintaining straight-edged hedges. They are great for cutting long, straight lines. Their design makes them ideal for trimming geometric designs and straight lines to create “boxy” shapes.
 - n) **Garden/lawn sword** is used for cutting weedy grasses in border areas and in avenues.
 - o) **Edging Knife/Lawn Edger** is used to create distinct borders between a lawn and other garden features like flowerbeds, paving.
 - p) **Pruning saw** is used to trim shrubs and trees. There are many types of folding saws, each designed for a particular type of branch or stem. All types of pruning saws should have hard-to-heat-treated teeth but in different sizes and shapes.
 - q) **Pruning knife**: The uses of a pruning knife are diverse and extensive. It performs various tasks from trimming vines to harvesting vegetables. You can use a pruning knife to slice string, cut flowers, prune vines, and graft trees.



Fig. 6.1: Different agricultural and horticultural tools

Practical



Notes

III. Tools Used for Sowing and Transplanting:

- a) **Seed dibbler:** Dibbler is a pointed wooden stick for making holes in the ground so that seeds, seedlings or small bulbs can be planted.
- b) **Trowel:** It is used to dig plant holes and transplant seedlings. You can also use it to remove unwanted weeds from the area.

IV. Tools Used for Plant Propagation:

- a) **Grafting knife** is used for propagating plants by grafting or budding. These knives have a sharp, thin blade that is designed to make precise cuts on plant stems and branches.
- b) **Grafting cum budding knife:** A budding-cum-grafting knife combines two knives that are used for both grafting and budding procedures. It has two blades: one for grafting and the other for performing budding. These knives are fastened to the handle's ends. High-carbon or alloy steel is used to make both knives.

V. Tools Used for Watering:

- a) **Rose can** is used to sprinkle or mist water or fertilizer solutions on the plants, seeds and more.
- b) **Garden hose pipe:** It is a flexible tube used to convey water. There are a number of common attachments available for the end of the hose, such as sprayers and sprinklers (which are used to concentrate water at one point or to spread it over a large area).

VI. Tools Used for Plant Protection:

- a) **Hand sprayer** is utilized for spraying insecticides and pesticides on small trees, shrubs and row crops. Its features include a frame on which a high-density polyethylene tank, fuel tank, engine, delivery pipe, shock proof cushion, and a spray hose.
- b) **Knapsack sprayer** is used for spraying insecticides and pesticides on small trees, shrubs and row crops.

VII. Tools Used for Harvesting:

- a) **Mango harvester:** These are used to harvest fruit from trees. Its blade cut the fruit along with the stem. It also has a conveyor that brings the fruit

Practical



Notes

down. Mango Fruit picker increases the shelf life of the fruit by cutting the fruit along with the stem and also increases labour productivity.

- b) **Sickle:** It is designed with variously curved blades and typically used for harvesting or reaping grain crops or cutting succulent forage for feeding livestock.

VIII. Miscellaneous Tools:

- a) **Lawn mower:** It is used to trim the grass, keep up with the weeds, and even collect leaves from around your garden. However, you should know how to use a lawn mower before using it to improve gardening. A lawn mower can be a great help when it comes to improving your gardening experience.
- b) **Roller:** After you have tilled the ground and spread seed, you can use your lawn roller to roll the soil and make sure the seeds make contact. Rolling after seeding helps press the seed into the soil so that it doesn't blow or wash away, and it also expedites the seed's germination process.



Fig. 6.2: Different agricultural/horticultural tools and implements

PRECAUTIONS

- Stay focused while operating equipment to prevent accidents caused by distractions from surroundings.

Practical**Notes**

- After use, clean tools and store them securely to prevent damage from improperly stored equipment.
- Always check for defects such as splintered handles or dull blades. If a tool is damaged, it should be removed from use immediately.

OBSERVATIONS TO BE RECORDED

1. Write different farm implements required for mango production.
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2. Prepare a list of commonly used farm implements and collect price from the nearby by farm implement shops.
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3. Identify and discuss about different farm tools available in your house.
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4. Imagine you are part of a local gardening club and are responsible for preparing a small vegetable garden plot. You have a choice between using a spade and a khurpi to loosen the soil and remove weeds.
 - a) Describe an activity in the garden where the spade would be more useful than the khurpi, and explain why.
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 - b) Explain when the khurpi might be a better choice, and why.
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FOR THE TEACHER

- Guide the learners on how to use the tools safely and effectively.

CALCULATION OF FERTILIZER REQUIREMENT OF A CULTIVATED LAND



Notes

Plants need nutrients, like humans, to grow strong and healthy. Fertilizers provide these nutrients. If too much fertilizer is used, it can wash away into rivers and lakes when it rains. This can harm fish and other wildlife. By calculating how much fertilizer to use, we can make sure that plants get just the right amount of nutrients needed to produce fruits, vegetables, or flowers. Use of optimum amount fertilizer helps farmers to save money and use resources wisely. This way, the soil stays balanced and productive for many years. In this exercise, you will explore about various methods to determine fertilizer needs of your farm area.



LEARNING OUTCOMES

After performing this exercise, the learner:

- explains the methods of calculating the quantity of fertilizers needed for a given area, and
- recommends optimum dose of nutrients for proper growth and development of plants.

WHAT YOU SHOULD KNOW

Fertilizers may contain a single primary nutrient (**straight fertilizer**) or may have two or more primary nutrient (**complex fertilizers**). You should have the following data for calculation of the fertilizer requirement of an area.

- Recommended dose/rate of fertilizer
- Nutrient content/grades of fertilizer material

Practical



Notes

- Area to be applied

It is important to mention that the nutrient contents of fertilizers are expressed as (%) of N, P_2O_5 and K_2O . For example: urea contains 46% nitrogen and single super phosphate (SSP) has 16% phosphorus. Therefore, fertilizer grade is expressed in percentage form. Fertilizer grade is defined as minimum amount of essential nutrients (nitrogen, phosphorus and potassium) present in the fertilizer. It is often represented by three numbers on the fertilizer packet. A fertilizer labeled 10-20-10 denotes that it has 10% nitrogen, 20% phosphorus (as P_2O_5), and 10% potassium (as K_2O) by weight.

The amount of primary nutrients required for optimum growth and yield of plants varies with crop and soil type. For example, if the nutrient recommendation for rice is 80-40-40 kg/ha, it indicates, the crop is recommended for application of 80, 40 and 40 kg of N, P_2O_5 and K_2O per ha, respectively. From this recommended nutrient dosage, you will need to calculate the required fertilizer amount considering the nutrient content of your chosen fertilizer.

HOW TO PROCEED

Let us understand how the fertilizer requirement is calculated.

For Straight Fertilizers:

Following expression is used to calculate amount of fertilizer required from a fertilizer source containing a single nutrient.

Quantity of fertilizer (kg)

$$= \frac{\text{Recommended dose of nutrient (kg / ha)}}{\text{Nutrient content in fertilizer (\%)}} \times 100 \times \text{Area (in hectare)}$$

Objective: To find out the amount of urea (46% N) to be applied in 1 acre crop area if the recommended dose of N is 80 kg/ha.

- First step: the quantity of urea as needed for 1 ha to be calculated in the following way.
 - 46 kg of N is obtained from 100 kg urea.
 - Then 80 kg N can be obtained from $(100/46) \times 80 = 174$ kg of urea
- In second step, the quantity of urea required for the given 1 acre of area to be calculated.

Practical

- ❖ Area in acre need to be converted to ha unit, accordingly, 1 acre=0.4 ha (*. 1ha=2.5 acres)
- ❖ For 1ha, the quantity of urea needed is 174 kg.
- ❖ For 0.4 ha, the urea requirement will be $174 \times 0.4 = 70$ kg.

For Complex Fertilizers:

In case of fertilizers containing more than one primary nutrient, the calculation process requires more attention towards deciding which nutrient to be calculated first. In such cases, the nutrient, which is principally provided by complex fertilizer will be determined first.

Take the example of di-ammonium phosphate (DAP) which contains 18% nitrogen (N) and 46% phosphorus (P).

- So here, the requirement of DAP will be calculated first for P only as it provides more phosphorus than nitrogen.
- Then we will determine how much amount of nitrogen is being provided by DAP through recommended DAP dose for P.
- If nitrogen requirement is not satisfied by the recommended DAP, then rest of the nitrogen will be applied through urea. This is to note that if we apply extra DAP for nitrogen, it will also provide extra phosphorus along with it, which may cause toxicity in plants.

Let's understand the above fertilizer calculation by determining the requirement of Urea, DAP (18-46-0) and muriate of potash (MoP) (0-0-60) for rice crop to be cultivated in 0.5 ha area.

- **First step:** Here, the calculation starts with DAP as it is a complex fertilizer. Further, the fertilizer requirement for multiple nutrients can either be calculated initially for 1 ha and subsequently for the given area at the end or from the beginning each fertilizer may be calculated for the required area. However, the former process is easier.
 - ❖ Calculating DAP requirement to meet the recommended $40 \text{ kg P}_2\text{O}_5/\text{ha}$
 - ❖ 100 kg DAP contains 46 kg P_2O_5
 - ❖ Then $40 \text{ kg P}_2\text{O}_5$ will be obtained from $(40/46) \times 100 = 87 \text{ kg DAP}$



Notes

Practical



Notes

- **Second step:** Calculation of amount of N supplied by 87kg DAP
 - ❖ 100 kg DAP contains 18kg P_2O_5
 - ❖ 87 kg DAP contains $(18/100) \times 87 = 15.7\text{kgH}''16\text{kg}$
- **Third step:** Calculation of amount of N to be supplied by urea
 - ❖ As DAP provides only 16 kg N, the rest amount of N($80-16=64\text{kg}$) has to be supplied from urea to meet the recommended dose.
 - ❖ Urea requirement (kg) = $(100/46) \times 64 = 139\text{kg}$
- **Fourth step:** Calculation of K requirement from MOP to meet the recommended 40kg K_2O for rice.
 - ❖ 100 kg MOP contains 60 kg K_2O .
 - ❖ Quantity of MOP required (kg) = $(40/60) \times 100 = 66.6\text{ H}''67$
- **Fifth step:** The above calculated fertilizers are for 1ha which will be quantified for the given 0.5ha area.
 - ❖ Therefore, the actual amount of fertilizers will be calculated as follows.

Amount of urea = $139 \times 0.5 = 69.5\text{kg}$

Amount of DAP = $87 \times 0.5 = 43.5\text{kg}$

Amount of MOP = $67 \times 0.5 = 33.5\text{kg}$

OBSERVATIONS TO BE RECORDED

Calculate the fertilizer requirement for the following crops, i.e., greengram, wheat, mustard and rice.

- 1) Greengram crop is cultivated in 2.5 acres of land with a recommended dose of fertilizer of 20-40-20 kg N, P_2O_5 , K_2O per ha. Calculate the amount of urea, single super phosphate (SSP) and muriate of potash (MOP) required for the crop. (Note: Urea, SSP and MOP contain 46% N, 16% P_2O_5 and 60% K_2O respectively)

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Practical



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- 2) A farmer has grown wheat in 2 acres of land for which he has been recommended to apply fertilizer at 100-50-40 kg N, P_2O_5 , K_2O per ha. He has brought gromor (28-28-0), urea and MOP to apply. Find out the total quantities of each fertilizer required for his crop field.

- 3) The recommended rate of fertilizer for a mustard crop grown in 1.5 ha of land is 60-30-30 kg of N, P_2O_5 , K_2O per ha. If urea, DAP and MOP fertilizers are available, then find out the quantity of each as required for the crop.

- 4) A rice crop receives a fertilizer recommendation of 100-50-50 kg N, P_2O_5 , K_2O per ha in which 50% N, full dose of P and K to be applied as basal and rest 50% N to be applied as top-dressing at 30 days after sowing. Find out the amount of each fertilizer material required at basal and top-dressing.

EXERCISE-7

Calculation of Fertilizer Requirement of a Cultivated Land

Practical



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COLLECTION AND PROCESSING OF SOIL SAMPLES FOR LABORATORY ANALYSIS

Soil is the medium on which plant growth happens. Plants take up nutrients and water from it. A soil is considered healthy for plant growth if it contains as well as supplies all the essential elements in suitable proportion. But how can you know about health of soil? For this you must have to analyze the soil for their physical, chemical and biological properties. Generally very small amount of soil is collected from a large field for analysis. Therefore special care and attention should be given during soil collection so that soil sample becomes truly representative of total field/area.



LEARNING OUTCOMES

After performing this exercise, the learner:

- recognizes the importance of proper soil sampling and
- demonstrates the scientific method to collect representative samples from field.

WHAT YOU SHOULD KNOW

An ideal soil sample should reflect the overall condition of the soil of the area from where it is collected. Therefore, we must delineate an area for sampling of soil. This delineated area is called **sampling unit**. Sampling unit should be uniform in nature. Generally an area up to 0.5 ha is considered as one sampling unit. A larger area may be divided into smaller areas/sampling unit for better representativeness of soil.

Depth of soil sampling is an important consideration as different plants penetrate different depths of soil. Generally, soils are collected from 0-15 cm depth in case of common agricultural crops like cereal, pulse or vegetable. For fruit tree or plantation

EXERCISE-8

To Collect and Process Soil Samples for Laboratory Analysis

Practical



Notes

crops, it is recommended to draw the samples separately from 0-30 cm, 30-60 cm and 60-90 cm; as their roots grow deeper in soil.

MATERIALS REQUIRED

Anyone of the following tools may be used for sampling purpose.

- | | |
|---------------------|---------------|
| 1. Spade | 2. Khurpi |
| 3. Screw type auger | 4. Tube auger |
| 5. Post-hole auger | |

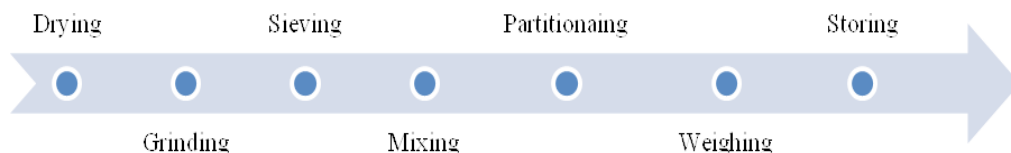
Surface soil samples (0-15 cm) are collected commonly by spade or *khurpi*. For the soil sampling at deeper depth, auger is used.

HOW TO PROCEED

For successful collection of soil sample, follow the steps given below

- 1) Identify the area from where sample needs to be collected and select the sampling tool as per your convenience.
- 2) Collect the samples by moving in zig-zag manner from the 15-20 well distributed spots of the field. Remove all the surface litter from the sampling site before collection.
- 3) If you are using spade or *khurpi*, at first make a 'V' shaped cut in soil and remove the soil from the cut. Then collect about 2 cm slice soil from any wall of 'V' shaped cut.
- 4) If there is any standing crop on the field, samples are to be collected from the space in between crop rows.

After soil sampling, they are prepared for laboratory analysis through following processes



1. **Drying:** For physical and chemical analysis, soil samples are dried. Generally, soils are air dried under a shade at room temperature. However, drying is not necessary for biological analysis of soil.

Practical



Notes

2. **Grinding:** Break the soil clods with by rubbing them with the help of a pestle with mortar. Generally wooden mortar is considered best for soil grinding.
3. **Sieving:** Sieving is a process through which stones/plant debris present within sample are removed. A sieve is a device with openings that separates finer particles from coarser ones. Pass the grinded soil through 2mm sieve.
4. **Mixing:** Assemble all the collected samples of one sampling unit at one place on a clean paper/polythene sheet/cemented floor and mix them thoroughly by hand.
5. **Partitioning:** After mixing the soils completely, spread the soils uniformly and divide them into four quarters. Discard two opposite quarters and remix the rest of two quarters.
6. **Weighing:** Repeat the partitioning process until about 500g of soil sample is obtained.
7. **Storing & Labeling:** Store the samples in clean polythene or cloth bags. Preferably these bags should be new.

Label the soil sample using important information like sample number, name of owner, name of sampling location, sampling depth etc. It is better to place the label both inside and outside of the sample bags.

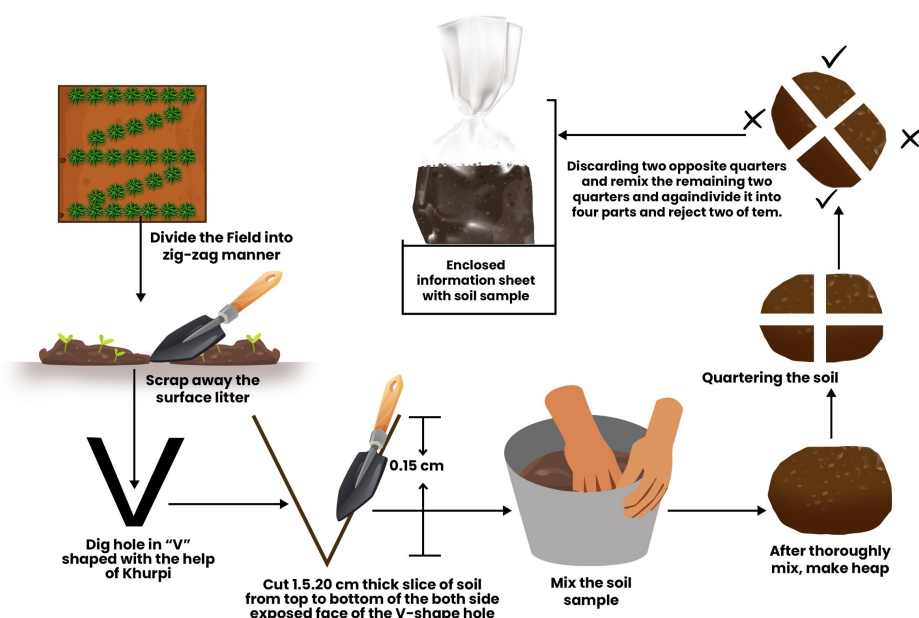


Fig. 8.1: Schematic steps in scientific sampling of soil

Practical



Notes

PRECAUTIONS

Special precautions need to be taken to avoid contamination of the soil samples. You may take following steps as precautionary measures.

- Avoid taking soil samples from recently fertilized plots, bunds, channels, near FYM/compost piles, trees and boundary of the field.
- Use the tools made of stainless steel for collection and grinding of soil. Rusted auger, *khurpi*, mortar, pestle can contaminate soil samples and modify the results of soil chemical analysis.
- Do not store the soil samples in such bags which are previously used for storing fertilizer, pesticides or other chemicals.
- Always avoid contact of any type of chemical with soil samples.
- If you are collecting a large number of samples from field, properly label the sample. If you do not collect samples carefully taking all precautions, you will not be able to get actual soil health status from analysis and ultimately it will in improper recommendation of management practices.

OBSERVATIONS TO BE RECORDED

OBSERVATION 1

Collect the soil sample from your garden or nearby area. Prepare and process them according to the steps mentioned above. Construct a flow chart of the operations which you have performed. List out the tools and materials that you have used for sampling purpose.

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OBSERVATION 2

Visit the nearby soil testing laboratories, Krishi Vigyan Kendra (KVK) or Agricultural Universities and submit your soil for analysis by the experts. Collect the soil test report and find out the nutrient status of your sample. Interpret your test result with the help of soil fertility rating based recommendation chart. Design a suitable plan to rectify the deficiencies (if present) in soil after discussing with your parents/mentor.

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CHECK YOUR UNDERSTANDING.

- a) Why proper sampling of soil is necessary?

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- b) Fruit plants require soil samples to be taken from deeper depths. Describe the causes.

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Practical*Notes*

EXERCISE-8

To Collect and Process Soil Samples for Laboratory Analysis

Practical



Notes

c) Why wooden mortar is considered best for grinding than other type of mortars?

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FOR THE TEACHER

- Help the learners in selecting ideal sites for sample collection.
- Remind students to clean tools before collecting samples from different areas, avoid touching soil directly with their hands and use clean sample bags.
- Show learners how to label each sample with key information like sample number, date, field name, sampling depth, and other relevant details.

DETERMINATION OF SOIL MOISTURE BY GRAVIMETRIC METHOD



Notes

Soil moisture represents the amount of water present in soil pore spaces including macro and micro pores. Presence of optimum amount of water in soil is crucial for seed germination, root development and plant growth. The soil water content is governed by many factors like soil texture, structure, porosity, organic matter content etc. As you have studied that irrigation requirement varies with type of crop, it is essential to assess soil water content during various crop growth stages for proper irrigation planning. In this exercise you will learn about a simple and inexpensive way to measure soil moisture.



LEARNING OUTCOMES

After performing this exercise, the learner:

- explains the method of determining soil water content and
- evaluates the water requirement of various crops for different soil types.

WHAT YOU SHOULD KNOW

Soil water can be measured in both direct and indirect way. In gravimetric method, soil moisture is determined directly. This method involves removal of water from soil sample by heating. Here soil samples are dried in oven at 105°C for 24-48 hours. After that soil water is calculated using mass of wet sample and dry sample in following way

$$\text{Moisture content (\%)} = \frac{\text{Weight of wet soil} - \text{Weight of dry soil}}{\text{Weight of dry soil}} \times 100$$

Practical



Notes

Generally soil water content is expressed in percentage. If soil moisture content declines below certain limit, irrigation is applied. When we multiply the bulk density with gravimetric moisture content, volumetric moisture content of soil is obtained.

Volumetric moisture content ($\text{cm}^3 / \text{cm}^3$)

*= Bulk density * Gravimetric moisture content*

Bulk density is defined as mass of soil solid per unit volume of soil (including pore spaces).

$$\text{Bulk density} = \frac{\text{Mass of soil solid}}{\text{Volume of soil solid} + \text{volume of soil pore space}}$$

Let's understand calculation of gravimetric and volumetric moisture content with an example.

A soil sample is collected, and the following data is recorded:

- Weight of wet soil: 200 g
- Weight of dry soil: 150 g
- Bulk density: 1.5 g/cm³

As per the formula given in previous section, the gravimetric moisture content will be
 $= \{(200 - 150)/150\} \times 100 = 33.33\%$

The volumetric moisture content will be $= (1.5 \times 33.33)/100 = 0.5 \text{ cm}^3/\text{cm}^3$

Interpretation

- Gravimetric moisture content of 33.33% indicates that 33.33% of the soil's dry weight is water.
- Volumetric moisture content of 0.5 cm³/cm³ indicates that half of the soil's total volume is occupied with water.

MATERIALS REQUIRED

- | | |
|--------------------------|----------------------------------|
| 1. Spade/auger | 2. Plastic bag |
| 3. Marker & notebook | 4. Drying container/aluminum box |
| 5. Weighing scale | 6. Hot air oven (optional) |
| 7. Calculator (optional) | |

HOW TO PROCEED

- Visit nearest agricultural field and collect the soil samples using spade/auger.
- Place the samples in plastic bag and close it properly.
- Label the bag with important information like location, date, depth of sampling.
- Bring the samples to laboratory and keep it in drying container.
- Weigh the moist soil with the help of weighing scale and note down the data.
- Dry the samples until weight stabilizes. This can be done in two ways
 - ❖ By oven drying the fresh samples for 24-48 hours at 105°C.
 - ❖ By air drying the samples for a week.
- After reaching stable weight, the samples are weighed again.
- Calculate the mass of water lost as a percentage of the mass of the dried soil.

Calculation:

- a) Mass of drying container = W_1 g
- b) Mass of moist soil + drying container = W_2 g
- c) Mass of dry soil + drying container = W_3 g
- d) Mass of moist soil = $(W_2 - W_1)$ g
- e) Mass of dry soil = $(W_3 - W_1)$ g

$$\text{Moisture content (\%)} = \frac{(W_2 - W_1) - (W_3 - W_1)}{(W_3 - W_1)} \times 100$$

PRECAUTIONS

- Ensure that the plastic bags are properly dried before storing samples.
- Be cautious about the oven temperature which should not exceed 105°C.

Practical*Notes*

Practical



Notes

OBSERVATIONS TO BE RECORDED

Activity 1:

	Sample 1	Sample 2	Sample 3
W_1			
W_2			
W_3			
$(W_2 - W_1)$			
$(W_3 - W_1)$			
Moisture content (%)			
Interpretation/remarks			

Activity 2:

You are growing wheat on your farm. But the farm is facing some challenges with irrigation management, and you need to measure the moisture content of the soil to determine irrigation requirement for wheat. To do this, you have collected a soil sample and measured the weight of the wet and dry soil. Their values are as follows:

- Weight of wet soil = 175 g
- Weight of dry soil = 140 g
- Bulk density = 1.4 g cm^{-3}

Calculate the gravimetric and volumetric moisture content of the soil to determine the soil water retention and plan appropriate irrigation.

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FOR THE TEACHER

- Discuss real-world applications and case studies to enhance learners' understanding of soil water and its importance in fields like agriculture.
- Guide learners in analyzing the moisture content data.

INTERPRETATION OF SOIL HEALTH CARD

*Notes*

India is an agrarian country. But many farmers in India do not know which types of crops they should grow to get maximum yield, as they lack knowledge about quality and the type of their soil. The Soil Health Card Scheme is very beneficial for farmers to improve the condition of the soil. A Soil Health Card (SHC) is a report generated from the laboratory analysis of soil samples. It is used to assess the status of soil health and when used over time, it can show changes in soil health due to prevalent agricultural practices. The interpretation of a Soil Health Card involves understanding the information it provides about the soil's nutrient status and other properties. SHCs are issued under the Soil Health Card Scheme provided by the Government of India, under the Ministry of Agriculture & Farmers Welfare to help farmers make informed decisions about soil management and crop planning.



LEARNING OUTCOMES

After performing this exercise, the learner:

- recognizes the benefits of soil health card;
- analyses the soil health card for understanding the influence of soil properties on crop productivity; and
- recommends suitable practices to maintain soil health, increase yields and ensure agricultural sustainability.

Practical



Notes

WHAT YOU SHOULD KNOW

Soil Health Card (“Swasth Dharaa, Khet Haraa”/ Healthy Earth, Green Farm):

SHC is a printed report that a farmer will be handed over for each of his holdings. It will contain the status of his soil with respect to 12 parameters which include

1. **Primary nutrients:** Nitrogen, phosphorus, potassium
2. **Secondary nutrient:** Sulphur
3. **Micro-nutrients:** Zinc, iron, copper, manganese, boron
4. **Chemical parameters:** pH, electrical conductivity (EC), organic carbon content (OC)

Based on these parameters, the SHC will also indicate fertilizer recommendations and soil amendment required for the farm. Any farmer can apply for a soil health card for his/her land, through District Agriculture Office. A farm will get the soil card once in every 3 years. Generally, soil samples are taken for SHC preparation after harvesting of Rabi and Kharif crop respectively or when there is no standing crop in the field.

Benefits of the Soil Health Card Scheme:

- Farmers will get a proper soil health record, and they will be aware of soil management practices. Accordingly they can plan the future crops and cropping systems on land.
- This card will assist farmers in determining which crops are best for investment and identifying the nutrients their soil lacks. Additionally, it will suggest the appropriate fertilizers, which will eventually result in higher crop yields.

The interpretation of a Soil Health Card (SHC) involves understanding soil properties like pH, organic carbon, salinity, and nutrient levels (N, P, K, micronutrients). It guides farmers on fertilizer application, crop suitability, and corrective measures to address deficiencies or imbalances. This helps optimize resource use, improve yields, and promote sustainable farming practices. Regular soil testing ensures continuous monitoring and soil health improvement.

Practical



Notes

Table 9.1: Rating chart for soil test values of essential nutrients in SHC

Nutrients	Rating		
	Low	Medium	High
Organic carbon (%)	< 0.4	0.4-0.75	>0.75
Nitrogen (kg/ha)	<280	281-560	>560
Phosphorus (kg/ha)	<12.5	12.5-25	>25
Potassium (kg/ha)	<135	135-335	>335
Sulphur (kg/ha)	<22.4	22.4-35	>35
Zinc (mg/kg)	<0.6	0.6-1.2	>1.2
Iron (mg/kg)	<4.5	4.5-9.0	>9.0
Copper (mg/kg)	<0.2	0.2-0.4	>0.4
Manganese (mg/kg)	<3.5	3.5-7.0	>7.0
Boron (kg/ha)	<0.5	0.5-1.0	>1.0

(Source: Handbook of Agriculture, ICAR, New Delhi)

Table 9.2: Rating chart for soil test values of electrical conductivity

Parameter	Saline soil	Non-saline soil
Electrical conductivity (dS/m)	> 4	< 4

Table 9.3: pH rating of soil

Soil rating	pH range
Extremely acidic	<4.5
Very strongly acidic	4.5-5.0

Practical



Notes

Strongly acid	5.1-5.5
Moderately acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3

HOW TO PROCEED

Let us understand how to proceed for interpretation of a Soil Health Card (SHC).

Step - 1: Collection and Documentation**a. Verify the Sample Information:**

Ensure the soil sample is properly labeled with details such as farmer's name, field location, and sample ID.

b. Record Soil Health Parameters:

Include data on soil texture, color, and initial observations.

Step - 2: Understand the Soil Parameters

Identify soil indicators such as pH, organic carbon, electrical conductivity (salinity), and primary and secondary nutrient levels (Nitrogen, Phosphorus, Potassium, micronutrients) and compare the values with rating chart for deficient, sufficient, or excessive ranges.

Step - 3: Data Interpretation

- Compare test results with critical levels or ideal ranges for each parameter.
- Classify the soil as deficient, sufficient, or excessive for each nutrient.
- Identify soil challenges (e.g., salinity, alkalinity, or organic matter deficiency).

Step – 4: Prepare the Soil Health Card

Create a farmer-friendly SHC summarizing:

- Soil test results (parameters and their values).
- Recommendations for fertilizers and crop selection.
- Guidelines for long-term soil health improvement.

Step -5: Communicate Results Effectively

- Explain the SHC findings to farmers.
- Provide hands-on training or demonstrations if necessary.

Example: A farmer from a wheat-growing region brings a soil sample for testing, seeking recommendations for the next cropping season.

1. Collect and Analyze the Sample

- a. **Basic Details:** Record the farmer's name, field location, and soil sample ID.
- b. **Lab Analysis:** Soil tests for key soil parameters are conducted and following results are found.
 - **pH:** 8.2 (slightly alkaline)
 - **Organic Carbon:** 0.35% (low)
 - **Nitrogen (N):** 180 kg/ha (low)
 - **Phosphorus (P):** 25 kg/ha (adequate)
 - **Potassium (K):** 300 kg/ha (sufficient)
 - **Zinc (Zn):** 0.5 ppm (deficient)

2. Interpretation of Results

- ❖ **pH:** The soil is slightly alkaline, which may affect nutrient availability.
- ❖ **Organic Carbon:** Low fertility, indicating poor organic matter.
- ❖ **Nitrogen:** Deficient, which could limit plant growth.

Practical

Notes

Practical**Notes**

- ❖ **Phosphorus and Potassium:** Adequate levels for most crops.
- ❖ **Zinc:** Deficiency may hinder enzymatic functions in plants.

3. Provide Recommendations❖ **For pH Correction:**

Add 1–2 tons/ha of gypsum to neutralize alkalinity.

❖ **For Fertilizers:**

- Urea (Nitrogen): Apply 75 kg/ha during sowing and top-dress based on crop stage.
- Avoid phosphorus fertilizers as P is sufficient.
- No potassium fertilizer is required in current season.

❖ **For Zinc:**

Apply zinc sulfate (21%) at 10 kg/ha.

❖ **For Organic Carbon:**

Incorporate 5–10 tons/ha of farmyard manure or compost before sowing.

4. Crop Suitability Suggestions

- ❖ Recommend wheat as it is suitable for the field conditions, with adjustments made for nutrient deficiencies.
- ❖ Suggest crop rotation with legumes (e.g., chickpeas) to improve nitrogen fixation naturally.

OBSERVATIONS TO BE RECORDED

A soil test report contains following information

- pH – 3.2
- Organic carbon (%): 0.6%
- Nitrogen: 420 kg/ha
- Phosphorus: 5 kg/ha
- Potassium: 165 kg/ha

- Sulphur: 20 kg/ha
- Zinc: 0.2 mg/kg
- Boron: 0.1 kg/ha

Interpret soil test report and present your findings, recommendations, and step-by-step guidance for the farmer in a simple format.

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PRECAUTIONS

- Ensure that soil samples are collected correctly and represent the entire field or specific area being tested.
- Accurately interpret the soil health card parameters.
- Consult with local agronomists or extension specialists who can provide suitable advice based on regional soil characteristics and crop requirements. Local guidelines can significantly enhance the soil health and crop yield.

FOR TEACHER

- Discuss the significance of accurate soil sampling methods and proper soil analysis technique in developing a reliable soil health card
- Help the students to take informed decision based on soil test data

EXERCISE-10

Practical



Notes

Department of Agriculture & Cooperation
Ministry of Agriculture & Farmers Welfare
Government of India

Directorate of Agriculture
Government of Goa

Soil Health Card No. _____

Name of Farmer : _____

Validity : From _____ To _____

SOIL HEALTH CARD		Farmer's Details	
Name			
Address			
Village			
Sub-District			
District			
PIN			
Aadhaar Number			
Mobile Number			
Soil Sample Details			
Soil Sample Number			
Sample Collected on			
Survey No.			
Khasra No. / Dag No.			
Farm Size			
Geo Position (GPS)	Latitude: Longitude:		
Irrigated / Rainfed			

Name of Laboratory					SOIL TEST RESULTS				
S. No.	Parameter	Test Value	Unit	Rating					
1	pH								
2	EC								
3	Organic Carbon (OC)								
4	Available Nitrogen (N)								
5	Available Phosphorus (P)								
6	Available Potassium (K)								
7	Available Sulphur (S)								
8	Available Zinc (Zn)								
9	Available Boron (B)								
10	Available Iron (Fe)								
11	Available Manganese (Mn)								
12	Available Copper (Cu)								

Secondary & Micro Nutrients Recommendations		
Sl. No.	Parameter	Recommendations for Soil Applications
1	Sulphur (S)	
2	Zinc (Zn)	
3	Boron (B)	
4	Iron (Fe)	
5	Manganese (Mn)	
6	Copper (Cu)	
General Recommendations		
1	Organic Manure	
2	Biofertiliser	
3	Lime / Gypsum	

International Year of Soils

2015

Healthy Soils for a Healthy Life

Fertilizer Recommendations for Reference Yield [with Organic Manure]				
Sl. No.	Crop & Variety	Reference Yield	Fertilizer Combination-1 for N P K	Fertilizer Combination-2 for N P K
1	Paddy (Dhaan)			
2				
3				
4				
5				
6				

Fig. 10.1: Soil health card

You may explore School Soil Health Card Library through the following link (<https://soilhealth.dac.gov.in/school-library>) to know more about soil testing and soil health.

COLLECTION AND IDENTIFICATION OF COMMON PLANT DISEASES



Notes

Agricultural crops suffer heavily due to diseases and pests. It is essential to have basic knowledge about different kinds of plant diseases and their methods of management to avoid enormous yield loss. The collection and identification of plant diseases are crucial steps in understanding, diagnosing, and managing crop health. The basic steps involve field observation, collection of samples showing typical disease symptoms and laboratory analysis. In this exercise, you will learn about schematic steps followed in correct identification of common diseases.



LEARNING OUTCOMES

After performing this exercise, the learner:

- recognizes scientific procedure to identify various plant disease causing biotic agents;
- infers diagnostic methods to monitor and predict disease outbreaks; and
- recommends appropriate management practices for their control.

WHAT YOU SHOULD KNOW

To effectively understand and carry out the process of collecting and identifying plant diseases, you should have sound knowledge in the following aspects:

- Collection of plant diseases involves sampling infected plant parts (i.e., leaves, stems, roots) under proper field conditions to avoid contamination.
- It's essential to ensure the disease symptoms are well-preserved for accurate diagnosis in the lab.

Practical**Notes**

- Proper identification requires knowledge of disease symptoms (such as lesions, molds, or discoloration) and their association with specific pathogens.
- Laboratory techniques like microscopic examination, culturing, and molecular methods (PCR) help identify fungal, bacterial, viral, and nematode pathogens.
- Accurate diagnosis aids in selecting appropriate management strategies for controlling plant diseases.

Culturing is essential techniques in microbiology used to grow and study microorganisms under controlled conditions. These techniques allow scientists to isolate, identify, and analyze microbial species for various applications, including research, diagnostics, and industrial processes.

Polymerase Chain Reaction (PCR) is a laboratory technique used to make many copies of a specific segment of DNA. It is like a photocopy machine for DNA. It allows scientists to take a tiny amount of DNA and create millions or even billions of identical copies. This is crucial for studying genes, diagnosing diseases, and forensic analysis.

HOW TO PROCEED

Let us understand how to proceed for identification and collection of common diseases of plants.

Step - 1: Initial Observation and Collection of infected plants from crop fields:

- ❖ **Select affected plants:** Examine the plant samples visually exhibiting typical symptoms of disease (e.g., wilting, discoloration, spots, lesions, or mold growth).
- ❖ **Collect samples carefully:** Use clean, sharp tools to cut the infected parts, such as leaves, stems, or roots and place them in a sterile container or paper bag.
- ❖ **Label samples:** Note down important details such as the plant species, location, date, and observed symptoms on aluminum tags to assist in diagnosis. Record symptoms carefully, noting the severity and distribution of the disease.

Practical

Step - 2: Transport and Preservation:

- ❖ Transport samples to the lab as soon as possible, ensuring they remain in a cool, dry condition.
- ❖ If immediate transport is not possible, preserve the sample by drying it or storing in a refrigerator or in ice box.

Step - 3: Identification Methods:

- ❖ **Microscopic examination:** Observe microscopic structure of pathogens (fungal hyphal structure, mycelium, conidia, fruiting bodies), bacterial (cell shape, arrangement) and viral (characteristic shape like helical, icosahedral or complex form) under a microscope.
- ❖ **Culturing:** If necessary, isolate the pathogen by culturing on selective media to identify fungal or bacterial organisms. However, for viral diseases as they are unculturable and only live on live host (obligate parasites), mechanical sap inoculation and propagating method are best method to maintain its culture.
- ❖ **Molecular techniques:** Use PCR (Polymerase Chain Reaction) or DNA sequencing for precise pathogen identification, especially for viruses or difficult-to-culture organisms under *in vitro* condition (laboratory condition).



Notes

Step – 4: Confirming/ Diagnosis:

- ❖ Compare findings with known disease symptoms and pathogen descriptions from authenticated books of plant pathology or manual.
- ❖ Seek expert advice from scientist or use diagnostic keys for specific pathogens, if needed.

Step -5: Disease Management:

- ❖ Once identified, diagnose the disease with appropriate management (e.g., chemical treatments of fungicides, bactericides, and pesticides), cultural practices (proper spacing, soil health and irrigation management), and resistant varieties (resistant or tolerant to specific diseases).

Let's understand the above-mentioned steps with an example.

Example: Wheat Rust Disease (*Puccinia* spp.)

Practical**Notes**

Objective: To collect and identify the visual symptoms as well as manage the wheat rust disease

Wheat Rust Disease (*Puccinia* spp.) is one of the most economically significant plant diseases, with major impacts on wheat production globally. There are three main types of wheat rust: **stem rust**, **leaf rust**, and **yellow (stripe) rust**.



Fig. 11.1: Stem rust of wheat

A. Field Collection:

- **Location:** Look for wheat fields showing symptoms of rust, typically during the growing season (spring or early summer).
- **Sampling:** Collect samples from different areas within the field to capture variation in infection severity. Collect leaves, stems, and heads that show signs of the rust (yellow, orange or red pustules).
- **Symptom Observation:**
 - ❖ **Stem Rust (*Puccinia graminis*):** Red or brown pustules on the stems.
 - ❖ **Leaf Rust (*Puccinia triticina*):** Small, reddish-orange pustules on leaves, often with a powdery appearance.
 - ❖ **Yellow (Stripe) Rust (*Puccinia striiformis*):** Yellow to orange, linear pustules that appear in rows on the leaves.

B. Lab Identification:**● Microscopic Examination:**

- ❖ Use a light microscope to examine pustules and spores. Rust fungi produce distinctive urediniospores (repeating asexual spores), which are orange to red and oval or globose.
- ❖ Identify rust based on spore morphology (size, shape, and color).

● Spore Sampling (optional activity): If necessary, collect spores from the pustules and culture them on selective media to confirm the pathogen.**● Molecular Methods (optional activity):** PCR (Polymerase Chain Reaction) or DNA sequencing may be used for precise pathogen identification, especially in cases of mixed infections or unknown strains.**C. Management of Wheat Rust disease****a) Preventive Measures:**

- ❖ **Resistant Varieties:** Plant wheat varieties resistant to rust pathogens may be cultivated. Continuous breeding for resistance is essential, especially against emerging new strains of rust (Example: HD 2967, Pusa Gowthami).
- ❖ **Early Planting:** Delaying planting can reduce exposure to early-season rust infections, particularly in areas with a history of rust outbreaks.

b) Cultural Practices:

- ❖ **Crop Rotation:** Rotate wheat with non-host crops to reduce rust spore buildup in the soil and surrounding areas.
- ❖ **Field Hygiene:** Remove and destroy infected plant debris after harvest to minimize overwintering spores.
- ❖ **Proper Spacing and Air Circulation:** Ensure good plant spacing for better airflow, which reduces the ideal humid conditions for rust development.
- ❖ **Avoid Overcrowding:** Crowded crops increase the chances of rust

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spreading due to higher humidity in the canopy.

c) **Chemical Control:**

- ❖ **Fungicides:** Use fungicides (e.g., Triadimefon, Folicur 250W, Tebuconazole, Azoxystrobin) to protect crops from rust infection, especially during early and mid-season when the disease is most active. Apply fungicides based on a disease threshold or monitoring data.
 - **Application Timing:** Fungicides are most effective when applied before visible symptoms appear or at the first sign of infection.
 - **Rotating Fungicides:** To avoid resistance development, rotate fungicides with different modes of action.

d) **Biological Control:**

- ❖ Use biocontrol agents like *Trichoderma asperellum* or *Bacillus subtilis* that have shown promise in inhibiting rust growth and protecting plants from infection.

e) **Integrated Disease Management (IDM):**

- ❖ **Monitor Disease Progression:** Regularly monitor wheat fields for rust outbreaks using disease forecasting systems, which track environmental conditions conducive to rust infection.
- ❖ **Integrated Approach:** Combine resistant varieties, cultural practices, fungicides, and biological control for effective and sustainable management.
- ❖ **Early Warning Systems:** Use satellite imagery and weather forecasting tools to predict rust outbreaks and prepare for timely interventions.

f) **Post-Harvest Management:**

- ❖ **Storage Conditions:** After harvesting, ensure proper grain storage conditions to prevent fungal growth in the stored wheat.
- ❖ **Handling:** Avoid mechanical damage during harvest and storage, as injured plants are more susceptible to secondary infections.

OBSERVATIONS TO BE RECORDED

Visit the prominent crop fields in your area or examine the plants in your surroundings. Identify any diseases affecting the crops and attempt the following exercises.

Observation 1

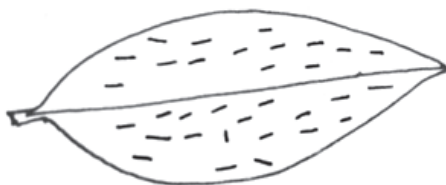
Categorize the disease samples that you collected from the crop field/garden into the specified groups. Mark the appropriate places with tick marks.

Sl. No.	Name of the disease	Disease causing agent		
		Bacterial disease	Fungal disease	Viral infection
1.	Stem rust of wheat		✓	

Observation 2

Draw the plant disease symptoms that you observed during plant sample collection in your nearby places.

1. Rust



2. Blight

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*Notes***Activity 1**

Prepare a herbarium sheet of different plant diseases with the following details (Site of collection, date of collection, Name of the disease, name of the collector).

PRECAUTIONS

- Always use sterilized tools such as knives, and containers to avoid cross-contamination between plants.
- Wear gloves and masks to protect yourself from potential pathogens.
- Collect multiple samples from the affected plant to get a comprehensive understanding of the disease.
- Accurately diagnose plant diseases, as symptoms can often be mistaken for nutrient deficiencies or insect infestations.

FOR TEACHER

- Train the learners to recognize disease symptoms precisely like spots, discoloration, wilting, or abnormal growth patterns.
- Provide students with access to identification guides, textbooks, and online resources to help them accurately diagnose plant diseases.

IDENTIFICATION OF INSECT PESTS OF CROP PLANTS



Notes

Insects are the most abundant living creature on earth. Some of them are quite helpful while others are harmful for humans. Insects that cause economic loss to humans are referred to as pests. The identification of pests of plants is a critical step in effective pest management. Different insects require different methods for their removal or control. If we know which insect is causing the nuisance, we can use the best method to control it without harming other helpful insects. Successful pest identification involves recognizing the pest's characteristics, specific symptoms on plants, understanding its life cycle, feeding habits and damage. In this exercise, you are going to learn about the sequential processes to identify and diagnose insect pests for providing the right solution at right time.



LEARNING OUTCOMES

After performing this exercise, the learner:

- identifies the common types of plant pests (e.g., insects) and their specific characteristics on the basis of their physical features;
- diagnoses pest-related problems in plants using visual symptoms (e.g., damaged plant parts, presence of pests or pest excretions like honeydew);
- recognizes how each developmental stages of insect (e.g., eggs, larvae, pupae, adult) contributes to plant damage; and
- applies suitable pest control measures based on the pest species, plant type, and environmental factors.

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Notes

WHAT YOU SHOULD KNOW

For the identification of pests of plants, you should know the following:

1. **Pest Characteristics:** Understand the physical traits of common pests, such as size, shape, color and feeding behavior (e.g., sap-sucking or root feeders).
2. **Symptoms of Infestation:** Recognize plant damage symptoms like leaf discoloration, wilting, holes, and the presence of excretions such as honeydew.
3. **Life Cycle and Behavior:** Learn the life cycles of pests to identify the stages (e.g., eggs, larvae, adults) and when they are most active or damaging.
4. **Damage Patterns:** Identify how different pests affect plants, such as defoliation, fruit damage, or stunted growth.
5. **Control Measures:** Be familiar with methods for pest control, such as cultural practices, biological control, and chemical treatments.

MATERIALS REQUIRED

- | | |
|---|---------------------------|
| 1. Small vial/containers | 2. Plastic bags |
| 3. Notebook and pen | 4. Gloves |
| 5. A magnifying glass/a hand lens/
microscope (optional) | 6. 70% ethanol (optional) |

HOW TO PROCEED

Let us understand how to proceed for identifying pests of plants.

Step - 1: Initial Observation:

Examine the Plant Parts: Start by inspecting the overall health of the plant. Look for any signs of stress, such as wilting, yellowing leaves, or stunted growth.

- **Leaves:** Check both sides of leaves for pests like aphids, whiteflies, and caterpillars. Look for feeding marks (holes, spots, or yellowing) and any excretions like honeydew or frass.
- **Stems and branches:** Inspect for pests such as scale insects, mealybugs, or borers. Look for small, white, waxy masses or entry holes.

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- **Roots:** If you suspect root-feeding pests (like nematodes or root weevils), gently remove some soil around the roots to check for galls or other damage.

Examine the visible pests

- **Physical inspection:** Using a magnifying glass or a hand lens, look for the pests themselves—small insects like aphids, mites, or thrips may be hard to see with the naked eye.
- **Check for webbing and pest eggs and larvae:** Observe fine silk webbing around leaves or stems that may indicate spider mites or webworms. Inspection of tiny, clustered eggs on underside of leaves or stem and larvae in soil or feeding on plant tissue.
- **Signs of movement:** Some pests, such as caterpillars or beetles, may be visible feeding on plant tissue.

*Notes***Step - 2: Proper Packaging and Storage**

- **Preserve Specimens:** For insect pests, place them in small vials or containers with a little alcohol (usually 70% ethanol) to preserve the specimen. For larger pests (e.g., caterpillars or beetles), place them in an airtight container.
- **Label Samples:** Properly label all field samples with important information like the plant species, date of collection, location (GPS coordinates), and symptoms observed. This is crucial for accurate identification and further research.
- **Maintain Plant Samples:** If you are collecting plant material (e.g., leaves or roots), ensure they are kept in a cool place, such as a plastic bag with ventilation holes or a cooler. For tissue samples, place them in a sterile, sealed container to prevent decay.

Step - 3: Identification Methods:

- **Initial Inspection:** In the laboratory, begin by thoroughly examining the collected pests using a magnifying lens or microscope.
- **Taxonomic Identification:** If necessary, compare the samples with known pest species in field guides, identification keys, or pest databases to identify the pest to species level.
- **Morphological Identification:** Use the microscope to observe minute details like wing venation, mouthparts, and other distinguishing features that can help identify the pest at a higher taxonomic level (e.g., family or genus).

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- **Check for Eggs or Larvae:** Examine plant material for eggs, larvae, or pupae. These life stages often provide additional clues about the pest species.

Step – 4: Confirming Diagnosis using pest and pathogen analysis:

- **Diseases Pests:** If the pest appears to be causing a disease (e.g., fungi, bacteria or viruses), culture the pathogen or using molecular tools like PCR to identify the specific pathogen.
- **Damage Patterns:** Assess whether the pest is a direct feeder (e.g., chewing or sucking) or a vector/carrier for other plant diseases.
- **Examine Damage Effect:** In the case of suspected root-feeding or soil-dwelling pests (e.g., nematodes, grubs), lab tests might include extracting soil samples to check for pest larvae or egg presence.

Step -5: Pest Management:

- Once identified through entomologist or reference collection, determine the appropriate pest management strategies (e.g., chemical, biological, or cultural methods) tailored to the identified pest species.

Let's understand the procedure to identify the insect-pests with as example of Pink Bollworm (*Pectinophora gossypiella*)

Step 1: Initial Observation

- ❖ **Plant Symptoms:** Cotton plants will be monitored for shedding of squares and bolls, and rosette-shaped holes on some bolls, with lint likely to be stained by larval excreta.
- ❖ **Bolls:** Damaged bolls will be opened to check for small pink larvae feeding on the seeds inside.
- ❖ **Leaves and Stems:** The leaves and stems will also be inspected for signs of pest activity, although these are unlikely to show visible damage.

Step 2: Proper Packaging and Storage

- ❖ **Preservation:**
 - Larvae collected from the bolls will be preserved in vials containing 70% ethanol.

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- Damaged bolls will be stored in a labeled plastic bag with ventilation holes, indicating plant details, collection date, and location.

Step 3: Identification Methods❖ **Morphological Identification:**

- Using a magnifying lens, the larvae will be observed for their pinkish coloration and four pairs of abdominal prolegs, which are characteristic of the pink bollworm.
- Adult moths will be captured using pheromone traps to confirm species identification. The adults are expected to have dark brown forewings with fringes and whitish hindwings.

Step 4: Confirming Diagnosis

- ❖ **Damage Pattern:** The larvae will likely cause internal seed destruction, lint staining, and boll rotting, consistent with pink bollworm damage.
- ❖ **Life Cycle Stages:** Eggs laid near the bracts, larvae feeding inside bolls, and adult moths captured in pheromone traps will confirm the life cycle stages.



Fig. 12.1: Adult moth and larvae of Pink bollworm (*Pectinophora gossypiella*)

Step 5: Pest Management

- ❖ **Cultural Control:** The leftover cotton stalks and crop residues will be removed to eliminate overwintering larvae

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- ❖ **Biological Control:** Release of *Trichogramma chilonis*, a parasitoid targeting pink bollworm eggs, will be planned.
- ❖ **Chemical Control:** Insecticides such as emamectin benzoate will be applied during early larval stages to control the infestation.
- ❖ **Integrated Pest Management (IPM):** Pheromone traps will be used for monitoring and mating disruption, along with the cultivation of resistant cotton varieties (e.g., Bt cotton).

OBSERVATIONS TO BE RECORDED

Explore the plants in your garden or major crop fields in your locality. Search for presence of insect pests in plant and observe how their activity is affecting plant or plant parts. You should take a detailed observational note for each insect encountered. Try to complete the following exercises.

Observation 1

List out the insects that are commonly found in your area/locality and identify their habitat and nature of damage symptoms.

Sl. No.	Name of insects	Type of habitat	Damage symptoms
1.	Tobacco caterpillar (<i>Spodoptera litura</i>)	Leaves of tomato	Caterpillars feed aggressively on leaves, large and irregular holes in the leaves, in severe cases plants are completely defoliated.

Observation 2

Classify the insects that you have found according to their feeding habit. Mark the appropriate places with tick marks.

Sl. No.	Name of insects	Beneficial/harmful to plants	Feeding habit	
			Chewing mouth parts	Piercing and sucking mouth parts
1.	Tobacco caterpillar	Harmful	✓	

PRECAUTIONS

- Collect insects without causing harm to their natural habitat.
- Avoid toxic species and identify potentially harmful insects (e.g., those carrying venom or diseases) and handle them with extra care.
- While collecting the insects, wear gloves, long-sleeved shirts, and closed footwear to prevent insect bites or stings.
- Use nets or forceps to handle insects, avoiding direct contact.

FOR TEACHER

- ❖ Explain the methods and safety precautions for collecting and identifying insect pests.
- ❖ Guide the learners in selecting safe, secure and accessible locations for collection, considering environmental and legal restrictions.

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- ❖ Monitor the learners closely to prevent accidents, insect bites, or exposure to harmful species.
- ❖ Provide appropriate tools like nets, forceps, jars, and labels, as well as field guides or identification manuals to the learners.

CALCULATION OF PESTICIDE REQUIREMENT OF CROPS



Notes

Protecting agricultural crops from insect and disease attack is a crucial step in the crop production process. Generally different types of pesticides are applied to control a variety of pests infesting the agricultural field. However, it has been found that pesticides are often administered in excess quantity which results in contamination of food and water, environmental pollution, human health hazards and decline in beneficial organisms. Therefore, determining the optimal amount of pesticides needed for a specific area is essential to prevent the negative side effects associated with pesticide application.



LEARNING OUTCOMES

After performing this exercise, the learner:

- identifies the relationship between pesticide formulation, dosage, and water volume;
- calculates the pesticide requirement of an area based on recommended dosage;
- prepares and applies pesticides safely following recommended guidelines.

MATERIALS REQUIRED

1. Pesticide label or usage guide (containing recommended dosage).
2. Measuring cylinder or balance (for liquid and powder formulations).
3. Notebook and pen for recording observations and calculations.
4. Sprayer equipment with specified water capacity.
5. Calculator.

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WHAT YOU SHOULD KNOW

Pesticides are chemical substances that are developed to prevent, destroy, repel, or mitigate pests such as weeds, insects, and fungi that can affect crop growth and yield. They are composed of two types of ingredients i.e. active ingredient (a.i.) and inert ingredient.

a. Active Ingredient (a.i.):

The chemical in a pesticide that is directly responsible for the toxicity of the product is known as active ingredient. These chemicals are primarily responsible for the inhibition or killing of pests. The active ingredient of each pesticide formulation is displayed by the manufacturer on its package. Generally they are expressed as percents by weight or by volume.

b. Inert Ingredient

These chemicals do not create toxicity against pests but are essential for effective formulation and application of the pesticide. They include solvent (helps to dissolve active ingredients), emulsifier (helps to form stable solution) and surfactants (improves the ability of the pesticide to spread and adhere to surfaces).

The mixture of active and inert ingredients that is designed to improve the handling, storage, application, and overall effectiveness of pesticides is called **pesticide formulation**.

Types of pesticide formulations:

A. Emulsifiable Concentrate (EC)

An EC is a liquid formulation where the active ingredient is dissolved in an organic solvent and combined with emulsifiers. When mixed with water, it forms a milky emulsion. It possesses specific characteristics that include

- Easy to mix with water
- It requires less agitation during application.
- Suitable for foliar sprays

Advantages:

- High effectiveness on pests due to uniform coverage

- Long shelf life

Disadvantages:

- Can be phytotoxic (cause plant damage) if overdosed
- Risk of skin absorption, so protective equipment is necessary

Example: Chlorpyrifos 20% EC.

B. Wettable Powder (WP)

WP is a dry, powdery pesticide formulation that contains the active ingredient combined with a wetting agent. When mixed with water, it forms a suspension. It requires constant agitation to maintain uniformity in the spray tank. Generally it is applied as a foliar spray.

Advantages:

- Less risk of phytotoxicity compared to EC formulations
- Stable and safe for long-term storage

Disadvantages:

- Can cause wear and tear on sprayer nozzles due to abrasiveness
- Dusty, which may pose inhalation risks during handling

Example: Carbendazim 50% WP

C. Suspension Concentrate (SC)

SC formulations are stable, water-based suspensions of finely ground active ingredient particles. It is a ready-to-use liquid formulation that requires less agitation than WP.

Advantages:

- Low risk of inhalation during mixing
- Easy to apply with minimal drift

Disadvantages:

- May settle in storage if not properly shaken before use

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Practical**Notes**

Example: Difenoconazole 25% SC

D. Dustable Powder (DP)

DP formulations are dry powders applied directly to crops without mixing in water. They are used for seed treatments or surface applications.

Advantages:

- Easy to apply in certain situations (e.g., in dry conditions)
- Good for treating localized areas

Disadvantages:

- High risk of drift during application
- Not suitable for large-scale applications

Example: Sulfur 85% DP

E. Granules (G)

Granules are solid formulations where the active ingredient is coated onto or absorbed into granular materials. They are applied directly to the soil and effective for systemic pesticides or soil pests.

Advantages:

- Minimal drift during application
- Long-lasting effect as it releases slowly

Disadvantages:

- Not suitable for foliar pests

Example: Carbofuran 3% G

F. Water-Dispersible Granules (WDG) or Dry Flowable (DF)

WDG formulations are granules that break down into fine particles when mixed with water, forming a suspension.

Key Features:

- Similar to WP but with reduced dustiness.

Advantages:

- Safer to handle than WP
- Mixes easily with water

Disadvantages:

- Requires agitation to maintain uniformity in the spray tank

Example: Azoxystrobin 50% WDG

G. Soluble Concentrate (SL)

SL is a liquid formulation where the active ingredient is dissolved completely in water. It forms a true solution when mixed with water.

Advantages:

- No agitation required during application
- Easy to measure and mix

Disadvantages:

- Limited to active ingredients that are water-soluble

Example: Glyphosate 41% SL

HOW TO PROCEED**Step 1: Understand the Pesticide Details**

- Read the pesticide label carefully to determine:
 - ❖ The recommended dosage (e.g., ml/ha for liquid or kg/ha for powder).
 - ❖ The concentration of the pesticide (e.g., 25% EC, 50% WP).
 - ❖ Safety instructions for handling and application.

Step 2: Measure the Spray Volume

- Determine the volume of water required per hectare for the sprayer being

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used. For instance:

- ❖ For high-volume sprayers, typically 400-500 litre of water is required per hectare.
- ❖ For low-volume sprayers, 150-200 litre of water may suffice.

Step 3: Calculation of Pesticide Requirement

- Calculate the required amount of pesticide use the following formula

$$\text{Pesticide required} = \frac{\text{Recommended dosage} \times \text{Area}}{\text{Spray volume}} \times 100$$

Where,

- **Recommended dosage** is the amount specified by the pesticide label (e.g., ml/ha or kg/ha).
- **Area** is the land size in hectares (usually 1 ha for this calculation).
- **Spray Volume** is the total volume of water required to spray 1 hectare.

Or

$$\text{Pesticide required (kg)} = \frac{100 \times R \times A}{P}$$

Where,

- R is rate of application in kg a.i./ha
- A is area to be applied in hectares
- P is percent (%) active ingredient in commercial product

Let's understand the procedure to calculate the pesticide requirement of an area with an example.

For Liquid Formulation:

Question 1: Calculate the amount of Chlorpyrifos 20% EC required for 1 hectare area from following information.

- **Pesticide:** Chlorpyrifos 20% EC

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- **Recommended dosage:** 20 ml per 10 litre of water
- **Target pest:** Cotton bollworm
- **Spray volume:** Typically, 500 litre of water per hectare for cotton crops.

Step 1: *Understand the recommendation*

The pesticide dosage is given as 20 ml per 10 litre of water. We need to calculate the total amount of pesticide required for 1 hectare area based on the total spray volume (500 litre per hectare).

Step 2: *Determine total water requirement*

Water required for 1 hectare is 500 litre.

Step 3: *Calculation of pesticide requirement*

Using the given dosage (20 ml. pesticide per 10 litre of water), we can calculate the pesticide amount for 1 hectare area.

1 litre of water requires $(20 \div 10) = 2$ ml of Chloropyriphos

Then, 500 litre of water requires $(500 \times 2) = 1000$ ml of Chloropyriphos = 1 litre of Chloropyriphos

Step 4: *Prepare the spray Mixture*

Mix 1 liter of Chlorpyrifos 20% EC in 500 litre of water in the sprayer tank.

- Stir the solution thoroughly to ensure uniform mixing.

Step 5: *Application*

- Spray the mixture evenly across 1 hectare of cotton, targeting areas where bollworms are present or suspected.

For Powder Formulation

Question 2: Calculate the amount of Carbendazim 50% WP required to be applied in 0.5 ha maize field for controlling fungal disease.

- **Pesticide:** Carbendazim 50% WP
- **Recommended Dosage:** 350 g a.i./ha



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Calculation:

- We know that 1 ha area = 10,000 m² area. So, 0.5 ha area = $(10,000 \times 0.5) = 5,000 \text{ m}^2$ area
- 10,000 m² area requires 350 g a.i. fungicide, so 0.5 ha or 5000 m² area requires $(350/2) = 175 \text{ g a.i.} = 0.175 \text{ kg a.i.}$
- Carbendazim 50% WP indicates that commercial product of Carbendazim has 50% active ingredient (a.i.). Therefore,
 - ❖ 50 unit of a.i. is available in 100 unit of Carbendazim
 - ❖ 1 unit of a.i. is available in $(100 \div 50) = 2$ unit of Carbendazim
 - ❖ 0.175 unit of a.i. is available in $2 \times 0.175 = 0.35$ unit of Carbendazim or 0.35 kg of Carbendazim.
- So, 0.35 kg or 350 g of Carbendazim is required for application in 0.5 ha maize field.

Otherwise, you can directly use formula for calculation.

Pesticide required (kg) = $(100 \times 0.35 \times 0.5) \div 50 = 0.35 \text{ kg/350 g}$

Note: You should strictly follow the units recommended for different parameters when using formula for herbicide calculation.

OBSERVATIONS TO BE RECORDED

- 1) Atrazine 50 WP @ 0.5 kga.i./ha is required for controlling broadleaf weeds in maize field. Calculate the quantity of Atrazine 50 WP required for 20 m² area.

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Practical



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- 2) Calculate the amount of Glyphosate 41% SL required for a 2-hectare area if the recommended dosage is 5 ml per litre of water and the spray volume is typically 300 litre per hectare.

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- 3) Determine the amount of Mancozeb 75% WP required for treating a quarter-hectare area when the recommended dosage is 2 kg per hectare.

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- 4) How much Imidacloprid 17.8% SL is needed for a half-hectare area if the recommended dosage is 15 ml per hectare and the spray volume is 200 litres?

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Practical**Notes**

- 5) Calculate the amount of Fipronil 20% SC required for a 0.3 ha rice field for controlling rice stem borer. The recommended dosage of Fipronil 20% SC is 250 g a.i./ha.

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- 6) Determine the quantity of *Bacillus thuringiensis* (Bt) 10% WP needed for a 2-hectare vegetable field to manage caterpillar pests given that the recommended dosage is 500 g of active ingredient (a.i.) per hectare.

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PRECAUTIONS

1. Ensure accurate measurements to avoid over- or under-application.
2. Always use clean water for mixing pesticides.
3. Dispose of leftover pesticide solution and containers as per safety guidelines.

FOR TEACHER

- Provide foundational knowledge about different pesticide formulations required for accurate calculation of pesticides.
- Show the learners the step-by-step procedures to measure pesticides for certain areas.
- Explain the potential risk and safety protocols to be followed during the handling of pesticides by learners.

ESTIMATION OF POST-HARVEST LOSSES IN FRUITS AND VEGETABLES



Notes

The world is facing serious concerns regarding the starvation of the population. This is result of the inability to use natural resources in a fair, rational, and sustainable manner that supports fair food supply, labour, land, clean water and agricultural input. Reduced postharvest loss can save scarce resources, make agriculture more environmentally friendly, and improve food security by reducing losses of fresh produce instead of increasing production volumes. Losses occur at every stage from the farm until it reaches the consumer. It is essential to estimate these losses at every point which can be done through suitable sampling methods.



LEARNING OUTCOMES

After performing this exercise, the learner:

- demonstrates the necessity of post harvest management of food crops and
- manages the post-harvest losses in fruits and vegetables through their precise estimation.

WHAT YOU SHOULD KNOW

Post-harvest food loss accounts for both the loss of quantity as well as quality of produce which makes it unacceptable for consumption. These are influenced by many factors like temperature, humidity, mechanical injury, mode of transportation, packaging etc. Quantification can help keep track and check on the post-harvest losses. Accordingly, an action plan can be set up for the reduction of losses.

Estimating post-harvest moisture loss involves evaluating the reduction in moisture content from harvested produce or materials due to drying or storage conditions. This

Practical**Notes**

is essential for quality preservation, economic viability, regulatory compliance, and resource efficiency.

MATERIALS TO BE REQUIRED

- Fruit/vegetable samples
- Weighing balance

HOW TO PROCEED

1. Collect samples like fruits or vegetables from the market/farm.
2. Weigh the samples on weighing balance immediately and record it.
3. Keep the samples in normal temperature and pressure for seven days.
4. Again weigh the samples after seven days.
5. Calculate the difference in weight and express it as per cent.

Calculations:

Suppose, weight of the samples at initial stage = W_1

Weight of the samples after seven days = W_2

$$\text{Loss in weight (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

PRECAUTIONS

- Select representative samples that reflect the typical quality and size of the produce.
- Weigh the produce immediately after collection. Any delay can cause error estimation of post-harvest weight loss.
- Avoid excessive handling to prevent bruising or damage, which accelerates spoilage and weight loss.

RECORDING OF OBSERVATION

1. Collect the data given in the table and calculate the loss of weight of samples in percentage.

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	Initial weight	Final weight	Loss in weight (%)
Sample 1			
Sample 2			

2. Explain the probable reasons for loss in weight of the samples.

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FOR THE TEACHER

- Explain the effect of external factors like temperature changes, level of humidity, pest infestation and physical handling on post-harvest loss of agricultural products.
- Guide the learners in collecting the representative samples.



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IDENTIFICATION OF VARIOUS FOOD STORAGE STRUCTURES

The food products are prone to infestation by insects, rodents, birds, fungi, yeasts, bacteria and other pests which decrease their nutritional value and consumers' preferences. Around one-third of the food produced in India is wasted due to improper storage. Food storage helps mitigate the variability of food supply due to seasonal changes or unforeseen events. By storing food, it can be consumed over an extended period, ensuring availability during lean seasons or emergencies. By storing their produce well, farmers can prevent price declines during harvest seasons and sell their produce at the best times.



LEARNING OUTCOMES

After performing this exercise, the learner:

- differentiates between traditional and modern storage structures;
- identifies the different structures used for storing food grains; and
- illustrates modern storage facilities found in India.

WHAT YOU SHOULD KNOW

Food is a perishable commodity and therefore it must be kept in a favorable environment after harvesting to reduce losses. Storage structures provide this favourable environment to harvested products. Such structures can be classified into two groups

- a) **Traditional structure:** The earthen pots, mud bins, underground pits, baskets are the examples for traditional storage structures. In India, majority of the grains are stored by traditional methods which do not protect them from biotic and abiotic agents.

Practical

- b) **Modern structure:** The modern storage structure includes covered storage, Cover and Plinth method (CAP), silos and silo bag technique. Compared to traditional methods, they provide more protection and shelf life of the food grains.

Proper use of storage structures can significantly reduce the food wastage which also has a positive impact on the environment. Creating an effective food storage structure involves several practical considerations to ensure the safety and longevity of stored food grains.

MATERIALS TO BE REQUIRED

- 1) Notebook
- 2) Pen
- 3) Pencil
- 4) Measuring tape

HOW TO PROCEED

1. Visit to local mandi, fruit vendor and farmer's house.
2. Observe the different storage structures used by them to store the grains.
3. Make a diagram/sketch of the structures. You may take photograph of the storage structure.
4. Record the characteristics of the specific storage structures (e.g. height, width, constructional material, longevity, any other arrangement inside storage structure).

OBSERVATIONS TO BE RECORDED

Observation 1:

Illustrate the diagram of the commonly found storage structures found in your locality and write their specifications. Try to group them into traditional and modern structures.

Name of the structure	Diagram	Characteristics



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Practical*Notes***Observation 2:**

Collect the picture of the following modern storage structures and place them in suitable places. Also briefly describe their specifications.

1.	Silos	
2.	Zero energy cooling chamber	
3.	Cover and plinth	
4.	Silo bag technique	

PRECAUTIONS

- Ensure good ventilation during identification of closed storage spaces to avoid inhaling dust, mold spores, or harmful gases.
- Wear the proper safety equipment, such as masks, gloves, and occasionally eye protection, particularly when examining dusty or possibly polluted storage spaces.
- Be cautious around older structures that may have deteriorated and pose a risk of collapse.

FOR THE TEACHER

- Ensure the safety of learners while inspecting the food storage facilities.

PLATFORM TESTS OF RAW MILK



Notes

Milk and milk products are convenient sources of nutrition for people in many countries. But they are highly susceptible to adulteration and can easily become contaminated with microbes. As a result, it is essential to assess the quality of milk through platform tests. Platform tests or milk reception tests are the commonly used names for the tests carried out during raw milk collection and/or reception. These tests are rapid quality control tests, simple to perform and do not require any specialized or advanced equipment. Temperature measurement, organoleptic tests, clot-on-boiling test (COB), pH, titratable acidity, sediment test, alcohol test and direct microscopic count (DMC) are some of the examples of platform tests.

Sl. No.	Name of platform test	Purpose
1.	Temperature measurement	To assess the extent of microbial growth in milk
2.	Alcohol test	To determine fitness of milk for heat processing
3.	Clot-on-boiling test	To detect acidity or any early stages of milk spoilage
4.	pH/acidity of milk	To measure the freshness of the milk
5.	Organoleptic test	To determine the milk quality from its external appearance like colour or smell

Practical



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LEARNING OUTCOMES

After performing this exercise, the learner:

- explains the importance of temperature in preservation of milk;
- demonstrates the skill to determine the acidity level of raw milk;
- recommends the suitability of milk for heat processing;
- identifies the level of spoilage in milk samples;
- assesses the freshness of the milk at his/her disposal; and
- determines the milk quality from its external appearance like colour or smell.

EXERCISE 16.1: MEASUREMENT OF THE TEMPERATURE OF THE RAW MILK

In the dairy business, measuring the temperature of raw milk is important for a number of reasons. Ensuring the safety, quality, and regulatory compliance of dairy products is contingent upon maintaining the appropriate temperature throughout the milk processing chain.

WHAT YOU SHOULD KNOW

The handling and transportation of the raw milk must be done under refrigerated conditions. To maintain the temperature in the safe zone, the bulk milk is transported at 4-5°C or below. Milk temperature above 7°C indicates improper transportation and the possible microbial growth in the lot.

MATERIALS TO BE REQUIRED

- 1.) Dipper
- 2.) Beaker
- 3.) Calibrated thermometer

HOW TO PROCEED

- Take milk sample in a beaker from the lot with the help of sampler or dipper.
- Dip a clean thermometer within the milk and note the temperature of the sample.

- Care must be taken that the sample should be uniform and representative of the bulk.

PRECAUTIONS

- Make sure thermometers are routinely calibrated before using them to measure the temperature of milk.
- Insert the thermometer directly into the milk for a sufficient duration (approximately 15 seconds) to obtain an accurate reading.
- Keep milk samples away from direct sunlight and heat sources to prevent spoilage.

OBSERVATIONS TO BE RECORDED

	Sample 1	Sample 2
Temperature of milk (°C/°F)		
Interpretation/Remarks		

EXERCISE 16.2:ALCOHOL TEST

The quality of milk can be judged through the alcohol test. It can also help determine the milk's susceptibility to coagulation, heat stability, and salt balance. The alcohol test serves as an essential tool for ensuring that raw milk meets quality standards before further processing. By identifying potentially unstable milk, dairy producers can maintain product integrity and consumer safety.

WHAT YOU SHOULD KNOW

Alcohol test is used for rapid determination of elevated acidity of milk. Alcohol test is based on fact that the proteins in milk become susceptible to alcohol precipitation due to lactic acid formation by bacteria. Such milk is not fit for any processes applying high heat treatment (e.g. pasteurization, sterilization, evaporation). This is because the proteins in milks having increased acidity lose its stability to the temperatures used for heat processing. It also determines abnormal milk such as colostrum.

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MATERIALS TO BE REQUIRED

1. Test tubes
2. Pipette
3. Ethylalcohol (68 % by wt. or 75% by vol.)

HOW TO PROCEED

1. Transfer 5 ml of sample to a test tube.
2. Add equal quantity of alcohol.
3. Mix the contents, rotate in a horizontal position and examine.
4. The formation of flakes or clot is indicative of a positive test. If no coagulation occurs, it indicates that milk can withstand heating operations for further processing and product manufacture.

PRECAUTIONS

- Collect milk samples in clean containers to prevent contamination.
- Use ethyl alcohol in the correct concentration to achieve reliable results.
- Mix the alcohol and milk sample in equal volume (1:1 ratio) to get accurate result.
- Ethyl alcohol is flammable, so handle it carefully

OBSERVATIONS TO BE RECORDED

	Sample 1	Sample 2
Appearance of flakes/clots (Positive or negative)		
Interpretation/Remarks:		

EXERCISE 16.3: CLOT-ON-BOILING TEST

The clot-on-boiling (COB) test is a quick, simple method to assess the stability of milk proteins, especially casein. This test is commonly used to detect acidity or any early

stages of milk spoilage, which can be caused by bacterial contamination or improper handling. Early identification of spoilage can prevent milk from being used for further processing or distribution, maintaining quality standards.

WHAT YOU SHOULD KNOW

This test is used for rapid testing of increased acidity of milk. Heating causes precipitation of milk proteins if it is sour. This method is slower than alcohol test but is very useful where and when an alcohol test is not feasible. It also helps to determine presence of colostrum in milk.

MATERIALS TO BE REQUIRED

1. Test tubes
2. Pipette
3. Boiling water bath

HOW TO PROCEED

1. Transfer 5 ml of sample to a test tube.
2. Heat the tube in a boiling water bath and hold for about 5 min.
3. Remove the tube, rotate in a horizontal position and examine for clots.
4. The formation of clot is indicative of a positive test. If no coagulation occurs, it indicates that milk can withstand heating operations at the time of testing.

PRECAUTIONS

- Do not overheat the sample, as prolonged heating may lead to protein denaturation in fresh milk, giving a false-positive result.
- Check immediately for clots after boiling. Delayed monitoring may not provide an accurate picture of the milk's stability because clots can occasionally form as the milk cools.

OBSERVATIONS TO BE RECORDED

	Sample1	Sample2
Appearance of flakes/clots (Positive or Negative)		
Interpretation/Remarks:		

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EXERCISE 16.4 DETERMINATION OF ACIDITY OF MILK

Acidity is a measure of freshness of the milk. It serves a basis of quality control in many dairy manufacturing processes. The acidity of the milk is always expressed as lactic acid equivalent because souring of milk is mainly due to lactic acid developed as a result of bacterial fermentation of lactose.

WHAT YOU SHOULD KNOW

Acidity is determined by titrating a known volume of milk against a standard alkali using indicator phenolphthalein. This includes both natural acidity of milk which is due to alkali combining ability of certain milk constituents (proteins, citrates, phosphates) and real acidity due to lactic acid that has developed due to bacterial action. The normal range of acidity of milk varies from 0.14 to 0.17 %. Any value higher than 0.17% indicates the presence of acidity due to fermentation.

MATERIALS TO BE REQUIRED

1. Conical flask/porcelain dish
2. 10 ml pipette
3. 10 ml burette
4. Measuring cylinder
5. Glass rod
6. Standard 0.1N NaOH solution
7. Phenolphthalein indicator

HOW TO PROCEED

1. At first, thoroughly mix the milk avoiding incorporation of air bubbles.
2. Measure accurately 10 ml of milk in titration flask/ porcelain dishes.
3. Add an equal volume of freshly boiled and cooled water.
4. Add 1 ml of phenolphthalein indicator to it.
5. Titrate the contents against standard NaOH solution from burette until a persistent pink color is observed.

6. Note down the volume of alkali used for titration from the burette.

OBSERVATIONS AND CALCULATIONS TO BE RECORDED

Observation 1

	Sample 1	Sample 2
Vol. of milk taken for titration		
Initial reading (NaOH)		
Final reading (NaOH)		
Vol. of 0.1 N NaOH utilized		

Calculation

$$\text{Titrateable acidity (\% lactic acid)} = \frac{9 * V_1 * N}{V_2}$$

Where,

V_1 = Vol. of Std. NaOH solution. required for titration

V_2 = Vol. of milk taken for titration

N = Normality of NaOH solution

Note: 1 ml of 0.1 N NaOH $\equiv$ 0.009 g of Lactic Acid

Interpretation/ Remarks

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*Notes***CHECK YOUR UNDERSTANDING**

1. What is the importance of platform tests?

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2. What is the effect of acidity development on the quality of milk?

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3. What is the relation between COB and alcohol test?

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**EXERCISE 16.5 QUALITY EVALUATION OF FLUID MILK:
ORGANOLEPTIC TESTS**

Testing milk for organoleptic characteristics is also known as sensory analysis and is of fundamental importance in quality testing. It is quick testing method and uses normal senses of sight, smell and taste in order to observe and record the overall quality. The outcome of this test is obtained immediately, and this test can be performed at minimum cost. This kind of testing is very reliable if performed by a trained person. It permits rapid screening out of poor quality milk at reception. Testing for organoleptic characteristics is used as a screening test to determine the acceptance or rejection of milk.

WHAT YOU SHOULD KNOW

Identification of abnormal colour/appearance and off flavours in milk

- In order to judge the appearance of the milk, remove the lid of the milk container and note down the appearance at the surface of the milk and the lid.
- Check if any visible dirt particles, changes in viscosity and abnormal colour of the milk persist, etc.
- After emptying the container, inspect the inside of the lid and the container for visible dirt and impurities.
- The appearance, colour, smell and taste of milk should be normal and typical to milch animal. Normal milk has a pleasant, slightly sweet taste with no odour. This natural sensory quality must be perceived and fixed in mind to serve as a reference for test sample. It is customary to have a sample of good tasting milk available for comparison during judging.

Some abnormal colours/consistency and their cause:

- a) Pink colour: Contaminated with blood
- b) Yellow colour: Due to pus or colostrums
- c) Blue thin colour: Removal of fat and/or adulterated with water.
- d) Large clots or flakes: Sour milk or mastitis milk.
- e) Small white clots or grains: Mastitis milk or adulteration with flour and skim milk powder.
- f) Visible dirt and impurities: Production under unhygienic conditions.

Some common abnormal off flavours (smell and/or taste) and their cause:

- **Bacterial contamination** - Acid, fruity, malty, putrid, unclean and lacks freshness:
 - ❖ Bacterial degradation generally results from contact of milk and improperly washed or sanitized equipment and improper cooling of milk.
- **Chemical changes**
 - ❖ Sour: Lactose fermentation
 - ❖ Salty: Increase in chloride content and decrease in lactose content, mastitic milk, colostrums.



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- ❖ Boiled: Release of volatile sulphides
- ❖ Rancid: Lipolysis of fat
- ❖ Tallow: Oxidation of fat

- **Absorption of off-flavours from air, milk containers etc.**

- ❖ Absorbed flavor defects can develop before, during and after milking, also when milk is stored uncovered.
- ❖ Strong smells like paint, phenol, cresol, lysol, petroleum, etc. Strongly smelling paints, disinfectants and other chemical should not be handled and stored in places where the dairy animal are kept and milked.

- **Off-flavours from feeds:** Garlic, onion, beets, bad silage, certain plants and pastures impart off-flavours to milk.

HOW TO PROCEED

The organoleptic test should be carried out immediately after opening the lid of the milk can/container. It should be done in a well ventilated room.

➤ **Colour/Appearance**

Note the colour, appearance and cleanliness of milk and record in observations.

➤ **Odour**

- i. Maintain a temperature of 15-20°C so that off odour, if any, present in milk could be detected.
- ii. Keep the container covered, shake it and place the nose directly over the container, detect the odour readily by sniffing the container.

➤ **Taste**

- i. Mixing or agitation is important before tasting.
- ii. Milk should not be too warm. A temperature rise while taking into mouth serves to volatilize importance constituents.
- iii. Take a generous sip, roll around the mouth, note flavor sensation and expectorate it.
- iv. Rinse mouth with warm water after tasting of subsequent samples.

- v. Draw a breath of fresh air through the mouth and then exhale slowly through the nose, this may enhance after taste.
- vi. With practice, faint odours and flavours could be noticed.

PRECAUTIONS

- Maintain good hygiene during testing to avoid introducing foreign flavors or odors into the milk samples.
- Carefully record every observation made during testing to monitor quality over time.

OBSERVATIONS TO BE RECORDED**Observation 1:**

	Colour	Odour	Taste	Interpretation/ remarks
Sample 1				
Sample 2				
Sample 3				

CHECK YOUR UNDERSTANDING

1. A dairy farm reports a sour taste in milk despite proper refrigeration. What bacterial species could be responsible, and how would you test them?

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2. A dairy plant receives complaints about small white clots in milk. What could be the possible reasons for this abnormality and how would you confirm the source?

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3. When does milk absorb undesirable flavor?

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4. Differentiate the colour of whole cow milk and separate milk.

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FOR TEACHER

- Demonstrate step-by-step procedure of each test before allowing learners to perform them.
- Supervise the learners, especially when handling potentially hazardous materials like ethyl alcohol and boiling water bath.
- Guide the learners how to dispose of chemicals, hot liquids, and milk samples properly after completing the tests.
- Provide detailed instructions on how to conduct organoleptic tests, including the proper techniques for smelling, tasting, and visually inspecting milk samples.
- Help the learners to develop their sensory evaluation skills.
- Inform learners about relevant quality standards and regulations governing milk quality.

DETERMINATION OF THE COST OF CULTIVATION



Notes

The whole amount of money farmers spend in cultivating land or rearing livestock is referred to as the cost of cultivation. This covers a range of inputs, including labour, machinery, irrigation, seeds, fertilizer, pesticides, land rental, and other operating expenses. The location, agricultural techniques, and kind of crop or animal can all affect the particular cost components. In this lesson, we will learn about the process of calculation of cost of cultivation.



LEARNING OUTCOMES

After performing this exercise, the learner:

- defines various cost concepts associated with agricultural economics;
- differentiates between marketed surplus and marketable surplus; and
- determines the cost of cultivation of major crops grown in their area.

WHAT YOU SHOULD KNOW

Some commonly used terms for understanding the economics of agriculture:

- A. **Farm:** A piece of land where crops and/or livestock enterprises are taken up for crop or livestock production.
- B. **Agricultural holding:** The area of land owned by a household (farmer) for crop cultivation or raising of livestock as a single unit.
- C. **Operational holding:** It refers to total land area held under single management or by a farmer-household for the purpose of crop cultivation. It includes own land holding plus leased-in land and excludes leased-out land.

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- D. Marginal farmer:** A farmer-household having landholding less than or equal to one hectare (or 2.47 acres).
- E. Small farmer:** A farmer-household whose land holding is between 1 to 2 hectares.
- F. Cost of cultivation:** It refers to the cost incurred for various agricultural inputs during cultivation of any crop. It is expressed as ₹ per acre or ₹ per hectare.
- G. Cost of production:** It refers to the cost of various inputs incurred in cultivation of per unit quantity of any crop output. It is written as ₹ per quintal or ₹ per kg.
- H. Imputed value of family labour:** It is an assumed value given for the family labour employed in farming. In such case, no direct payment is made, but prevailing wage rate in the locality for agricultural purposes are considered for family labour for calculation purposes.
- I. Fixed cost:** Any expenses that remain the same no matter how much area a farmer cultivates. These costs remain same regardless of scale of output. It may include lease and rental payments, and interest payments.
- J. Variable cost:** The expenses that change based on volume of production or area of crop cultivation. This means that variable costs increase as production rises and decrease as production falls. Some examples of variable costs include labor, seed, fertilizer, irrigation, etc.
- K. Marketable surplus:** The marketable surplus is the residual left with the producer/farmers after meeting his requirement for family consumption, farm needs for seeds and feed for cattle, payment to labour in kind, payment to landlord as rent and payment for social and religious obligations.
- L. Marketed surplus:** It is the quantity of the produce which the producer/farmer actually sells in the market, irrespective of the requirements for family consumption, farm needs and other payments. The marketed surplus may be more, less, or equal to the marketable surplus.
- M. Marketing channel:** In general, marketing channel consists of group of people and organizations that work together to move products from production to consumption. In agriculture, we depict marketing channel by the people and their roles through whom the crop output moves from farmers to consumers. For example: Wheat produced by the farmers reaches to the final consumers through

Village trader → wholesaler → food processor → retailers → consumers

- N. Consumers' price:** It is the price paid by the consumer to purchase the product for their own consumption.
- O. Farm gate price:** It is price received by the farmer at his farm when he sells the crop output. In case of farmer decides to take the produce to the market, the farmgate price is the net price of the commodity after transportation and marketing costs have been subtracted from the selling price.

HOW TO PROCEED

Following exercise requires learners to visit a farmer's field, agriculture market (mandi) or weekly market and interact with consumers to collect some basic information to understand the economics of farming.

CALCULATING COST OF CULTIVATION OF MAJOR CROPS

Explore major crops being cultivated by the farmers in your area. Choose any one crop which was grown in last season. Collect following information regarding the expenditure incurred in crop cultivation:

- A. Area under the crop (in acres):
- B. Total expenditure (in rupees) incurred on
 - a. Seed -
 - b. Fertilizers -
 - c. Pesticides & herbicides -
 - d. Irrigation -
 - e. Human labour hired -
 - f. Charges on hiring farm machines -
 - g. Land rent paid by the farmer -
 - h. Interest paid for the capital borrowed to cultivate both the crops -
 - i. Anyother items purchased and used in crop cultivation–
 - j. Total yield (in kilograms or quintals)–

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k. Price of output -

C. Find out number of mandays spent by the family members in cultivating each of the crops. (Note: total 8 hours spent in farming is considered one manday).

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D. Assign equivalent wage rate for the family labour for crop cultivation.

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E. Calculate the cost of crop cultivation (in Rs. per acre).

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F. Find out the crop yield (in quintal per acre).

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G. Calculate the cost of production (in Rs. per quintal).

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H. From above assignment, find out the components of fixed cost and variable cost incurred by the farmer.

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I. Compute marketed and marketable surplus of that crop output for the farmer's household.

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J. Find out marketing channels of that crop- how the crop output moves from farmer's field to the final consumer.

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K. Calculate share of the farmer in consumer's price for the crop.

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L. Find out the prices of different retailers selling the same commodity in the local market, and what are the reasons for selling at different prices?

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FOR TEACHER

- Provide basic understanding about various cost concepts related to agriculture.
- Instruct learners on how to collect relevant data necessary for cost calculations.
- Evaluate learner's calculations and provide constructive feedback.

UNDERSTANDING OF THE CONSUMER BEHAVIOUR IN MARKET



Notes

Consumer behavior refers to the study of individuals, groups, or organizations and the processes they use to select, secure, use, and dispose of products, services, experiences, or ideas to satisfy their needs and wants. Understanding consumer behavior is crucial for businesses and marketers as it helps them tailor their products, services, and marketing strategies to meet the preferences and expectations of their target audience.



LEARNING OUTCOMES

After performing this exercise, the learner:

- explains how the consumer decides to purchase the optimum quantity;
- analyzes how he/she should allocate the money among different commodities so that his/her total level of satisfaction is maximized; and
- applies the theory of Diminishing Marginal Utility in real life situation.

WHAT YOU SHOULD KNOW

Before starting this exercise, you should know important terms and assumptions related to consumer behaviour. Let's discuss them one by one.

- A. Rationality:** Principle of rationality says that the consumer behaves rationally and he chooses the commodity that yields maximum satisfaction the first and then moves to other commodities that provide less satisfaction, afterwards.
- B. Maximization of satisfaction:** Every rational consumer tries to maximize his satisfaction with the given money income.

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Notes

- C. Money income is limited:** Every consumer has a limited money income to spend on goods and services. In this limited money, as they have to maximize their satisfaction/ utility from consumption of commodities, consumers therefore, make choices.
- D. Utility is cardinally measurable:** Theory of Cardinal Utility says that we can measure the satisfaction in terms of money income and call it 'Util'. Therefore 1 util=1 unit of money income. This is however, not possible in real world and so economists later suggested that satisfaction can only be relative under the money income and therefore people substitute the expensive good with cheaper good or purchase more of highly priced good and less of low priced, or purchase the one with high utility first and less utility later.
- E. Diminishing Marginal Utility:** The consumption of a commodity is subjected to the law of diminishing marginal utility. It is assumed that the satisfaction or utility derived from the successive units consumed of a commodity decreases with the units consumed. This is an axiom of the theory of consumer behaviour.
- F. Constant marginal utility of money:** The principle of Diminishing Marginal Utility or the Theory of Cardinal Utility assumes that the marginal utility of money is constant whatever your income level is.
- G. Utility is additive in nature:** The theory of cardinal utility assumes that the utility derived from each unit of a commodity or different commodities is additive in nature. So total utility = utility from first unit + utility from second unit ++ utility from last unit

Formulae:

Marginal Utility = Change in Total Utility/ Change in number of units of good consumed

HOW TO PROCEED

Follow the successive actions listed below to understand the consumer behaviours.

- 1) Visit a local market and explore the market environment.
- 2) Interact with buyers and sellers to know about their choices and preferences.

OBSERVATIONS TO BE RECORDED**Activity 1:**

Explore the nearest market and take the following data from few consumers, while they are marketing

- How much money they planned to spend that day on the purchase?
- What was the first product that consumer bought and how they started purchasing the commodities?
- What was the first commodity that they purchased and why?
- How did they decide the quantity of the different commodities to be brought?

You will notice that

- Their decision to buy certain things is limited by price of commodities and the money in hand.
- They spent money on goods that they believed would be most to least useful. That also governed the quantity of purchase.

Conduct a survey of your nearby agricultural market and collect data on price of a product and quantity demanded at each price point. Draw a graph by plotting the price (P) on the vertical (y-axis) and the quantity demanded (Q) on the horizontal (x-axis). This activity will help in the derivation of demand curve (refer figure 20.1 in the lesson 'Basics of agricultural economics'), which you will find sloping downwards.

Activity 2:

In the following table, total utility and marginal utility for each unit of consumed commodity are given. Plot the following data on a graph considering unit of commodity on X axis and total as well as marginal utility on Y axis. Give the interpretation of changes in total utility and marginal utility in your own words.

Unit of Commodity (X axis)	Total Utility (TU) - Y axis	Marginal Utility (MU) - Y axis
1	30	30
2	45	15

Practical

Notes

EXERCISE-18

To Understand the Consumer Behaviour in Market

Practical



Notes

3	55	10
4	60	5
5	55	-5
6	45	-10
7	35	-10

You will see that the total utility reaches peak when 4th unit was consumed and then starts declining with every successive unit.

FOR TEACHER

- Guide the learners in developing the demand curve with the help of collected data.
- Help the learners in finding out the relationship between total and marginal utility.

ANNEXURE I

Practical

List of Credits

EXERCISE 1

Fig. 1.2: Common cereal plants, Courtesy: Dr. A. Das

Fig. 1.3: Seeds of rice, wheat, maize, sorghum, pearl millet and kodo millet, Courtesy: Dr. A. Das

Fig. 1.4a: Plants of pigeon pea, Courtesy: <https://shorturl.at/YU6HV>

Fig. 1.4b: Plants of pea, Courtesy: <https://shorturl.at/Na3vz>

Fig. 1.4c: Plants of Bengal gram, Courtesy: <https://shorturl.at/31WCH>

Fig. 1.5: Seeds of blackgram, greengram, chickpea, fieldpea, Courtesy: Dr. A. Das

Fig. 1.6: Seeds of black mustard, sunflower, safflower, soybean and groundnut, Courtesy: Dr. A. Das

EXERCISE 2

Fig. 2.1: Morphological character of solanaceous crops, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

Fig. 2.2: Morphological character of pulse crops, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

Fig. 2.3: Morphological features of cucurbitaceous crops, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

Fig. 2.4: Morphological features of root crops, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

Fig. 2.5: Morphological character of solanaceous crops, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

Fig. 2.6: Morphological character of cole crops, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

Fig. 2.7: Morphological features of onion, drumstick and curry leaf, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

*Notes*

Practical**Notes****EXERCISE 3**

Fig. 3.1: Sample of a herbarium sheet, Courtesy: Dr. A. Das

EXERCISE 5

Fig. 5.1: Soil solarization of field using transparent polyethylene sheet, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

Fig. 5.2: Raising of onion nursery over raised bed method with line sowing, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

Fig. 5.3: Plug tray and poly bag method of nursery raising, Courtesy: Dr. R.K. Dubey & Dr. S.A.H. Patel

EXERCISE 6

Fig. 6.1: Different agricultural and horticultural tools, Courtesy: Dr. E.K. Naik

Fig. 6.2: Different agricultural/horticultural tools and implements, Courtesy: Dr. E.K. Naik

EXERCISE 10

Fig. 10.1: Soil health card, Courtesy: <https://soilhealth.dac.gov.in/>

EXERCISE 11

Fig. 11.1: Stem rust of wheat, Courtesy: <https://shorturl.at/OC6LR>

EXERCISE 12

Fig. 12.1: Adult moth and larvae of Pink bollworm, Courtesy: <https://bit.ly/4kO9hZP> and <https://bit.ly/4hD0LKe>



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