Plant Science

Basic Horticulture

Government of Nepal
Ministry of Education, Science and Technology
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Grade 9

Technical and Vocational Stream
Learning Resource Material

Basic Horticulture

(Grade 9)

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Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for Plant Science has been developed in line with the Secondary Level Plant Science Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students and parents.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Pro.Dr. Kaniya Prasad Singh, Pro.Dr. Gyan Kumar Shrestha, Dr. Kishorchandra Dahal, Anita Bolakhe is highly acknowledged. The learning resource material is written by Rikhiram Neupane, Santosh Koirala, Niraj Belbase, Purnima Paudel, Mahesh Poudel, Dayamond Pokharel the subject matter of the materials, was edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala and language was edited by Mr. Binod Raj Bhatta. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes constructive feedback for the betterment of the material.

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Table of Content

Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows

or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a

given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other's work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

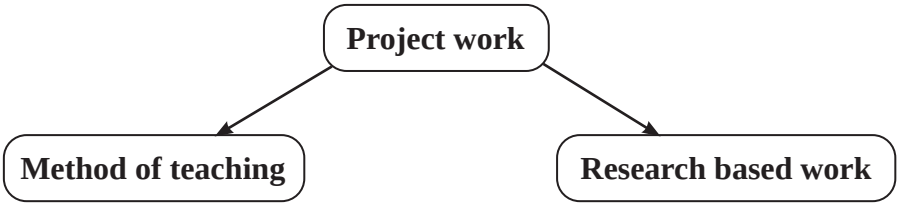
Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions.

Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.



Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and Presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual Materials:** Videos, animations, podcasts, and other

multimedia resources that bring concepts to life and cater to auditory and visual learners.

- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, Charts, and Graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life Examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C. Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.

Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.

Homework exercises: Assign tasks that provide ongoing feedback on individual progress.

Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.

Final projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.

Peer feedback forms: Provide structured forms for students to assess their peers.

Classroom presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.
True/False questions: Assess factual understanding with true/false questions.

Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.

Reflection statements: Ask students to write reflective statements about their work.

Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.

Performance observations: Assess practical skills through direct observation.

Field trips: Evaluate students' ability to apply knowledge in real-world settings.

Introduction

Unit 1

1.1 Meaning & Definition of Horticulture and its Branches

Introduction

The word "Horticulture" is derived from two Latin words i.e. *Hortus* means garden and *Culture* means knowledge of growing these crops. Hence, horticulture is a science of studying garden plants. In other word, horticulture is the science and art of growing garden crops such as fruits, nuts, vegetables, cookery herbs and spices, beverage crops, and medicinal, as well as ornamental plants. Horticulture crops includes both ediable plants that might be fruits like mango, banana, apple, strawberry etc.; that might be vegetable like tomato, potato, brinjal, cucumber, etc.; that might be spices like ginger, cardamom, garlic, leek, etc; and that might be beverage crops like tea, coffee, etc. and non-edible crops usually landscape and ornamental plants like rose, dhupi, carnation, jasmine , etc. The details on these diverse groups of plants that are studied on subject horticulture are discussed below in branches of horticulture. For now, we can conclude the introduction of horticulture as a branch of agriculture which deals with production, management, processing and marketing of flowers, vegetables, fruits, ornamental plants, plantation crops, etc.

Branches of Horticulture

a. **Olericulture**

The word "Olericulture" is derived from the Latin word '*Oleris*' which means 'pot herb' and the English word '*culture*' which means cultivation. Thus, olericulture means cultivation of pot herb. However, in the present days,

it is broadly used to indicate the cultivation of vegetables like potato, tomato, chili, cauliflower, spice crops, radish, carrot, etc. In other word, olericulture is a branch of horticulture which deals with practice and cultural management required for successful production of vegetable crops and their seeds.

b. **Pomology**

The term “Pomology” is a combination of two Latin words *pome* which means fruits and *logos* meaning culture. “*Poma*” in Greek means fruits later subsequently transfer in to “Pome” in Latin word means fruits, *logos* meaning study. Hence, Pomology is a branch of horticulture which deals with various aspects of fruits like apple, mango, pineapple, pear, pomegranate, etc. starting from raising of saplings, growing them properly and providing various intercultural operations.

c. Floriculture

The word "Floriculture" comes from two Latin words: *"flos"* or *"floris,"* meaning flower, and *"culture,"* meaning to grow or cultivate. So, floriculture simply means the growing of flowers. It involves the production, care, and marketing of flowers and decorative plants such as roses, marigolds, orchids, and ornamental shrubs. In other word, Floriculture is a branch of Horticulture which deals with commercial growing, marketing and arranging flowers and ornamental plants, which includes annuals, biennials and perennials i.e. trees, shrubs, climbers and herbaceous perennials.

d. **Landscaping**

Landscaping is an art and science of planning, designing, and modifying the outdoor spaces to make them more beautiful, useful, and natural-looking. The word "landscaping" comes from the word *"landscape,"* which means to a outlook of natural scenery, and the suffix *"-ing,"* which refers an process. So, landscaping means the process of upgrading given space by planting trees, flowers, and grass, building pathways, fountains, or placing other decorative objects.

It includes both soft landscaping described as planting flowers, grass, and trees and hard landscaping described as making walls, pavements, and water features.

e. **Post-Harvest Technology**

Post-harvest technology is the branch of agriculture that deals with all the activities performed after harvesting of produce. The word comes from "post" meaning *after*, "harvest" meaning *the collection of produce*, and "technology" meaning *the use of scientific techniques and equipments*. Hence, post-harvest technology is the branch of agriculture that deals with the use of scientific knowledge and methods to handle; store, process, and transport produce after harvesting to maintain their quality and to extend their shelflife.

f. **Plantation Crops**

Plantation Crops is a specific branch of horticulture that deals with the cultivation, management, harvesting, processing, and marketing of commercial, long-duration, and perennial crops that are mostly grown on a large scale. These crops are usually cultivated for their commercial value rather than fresh consumption.

Examples of these crops tea, coffee, coconut, arecanut, rubber, oil palm, cocoa, etc.

g. Spice Crops

Spice crops are plants those mainly grown for their flavor, aroma, or seasoning value. They include crops like ginger, garlic, turmeric, cardamom, black pepper, chili, coriander, etc.

h. **Ornamental Horticulture**

This branch of horticulture deals with plants, trees or both that is commercially important for landscaping and avenue plantation. Turf or lawn grasses are also come under this branch. Both flowering plants like marigold, gladiolus, rose, hibiscus, etc. and foliage plants like dhupi, sami, durenta, croton, etc. are studied under ornamental plants. In ornamental horticulture potted plants, both in-door and out-door plants and field ornamentals are dealt under this branch.

1.2 Importance & Scope of Horticulture

1.2.1 Importance of Horticulture

As discussed already, horticulture is the science that usually studied about the garden crops like vegetables, fruits, ornamentals, spices and beverage crops. These crops are in daily use in our life and have various importance which are discussed below:

a. Economic Importance

Horticultural crops are the major source of income of Nepalese farm family. These crops produce higher yield and generate higher return in comparison to other crops. Horticulture crops also contribute significant amount of national GDP (Gross Domestic Products).

b. Nutritional Importance

Horticulture crops are rich source of vitamins, minerals, and other nutrients. Vegetable play a vital role in the balance diet of human being. Vegetable contain carbohydrate, proteins, minerals, vitamins, and also possess medicinal properties.

Likewise, fruits are also the major sources of vitamins, minerals, carbohydrates, fats, proteins etc. are recognized as protective foods as they are necessary for the maintenance of human health.

c. Social Importance

Farming is the integral part of Nepalese society as rural society are link together through farming like varo-perma, baethhi, etc. Horticulture crops aid to uplift not only the economic condition of the farm family but also the social condition of that family. Growing crops are linked with rural life from tradition. So, it has significant social importance in Nepal.

d. Cultural and Religious Importance

Horticulture crops have considerable cultural and religious values in different societies in our country. For example: Marrying a Newari girl to the bel fruit is considered mandatory in Newari culture. Sending areca-nuts has been a way to invite people to cultural and religious ceremony in Nepal. A gift of a Cheuri tree to a marrying girl in chepang society is considered very prestigious. Similarly, the importance of walnut, marigold, and makhamali in tihar is also the example of its cultural and religious.

e. Aesthetic Importance

For the beautification of hotels and parks, plantation of flowering fruit trees is considered important and even the roadside avenues are decorated with fruit trees. Most visitors can enjoy the flowering peach trees available at kirtipur farm. The red flowers of pomegranate and deep red fruits of crab apple have been praised by many people. The statements above are the examples of aesthetic importance of horticulture.

f. Medicinal Importance

Horticulture crops are enriched naturally with essential mineral, vitamins, amino acids, etc. Various horticultural crops have medicinal value. Below are few example on behave of medicinal importance of horticulture crops. Proverb “An

apple a day keeps the doctor away"; eating 3-4 amala fruit per dayboost immune system; guava is good for diarrhea; and papaya is excellent fruit for stomach problems.

g. Industrial Importance

Horticultural crops are the raw materials of various industries. For example, canning industries uses tomato, peas, beans etc, pickling industries use cucumber, chilies, cauliflower etc. alcohol extraction industries use potato, sweet potato and yam, the wine and juice made from grapes are very famous, lapsi has many small-scale industries product and so on.

h. Environmental Importance

Fruit and plantation crops have heavy foliage which is the key sites of carbohydrate metabolism. During the process of metabolism, these crops intake CO_2 and release O_2. Other pollution such as sound, heat etc. is also prevented by fruit plants. Moreover, they have deep and spreading roots that hold soil particles firm. Hence, the roots reduce soil erosion and conserve fertile soil. So, horticulture play vital role in environment conservation.

i. Agro-Tourism Importance

Fruits and plantation crops have very good potentials to attract national and international tourists due to attractive flowers, fruits which encourage relaxation. Kiwi farm of Kavre district have attracted many visitors. During the flowering and fruiting periods of different kinds of fruit species, many visitors go to Kirtipur farm to enjoy. Tea and cardamom gardens and industries in eastern Nepal are focal tourist points.

1.2.2 Scope of Horticulture

Here, scope means the range, extent, and areas where horticulture is applied or can contribute. In simpler terms, scope refers to "How broad is horticulture? and What are its areas of importance, uses, and opportunities?". In Nepal horticulture has broader scopes which are describe below:

a. Climatic Diversity

Nepal has a wide range of climatic variation from terai to high mountains. This climatic diversity add scope on cultivation of a variety of horticultural crops like mango, banana, citrus, apple, walnut, and off-season vegetables.

b. Biodiversity

Biodiversity of Nepal is the boon with various indigenous species of fruits, vegetables, spices, and medicinal plants. This diversity increases the scope of horticulture on the both sector of research and production.

c. Employment Opportunity

Self employment and employment opportunity on the sector of farming, nursery management, fruit and vegetable processing, floriculture, landscaping, and marketing add the scope of horticulture.

d. Increasing Demand and Trade Deficit

Now a day, due to the boost in consumer ability and awareness, the demand for fresh and processed horticultural products is rising. However, Nepal imports large amounts of fruits and vegetables from India. The increasing demand and trade deficit boost the scope of horticulture in Nepal.

e. Export Potential

Nepal has high potential to export horticultural produce like large cardamom, ginger, tea, medicinal herbs, etc. With proper post-harvest handling and market access, horticultural exports can significantly contribute to broaden the scope.

f. Agro-Tourism

The beauty of horticultural farms, flower gardens, authentic local recipe taste, hygiene of organic food, etc. attracts tourists. The concept and opportunity for agro-tourism makes horticulture a broader sector.

g. Use of Marginal Land

Nepal has sloped or less fertile lands too and these lands are not suitable for

cereal crops. Such marginal lands can be used for growing fruit trees, spices, and medicinal plants.

h. Availability of Manpower

Nepal has a larger young population. With proper training and support, rural youth can be engaged in commercial horticulture, nursery business, and value-added processing.

i. Access to Government Agencies

Farmers can access knowledge, training, and support from government bodies like Krishi Gyan Kendra (Agricultural Knowledge Centers), Prime Minister's Agriculture Modernization Project (PMAMP), and the Department of Horticulture. These agencies play a key role in promoting horticultural practices.

ii. Government Subsidy Policy

The Government of Nepal provides subsidies on improved seeds, saplings, irrigation tools, plastic tunnels, and machinery under various programs. These policies make it easier for farmers especially youth to start or expand horticultural activities.

1.3. Classification of Horticulture Plants

A. Classification According the Uses

1. Fruits

a. Tree fruits i.e. fruits bearing on trees (e.g. mango, litchi, apple etc.)

b. Nut fruits i.e. fruits bearing on trees but which are enclosed by a stony structure (e.g. cashew, aereca nut, almond, etc)

c. Vine fruits i.e. fruits bearing on vine (e.g. kiwi, grapes, etc.)

d. Herbaceous fruits i.e. fruits bearing on succulent herbaceous plants(e.g. banana, pineapple, etc.)

2. Vegetables

a. Leafy vegetables i.e. crops grown mainly for their leaves (e.g. amaranthus, broadleaf mustard, lettuce, etc.)

b. Cole crops or crucifers i.e. crops that belong to the crucifer family (e.g. cabbage, cauliflower, chinese cabbage, etc.)

c. Root and bulb crops i.e. crops with swollen underground stem or roots (e.g. sweet potato, onion, gabi, carrot, radish, etc.).

d. Legumes or pulses i.e. crops that belong to the legume family (e.g. beans, peas, etc.)

e. Solanaceous crops i.e. crops that belong to the solanaceous or nightshade family (e.g. eggplant, pepper, tomato, etc.).

f. Cucurbits i.e. crops belonging to the cucurbit family (e.g. squash, watermelon, cucumber, etc.).

g. Tree vegetables (e.g. drumstick)

3. Ornamentals

a. Cut flowers i.e. plants grown for flowers but harvested with stems and usually placed in water and arranged in vases or bouquets (e.g. gladiolus, roses, carnation, etc.).

b. Loose flowers i.e. plants grown for flowers but harvested without stem and usually used in making garlands, religious offerings, and rangoli designs (e.g. marigold, chrysanthemum, etc.).

c. Cut foliage i.e. a plant whose foliage provides the background in floral arrangement (e.g. fern, palm, asparagus, etc.).

d. Flowering pot plants i.e. plants grown in containers for their beautiful flowers, usually used for display purpose (e.g. chrysanthemum, bougainvilla, roses, etc.).

e. Landscape plants i.e. plants used for landscaping purposes. Almost all the ornamentals fall under this category.

f. Foliage plants i.e. plants grown for their attractive foliage. (e.g. begonia, philodendron, dhupi etc.).

g. Turf i.e. used for lawns or greens (e.g. manila grass, bermuda grass, etc.)

4. Plantation Crops

a. Oil crops i.e. grown for their oil content (e.g. coconut, oil palm, etc.)

b. Fiber crops i.e. grown for their fibers which are used for textiles, cordage, pulp, paper, twines, sacks, bags, mats, decors (e.g. abaca, maguey, etc.).

c. Beverage crops i.e. used for brewing non-alcoholic drinks (e.g. coffee, cacao, tea, etc.).

d. Spices, condiments and essences i.e. used to provide special flavors, scents and colors to food, perfumes, soaps and body dressings (e.g. black pepper, vanilla, canella, etc.).

e. Latexes and resins i.e. crops where products of the sap (latex) tapped from the bark or fruit peel are obtained (e.g. rubber, pine, etc.)

f. Medicinal and botanical pesticides i.e. crops with curative, laxative or pesticidal properties (e.g. tulsi, lemongrass, neem, etc.)

B. Classification According to Growth Habits

1. **Vine:** Vines are those plants that require support for upright growth. Examples: cucumber, grapes, etc.
2. **Shrub:** Shrubs are those woody plants that have multiple stems and/ or height less than 5m. Examples: duranta, croton, hibiscus, rose, etc.
3. **Herb:** Herbs are those plants that have soft and succulent stem throughout their growing season. Examples: marigold, tomato, cabbage, banana, papaya, etc.
4. **Tree:** Tree are those plants that have woody single central stem and usually taller than 5m in height. Examples: pine, litchi, mango, etc.

C. Classification According to Life Span

1. Annuals

Annuals are those plants that complete their life cycle in single growing season. For examples: tomato, cabbage, marigold, gerbera, etc.

2. Biennials

Biennials are those plants that require two growing season to complete their life cycle. Biennials plant passes through two growing season i.e. 1st growing season for vegetative growth and next growing season for reproductive growth and goes to resting or dormancy period between these growing seasons. Examples: carrots, onion, cabbage, etc.

3. Perennials

Perennials are those plants that pass multiple growing seasons in their entire life cycle. Perennials continue growing indefinitely. They give new growth each year. For examples: Mango, papaya, grapes, drumsticks, tree tomato, etc.

A. Classification of Horticultural Crops Based on Climate and Geography

1. Tropical Crops (Below 750 meters altitude)

The tropical crops are those crops that are grown in hot and humid area of Nepal that sited below 750 MASL (Meter above Sea Level). This zone mainly consists terai region, inner terai and foot hills of the country. Examples of horticultural crops best suited for this region are:

- **Fruits:** Mango, banana, papaya, litchi, guava, jackfruit, citrus (lime, sweet orange)
- **Vegetables:** Okra, cucumber, tomato, brinjal, sponge gourd
- **Spices:** Ginger, turmeric, chilli
- **Others:** Coconut (limited), arecanut, betel leaf

2. Sub-Tropical Crops (750–1,500 meters altitude)

The sub - tropical crops are those crops that are grown in warm and moderate climatic region of Nepal that sited 750 to 1500 MASL. This zone mainly consists lower hills and valleys surrounded by hills. Examples of horticultural crops best suited for this region are:

- **Fruits:** Mandarin orange, guava, pomegranate, pear, persimmon, peach (low chill)
- **Vegetables:** Tomato, cauliflower, cabbage, beans, onion
- **Spices and Medicinal Plants:** Ginger, turmeric, timur (Zanthoxylum)
- **Flowers:** Marigold, rose, chrysanthemum

3. Warm Temperate Crops (1,500–2,000 meters altitude)

The warm temperate crops are those crops that are grown in the region of Nepal where summer are warm and winter cool & pleasant that sited 1500 to 2000 MASL. This zone mainly consists mid - hills of the country. Examples of horticultural crops best suited for this region are:

- **Fruits:** peach, pear, plum, persimmon
- **Vegetables:** Peas, carrot, radish, broccoli, cabbage, lettuce
- **Flowers:** Carnation, gladiolus, gerbera
- **Spices:** Garlic, onion

4. Cool Temperate Crops (2,000–2,500 meters altitude)

The cool temperate crops are those crops that are grown in the region of Nepal where summer are cool and winter cold that sited 2000 to 2500 MASL. This zone mainly consists high - hills of the country. Examples of horticultural crops best suited for this region are:

- **Fruits:** High chill apples, pear, walnut, cherry, hazelnut
- **Vegetables:** Potato, leafy greens, cole crops
- **Medicinal Plants:** Chiraito, pakhanbed, jatamansi

5. Alpine and Semi-Arid Crops (Above 2,500 meters altitude)

The alpine and semi - arid crops are those crops that are collected in the region of Nepal where climate is cold with snow in winter that sited above 2500 MASL. This zone mainly consists high mountainous region of the country. In this region of Nepal commercial cultivation is rear. Examples of horticultural crops best suited for this region are:

- **Fruits:** High-chill apples, wild berries
- **Medicinal and Aromatic Plants:** Yarsagumba, Satuwa, Panchaule, Kutki

Exercise

Choose the correct answer from the given alternatives.

1. …….is a tree fruit.

   a. Mango b. Strawberry

   c. Banana d. Grapes

2. …….is a leafy vegetable.

   a.Cabbage b. Amaranthus

   c. Onion d. Radish

3. Study of vegetables is called…….

   a.Floriculture b. Olericulture

   c. Horticulture d. Pomology

4. Study of flowers is called…..

   a. Olericulture b. Floriculture

   c. Pomology d. Horticulture

5. Pomology is the study of…..

   a. Flowers b. Vegetables

   c. Fruits d. None of these

Write short answer to the following questions.

1. Write the importance of horticulture in Nepal.
2. What are the branches of horticulture?
3. Classify vegetables according to growth habit.
4. How horticulture plays an agro tourism role in Nepal?
5. Justify that there is great importance of horticulture crops in human diet.

Write long answer to the following questions.

1. Explain in detail about the scope of horticulture in Nepal.
2. Classify horticulture crops.
3. How can you point out the importance of horticulture in Nepal. Explain in detail.

Project Work

1. Field Visit and Report

Arrange a visit to a nearby horticulture farm. Guide the students to identify the different plants and ask them to classify these plants based on various criteria. Assign homework to prepare a report on the visit.

2. Herbarium Collection

Assign students the task of collecting herbarium samples of different horticultural crops.

3. Group Discussion

Divide the students into groups and assign each group a specific topic related to the scope and importance of horticulture. Ask them to discuss the topic, prepare a handout, and present it in class.

Unit 2

Climate

2.1 Concepts of Climate & Weather

2.1.1 Climate

Climate is the average weather condition of a specific region recorded over a long period of time (usually 30 years or more). Climate represents the pattern of temperature, rainfall, wind, and other weather elements of certain region. For example: The climate of Terai is hot and humid, while the climate of mountainous region cold and semi – arid.

2.1.2 Weather

Weather refers to the condition of the atmosphere at a particular place and time. It includes short-term changes in climatic variables like temperature, rainfall, wind, humidity, cloud cover, and sunshine. Weather is highly variable and changes constantly, sometimes hour to hour. For example: A rainy morning, cold December this year, lower precipitation in this year in june, this year there is higher snowfall in mountain, etc.

2.1.3 Difference Between Weather and Climate

Parameters	Weather	Climate
Meaning	Weather is everyday atmospheric condition of a particular place, as regards temperature, humidity, wind speed, etc.	Climate summation of weather in a particular region, over long period of time.
What it is?	Minute by minute state of atmosphere in an area.	Average weather in a region.

Represents	What are the condition of atmosphere in a geographical location, over short period.	In what way atmosphere acts over typically long period.
Variation	Varies constantly.	Does not vary constantly.
Assessment	For short term	Over a long period

2.2. Environmental Factors Affecting Horticultural Crops Production

All crops require suitable environmental condition for optimum growth and development. There are various environmental factors that should be considered for cultivation of any crops. Better consideration of these factors can assist to produce optimum yield.

Major environmental factors affecting horticultural crops production are as follows:

a. Temperature

Temperature is one of the most important environmental factors for crop growth. Every fruit crop requires well defined range of temperature for proper growth and development. Too high or too temperature may cause adverse effect in crop production. High temperature destroys protoplasm of cell which retards the growth of plant. High temperature may cause sun borne and sun scald disease. Whereas, Low temperature kills the buds, blossoms, inflorences and terminal part of the crops. It also causes bark and trunk splitting. If chilling temperature causes yellowing of leaves and blacking fruits in banana.

b. Light

Light is one of the major climatic or environmental factor that affect the crop production. Plant absorbs different intensities of light for its growth and development. Flowering, fruiting quality of fruits also depends upon the intensity and duration of light absorbed by plants. Plants exposed to sunlight give better quality of produce. Light also plays an important role for the process of photosynthesis. It also plays an important role in colour development too.

c. Rainfall and Humidity

Optimum atmospheric humidity and rainfall is also important factor of environment for proper growth and development of horticultural crops. The water requirement of crops varies among the each crop. The amount and distribution of rainfall affect the crops. Well distributed rainfall with optimum amount is considered suitable for proper growth and development of crops. Higher amount and concentrated rainfall causes physical damage to the crop directly and/or creates water logged condition and damage indirectly. Similarly moderated humidity is ideal for most of the crops leaving some exceptions. Higher humidity and lower humidity mostly causes disease and insect pest infestation to the crops.

d. Wind

Wind is another major factor that affects horticulture crop production. Wind help to maintain temperature of the surrounding and aid in pollination. For proper pollination mild wind flow is required. Strong wind damages the crops physically and causes flower and fruit drop. Cold wind causes chilling injuries.

e. Snow

With the snow cover, diseases that over-winter on leaves, such as leaf spot, leaf scorch, and powdery mildew on strawberries, downy mildew on grapes, and apple scab will be more prevalent in snow. With a prolonged snow melt, there is a good chance that soils will be saturated for extended periods of time and create conditions conducive for the development of soil borne root rots caused by *phytophthora*, *Pythium*, or *Verticillium* wilt, particularly when they have been planted on soils that are not well drained. With the heavy snow pack that has accumulated, especially in areas with high drifts, there is a risk of limb breakage in fruit trees.

f. Hailstorm

Hail can injure fruit's shoots, and limbs. The extent of the injury usually depends on the size and shape of the hail and the duration of the event. Injury can range from torn or shredded leaves and small dents that don't break the fruit skin to

effects so severe that an entire crop is lost due to physical damage. In some cases, replacement of trees is necessary, especially when young trees have significant bark injury. Fungicide protection of injured tissues may be necessary immediately after a hailstorm to prevent fungal colonization of wounds.

g. Soil Moisture

Soil moisture depends on the amount of precipitation, intensity of water consumption by plants, air temperature, and other factors. Ample moisture levels are of high importance to yields; thus, plants will not grow and develop with inadequate soil moisture. Soil moisture levels also affect air content, salinity, and the presence of toxic substances. It regulates soil structure, ductility, and density as well as influences soil temperature and heat capacity. It prevents soil from weathering and also determines the readiness of fields to be worked upon.

Exercise

Choose the correct answer from the given alternatives

1. Study of climate is known as…….

   a. Metrology b. Etiology c. Topology d. Climatology

2. ……is the weather condition for longer period.

   a. Climate b. Weather c. Both a and b d. None of these

3. Study of weather is known as……..

   a. Metrology b. Etiology c. Topology d. Climatology

Write short answer to the following questions.

1. Differentiate between weather and climate.
2. Define wind, storm, hail storm, rainfall and humidity.
3. How does the light affect the growth and development of crops?

Write long answer to the following questions.

1. Enlist the environmental factor that affects the crop production and describe one of them in details.
2. Describe the impact of temperature on crop production with examples.

Project work

1. Field Visit and Report Writing

Conduct a field visit to nearby metrological station. Assign students a report on field visit in group or individually

2. Recording of metrological data

Involve students in data recording of rainfall, minimum & maximum temperature and relative Humidity of school area for some weekly or long. Guide students to record metrological data of your region in from news. Compare these data and conduct group discussion.

Home Garden and Small-scale Farming

Unit 3

3.1 Definition of Home Garden, Difference Between Home Garden and Kitchen Garden

3.1.1 Home Garden

Figure5. Home garden

A home garden is a comparatively larger area near or around the house where food crops, vegetables, fruits, herbs, flowers, and sometimes medicinal plants are grown and maintained by household members and their products are primarily intended for the family consumption. Home garden is considered as a traditional method of growing food at home form long time ago. In many villages and countryside, farmers have been practicing home gardening for generations.

3.1.2 Kitchen Garden

A kitchen garden is a small piece of land usually 10 - 50m^2 near the house where vegetables, fruits, and herbs are grown for daily cooking. A kitchen garden is

usually made in the backyard or near the kitchen of a house. It helps families get fresh and healthy food. People grow vegetables like tomatoes, spinach, and carrots, and herbs like coriander and mint.

The kitchen garden is a part of the home garden. A home garden includes many types of plants i.e. for food, beauty, or medicine, while, a kitchen garden mainly focuses on vegetables and herbs. Both help in providing fresh, healthy food at home.

3.1.3 Difference Between Home Garden and Kitchen Garden

Home Garden	Kitchen Garden
A home garden is a larger area where different types of plants like vegetables, fruits, flowers, herbs, and even medicinal plants are grown.	A kitchen garden is smaller and a part of the home garden focused mainly on growing vegetables and herbs for daily cooking.
The home garden is usually spread around the house, including the front yard, backyard, or side spaces.	The kitchen garden is generally located close to the kitchen for easy access while from kitchen.
In a home garden, plants may be grown not only for food but also for decoration, religious use, and traditional medicine.	In a kitchen garden, plants are mainly grown to produce fresh and organic vegetables and herbs for daily consumption.
The size of a home garden is usually larger, ranging from 50 to 200 square meters or more.	The size of a kitchen garden is smaller, often between 10 and 50 square meters.
The home garden may require more time, planning, and care as it contains a variety of plants.	The kitchen garden is easier to manage and maintain, even with limited time and space.

3.2 Basis of Crops Selection for Home Garden

It is important to take various considerations for crops selection for home garden. We should have plan and concepts on "What to grow in a home garden". The following points are the basis in selecting crops for the home garden:

1. **Climate and Season:** Owner should choose crops that grow well in local weather and season. For example: Grow cauliflower in winter, okra in summer.
2. **Available Space:** Owner should select plants according to the size of the garden. For example: If small space is there leafy greens, herbs, etc. might be right selection, while if big space is there papaya, guava, etc. might be right selection.
3. **Family Needs:** In home garden, crops should be grown on the basis of family needs or what is regularly consumed. For example: If your family eats a lot of spinach, plant more spinach.
4. **Ease of Growing:** For home garden choose crops that are easy to grow and care. For example: Radish and coriander are easy for beginners.
5. **Pest and Disease Resistance:** It is judicious to select varieties that are strong against pests and diseases for home garden.
6. **Harvest Time:** For home garden choose crops that give quick or multiple harvests. For example: Tomato, chili, beans, etc.

Exercise

Choose the correct answer from the given alternatives

1. What is the main purpose of a kitchen garden?

   a. Decoration

   b. Growing fruits for sale

   c. Growing vegetables and herbs for daily cooking

   d. Growing timber trees

2. Which of the following is usually grown in a home garden but not necessarily in a kitchen garden?

   a. Tomatoes b. Spinach

   c. Mango tree d. Coriander

3. A kitchen garden is usually located:

   a. Far from the house b. Near the farm

   c. In the kitchen d. Close to the kitchen or backyard

4. The size of a typical home garden is:

   a. 1–5 m^2 b. 10–20 m^2

   c. 50–200 m^2 d. 500–1000 m^2

Write short answer to the following questions.

1. Define home garden and kitchen garden.
2. Define a kitchen garden and write one advantage of having it at home.

Write long answer to the following questions.

1. Differentiate between home garden and kitchen garden in five points.
2. What points should be considered while selecting crops for a home garden? Explain each briefly with examples.

Project work

1. Observation and Drawing

Guide students to draw the layout of a home garden. Ask students to show where you would plant vegetables, fruits, and herbs if you had 100 m^2 of space.

2. Discussion

Guide students in groups to discuss what types of vegetables and herbs your family uses daily. Say them to list 5 crops that could be grown in a kitchen garden.

Unit 4

Organic Farming

4.1 Concept and Definition of Organic Farming

The word "organic" means natural and free from harmful chemicals. It refers to things that come from nature, like plants, animals, and natural materials. When we talk about farming, "organic" means cultivation or animal husbandry done by using only organic things without adding artificial or chemical products.

Generally, organic farming is a method of growing crops and raising animals by using only natural or organic materials. It does not use chemical fertilizers, chemical pesticides, or genetically modified seeds. Instead, it uses compost, animal dung, green manure, and natural ways to protect plants and improve the soil. Hence, organic farming can be defined as the form of agriculture that relies on crop rotation, green manure, compost, organic pest management, & organic nutrient management and excluding or strictly limiting the use of synthetic fertilizers and synthetic pesticides, plant growth regulators, livestock antibiotics, food additives, and genetically modified organisms.

In organic farming, farmers work with nature. This type of farming gives safe and healthy food, protects the environment, and keeps the land fertile for future generations.

4.2 Principle of Organic Farming

There are four principles of organic farming. They are discussed below:

1. Principle of Health

Organic farming works to improve the health of the soil, plants, animals, and people together. It avoids chemical fertilizers and pesticides to produce safe and

nutritious food.

2. Principle of Ecology

Organic farming follows natural ecological cycles and systems. It uses methods like crop rotation, composting, and natural pest control to maintain a balanced, nature-friendly farm.

3. Principle of Fairness

Organic farming supports fair treatment for farmers, workers, consumers, animals, and the environment. It promotes honesty and equity in relationships across the entire food chain.

4. Principle of Care

Organic farming encourages careful and responsible decisions. Farmers avoid harmful or risky methods to protect the environment and ensure future generations can also farm healthily.

4.3 Methods of Organic Farming

Organic farming depends on natural processes to maintain soil fertility, manage pests, and produce healthy crops without the use of synthetic chemicals. The following methods are adopted for organic farming:

1. Crop Rotation

Crop rotation is one of the vital methods of organic farming. Crop rotation is the practice of growing different crops in sequence on the same field. This method prevents pests and diseases that target one plants by interrupting their life cycles. While rotating crops if one of the crops is leguminous crops like beans or peas, they enrich the soil by fixing atmospheric nitrogen. Additionally, alternating deep-rooted and shallow-rooted plants improves soil structure and nutrient availability.

2. Soil Fertility Management

When doing organic farming soil fertility management is important and can be

done by using natural materials to nourish the soil as described below:

- **Farm Yard Manure (FYM)**

  It is prepared by decomposing animal dung, urine, and bedding materials. Properly decomposed FYM appears dark, crumbly, and odorless, and it enhances soil fertility, soil water retention and nutrient-holding capacity.

- **Compost**

  Compost is prepared by recycling organic waste (crop residues, kitchen scraps) through controlled decomposition. Layered materials in pits or heaps are kept moist and turned regularly. After 3–4 months, the waste transforms into humus-rich compost. The benefits of using compost are as of FYM.

- **Vermicompost**

  Vermicompost is prepared by using red earthworms (*Eisenia fetida*) to digest organic waste in shallow bins, producing nutrient-dense castings. These castings are mixed with soil to enhance soil fertility, maintain soil physical & chemical properties and to boost plant growth.

- **Green Manure**

  Green Manure involves growing nitrogen-fixing plants like sunnhemp or dhaincha and plowing them into the soil before flowering. This adds organic matter, improves soil texture and enhances fertility.

3. Natural Pest and Disease Control

In organic farming, natural pest and disease control methods are applied singly or in combination to minimize harm. The natural pest and disease control methods are described below:

- **Biological control** introduces beneficial organisms (e.g., ladybugs for aphids).
- **Mechanical methods** include hand-picking pests, using barrier nets,

or applying sticky traps.

- **Cultural practices,** such as intercropping pest-repelling plants (e.g., garlic with tomatoes) or removing diseased plants, disrupt pest habitats.
- **Biopesticides** like neem oil offer targeted, low-toxicity solutions.

4. Use of Biofertilizers

Biofertilizers are the microorganisms incorporated in soil or seeds to enhance soil health. There are other many biofertilizer that can be use during organic farming. Bacteria like *Rhizobium* for legumes fix nitrogen, while fungi like mycorrhizae help roots to absorb phosphorus and water. These are applied to seeds or soil to support nutrient uptake and increase nutrient availibility.

5. Sustainable Field Practices

Sustainable field practices conserve resources and suppress weeds and can be performed as described below:

- **Water management** includes early-morning irrigation and mulching with straw to reduce evaporation.
- **Weed control** relies on manual removal and organic mulch barriers to block sunlight that decompose to enhance fertility and maintain soil properties.

4.4 Advantages and Disadvantages of organic farming

Advantages of organic farming

- Improvement in health levels
- Minimize soil pollution, less groundwater pollution
- Protection of beneficial insects
- Conservation of ecosystem and environment
- More sustainable
- Organic garbage can be composted and reused
- Organic food may taste better

- Better nutrition values on average
- Better for the health of farmers and consumer
- Use of local materials
- More original form of farming

Disadvantages of organic farming

- May not be suitable for growing on a large scale
- Yield might be low in initial years of transformation
- Pest management will be more complicated
- Products may be too expensive for poor people
- Regulatory standards may be hard to meet
- High certification costs
- Small farmers may go out of business
- Organic farming can be time-consuming
- Organic farming needs plenty of knowledge

Exercise

Choose the correct answer from the given alternatives

1. …….is not a principle of organic farming.

   a. Health b. Ecology c. Fairness d. Wealth

2. There are……principles of organic farming.

   a. 2 b. 3 c. 4 d. 5

3. Daincha is a……..

   a. Green manure b. Organic manure

   c. Chemical fertilizer d. None of these

Write short answer to the following questions.

1. Write about the principle of organic farming.
2. What are the advantages of organic farming?
3. What are the disadvantages of organic farming?

Write long answer to the following questions.

1. Write different methods of organic farming.
2. Describe the principle of organic farming. How both farmer and consumer will be benefited by organic farming.

Project work

1. **Compost Making**

   Instruct students to collect dry leaves, vegetable peels, and cow dung. Layer them in a compost pit or bucket. Observe it weekly and note changes.

2. **Farm Visit Report**

   Visit a local organic farm. Observe the crops and natural methods used. Write a short report about what you saw and learned.

3. **Chart Making**

   Guide students to make a chart showing 5 methods of organic farming like composting and crop rotation. Use drawings or keywords to explain each.

Unit 5

Orchard Management

5.1 Introduction to Orchard

An orchard is a piece of land where fruit crops are cultivated commercially in an orderly manner. It is an area where intensive cultivation of fruit crops is done.

In simple words: "An orchard is a garden of fruit trees."

It is essentially a planned area where trees are systematically planted and cared for to produce fruit and nuts. Orchards can vary in size, from small family-owned farms to large commercial plantations. Common trees found in orchards include apples, orange, peach, cherry, mango, banana, litchi, almond, etc. The layout of an orchard is often designed to optimize growth, making it easier for farmers to harvest the produce efficiently.

An orchard is an important part of horticulture. Different types of orchards can be planned depending on land size, climate, fruit type, and purpose. With proper planning and care, orchards can give good fruit yield and profit.

5.1.1 Orchard Management

Orchard management refers to growing of fruit plants in an orderly manner and maintains them for successive economic returns. In another words, Orchard management refers to the principle and practices adopted for cultivation of fruit crop on a piece to obtain optimum return.

It is a systematic management of orchard starting with planning followed by cultivation, care and maintenance, and harvesting of fruits. Farmers and gardeners use different methods to make sure trees stay healthy, get enough water, and don't get damaged by insects or diseases. Good orchard management practices include:

- Planning (land, fruits, quantity, etc.)
- Cultivation of fruit trees (starting with laying out)
- Intercultural operations
    - Training and pruning
    - Fertilizer application
    - Irrigation and drainage management
    - Pesticides and hormones application
    - Mulching, etc.
- Harvesting fruits in proper way

In conclusion, orchard management refers to the principle and practices adopted for cultivation of fruit crop on a piece of land to get maximum income.

5.1.2 Factors to be Considered While Establishing an Orchard

1. Climate and Weather

Suitable weather conditions such as relative humidity, rainfalls, nature of wind, wind velocity, temperature, amount of light, etc. are the most important factors to be considered while establishing an orchard. Different fruit crops require different amount of weather factors. Depending upon the fruits to be planted, orchard should be managed.

2. Soil Types and Soil Fertility

The soil should be fertile with proper drainage facility. The pH should be 6.0-8.0 depending upon the fruit crops. The land should be slightly sloppy. Mostly clay loam type of soil is preferred for a fruit orchard.

3. Irrigation Facility

In an orchard, there must be a good facility of water for irrigation. It is always recommended to select the site for orchard where there is availability of water sources with efficient irrigation canal.

4. Inputs Availability

The area to be selected for an orchard should be accessible to every types of inputs required for the management of the orchard.

5. Availability of Labor

Labor is one of the most essential inputs. Therefore, the site for an orchard should be selected in a place where availability of labor is easy.

6. Transportation Facilities

Transportation facility is must for transporting both inputs and output. The site which lacks transportation facility requires extra labor which is more costly, time consuming and difficult.

7. Market and Storage Facilities

The site of an orchard should be selected in such a place where market is easily accessible to sell the product. Most of the fruits are perishable in nature. Therefore, the storage facilities should also be considered for prolonging the shelf life of fruits.

5.1.3 Orchard Layout or Design

Orchard layout means planning the arrangement of fruit trees in a proper pattern on the land before planting. It is the way fruit trees are arranged in an orchard. A good layout helps trees grow properly, makes it easier for farmers to take care of them, and improves fruit production.

In simple words: Orchard layout is the plan of planting fruit trees in a proper and organized way.

Importance of Proper Orchard Layout

a. Better use of space – Trees are planted with enough gaps for growth
b. Good sunlight exposure – Helps trees produce more fruits.
c. Easy movement – Farmers can easily water, prune, and harvest fruits.
d. Prevents overcrowding – Reduces competition for nutrients and water.

e. Protects trees from diseases – Spacing helps stop the spread of pests and infections.

5.1.3.1 Systems of Orchard Layout

There are several ways to arrange trees. These are called layout systems.

1. Square System

- Trees are planted in straight rows and columns forming squares.
- It is the most common and simplest method of planting trees.
- Trees are planted at equal distance in rows and columns.
- Common in flat lands.
- Land is not fully utilized in this system.
- Example: Spacing of 10 m × 10 m for mango, Spacing of 5 m × 5 m for guava.

2. Rectangular System

- The rectangular system is a method of planting fruit trees where the distance between rows in greater than the distance between trees within a row. This arrangement allows for better air circulation, sunlight exposure, and ease of movement for farm operations.
- It is useful for orchards with different sizes.
- This system is suitable for crops like apple, banana, pear, plum, peach, mango, etc.
- Example: Banana can be planted at the spacing of 3.6 m × 2.4 m.

3. Triangular System or Alternate System

- The triangular system is a method of planting fruit trees where each tree is placed at the corners of an equilateral triangle. This arrangement allows for better air circulation, sunlight exposure, and efficient use of space compared to square or rectangular layouts.
- This system is suitable for crops like papaya, coconut, pineapple, etc.

- Though this system provides more open space to the plants, it becomes difficult to carry out intercultural operations.

4. Hexagonal System

- Trees form a hexagon (six-sided shape) for maximum space use.
- More trees can be planted per area. This system has an advantage in the sense that it accommodates 15 percent more trees per unit area than in the square system.
- Requires careful planting to maintain the shape.
- The main disadvantages about this system are the complex nature of its layout and greater population of trees and causing more competition for moisture and nutrient uptake.
- Also known as equilateral triangular system.

5. Quincunx System or Diagonal System

- It is like the square system, but extra trees are planted in the center of squares.
- Allow extra fruit production.
- Common in high-density orchards.

6. Contour System

- In this system trees are planted along natural land slopes.
- Prevents soil erosion in hilly areas.
- It helps rainwater flow naturally to the trees.

5.2 Training and Pruning of Fruit Crops

Training of fruit crops refers to the process of giving desired shape to plants with the aim of optimizing the production and facilitating the intercultural operations. Training includes tying, fastening, staking or supporting over a trellis or pergola in a certain fashion or some of its parts are removed to provide a specific framework. Some tall growing varieties of apple are trained as dwarf trees by

pruning some of their top branches so as to keep their bearing surface low for easy picking. Grape vines are trained by bending and supporting their branches on horizontal wire trellises or on the roof of pergola.

Pruning is the practice of cutting away a portion of the plant, such as branches, shoots, leaves, or roots, to improve its health, shape, growth, repair injury, and productivity. The fruit trees if left to grow naturally, will not bear abundantly unless they are pruned or to a specific form.

Not all species or varieties of fruit trees require regular training and pruning. For example, some evergreen tropical trees like mango, sapota, coconut, date palm, jackfruit, etc. do not require regular training and pruning as they naturally grow with a balanced shape, and upright structure. However, they may require some occasional prunings to remove dead and diseased branches. Similarly, fruit crops like papaya, banana, and pineapple also do not require training and pruning to grow well and produce abundantly. Whereas most deciduous trees such as pear, plum, peach, apple, grape, kiwi, etc. have to trained and pruned annually. In some trees like citrus, pomegranate, and guava only initial training and pruning at early stage is done to train them to the desired form.

It is difficult to distinguish between training and pruning clearly. However, the differences between training and pruning are as follows:

S.N	Training	Pruning
1.	It is the process of giving desired shape and size to the trees.	It is the process of removing diseased, insect infected, died and other unwanted branches from trees.
2.	The purpose of training is to provide shape as per the requirement.	The purpose of pruning is to improve the growth, flowering and fruiting capacity and quality of the product.

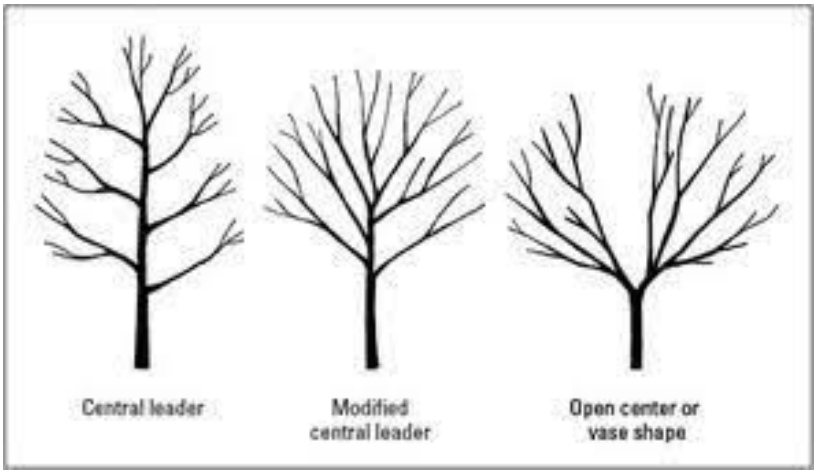
3.	Types of Training: Central Leader System Open Center System Modified Leader System	Types of pruning: Heading back Thinning Out
4.	It helps in intercultural operation.	It helps in intercultural operation.

Objectives of Training

- To develop strong framework of tree.
- To control and regulate shape of trees so that orchard cultural operations, harvesting etc. can be done easily.
- To have a better crotch angle between scaffold branches of trees.
- To facilitate interception of sunrays to each and every part of trees.
- To develop balance between vegetative and reproductive growth.

Objectives of Pruning

- To control flowering and fruiting
- To enlarge productions in plants which bear on new shoots.
- To obtain regular bearing
- To remove water sprouts
- To remove diseased, damaged, insect infested and weak shoots.
- To thin out flowers and fruits.
- To ensure access to sunlight to bearing shoots.
- To invigorate the plants.
- To have balance between vegetative and reproductive growth.



5.3 Methods of Training and Pruning

Methods of Training

1. Central Leader System

In this system, the main trunk is allowed to develop without interruption. The first branch is allowed to grow at 45 to 50 cm height from ground level and other branches are allowed to grow on main stem at a distance of 15 to 20cm.

This system leads to a spreading structure. It facilitates thinning, spraying, picking, removal of diseased portions. It exposes the tree to maximum extent and this has a uniform distribution of fruits on the branches. This system is not suitable for high altitude where frost observance is common.

2. Open Centre System

In open centre system, the main stem is allowed to grow only upto a certain height and the leader stem is cut to encourage lateral branch production. In this system, the main trunk is cut, when the plant attains a height of 40 to 50 cm. 3-5 nearly equally developed primary lateral branches which are well scattered, arranged and distributed are allowed to develop from trunk.

This system leads to a spreading structure, through with somewhat weaker crotches facilitating thinning, spraying, picking, removal of diseased portions.

It exposes the tree to maximum extent and this has a uniform distribution of fruits on the branches.

It is mostly practiced in peaches, apple, cherries and American type of plum.

3. Modified Leader System

This is intermediate form of central leader and open center system and has the benefits of both systems.

It is first trained like center leader by allowing stem to grow for first 4-5 years and then headed back to 75-120 cm height from ground level.

On the main stem, the first shoot is selected at the height of 40cm from the ground and 4-5 branches located at a distance of 15-20 cm and placed all around the main stem are selected. When properly formed, it provides stronger crotches, better spacing between laterals and more height than open head tree. Easy in spraying, pruning and harvesting. Mostly used for commercial fruits i.e. apple.

Some Special Method of Training

1. Bush System

In this system, the height of the plant is kept to 2 meters. During first year, the plant is cut at a height of 70 cm. No shoot is allowed to grow up to a height of 25-30 cm above the height, 3-4 branches are allowed to grow over which number of branches emerge out. The plants acquire the shape of bush. The centre of the plant is kept open. This system is suitable for apple.

2. Pyramid System

In this system, the plants are trained in the fashion so that the lower branches may remain longer and higher branches gradually smaller. The alternative tiers of horizontal branches radiating from main stem scattered all round, gives the plant an appearance of pyramid. The branches are allowed to grow on main stem at 20 cm height from ground level. The plants are pruned from the tip of main stem and branches to maintain pyramid shape.

3. Cordon System

Cordon refers to closely spurred single stemmed tree tied to a support e.g. wires or bamboo canes, either in vertical, oblique or horizontal position. This system usually finds favor in apples and pears. The trained plants bear early crop as compared to dwarf pyramid and bush system. The plants are planted at a distance of 1-1.5 m. The stem of the plant is tied with wire. The wires of 12 to 13 gauges are fixed to the ground using cement and concrete at 4.5-6 meter interval. The plants are maintained single stemmed by practicing severe pruning of emerged branches during winter and summer.

4. Espalier System

The tree trained through this system consists of three to six tiers of horizontal branches trained to grow one foot apart from one another at right angles to the main stem. Thus, the branches grow parallel to the ground. In this system, using poles, three to six rows of wires are stretched one above the other. The first row of wire is stretched at a height of 60 to 70 cm, the second row at 130-140 cm height and the third row is stretched at a height of 200 cm from ground level. Over these wires, the branches of the trees are trained in both the directions parallel to the ground. In this system, the line to line distance of the plant is kept less as the plants are grown only in two directions along with wire. This system usually use in apples and pears.

5.3.1 Training System for Grape Vines

1. Head System

The plants trained through this system, develop in a bush shape. During early years, the vines require support. After 4-5 years, the stems become sturdy enough to stand at its own strength. The plants are allowed to grow to a height of 75-90 cm at the terminal portion of shoot, 5-6 side branches are allowed to grow. The growth of side shoots, which are one year old, is pruned during winter. Flowers and fruits appear on pruned shoot. This system is suitable for less vigorous cultivar and is very simple and inexpensive. This is practiced in Beauty seedless,

Delight, and Gold etc.

2. Kniffin System

This is also known as 4-canes system. In this system, two rows of wire are stretched at a height of 1.05 and 1.65 meters from ground level with the help of iron or concrete poles. The vines are cut at a height of 1.65 meters from ground level. Along with both the line of wire, 2 branches of the vines are trained parallel to the ground. Thus, the vines develop 4 arms. This system is suitable for medium vigorous cultivar. This is practiced in Beauty Seedless, Early Muscat, Bhokri and Delight etc.

3. Bower System

This system is well suited for vigorous cultivar. The vines are trained on criss-cross network of wires. To create network of wires, poles are fixed at a distance of 4.5 to 6 meters. The poles are 2.1meter to 2.4 meter high. Angle irons fixed through poles to develop a roof like structure. At a distance of 60 cm, holes are drilled in angle iron. Through these holes, wires are stretched length and width wise to have a criss-cross network of wires. The vines are allowed to grow single stem till it reaches the network of wires. Then, it is pinched off to facilitate production of side shoots. Two vigorous shoots in opposite direction are selected at the wire level for training as primary arms. On each primary arms, three laterals on either side are selected at 60 cm distance to develop as secondary arms. Each secondary arms are allowed to have 8-10 tertiary branches. The tertiary branches form the fruiting canes and cover the entire network of wire. It is most expensive of all systems but still practiced at a commercial scale. In tropical climate, where the vines grow vigorously and have prominent apical dominance, bower system is best suited for training grape vines.

5.3.2 Methods of Pruning

1. Heading Back

Removal of terminal portion of shoot leaving basal portion intact is termed as heading back. In this method approximately one third to one half of terminal

end is removed. Heading back of terminal bud destroys the apical dominance by which bud growth is encouraged. Thus, heading back induce bushy, compact, dense or much branched of growth.

2. Thinning

It is the process of complete removal of branches or a part from the plant. When a shoot is entirely removed from the point of its origin and no re-growth is allowed to occur from the cut ends, it is called thinning out. It improves light penetration, enhances air circulation, and reduces overcrowding. This process does not stimulate new shoot growth.

3. Ringing or Girdling

In this process, a circular ring of bark measuring about 3 cm in length is removed. It hastens flowering and fruiting by allowing greater accumulation of photosynthates in upward portion of the plants.

4. Dehorning

Dehorning is a severe form of pruning where main branches are drastically cut back near to the trunk. This type of pruning is done to remove non-productive limbs when trees have become woody and unproductive. After dehorning is done in trees, they stimulate vigorous new shoot development from dormant buds. It is also done to reduce canopy size when trees become too large for efficient management. This method is best performed during dormant season.

5. Notching

Making a notch above a bud by removing a wedge-shaped piece of bark is termed as notching. It checks the influence of hormone and encourages growth.

6. Nicking

Making a notch below a bud by removing a wedge-shaped piece of bark is termed as nicking. This ensures accumulation of carbohydrates from leaves to the bud and may result in the formation of fruit bud.

7. Bulk Pruning

Bulk pruning is a method of pruning trees in which the removal of a large volume of old, unproductive, diseased, or overcrowded branches of a fruit tree is done. It is also called as heavy pruning. The main purpose of this method is to rejuvenate old trees.

5.4 Orchard Soil Management Practice to Maintain Soil Fertility

Soil is the most important material for plant growth and nutrition. To conserve soil from erosion and maintain its fertility and productivity, adequate practices must be adopted.

Soil management practices have following objectives:

- To provide favorable moisture to plant.
- To provide sufficient nutrition for maximum production.
- To add organic matters to soil.
- To improve physical and chemical composition of soil.

There are several soil managements practices that have been used to improve the soil fertility in horticultural field/orchard. Individual or combined practices are effective to maintain the good soil fertility.

The following practices are adopted for soil fertility management of an orchard:

1. Clean Cultivation

This practice involves regular ploughing, disking and harrowing of the area between plant rows. So, the land will be free from weeds, increase the infiltration and makes easy to mix fertilizers and green manure. It is not a desirable practice to the horticulturist if nutrient supply and irrigation are limited. It is done to keep the field free from weeds and to make the top soil loose.

2. Cover Cropping

It is a practice of growing weepy and bushy plants with dense vegetative growth under horticulture trees. It is more important in the areas of high rainfall. Crops

like: berseem, Lucerne, beans, sweet potato, etc. can be grown.

3. Intercropping

It is growing up of two or more crops on the same piece of land. It is also known as companion or mixed cropping. Crops like: fruit trees+vegetable crops, coconut+ banana+ pineapple (multi-storeyed crops) can be grown as intercropping.

4. Crop Rotation

It is growing of two or more crops one after another on the same piece of land. Crops like: rice-vegetables, cabbage-beans-Cole crops-cucurbits, tomato-okra-cowpea can be grown.

5. Mulching

This is the process of covering naked soil around the stem of growing plant with layer of organic material usually plant residues and several other materials. Mulching helps to conserve soil moisture, reduce evaporation, reduce compactness, maintain soil fertility, decrease soil erosion and control weeds population.

6. Green Manuring

Green manuring plants like dhaincha and other legumes are grown when they are needed and then buried by ploughing. Flowering stage is appropriate for ploughing. Ideal green manuring crops should be fast growing to produce large amount of organic matter and also to fix atmospheric nitrogen.

7. Soilless Culture

It is a system of soil management where plants are grown in permanent grass without tillage and additional organic matter. This practice is mostly used to control soil erosion in orchards. Grape vines, grasses, legumes etc. are planted between rows and raised without tillage. It is not very practicable in tropical and sub-tropical belts. It is mostly practiced in cold and moist regions of steep slopes where erosion is a serious problem.

8. Terracing

Land which are slopy and where there is more problem of erosion would require the use of terracing. Cultivation by terracing checks the soil from erosion by reducing the velocity of runoff water.

9. Reclamation of Problematic Soil

Soil reaction (pH) is a measure to determine concentration of hydrogen ions in the soil, although not directly influencing plant growth. It has a number of indirect effects such as the availability of various nutrients and the activity of beneficial microbial activity. A pH range of 5.5-7.0 is best for plant growth usually. 7.0 is a neutral point and below this is called acidic and above it is alkaline. To lower the pH of an alkaline soil, calcium sulphate ($CaSO_4$) is used and to higher the pH of soil, calcium nitrate and quick lime (CaO) is applicable.

9.1 Liming in Orchard

Liming simply refers to the process of applying lime (calcium-containing compounds) in soil to correct soil acidity and improve soil health. The liming material that is used in agricultural field is called agricultural lime. The common agricultural lime that are in use are calcium carbonate ($CaCO_3$) and dolomite ($CaMg(CO)_3)_2$. These liming materials also add calcium in soil.

Liming is primarily done to raise the soil pH. It also has some other benefits. The importance of liming in orchard are listed below:

- Liming raises soil pH, reducing acidity that can stunt plant growth.
- It improves nutrient availability by helping in better uptake of nutrients like nitrogen, phosphorus, and potassium.
- Creating favorable pH after liming helps in improving soil structure and proper root development of plants.
- It adds essential nutrients like calcium and magnesium.

9.2 Method of Liming in Orchard

Generally, liming should be done before planting or during the dormant season in orchard. But while applying lime, we must perform soil test to know about the soil pH. After that only we can estimate the amount of lime required in our orchard. Liming can be done by broadcasting and in ring method. In ring method, circular ring should be made around the tree by digging. There the appropriate amount of lime should be added in 15-20 cm depth and covered by soil. The distance between the trunk and ring depends upon the size of the tree. After the application of lime, light watering should be done.

In broadcasting method, lime can be thoroughly mixed with soil and can be broadcasted in the orchard. This method is appropriate for large scale orchards.

5.5 Mulching

Mulching can be defined as a process in which plant roots zone soil is covered with organic or inorganic materials to conserve soil moisture, check weeds and control soil temperature. It covers the soil and make more favorable conditions for plant growth, development. The practice of applying mulch is an ancient and effective technique.

Advantages of Mulching

- It conserves soil moisture by reducing the evaporation of water from the soil.
- It suppresses the weeds and thereby checks the loss of water and nutrients from the soil.
- It controls the fluctuation of soil temperature by insulting soil surface which prevents freezing injury to roots and provides a warmer condition for better root growth and physiological activities.
- The organic mulch increases the organic matter content of the soil and improves the soil fertility and availability of plant nutrients.
- The organic mulch provides congenial soil environment for earthworms.

- It protects soil from wind and water erosion.
- The plastic mulch improves the fruits quality and reduces the fruits rotting by preventing the fruits from contacting soil.
- It improves the seed germination and checks the loss of fertilizers by leaching.
- It reduces the compaction of soil and particularly organic mulch enhances the soil aeration.
- It conserves the depleting natural resources like water.

Disadvantages of Mulching

- The harmful pests can get shelter beneath the mulch.
- The warm and moist environment beneath the mulch provides favourable conditions for disease development.
- The pollution and post use disposal issue arise when non-degradable plastic is used in mulching.
- The crop residues and hay used in mulching may carry and spread the seeds of pernicious weeds.
- The plastic mulches may cause anaerobic condition harmful for roots.

5.5.1 Types of Mulching

Generally, mulching has two main types organic mulching and inorganic mulching.

Organic Mulching

An organic mulch is made up of natural materials such as paddy straw, wheat straw, bark, dry grasses, wood chips, dry leaves, pine needles, sawdust, grass clipping, etc. But this organic mulch material gets decomposed easily and needs frequent replacement, and attracts insects, slugs, and cutworms.

1. Straw Mulch: This is the most common material used in organic mulch. Paddy and wheat straw is the most common mulching materials used

for vegetable crops and fruit crops. Among organic mulching materials, straw has a long life compared to other mulches like grasses, leaves, and sawdust. Paddy straw and wheat straw after decomposition makes the soil more fertile

2. Grass Clipping Mulch: This is one of the most easily available material. Green grass or dry grass are used for grass clipping. After decompose, grass provides nitrogen to the soil. In the rainy season, green grass development of its root system, so my suggestion uses dry grass for mulching.

Inorganic Mulching

In Inorganic mulching, materials like plastic films, geotextiles, Gravel, and pebbles can be used as inorganic mulch. Inorganic mulches are extensively used in commercial agriculture. Plastic mulch is the most common material used among all inorganic mulches. It does not decompose easily. Plastic mulch is made up of polyethylene material. In plastic mulching, various types of plastic mulching are available according to crop and need.

a. Clear Plastic Mulch

This type of mulch allows the soil to warm. This mulch is mostly used in the cooler area; if you take the crop a little early, then use this clear mulch this mulch useful for strawberry cultivation in the winter season.

b. Black Mulch

As the name suggests in black mulch, both side of this is black in colour. This mulch doesn't transfer any light. It helps in conserving moisture, controlling the weed.

c. Yellow-Brown Mulch

In this type, the brown side is touching the soil, and the yellow is facing upward. It is used in the area where you have a lot of infestation of whitefly. Yellow colour attracts whitefly so when whitefly come into contact with mulch due to sun heat they are killed.

d. Silver-Black Mulch

This mulch is very popular among the farmer. This mulch is suitable for almost every crop. This mulch reflects 27% of the light to the fruits and plant which improves color development. It is observed that pomegranate and strawberry fruits are more premontane in colour.

e. White-Black Mulch

White-black mulch transferred more than 60% of the photoactive radiation back to the plant hence enhancing the plant growth, and the plant becomes thickest and stronger leave with lesser insect and pest attack and disease.

5.5.2 Comparison between Organic and Inorganic Mulches

Organic Mulch	Inorganic Mulch
It includes any material of natural origin such as grass, straw, leaves & saw dust that decomposes naturally.	. It includes inorganic materials such as plastic films.
It has relatively low cost, especially if reusing farm waste and crop residues.	It is much expensive than organic mulches.
It is not easily available in large quantities.	It is often available in large quantities at commercial centers.
High replacement frequency.	Low maintenance as well as low replacement frequency.
High decomposition rate.	Low decomposition rate.
Difficult to handle, transport and lay.	Easy to handle, transport and lay.
It suppress weed growth only if the mulch layer is thick.	It drastically suppresses weed growth.

5.5.3 Techniques of Mulching

There are some precautions that should be taken before installing the Mulch on the fields such as:

- The area of the Mulch should be equal to the canopy of the plant.
- The Mulch sheet of the required size should be cut from the main roll.
- Before the application of the Mulch, the area should be cleaned properly and stones, pebbles, and weeds should be removed.
- The land should be tilled and watered before the application of Mulch.
- To anchor the Mulch material properly in the area, making trenches around the area is helpful.
- The material is spread around the tree or plant and the ends should be buried into the ground at least 7-10 cm deep or into furrows at an angle of 450.
- Holes at the corners of the sheet can facilitate water movement.
- The opening of the Mulch material should be parallel to the wind direction.
- The sides of the Mulch material should be covered with 4-6 inches of soil to make the Mulch immovable.
- Mulch has to be laid during non-windy conditions.
- It should be laid evenly on the soil bed without any creases, but should not be very tight so as to facilitate expansion and shrink during various weather and environmental conditions.

5.6 Soil Fertility Management

Soil fertility is the capacity of a soil to supply available nutrients to plants in an adequate amount and in suitable proportions to maintain the growth and development of plants. Soil fertility management refers to the management of appropriate amount of nutrients in the soil to provide nutrients to different crops for their proper growth and development. Inherent amount of nutrient present in soil may not be always adequate to every plants for regular cropping. Once the crop is planted in a certain field, it extracts required amount of nutrient from that field. This makes the soil deficit of different soil nutrients which should be additionally applied by farmer to provide adequate nutrients to other crops.

There are different sources of nutrients depending upon its origin.

1. Organic Fertilizers

Organic fertilizers are natural materials of either plant or animal origin, including livestock manure, green manures, crop residues, household waste, compost and woodland litter. They are slow acting and low in concentration than inorganic synthetic fertilizers.

Examples of Organic Fertilizer

a. Farm Yard Manure (FYM)
b. Green Manures
c. Compost
d. Vermi-compost
e. Night Soil
f. Poultry manure
g. Bird guano
h. Oil cakes
i. Neem cakes
j. Bone powder of different animals (Bone meal)

2. Inorganic Fertilizers

Inorganic fertilizers are those fertilizers mined and synthesized from mineral deposits with little processing or industrially manufactured through chemical processes. They are fast acting and high in concentration than organic fertilizers.

Examples of Inorganic Fertilizer

a. Urea
b. Di-ammonium Phosphate (DAP)
c. Muriate of Potash
d. Sodium Nitrate

e. Ammonium sulphate

f. Single super phosphate (SSP)

g. Double super phosphate (DSP)

h. Triple super phosphate (TSP)

i. Potassium sulphate

5.7 Windbreak

The wind break means close planting of tall growing trees all around the orchard is called as wind breaks. Fruit orchards usually cause heavy losses when exposed to strong wind. Heavy wind increases the losses of moisture both by increasing transportation and surface evaporation. The high winds also cause the damage to fruit trees braking of branches, destruction of blooms dropping of immature fruit and erosion of surface soil. The fruits are reduced on the exposed orchard firstly due to drying of a stigmatic fluid yield and secondly due to reduced activities of pollinating insect. The growth and yield in protected orchard are definitely better than the exposed orchard. Hence, establishment of a tall growing windbreak is necessary to protect the orchard.

Selection of Wind Breaks

While selecting wind more importance is given to the height than the thickness. Windbreaks will give full protection to a distance of 4-5 times the height of trees and partial protection for some distance where land is level. The wind break should be erect and tall growing, hardy and drought resistant occupy less space as for as possible. It should be mechanically strong and dense to resist maximum wind.

Planting and Spacing of Wind Breaks

Planting of wind breaks should be done at least 2 years after plating of fruit trees. These wind breaks they are planted in rows. The first row of it should be planted 40 feet away from fruit plants one to two rows of such trees are planted on the west and south side of orchard at a close spacing to from a thick screen. They

are plated at the spacing of 12 feet x 12 feet or 15 feet a thick screen. They wind breaks they are planted in rows.

Precaution after Planting of Wind Break

The windbreak trees sometimes may compete to the fruit trees for water and nutrient. To prevent this competition, a trench may dig about 3 feet deep and 20 feet away from the row of wind break trees and all the roots of wind break trees exposed in the teach are cut off.

Species Used as Wind Breaks

The trees are commonly used as windbreaks are as follows:

Polylthia langifolia, casurina equsitifolia, Erythrina indica, Eucalyptus ciirddors, Gravilla robustus, Dalbergia sisso, Syzygium cumin, Mangifera indica, Averhoa carambola, Bambusa spp.

To stop soil erosion by wind the wind the breaks which are used, they are *Eryhina indica. Bionomia megaputomica, Millingtionia hortensis, Cassia pungent* etc. For protection of banana, papaya and beetle vine orchard a wind break of *Sysabenia* spp. are used.

Advantages of Wind Breaks

- It reduces the wind velocity.
- It checks the evaporation losses of water from the soil surface.
- It prevents the damage caused by cold wind and frost.
- It increases the fruit production by minimizing wind damage.

5.8 Alley Cropping

Alley cropping is the planting of rows of trees or shrubs wide enough to create alleyways within which agronomic or forage crops are planted or produced. Alley cropping can have many ecological and economic benefits.

1. Reduced soil erosion: Especially when established in sloping areas, alley cropping can slow erosion, thereby improving water quality.

2. Improved crop performance: Added organic matter from trees and shrubs can increase soil productivity. Alley cropping also creates a microclimate from the increased shade and reduced wind, which in turn increases water use efficiency by crops.
3. Reduced use of chemical fertilizers and pesticides: Weeds are better controlled, and increased nutrient flow improves soil fertility without the use of fertilizers.
4. Minimized nitrogen leaching: Nitrogen leached beyond the cropping root zone is often captured by the deeper tree root systems. Minimizing this leaching improves water quality.
5. Promotion of biodiversity: Planting diverse vegetation provides more wildlife with more potential habitat.

5.9 Sod Culture

This practice is followed in the orchard located on sloppy land, particularly when the gradient of the slope is greater than 10 per cent. In this system, grasses are allowed to grow in the interspaces between the trees without tillage or mulching. Mixing of clovers i.e. red clover (*Trifolium pretense*) or white clover (*Trifolium repense*) with grasses is useful for improving soil fertility. The grasses are mowed periodically to reduce competition for water and nutrients with the trees. Orchard grass (*Dactylis glomerata*) is suitable for areas facing north, tall fescues (*Festuca arundinaceae*) a drought tolerant perennial grass for areas facing south, and Timothy (*Phleum pretense*) for cold temperate region. This system prevents soil erosion to the greatest extent; however it should not be followed in orchards of young or dwarf trees because such trees are shallow rooted and compete for nutrients and water with grasses. The roots of large trees on the other hand penetrate the soil to a greater depth and are less likely to suffer from such competition. Tree basins are kept free of weeds by tillage or application of herbicides.

Advantages of Sod Culture

- Controls soil erosion.
- Maintains optimum soil moisture to ensure water and nutrients supply to trees.
- Maintains organic matter.
- Provides better aeration to the roots.
- Enhances microbiological activity in the soil through better aeration
- Avoids bruising of falling fruits.

5.10 Contour Cropping

It is generally followed on the hills where the plants are planted along the contour across the slope. It particularly suits to land with undulated topography, where there is greater danger of erosion and irrigation of the orchard is difficult. The main purpose of this system is to minimize land erosion and to conserve soil moisture so as to make the slope fit for growing fruits and plantation crops. The contour line is so designed and graded in such a way that the flow of water in the irrigation channel becomes slow and thus finds time to penetrate into the, soil without causing erosion. Terrace system on the other hand refers to planting in flat strip of land formed across a sloping side of a hill, lying level along the contours. Terraced fields rise in steps one above the other and help to bring more area into productive use and also to prevent soil erosion. The width of the contour terrace varies according to the nature of the slope. If the slope becomes stiff, the width of terrace is narrower and vice-versa. The planting distance under the contour system may not be uniform. When the slope is less than 10% contour bunding is practiced and if the slope is greater than 10% contour terracing is practiced. In this system the trees are planted along the contour line at right angles. Cultivation and irrigation can be practiced along the tree rows only.

Advantages of Contour Cropping

- This system can be adopted in hilly regions and in leveled land.

- Contour system can control the soil erosion.
- It helps simultaneously in the conservation of water.
- Preservation of plant nutrients supplied by manures and fertilizers possible.
- Contours form an easy path for movements on the hill slopes for carrying out various orchard operations such as weeding, manuring, pruning, harvesting, disease and pest control.

Exercise

Choose the correct answer from the given alternatives

1. Close planting of tall growing trees all around the orchard is called as……

   a. Wind breaks b. Contour c. Alley d. Slopes

2. Nicking is a method of……

   a. Training b. Pruning c. Both a and b d. None of these

Write short answer to the following questions.

1. What is mulching? Write its types.
2. Write the advantages of sod culture.
3. Write the advantages of mulching

Write long answer to the following questions.

1. Write in detail about different techniques of mulching.
2. Write about orchard soil management practice to maintain soil fertility.

Project work

1. Map Your Orchard

Give a task for students to draw a basic layout of an ideal orchard on chart paper (showing fruit rows, spacing, walkways).

2. Draw and Label

Assign students to draw training systems (central leader, open center) or types of mulch and label them.

3. Soil Observation Diary

Ask students to collect soil near a fruit tree and write 3–4 lines about its color, texture, and what is growing on it.

4. Tree Watch

Give homework or project work to observe a fruit tree near their home: Are there any pruned branches? Is mulch used? Ask to write short notes.

Plant Hrowth and Development

Unit 6

6.1. Dormancy

Dormancy refers to the state of plant or seed or bud in which growth and development are temporarily stopped. This can occur naturally in response to environmental factors such as changes in temperature or light, or it can be induced artificially by farmers. There are different types of dormancy like seed dormancy, bud dormancy, and whole plant dormancy or winter dormancy in perennials.

Types of Dormancy

i. Bud Dormancy

Bud dormancy is a resting phase during which buds do not grow, usually in response to unfavorable environmental conditions such as cold temperatures or drought. The major reasons that cause dormancy in buds are low temperature, shorter daylight (photoperiod), limited water availability, and increased production of abscisic acid. It occurs mostly in woody perennials like apple, peach, plum, apricot, rose, etc. Both the flower buds and vegetative buds get dormant in unfavorable conditions, which causes such plants to not produce new leaves, branches, and flowers. Bud dormancy occurs to protect the growing tips from cold, frost, or drought, to save energy during the times of low sunlight and to regulate growth cycles especially in temperate zones. Bud dormancy in trees gets broken when there trees obtain enough chilling requirement, due to hormonal changes, and because of lengthened days and warmer temperatures in spring.

ii. Seed Dormancy

Seed dormancy is the state in which seed is unable to germinate, even under

ideal growing conditions. It is the condition in which a viable seed fails to germinate even when it is placed in favorable environmental conditions such as moisture, temperature, oxygen, and light. It is a temporary pause in germination. Seeds remain dormant due to several reasons like hard seed coat, immature embryo, hormonal imbalance, presence of chemical inhibitors like abscisic acid, etc. Dormancy in seeds help them survive harsh environments, allows storage and transport, and promotes uniform germination after dormancy ends. It is the dormancy of seeds, which makes us able to eat the grains and beans after some months or even years.

iii. Whole Plant Dormancy or Winter Dormancy in Perennials

Dormancy in plants is a temporary period of suspended growth and metabolic activity that allows the plant to survive unfavorable environmental conditions, such as extreme cold, drought, or lack of nutrients. It is like a 'resting phase' where the plant slows down or stops its normal activities (like growing or producing leaves, flowers, or fruits) until environment becomes suitable again. The entire above-ground part of the plant becomes inactive and dies back. Only underground parts (roots, tubers, bulbs, rhizomes) survive. This type of dormancy is common in many herbaceous perennial plants like ginger, potato, asparagus, chayote, yam, turmeric, sweet potato, dahlia, onion, garlic, banana, gladiolus, etc. Dormancy occurs in cold and dry season after fruiting in such crops. In those crops, vines or shoots die back but roots or other underground parts remain dormant. Dormancy breaks up when the temperature warms up, rainfall and irrigation is available, and day length increases.

6.1.2. Methods of Breaking Dormancy

Dormancy in plants must be broken for seeds to germinate, buds to sprout, and plants to regrow. Different types of dormancy require different methods to wake the seed or bud or plant.

i. Methods of Breaking Seed Dormancy

Different seeds have different dormancy breaking methods. It's important to

understand the specific characteristics of the seed you're trying to germinate before deciding which method to use. There are several methods of breaking seed dormancy, which are described below.

a. Cold Stratification

Exposing seeds to low temperatures for a period of time, simulating winter conditions may induce germination in some seeds. Seeds of temperate climate like apple and cherry need to get exposed to cold and moist conditions to induce germination.

b. Scarification

It is one of the methods of breaking dormancy in which seed coat is physically or chemically scratched to allow water and oxygen to penetrate the seed. Seeds of beans and lotus require such type of dormancy breaking method.

c. Gibberellic Acid Treatment

It is a plant hormone used to stimulate germination in seed. Seeds of barley and lettuce can induce germination after the GA_3 treatment.

d. Hot Water Treatment

It is a method of exposing seeds to hot water for a period of time to soften the seed coat to enable germination.

e. Soaking

It is the method which involves allowing of the seed to soak in water for a period of time to allow for hydration and germination. Most of the leguminous seeds are soaked to induce germination.

ii. Methods of Breaking Bud Dormancy

Buds in trees and shrubs become dormant during winter or drought and resume growth in spring.

a. Chilling Treatment (Cold Treatment)

Buds when exposed to cold for several weeks breaks dormancy. It creates

natural winter conditions. Temperate fruits like peach and apple's bud dormancy can be broken by exposing them in cold temperature for longer period of time.

b. Application of Hormones (GA3)

Spraying gibberellins (GA_3) in some plants helps break dormancy. In grapes such practices are done.

c. Pruning

To break the bud dormancy pruning can be done in some woody plants like rose and guava. Such pruning removes the apical dominance and stimulates bud growth.

d. Improved Light and Water Availability

Increased sunlight and irrigation helps resume bud growth in dormant shrubs like citrus and hibiscus.

iii. **Methods of Breaking Plant Dormancy**

a. Replanting after Proper Rest

Plant like turmeric gets regrowth after replanting of rhizomes which were stored.

b. Warm Temperature and Water

When the temperature increases and water availability increases, plants lime yam and ginger start to grow again.

c. Artificial Sprouting

Exposing bulbs in onions to light and warmth initiates shoots before planting.

6.2. Germination and its Type

Germination is the process by which a plant seed sprouts and begins to grow. It involves the absorption of water by the seed, which causes the seed to swell and the seed coat to split open.

During germination, the radicle begins to form roots while the shoot (stem and leaves) begins to form. Additionally, the stored food reserves of the seed are used to support the growth of the new plant. Germination is a vital step in the lifecycle of a plant, as it marks the transition from a dormant seed to an actively growing plant. Water, oxygen, suitable temperature, and light or darkness depending on the seed type are the prerequisites for the germination of seed.

Example: When a bean seed is planted in moist soil, it swells, the seed coat breaks, and a small root (radicle) and shoot (plumule) start to come out. This is called as germination.

Types of Germination

There are two main types of seed germination based on the position of cotyledons (seed leaves) during sprouting.

i. Epigeal Germination

"Epi" means above and "geal" means ground.

In this type of germination, the cotyledons (seed leaves) come above the soil surface. The hypocotyl part elongates and pushes the cotyledons upward. Most of the dicots have this type of germination. Eg. Soyabean, sunflower, blackgram, green gram, etc.

ii. Hypogeal Germination

'Hypo' means below, and 'geal' means ground

In this type of germination, the cotyledons remain below the soil surface. The epicotyl part pushes the shoot upward. Cotyledons do not perform photosynthesis; they stay underground and provide stored food. Most of the monocotyledons have this type of germination. Eg. maize, rice, wheat, pea, lentil, chickpea, etc.

iii. Viviparous Germination

Viviparous germination is a special type of germination where the seed starts to grow (germinate) while it is still attached to the parent plant, before falling to

the ground. The radicle comes out from the seed while still inside the fruit. The seedling starts to develop on the plant itself. Eg. chayote, jackfruit (sometimes), maize (rarely).

6.3. Flowering

Flowering is the process in plants where they produce flowers, which are reproductive structures. After the initiation of flowering in plants, the juvenile phase stops and reproductive phase starts. Once the flowers are pollinated they can produce seeds which will grow into new plants. Flowering is an important aspect of the lifecycle of plants, as it enables them to reproduce and ensure the continuation of their species.

6.3.1. Photoperiodism

The response to changes in day length that enables plants to adapt to seasonal changes in their environment. Initiation of flowering depends upon the day length that any plants are exposed. There are different types of plants depending upon the day length they require to initiate flowering. They are

i. Short Day Plants

Short day plants are those plants which generally require less than 12 hours of daylight to initiate flowering. For example: Rice, Soya beans, Strawberries, Lettuce, Spinach, etc.

ii. **Long Day Plants**

Long day plants are those plants which generally require more than 12 hours of day length to initiate flowering. For example: Wheat, Barley, Carrot, Radish, Onion, Garlic, Spinach, Plum, Apricot, Peach, etc.

iii. Day Neutral Plants

Those plants which are independent of day length to initiate flowering are called day neutral plants. For example: Maize, tomato, cucumber, squash, etc.

S.N.	Short Day Plant	Long Day Plant
1	Plants flower when photoperiod is less than the critical day length	Plants flower when photoperiod is more than the critical day length
2	Interruption during light period with darkness does not inhibit flowering	Interruption during light period with darkness inhibit flowering
3	Flowering is inhibited if the long dark period is interrupted by a flash of light	Flowering occurs if the long dark period is interrupted by a flash of light
4	Long continuous and uninterrupted dark period is critical for flowering	Dark period is not critical for flowering
5	Flowering does not occur under alternating cycles of short day and short light period.	Flowering occurs under alternating cycles of short day followed by still shorter dark periods

6.3.2 Vernalization

Many plants do not come to flower before they experience a low temperature. These plants remain vegetative during the warm season, receive low temperature during winter, grow further and then bear flowers and fruits. Requirement of low temperature prevents precocious reproductive development in autumn. It allows the plant to reach vegetative maturity before reproduction can occur. The annual winter plants also possess spring varieties. The spring varieties are planted in spring. They come to flower and bear fruits prior to end of growing season. If the winter varieties are sown similarly, they fail to flower and produce fruits before the end of growing season. They are planted in autumn, form seedlings in which form they cover winter. The seedlings resume growth in spring. They bear flowers and fruits in summer.

Vernalization is, therefore, a process of shortening of the juvenile or vegetative phase and hastening flowering by a previous cold treatment.

Site of Vernalization

Meristematic cells only perceived the stimulus of vernalization. Meristematic cells are present in Shoot tip, Embryo tips, Root apex, Developing leaves etc.

Requirement of Vernalization

1. **Low Temperature**

   Usually 0^0C-4^0C low temperature is required for vernalization in most cases. The chilling treatment of temperature should not be immediately followed by high-temperature (about 40^0C) treatment. If the chilling treatment is given just after high-temperature treatment the property of vernalization is lost.

2. **Duration of Chilling Treatment**

   There is no fixed duration of chilling treatment for vernalization. Duration of low-temperature treatment varies from species to species from a few hours to a few days.

3. **Actively Dividing Cells**

   vernalization stimulus is perceived only by actively dividing cells of meristematic cells. Therefore, vernalization treatment is given to the germinating seeds or whole plant with meristematic tissues and other conditions.

4. **Water**

   Water is the reason for life. So, proper hydration is a must for perceiving the stimulus of vernalization by actively dividing cells of meristematic tissues.

5. **Oxygen**

   Vernalization also required proper aerobic respiration. The stimulus of vernalization has been named as “Vernalin”.

Importance of Vernalization

- Vernalization induces synthesis of growth hormones like Gibberellins.

- Vernalization can overcome some inhibitors and reduces their effects during growth and Flowering.
- Vernalization reduces the Vegetative period of a plant.
- Vernalization treatment prepares the plant for Flowering.
- Vernalization enhances the resistance power to cold and diseases in plants.
- Vernalization increases the yield of crops.
- Vernalization can Remove kernel wrinkles in wheat plants.
- Vernalization reduces the period between germination and flowering. Due to this, more than one crop can be obtained during a year in the same field.

6.4 Maturity

Maturity is the stage of fully development of tissue of fruit and vegetables only after which it will ripen normally. During the process of maturation the fruit receives a regular supply of food material from the plant. When mature, the abscission or corky layer which forms at the stern end stops this inflow. Afterwards, the fruit depend on its own reserves, carbohydrates are dehydrated and sugars accumulate until the sugar acid ratio form. In addition to this, typical flavour and characteristic colour also develop.

Factors Affecting Maturity

1. Temperature

Higher temperature gives early maturity. Lemon and guava takes less time to mature in summer than in winter. Sun-scorched portions of fruits are characterized by chlorophyll loss, yellowing, disappearance of starch and other alcohol insoluble material, increase in TSS content, decrease in acidity and softening.

2. Soil

Soil on which the fruit tree is grown affects the time of maturity. Such as

grapes are harvested earlier on light sandy soils than on heavy clays.

3. **Size of Planting Material**

This factor in propagated fruits affects fruit maturity. Such as in pineapple, the number of days taken from flowering to fruit maturity was more by planting large suckers and slips than by smaller ones.

4. **Closer Spacing**

Close spacing of hill bananas hastened maturity.

5. **Pruning Intensity**

Pruning intensity enhances the maturity of peaches.

6. **Girdling**

Girdling is the process of constricting the periphery of a stem which blocks the downward translocation of CHO, hormones, etc. Beyond the constriction which rather accumulates above it. In Grape vines it hastens maturity, reduces the green berries in unevenly maturity cultivar and lowers the number of short berries. It is ineffective when done close to harvest.

6.5 Juvenility

Juvenility describes the phase of growth following germination from seed during which flowering does not occur and the bud meristem is not "competent" to respond to seasonal environmental inductive cues, and hence remains vegetative. Physiologically, the juvenile state is a period when the plant is capable of exponential increase in size, when flowering cannot be readily induced, and when plant develops characteristics morphological forms of leaves, stems, thorns etc. For example: Juvenile leaves may simple and mature leaves are compound in bean and citrus.

It is important as it affects when a plant can become reproductive. Understanding this phenomenon and getting different ideas of accelerating growth to get early flowering will have great practical significance. It affects the plant breeding

efficiency, plant propagation, and to the selection of new cultivars. The length of the juvenile phase can vary from a few days to years depending on the species. For example, some herbaceous species remain juvenile few days (Cauliflower: 2-8 weeks, broccoli: 5 weeks) whereas apple seedlings usually remain vegetative for 7–9 years after seed germination. Plant hormones like GA and auxin are more likely control the juvenility.

The juvenile period of some plants are given below:

Plant	**Juvenile Period**
Rose	20-30 days
Grapes	1 year
Mango	5 years
Tomato, Brinjal	60 days

6.6 Fruiting

Fruiting is a process that takes place after fertilization of flowers. After fertilization, gamete formation takes place which is followed by formation of zygote. This process of zygote formation is called fruiting.

6.6.1 Fruit Ripening

Ripening refers to the processes which transform the mature fruit qualitatively so that the fruit may have specific flavor, aroma, color and consistency with better edible qualities. In another words, the qualitative change at the end of growth period which makes a fruit edible is called fruit ripening. Fruit ripening takes place after the maturation of fruits and when the fruits reach its maximum size. Ripening is also called as degradation process. During ripening, chemical change takes place for eg: starch turns to sugar; chloroplast are disintegrated which results loss of greenness of fruit. In fleshy fruit, ripening is accompanied by softening of flesh. Fruit varies in ripening behavior. For example: avocado ripening proceeds only after picking but many fruits ripen while the fruit is still attached to the tree or may proceed if the fruit picked at maturity.

On the basis of ripening behavior, fruits are classified as climacteric and non-climacteric fruits.

a. Climacteric

Climacteric fruits are defined as fruits that enter 'climacteric phase' after harvest i.e. they continue to ripen. During the ripening process the fruits emit ethylene along with increased rate of respiration. Ripe fruits are soft and delicate and generally cannot withstand rigors of transport and repeated handling. These fruits are harvested hard and green, but fully mature and are ripened near consumption areas. Small dose of ethylene is used to induce ripening process under controlled conditions of temperature and humidity. These fruit in fully ripe state are too delicate to withstand transportation over long distances and should preferably be ripened near the consumption area. Climacteric fruits are: mango, banana, papaya, guava, sapota, kiwi, fig, apple, passion fruit, apricot, plum, pear, etc.

b. Non-Climacteric

Non-climacteric fruits once harvested do not ripen further. Non-climacteric fruits produce very small amount of ethylene and do not respond to ethylene treatment. There is no characteristic increased rate of respiration or production of carbon dioxide. In order to improve external skin colour and market acceptance, citrus like orange, lemon, mousambi and kinnow can be treated with ethylene, as a de-greening agent. Ethylene treatment breaks down the green chlorophyll pigment in the exterior part of the peel and allows the yellow or orange carotenoid pigments to be expressed. Non-climacteric fruits are: orange, grapefruit, grapes, pomegranate, litchi, watermelon, cherry, raspberry, blackberry, strawberry, carambola, rambutan, cashew, etc.

6.6.2 Fruit Setting

Fruit setting is the transition phase of the ovary from the flower to the developing fruit, and takes place a few days after the floral opening. The ovary begins its development after pollination and fertilization or, in its absence, through parthenocarpy.

6.6.3 Fruit Drop

Fruit drop is the detachment or separation of a fruit from a branch of a tree or a plant, caused by the formation of a separation of layer of cells (abscission layer) on the fruit stalk due to a series of physiological and biochemical events. It may occur shortly after pollination and fruit set or even at the time of normal fruit ripening. There are so many reasons for fruit drop like internal (Hormonal balance, morphological and genetical) and external (biotic and abiotic) factors. Fruit drop is very much serious in some fruits like apple, peach, currant, mango, citrus etc. Fruit drop may occur at various stages of fruit growth, starting right from fruit setting till its harvesting. It may be natural, environmental or pest related. Among different drops, pre harvest drop is of great economic importance which can cause serious crop loss to farmer.

6.6.4 Fruit Senescence and its Types

Fruit senescence refers to the aging process that leads to the decline in quality and eventual death of fruits. It is characterized by changes in physical and chemical properties, such as softening, color changes, loss of firmness, and the production of ethylene and other volatile compounds. There are two main types of fruit senescence. They are:

i. Physiological Senescence

Physiological senescence is a normal and inevitable process that occurs as fruits age and is primarily triggered by the decline in hormonal balance and metabolic activity. This type of senescence is also influenced by environmental factors such as temperature and light exposure.

ii. Pathological Senescence

Pathological senescence is the type of senescence caused by disease, injury, or other external factors that disrupt the normal aging process. Pathological senescence can lead to premature aging, spoilage, and reduced marketability of fruits and vegetables.

Exercise

Choose the correct answer from the given alternatives.

1. The process of shortening of juvenile phase by cold treatment is called as ……..

   a. Germination b. Vernalization

   c. Maturation e. Senescence

2. In which type of germination, cotyledons come above the ground?

   a. Hypogeal b. Viviparous

   c. Epigeal d. Apogeal

3. Which of the following is a climacteric fruit?

   a. Orange b. Grape

   c. Mango d. Litchi

4. ……. hormone is commonly used to break seed or bud dormancy?

   a. Auxin b. Ethylene

   c. Abscisic acid d. Gibberellic acid

5. Which of the following is not a method to break seed dormancy?

   a. Scarification b. Cold stratification

   c. Spraying insecticide d. Soaking in water

Write short answer to the following questions.

1. Define dormancy and describe the types of dormancy.
2. What is photoperiodism? Enlist examples of a long-day plant.
3. Describe factors affecting fruit maturity.
4. How does fruit senescence affect post-harvest handling and marketability?

Write long answer to the following questions.

1. Describe types of germination with examples. How does viviparous germination differ from others?
2. Explain vernalization and its importance in plant development.
3. Compare climacteric and non-climacteric fruits. Why is it important to know the difference during harvesting and marketing?

Project Work

1. Conduct germination experiment by soaking seeds of bean, maize, etc. Plant them in labeled containers and observe epigeal and hypogeal germination. Maintain a germination diary and label radicle and plumule.
2. Arrange a field visit to local orchard to observe fruits like banana, guava, or tomato and record maturity signs like color, softness, aroma, ease of detachment. Suggest students to present findings in a group discussion.
3. Engage students to prepare flashcards of dormancy types and germination types and share in class for group revision.

Unit 7

Plant Growth Regulators

7.1 Meaning and Definition of Plant Growth Regulators

Plant Growth Regulators (PGRs) are synthetic or organic substances other than plant nutrients which promote and inhibit the physiological process of the plant.

PGRs regulate various aspects of plant growth and development, such as shoot and root elongation, flower initiation, and fruit maturation. These substances can be naturally occurring or synthetic and can either stimulate or inhibit growth, depending on their desired outcome. These substances are used in agriculture for various purposes such as to increase crop yield, improve crop quality, regulate flowering, and increase fruit size.

The PGRs can be applied as foliar sprays, soil drenches, or as a part of hydroponic nutrient solutions. The specific type and concentration of PGR used, as well as the timing of application, can have significant effects on plant growth and development.

7.2 Types of PGRs

There are five broad classes of plant growth regulators (PGR) they are:

1. Auxins
2. Gibberellins
3. Cytokinins
4. Ethylene
5. Abscisic acid

i. Auxins

It is characterized by capacity to induce elongation in plant cell.For example:

IBA: Indole Butaric AcidIAA: Indole Acetic AcidNAA: Nepthalene Acetic Acid

Uses

- Helps in root initiation.
- Responsible for photo-periodism.
- It causes apical dominance.
- It controls abscission.
- It helps in seed germination and breaking of dormancy.
- It helps in the development of fruit even in absence of pollination which is called parthenocarpy.

ii. Gibberellins

Gibberellins may be defined as a compound that stimulates cell division and cell elongation.

Uses

- It promotes stem elongation and cell division
- It promotes seed germination.
- It maintains balance between internode, growth and leaf development.
- It helps in breaking dormancy.

iii. Cytokinins

They are substances which mainly act on cell division and may have little or no effect on elongation of plant cell.

Uses

- It stimulates cell division
- It promotes the DNA, RNA synthesis.
- It stimulates root initiation.
- It helps in breaking dormancy of lateral buds.

- It inhibits protein degradation.
- It increases the shelf life of leafy vegetables.
- It breaks the dormancy of light sensitive seeds like lettuce, tobacco etc.

iv. Ethylene

A plant hormone that is responsible for fruit ripening is called ethylene.

Uses

- It results in the ripening of fruit.
- It helps in seed germination and breaking of seed dormancy.

v. Abscisic Acid

It is also called stress hormone because the production of hormone is stimulated by drought, water logging and other adverse environmental conditions.

Uses

- It induces dormancy of buds towards the approach of winter.
- It helps in prolonging dormancy of buds, storage organs and seeds; also known as dormin.
- Abscisic acid promotes abscission of flowers and fruits.
- It promotes flowering in some short day plants like strawberry.
- Promotes rooting in many stem cuttings.

7.3 Importance and Commercial Uses of PGRs in Fruit Crops

Plant growth regulators (PGRs) play an important role in the growth and development of fruit crops. They are used commercially to improve fruit quality, increase yield, and regulate the timing of fruit production. Some of the specific uses of PGRs in fruit crops are:

i. Improving Fruit Size and Quality

Gibberellins and cytokinins are commonly used to increase the size and quality of fruits, such as apples, pears, and stone fruits.

ii. Regulating Fruit Set and Drop

Abscisic acid and ethylene are used to regulate the timing of fruit set and drop, especially in crops such as citrus, tomatoes, and grapes.

iii. Improving Fruit Color

Cytokinins and gibberellins can be used to enhance fruit color in crops such as peaches, nectarines, and cherries.

iv. Controlling Flowering Time

PGRs can be used to control the timing of flowering in crops such as strawberries and blueberries, to ensure optimal fruit production.

v. Increasing Yield

Gibberellins and cytokinins can be used to increase the yield of crops such as avocados and mangoes.

The use of PGRs in fruit crops has become increasingly important as demand for high-quality, reliable and consistent fruit production continues to rise. However, it is important to note that the use of PGRs should be carefully planned and monitored to ensure that they do not have negative effects on the environment or human health.

Exercise

Choose the correct answer from the given alternatives

1. Which plant growth regulator is mainly responsible for fruit ripening?

   a. Gibberellin b. Cytokinin

   c. Auxin d. Ethylene

2. Which plant hormone is known as the "stress hormone"?

   a. Gibberellin b. Cytokinin

   c. Abscisic acid d. Ethylene

3. What is the main function of auxins in plants?

   a. Increase fruit color b. Ripen fruit

   c. Promote cell elongation d. Induce stress resistance

4. Which hormone would be most suitable to apply for breaking seed dormancy in lettuce seeds?

   a. Abscisic acid b. Gibberellin

   c. Cytokinin d. Ethylene

5. A farmer wants to increase fruit size in his apple orchard. Which plant growth regulator should he use?

   a. Ethylene b. Auxin

   c. Abscisic acid d. Gibberellin

Write short answer to the following questions.

1. Define plant growth regulators (PGRs). Enlist plant growth inhibitors with two commercial use of each.
2. Write functions of gibberellins.
3. Name any two PGRs and one use of each.
4. How does the application of cytokinins help in increasing the shelf life of

leafy vegetables?

5. Why is it important to carefully monitor the use of PGRs in fruit crops?

Write long answer to the following questions.

1. List and explain the five types of plant growth regulators with their major functions.
2. Discuss any four commercial uses of PGRs in fruit crops with suitable examples.
3. A horticulturist wants to induce early flowering in strawberry plants. Suggest a suitable PGR and justify your answer with its function.

Project Work

1. **PGR Flashcard Challenge** ***(Knowledge-building activity)***

   Ask students to create flashcards for each type of Plant Growth Regulator (PGR). On one side, they should write the name of the PGR, and on the other, list its functions and examples. Use the flashcards for quick quiz games or peer teaching sessions.

2. **Role Play: "Hormone Doctors"** ***(Application-focused activity)***

   Divide the class into small groups and give each group a plant-related case study (e.g., fruit drop in mango). Ask students to act as “plant doctors,” diagnose the issue, and suggest the right PGR with a short explanation of its role.

3. **Poster Presentation** ***(Higher ability + creativity)***

   Instruct students to prepare a poster showing the types of PGRs, their commercial uses, do’s and don’ts of application, and fruit examples. Encourage creativity and clarity in design and content.

Unit 8

Harvesting and Post-Harvest Handling of Fruits

8.1 Maturity Judgment of Fruits

Before discussing on the topic maturity judgment, it is important to know about the meaning of maturity. Here, maturity is the stage of fully development of tissue of fruit and vegetables only after which it will ripen normally. During the process of maturation, the fruit receives a regular supply of food material from the plant. When mature, the abscission or corky layer which forms at the stem end stops this inflow. Afterwards, the fruit depend on its own reserves, carbohydrates are dehydrated and sugars accumulate until the sugar acid ratio form. In addition to this, typical flavor and characteristic color also develop.

Maturity judgment of fruits refers to the process of determining when a fruit is ready to be harvested based on specific criteria. The criteria used to determine fruit maturity can vary depending on the type of fruit, but generally include factors such as size, color, texture, and sugar content.

It is important to harvest fruits at the right time, as over-ripe or under-ripe fruits can affect their flavor, texture, and overall quality. In some cases, harvesting too early or too late can also impact the storage life of the fruit.

Assessing the maturity of fruits is important to determine their quality and readiness for consumption.

8.1.1 Techniques of Maturity Judgments

Farmers use following methods to judge fruit maturity.

1. **Change in Color**
   - The fruit changes from green to its natural ripe color.
   - Example: Banana turns from green to yellow. Mango turns yellow, red, or orange.
2. **Size and Shape**
   - The fruit becomes full-sized and appropriate in shape.
   - Example: Apple becomes round and big. Orange becomes full and heavy.
3. **Firmness (Hardness or Softness)**
   - Some fruits become soft when ripe.
   - Example: Peach, papaya, and banana become soft when pressed gently.
4. **Separation from Plant**
   - Fruit comes off easily from the tree or plant.
   - Example: Apple or pear separates easily from the branch when lifted.
5. **Change in Taste**
   - Mature fruits taste sweeter or less sour.
   - Example: Mango becomes sweet; guava becomes less bitter.
6. **Aroma or Smell**
   - Ripe fruits give off a natural good smell.
   - Example: Ripe jackfruit and mango give a sweet smell.
7. **Days from Flowering**
   - Farmers know how many days it takes from flowering to fruit maturity.
   - Example: Tomato is harvested 50–60 days after flowering.
8. **Sound Test**
   - Some fruits give a dull sound when tapped if mature.
   - Example: Watermelon gives a dull (not sharp) sound when tapped.

8.2 Harvesting

Harvesting refers to the process of gathering or collecting a crop or other produce from the field or plant. This can include crops such as grains, fruits, and vegetables, as well as other products such as timber, fish, and minerals. Harvesting is typically performed at the end of the growing season or when the crops or other products have reached maturity, and is an important part of agricultural and other resource-based industries. The method of harvesting can vary depending on the type of product being collected and may involve the use of manual labor, machinery, or a combination of both.

8.2.1 Harvesting Techniques

Harvesting technique refers to the methods and practices used to gather crops or fruits from a plant or tree. This process can involve various techniques, such as handpicking, machine harvesting, or cutting the plant itself. The goal of harvesting is to obtain high-quality, ripe fruits or crops in a timely and efficient manner.

Harvesting techniques are important because they can have a significant impact on the quality of the harvested product. If the fruit is harvested too early or too late, or if it is handled improperly during the harvesting process, it may not be of optimal quality or may not last as long in storage. By using appropriate harvesting techniques, farmers and fruit growers can ensure that their crops are of high quality and meet the demands of consumers.

Harvesting techniques in fruits can vary depending on the type of fruit, the maturity of the fruit, and the intended use. Here are some general guidelines for harvesting common types of fruits:

Apples: They should be picked by hand, twisting the fruit gently and giving it a slight upward lift. Be careful not to bruise or damage the fruit.

Bananas: Bananas are harvested when they are mature but still green. They should be cut from the plant with a sharp knife, taking care not to damage the fruit.

Berries: Berries should be harvested when they are ripe and plump. They should be picked by hand, being careful not to crush the fruit or damage the plant.

Grapes: Grapes should be harvested when they are fully colored and have a slightly soft texture. They should be picked by hand, being careful not to damage the fruit or the plant.

Mangoes: Mangoes should be harvested when they are slightly soft to the touch and have a yellowish color. They should be cut from the tree with a sharp knife, taking care not to damage the fruit or the tree.

Oranges: Oranges should be harvested when they are fully colored and have a firm texture. They should be picked by hand, being careful not to damage the fruit or the tree.

Pineapples: Pineapples should be harvested when they are fully colored and have a sweet smell. They should be cut from the plant with a sharp knife, taking care not to damage the fruit or the plant.

Watermelons: Watermelons should be harvested when they are fully colored and have a dull sound when tapped. They should be cut from the vine with a sharp knife, taking care not to damage the fruit or the vine.

8.3 Post-Harvest Handling Techniques

Post harvest handling techniques refer to the various practices and procedures used to maintain the quality and value of crops of fruits after they have been harvested. These techniques are used to minimize losses, reduce spoilage, and extend the shelf life of the harvested product.

Post-harvest activities include:

- Sorting
- Grading
- Cleaning
- Cooling

- Packaging
- Storage, etc.

Here are some common post-harvest handling techniques

i. **Sorting and Grading:** Sorting and grading involves separating fruits according to their size, color, and quality. This is done to remove any damaged or overripe fruits, which can contaminate the rest of the batch and reduce the overall quality of the product.

ii. **Cleaning:** Cleaning is the process of removing any dirt, debris, or bacteria from the surface of the fruit. This is done to prevent the growth of mold or bacteria that can cause spoilage or reduce the shelf life of the product.

iii. **Cooling:** Cooling is used to reduce the temperature of the fruit, which helps to slow down the natural process of decay and preserve the color, flavor, and texture of the fruit. Cooling also helps to reduce the growth of bacteria and fungi that can cause spoilage.

iv. **Packaging:** Packaging is the process of placing the fruit in containers that protect it from damage during transport and storage. Packaging may also be designed to provide proper ventilation and temperature control to help extend the fruit's shelf life.

v. **Storage:** Proper storage conditions are essential for maintaining the quality and nutritional value of the fruit. Fruits should be stored in a cool, dry place that is free from pests and other potential sources of contamination.

vi. **Ripening:** Ripening is the process of allowing fruits to develop their full flavor and sweetness. This can be done naturally or through the use of ethylene gas, which can speed up the ripening process.

vii. **Freezing:** Freezing is one of the most common methods of processing horticultural crops. This method involves rapidly freezing the produce to preserve its quality and nutritional value. Frozen fruits and vegetables can be stored for extended periods and are commonly used in various food products such as smoothies, juices, and frozen dinners.

viii. **Canning:** Canning involves heating produce in jars or cans to kill bacteria and prevent spoilage. This method helps to preserve the quality and flavor of the produce while also extending its shelf life. Canned fruits and vegetables are commonly used in soups, stews, and other dishes.

ix. **Drying:** Drying is another common method of processing horticultural crops, which involves removing moisture from the produce. Dried fruits and vegetables can be stored for long periods and are commonly used in various food products such as trail mix, granola bars, and baked goods.

x. **Fermentation:** Fermentation is a method of processing horticultural crops that involves using microorganisms to transform the produce into a different form. Fermented fruits and vegetables are commonly used in various food products such as pickles, kimchi, etc.

xi. **Juice Extraction:** Juice extraction is a method of processing horticultural crops that involves extracting the juice from fruits and vegetables. The juice can be consumed as is or used in various food products such as smoothies and juices.

xii. **Pureeing:** Pureeing is a method of processing horticultural crops that involves blending the produce into a smooth, pureed consistency. Pureed fruits and vegetables are commonly used in various food products such as sauces, and soups.

8.4 Storage

Storage refers to the process of preserving and protecting harvested fruits and vegetables from damage, spoilage, and deterioration until they can be used or sold. Proper storage is important to ensure that the quality, flavor, and nutritional value of the produce is maintained over time, and that it can be safely consumed.

Depending on the nature of fruits and vegetables and the duration of storage, it may be short and long or temporary and prolonged. The storage is accomplished by natural and artificial means. Natural storage is done mainly by collecting the harvest. However, the artificial storage is executed by proper control of pests

and pathogenic diseases, regulation of atmosphere and chemical treatments. The post-harvest pest and disease attacks are controlled by application of insecticides and fungicides. While the atmosphere of the store is regulated by controlling the temperature, humidity, $CO_{2,}$ O_2, and gaseous composition.

There are different storage methods that can be used depending on the type of produce being stored and the intended use. Some common storage methods include:

1. Cold storage
2. Controlled atmosphere storage
3. Dry storage
4. Rustic storage
5. Cellar storage

Factors Affecting Storage of Fruits and Vegetables

The factors affecting storage of fruits and vegetables are enlisted below:

1. Pre-harvest factors
2. Harvesting and Post-harvest operations
3. Pre-cooling of fruits and vegetables
4. Sanitation of stores

8.5 Marketing

All horticultural crops are bulky and highly perishable by nature. It is therefore important to dispose of the produce as early as possible to avoid loss in weight and rotting. The losses can be reduced to the minimum through proper packaging, transport, cold storage, and handling. There are no separate markets for fruits in rural areas. However, 'Hat Bazaars' or periodic markets, mainly on a weekly basis, are in existence. Rural markets are needed to support the development of horticulture production programmes. The marketing of horticultural crops has become a problem in some commercial production areas; commercial growers sell the produce either directly to the consumer or to middlemen or retailers who

make a high profit. Usually the middleman's profit is added to the consumer price, which is always 100% higher than the price paid to the farmer. There are no regulated and organized wholesale markets for fresh fruits. Nepalese farmers are good producers, but poor sellers. Usually they sell their products to traders at very low prices.

Problems of Fruit and Vegetable Marketing

- Inappropriate packaging
- Improper grading,
- Lack of transportation and storage facilities
- Poor market information and market facilities are common problems in Nepal.

Exercise

Choose the correct answer from the given alternatives

1. Which of the following is not a method of judging fruit maturity?

   a. Change in color
   b. Sound test
   c. Smell of leaves
   d. Days from flowering

2. What technique is used to slow decay and preserve flavor in fruits after harvest?

   a. Sorting
   b. Cooling
   c. Juicing
   d. Fermentation

3. Which of the following storage methods is suitable for long-term fruit storage using low temperature and controlled gases?

   a. Cellar storage
   b. Dry storage
   c. Cold storage
   d. Rustic storage

4. Which fruit is harvested when it gives a dull sound when tapped?

   a. Mango
   b. Watermelon
   c. Banana
   d. Guava

5. A farmer stores his mangoes in a room where temperature and CO_2 are controlled. What kind of storage is he using?

   a. Dry storage
   b. Rustic storage
   c. Controlled atmosphere storage
   d. Cellar storage

Write short answer to the following questions.

1. Define fruit maturity and list any three methods used to judge maturity.
2. Write any two harvesting techniques for mango and banana.
3. Mention three common problems in fruit and vegetable marketing in Nepal.

4. Why is grading and cleaning important in post-harvest handling of fruits?
5. A farmer harvested guavas early and stored them in poor conditions. What problems may arise? Suggest two solutions.

Write long answer to the following questions.

1. Describe in detail any five post-harvest handling techniques of fruits.
2. Suppose you are a farmer in a rural area of Nepal. You have harvested a large quantity of Mango. Explain how you will judge maturity, harvest, store, and market them efficiently.
3. Explain the importance of proper storage and name any four storage methods used for fruits. What factors affect storage quality?

Project Work

1. Spotting

Set up 3–4 spots with fruits at different stages of ripeness, such as green, ripe, and overripe bananas. Ask students to observe and judge the maturity using factors like color, size, firmness, and aroma. Each group should fill out an observation chart based on their findings.

2. Group Discussion: "Post-Harvest Handling in My Community"

Divide the class into groups and ask them to discuss the post-harvest methods used in their local area and the problems face by farmers. Each group should prepare and present report to the class.

3. Role Play: "From Farm to Market"

Assign students with the role of farmer, transporter, trader, and customer. Have them act from fruit harvesting to selling in the market. Encourage them to highlight real-world issues like middlemen profit, storage losses, and price differences.

Unit 9

Preservation of Fruits

9.1 Preservation of Fruits

Preservation is all about protecting the foods against spoilage. We know fruits are highly perishable agricultural products. Fruits cannot remain fresh for a long time without applying appropriate post-harvest techniques to them. So, for the preservation of fruits, they require different techniques such as refrigeration, freezing, canning, drying, pickling, and many other forms of processing.

Principles of Preservation

There are basically three main principles of preservation of fruits. They are described below:

1. **Control of Moisture**

   The moisture content of fruits is a critical factor in determining their shelf life. Reducing the moisture content through drying, canning or freezing helps to prevent microbial growth and spoilage.

2. **Control of Temperature**

   Temperature control is important to slow down the metabolic activity of the fruits, and hence the rate of spoilage. Cold storage, refrigeration, and freezing are common methods of temperature control for fruit preservation.

3. **Control of Microorganisms**

   Microbial growth is a major cause of fruit spoilage. Chemical preservatives, heat treatment, and fermentation are methods used to control microbial growth.

9.2 Methods of Preservation

There are several methods of preserving fruits and vegetables. Among them, the most important method that can be applied for the preservation of fruits are described below:

1. Canning

Canning is a method of preserving fruits by sealing them in airtight containers, typically glass jars or metal cans, after they have been heated to a high temperature. Canning typically involves packing solid foods into cans or jars, sealing them with a lid, and then heating the container to kill any bacterial or microorganisms present. The resulting vacuum seal helps to preserve the food and prevent spoilage. There are wide variety of canned products that can be found in market such as canned pears, pineapples, cherries, oranges, apricots, etc.

The canning process typically involves the following steps:

1) Preparation of fruit
2) Packing of fruit
3) Addition of liquid and preservatives
4) Sealing of jars or cans
5) Processing
6) Cooling and storage

2. Bottling

Bottling is a similar but slightly different process than canning, and is typically used to preserve beverages and other liquid products.

Bottling involves filling bottles with the product, sealing them with a lid or cork, and then pasteurizing or heat-treating the product to kill any bacteria or microorganisms that may be present. The bottles are then cooled and labeled for distribution.

Procedure for Bottling

i. The bottles are thoroughly washed and sterilized.

ii. The fruit slices are filled leaving about 3 cm space at the top of the jar or bottle.

iii. The sugar syrup recommended for different fruits is filled boiling hot leaving a head space of 1-1.5 cm.

iv. Separate exhausting of bottles is not required and it is done simultaneously with sterilization by putting a pad of cloth (false bottom) under the bottles.

v. The bottles should not be abruptly immersed in hot water, otherwise they may break because of sudden rise in temperature. The temperature of the water should be about the same as that of the contents and should be raised gradually and the bottles kept in the boiling water for the required time.

vi. At the start of sterilization the lids are left loose and the level of boiling water should come up to the neck of the bottle.

vii. When sterilization is over, the mouths of bottles and jars should be immediately closed or corked tightly.

viii. Cooling of bottles is done and the bottles are labeled after drying. The products preserved in bottles require more attractive labels.

ix. Store in cool and dry place.

3. Drying and Dehydration

Drying is another method of preserving fruits, which involves removing most of the water content form the fruit. Removal of moisture from the fruits slows down the growth of microorganisms and enzymes that can cause spoilage.

There are several process of drying fruits are described below:

1. Sun Drying

Fruits are spread out in the sun to dry. This method is commonly used in hot, dry climates and requires several days to dry the fruit completely.

2. Oven Drying

Fruits are sliced and placed on racks in an oven set to a low temperature, typically between 130-160°F (54-71°C), and dried for several hours until they are dehydrated.

3. Dehydrator Drying

Fruits are sliced and placed in a dehydrator machine, which circulates warm air around the fruit to remove moisture. This method is quicker and more consistent than oven drying.

Exercise

Choose the correct answer from the given alternatives

1. Which of the following is not a principle of fruit preservation?

   a. Control of temperature b. Control of moisture

   c. Addition of fertilizer d. Control of microorganisms

2. In bottling, sugar syrup is poured:

   a. Cold b. Frozen

   c. Boiling hot d. After cooling the bottle

3. Which method uses sunlight for removing water from fruits?

   a. Oven drying b. Sun drying

   c. Dehydrator drying d. Freezing

Write short answer to the following questions.

1. Write principles of fruit preservation with one example of each.
2. Define canning and list steps involved in the process.
3. What is drying, and why is it useful in fruit preservation?
4. Suppose you have a mango tree at home. Describe how you would preserve mangoes using the bottling technique.
5. Compare drying methods based on process and suitability for rural areas.

Write long answer to the following questions.

1. Describe the complete procedure of bottling with all the steps involved.
2. Imagine you are a fruit grower in a village without cold storage. Discuss which preservation methods are suitable for your area and how you would apply them to extend shelf life and reduce waste.

Project Work

1. **Demonstration – "Dry Your Own Fruit"**

Suggest students to arrange slices of any fruits on a tray and place them under a fan or in direct sunlight. Over the next few days, ask them to observe and record how moisture reduces from the fruit.

2. **Observation Task: "Canning and Bottling Video"**

   Show a short video demonstrating the process of fruit canning or bottling. Ask students to take notes and then ask them some follow-up questions.

3. **Group Discussion: "Preserving Fruits at Home"**

   Guide students to discuss how fruits are preserved in their villages. In groups, help them to list the types of local fruits grown, common methods used (like drying or pickling), and any challenges faced. Each group should present their findings to the class.

Unit 10

Advanced Horticulture

10.1 Advanced Horticulture

Advanced horticulture refers to the application of advanced technologies, scientific knowledge, and innovative techniques to improve the production, quality, and efficiency of horticultural crops. It involves the combination of various disciplines such as plant physiology, genetics, biotechnology, engineering, and data science to optimize the growing conditions and enhance the performance of horticultural crops. Some examples of advanced horticulture practices are

1. Precision agriculture
2. Biotechnology (Genetic engineering, tissue culture, etc.)
3. Vertical farming (Hydroponics, Aeroponics, and aquaponics)

10.1.1 Protected Cultivation, its Importance and Problems

Protected cultivation refers to the practice of growing plants in an enclosed or partially enclosed structure, such as a greenhouse or a shade net house, in order to create a controlled environment that protects crops from adverse weather conditions, pests, and diseases. Protected cultivation is often used in horticulture for growing high-value crops such as fruits, vegetables, and flowers.

The importance of protected cultivation includes:

1. **Increased Crop Yield and Quality:** Protected cultivation provides a controlled environment for crops, which allows for optimal growing conditions and better crop yield and quality.
2. **Extended Growing Season:** Protected cultivation allows growers to extend the growing season by providing a warm and stable environment, which enables crops to be grown outside of their normal growing season.
3. **Reduced Pest and Disease Pressure:** By providing a barrier between the crops and the external environment, protected cultivation can reduce pest and disease pressure, thereby reducing the need for chemical treatments.
4. **Water Conservation:** Protected cultivation systems typically use drip irrigation or other efficient irrigation systems, which can help conserve water and reduce water usage.

However, there are also some problems associated with protected cultivation that are discussed below:

1. **High Initial Investment:** Setting up a protected cultivation system requires a high initial investment in materials such as greenhouses, shade net houses, or tunnels.
2. **Energy Consumption:** Protected cultivation systems require heating, cooling, and ventilation systems, which can consume a significant amount of energy and contribute to carbon emissions.
3. **Maintenance:** Protected cultivation systems require regular maintenance to ensure optimal growing conditions and prevent damage to the structure.
4. **Potential for Crop Failure:** If the environment within a protected

cultivation system is not properly controlled, crops can still fail due to factors such as disease, pest infestations, or extreme weather conditions.

Overall, protected cultivation can provide many benefits to horticulture growers, but it also requires careful planning, management, and maintenance to be successful.

10.2 Hydroponics

Hydroponics, also called soilless culture. It is the cultivation of plants in nutrient-enriched water, with or without the mechanical support of an inert medium such as sand, gravel, or perlite.

Various kinds of substrates have been used successfully, including rock wool (molten rock that is spun into fibres), fused shale, clay pellets, coconut coir, rice husks, granite chips, sand, pumice, perlite, and vermiculite. The fertilizer solution has different agricultural or horticultural fertilizer grade chemical compounds containing varying amounts of nitrogen, phosphorus, and potassium as well as the major elements necessary for plant growth and various trace, or minor, elements, such as sulfur, magnesium, and calcium. The solution can be used indefinitely. Periodic tests indicate the need for additional chemicals or water. The chemical ingredients usually may be mixed dry and stored. As the plants grow, concentration of the solution and frequency of pumping are increased.

A wide variety of vegetables and florist crops can be grown satisfactorily with hydroponic systems. Common crops include lettuces, spinach, tomatoes, peppers, cucumbers, radishes, strawberries, etc.

Advantages of Hydroponic System

The advantages of hydroponic system are as follow:

- Continuous cultivation in the same land
- Low cost and time for land preparation and soil sterilization
- Low possibility for residues of fumigants and other pesticides
- Low costs of irrigation and fertigation
- Low labour requirement
- All weather working conditions
- Maintenance of clean products
- Minimum environmental pollution (under proper handling of waste materials)
- Low soil and water borne pest and diseases

Disadvantages of Hydroponic System

The disadvantages of hydroponic system are as follow:

- High initial cost in hydroponics structures and equipment
- Requirement of skilled man power
- Requirement of quality water (i.e. low Na and Cl ions, less contamination)
- Less forgiving for mistakes
- Knowledge on the crop physiology is needed

10.3 Aeroponics

The term Aeroponics means to cultivate plants without using soil and water as medium; by maintaining all the parameters essential for growth of plants. The parameters are temperature, humidity, pH and electrical conductivity of nutrient solution etc. Here, the plant grows in the air with the assistance of artificial support instead of soil or substrate culture. It is an air-water plant growing technique where lower portions such as the roots of the plant are hanged inside the growth chamber under complete darkness in controlled conditions. However, the upper portions of the plant such as leaves, fruits, and crown portion are extending outside the growth chamber. Usually, the artificial supporting structure (plastic or thermo-foam) is provided to support and divide the plant into two parts

(roots and leaves). In the system, plant roots are openly exposed in the air and directly irrigated with a small droplet size of the water nutrient at interval basis. The nutrient solution is supplied through different atomization nozzles with or without high air pressure. The technique is economical in the use of fertilizers and saves water nutrient solution compared to other soilless systems.

An indoor aeroponics system uses less water and nutrients because the plant roots are sprayed in intervals using a precise drop size that can be utilized most efficiently by osmosis to nourish the plant. Water may contain a variety of elements according to local treatment plant additions and should be factored into final factor, or primary nutrients are nitrogen, phosphorus, potassium and are used by plants in different amounts according to the growth stage. Secondary nutrients are calcium, magnesium, and Sulphur, micro-nutrients are iron, zinc molybdenum, manganese, boron, copper, cobalt and chlorine.

Advantages of Aeroponics Technology

The advantages of aeroponics system are as follow:

- Aeroponic technology gives high yield with less space requirements.
- Plants can be grown close together.
- Fruits produced from the system are easier to harvest.
- This technology saves water as it cuts down water consumption by 98 percent.
- Fresh and healthy plants can be grown at homes; indoors or at roof top.
- Plants and root growth study in laboratories is easier for students and researchers.
- Plants consume more oxygen under aeroponic conditions; more oxygen equals more plant growth.
- Planting and harvesting can be done throughout the year.
- Due to clean and sterile growing conditions, plant diseases and infections reduce up to a great extent.
- In aeroponic system, plant roots have proper space to grow well. So, they

don’t stretch or wilt. Plants can be shifted to any growing media system without any transplantation

Disadvantages of Aeroponics system

The disadvantages of aeroponics system are as follow:

- Initially some training is required for system maintenance.
- Sanitary conditions are required to be maintained regularly.
- Initial cost of system is high.

Exercise

Choose the correct answer from the given alternatives

1. Hydroponics is also known as.....

   a. Vertical farming b. Soilless culture

   c. Organic farming d. Natural farming

2. A major advantage of protected cultivation is.....

   a. Increases pest attack b. Reduces yield

   c. Water conservation d. Higher chemical usage

3. Which of the following is not used in hydroponic systems?

   a. Perlite b. Clay pellets

   c. Ordinary soil d. Rock wool

Write short answer to the following questions.

1. Define protected cultivation. List any three problems of protected cultivation.
3. Differentiate between hydroponics and aeroponics.
4. Suppose you live in a city area with no farmland. How could hydroponics help you grow vegetables?

Write long answer to the following questions.

1. Describe protected cultivation. Explain its importance and limitations.

Project Work

1. **Poster-Making – "Modern Farming Methods"**

   Guide students to work in groups to make a poster either on protected cultivation, or on hydroponics, or on aeroponics with a diagram. Ask students to present in class.

2. **Classroom Debate – "Is Hydroponics Better than Soil Farming?"**

Organize a debate and encourage students to take part in a debate. Group A will support hydroponics; Group B will support soil farming.

3. Video Observation and Note-Taking

Show a short video on hydroponics or greenhouse farming. Ask students to write three advantages, two interesting facts, and one problem faced by the farmer. Ask students to share noted points with the class.

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