Plant Science

Horticultural Crop Production

Government of Nepal
Ministry of Education, Science and Technology
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Grade 10

Technical and Vocational Stream
Learning Resource Material

Horticultural Crop Production

(Grade 10)

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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. Saroj Kumar Mandal. 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.

2082 BS

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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.

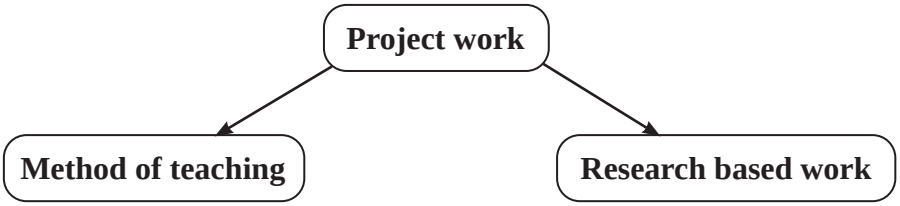
Interaction

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 Specific Horticulture Crops Growing Area in Nepal

Introduction

Nepal's diverse topography and climatic variation make it ideal for cultivating a wide range of horticultural crops. The Terai region, at an altitude of 60–1000 meters, has a tropical and subtropical climate, supporting the growth of fruits like mango, banana, litchi, and guava, as well as vegetables like tomato, brinjal, cucurbits, and leafy vegetables. This lowland area is also suitable for spices like ginger, turmeric, and chili, alongside tropical flowers like marigold.

The mid-hills, with an altitude of 1000–2,000 meters, feature a subtropical to temperate climate and are prominent for citrus fruits (orange, lime, and lemon), pear, peach, and plum. Vegetables like cabbage, cauliflower, carrot, and beans thrive here, as do cash crops like cardamom and garlic. This region is also renowned for tea cultivation in eastern areas like Ilam.

In the high hills above 2,000 meters, the temperate to alpine climate supports the cultivation of apples, walnuts, apricots, and potatoes, along with medicinal and aromatic plants such as Panchaunle and jatamansi. Districts like Mustang, Manang, Dolpa etc. are key contributors to high-altitude horticulture.

Eastern Nepal, which receives high monsoon rainfall, is known for its humid environment conducive to tea plantations, citrus fruits, ginger, and cardamom, with Ilam and Taplejung being notable areas. Conversely, Western Nepal, with less rainfall and varied microclimates, specializes in apple orchards in high hills (e.g., Jumla).

Nepal's climatic diversity, from tropical lowlands to alpine highlands, facilitates the cultivation of a wide variety of horticultural crops. This range not only

supports food security and rural livelihoods but also enhances export potential with high-value crops like apples, tea, cardamom, and medicinal herbs.

The specific horticulture crops growing areas in Nepal according to the **Prime Minister Agriculture Modernization Project (PMAMP)** are as follows:

Horticulture Crop	Growing Area
Tropical Fruits	
Mango	Super Zone: Saptari (Eastern Terai) Zones: Kapilvastu, Rupandehi, Nawalparasi, Dang (Western Terai)
Banana	Super Zone: Sarlahi (Central Terai) Zones: Chitwan, Nawalparasi, Kapilvastu, Jhapa
Papaya	Pockets: Kapilvastu, Chitwan, Saptari, Nawalparasi
Pineapple	Zones: Chitwan, Nawalparasi, Jhapa, Ilam
Sub-Tropical Fruits	
Citrus (Mandarin, Orange, Lime)	Super Zone: Sindhuli (Mandarin Orange Super Zone) Zones: Dhankuta, Ramechhap, Syangja, Lamjung, Kaski, Parbat, Gorkha, Baglung
Litchi	Zones: Sarlahi, Siraha, Udayapur, Jhapa
Guava	Zones: Chitwan, Dang, Nawalparasi, Makwanpur
Temperate Fruits	
Apple	Super Zone: Jumla Zones: Mustang, Dolpa, Kalikot, Mugu, Manang, Humla, Rasuwa
Pear	Zones: Kathmandu Valley (Bhaktapur, Lalitpur), Kavre, Dhankuta, Dolakha
Peach	Zones: Kaski, Ramechhap, Dolakha, Lamjung
Walnut	Zones: Humla, Jumla, Kalikot, Dolpa, Rukum

Vegetables	
Cauliflower & Cabbage	Super Zone: Kavre Zones: Chitwan, Makwanpur, Dhading, Nuwakot, Lalitpur
Tomato	Zones: Kathmandu Valley, Dhading, Chitwan
Chili & Capsicum	Zones: Makwanpur, Nawalparasi, Dhading
Spices and Medicinal Plants	
Cardamom	Super Zone: Taplejung Zones: Panchthar, Ilam, Bhojpur
Ginger	Super Zone: Salyan Zones: Surkhet, Dang, Palpa, Dhankuta
Turmeric	Zones: Jhapa, Morang, Kailali
Aromatic Plants	Zones: High-altitude regions like Dolpa, Humla, Manang
Floriculture & Ornamental Plants	
Cut Flowers (Rose, Gladiolus, Marigold)	Super Zone: Kathmandu Valley Zones: Lalitpur, Bhaktapur, Kavre
Ornamental Plants	Zones: Pokhara, Chitwan, Kathmandu

1.2 Potential of Horticultural Crop Production in Nepal

Nepal has high potential of horticultural crop production in Nepal. There are different factors that create the scope of producing fruit crops, vegetables, flowers, ornamental plants, plantation crops, and medicinal plants. Diverse geographical condition, different agro-climates, presence of micro-climates, increasing demand, and evolving agricultural policies in favor of farmers are some contributing factors that create the potential of producing horticultural crops.

a. Agro-Climatic Variation

In Nepal there are a variety of climatic zones where variety of horticultural crops can be grown easily. All, tropical, sub-tropical, and temperate vegetables, fruits, flowers, medicinal plants, etc. can be successfully cultivated within the country. Thus, there is a great scope of producing horticultural crops in Nepal.

Agro-climatic zones	Fruits
Tropical	Mango, Banana, Papaya, Pineapple, Jackfruit, Coconut, etc.
Sub-tropical	Citrus, Guava, Pomegranate, etc.
Warm temperate	Peach, plum, apricot, pear, etc.
Cool temperate	Apple, walnut, almond, etc.

b. Increasing Demand

The demand for food products is increasing due to some basic factors such as the increase in population and the changing food habits of people. We all know that increasing population increases the mouths to feed. Additionally, people's concern about healthy food habits has also increased the demand for vegetables and fruits. Similarly, other horticultural crops such as flowers, medicinal plants, and ornamental plants also have increased demand. Thus, the increasing demand ensures the potentiality of growing such crops.

c. High Value Crops

Most of the horticultural crops are high value crops. They have the scope of fetching high value in the market. The high market value of these crops can easily attract farmers to engage in horticultural crop production. Thus, there is a great scope of horticultural crop production in Nepal.

d. Import Substitution

Most of the vegetables, fruits, and flowers are imported in Nepal from India and China. Our country is highly dependent on imported horticultural products. We have large amount of arable land in Nepal where we can successfully increase

our horticultural crop cultivation. This can lead to import substitution. Thus, to substitute our large amount of import, we have the scope of horticultural crop production.

e. Improving Farmer Friendly Agro-Policies

Recently, farmer friendly agriculture policies are getting evolved in Nepal. Subsidies in inputs, crop and livestock insurance policy, agriculture promotion policy, etc. are some of them. Such policies have helped encourage the farmers to get engaged in agricultural activities. Thus, such policies have increased the scope of horticultural crop production in Nepal.

f. Growth of Agritourism

The growing interest in agritourism, particularly in regions like Ilam (tea), Mustang (apples), and Kavrepalanchok (citrus), can provide additional income to the farmers and local people. Scenic beauty of such places attracts national and international tourists, which ultimately increases the revenue of the local people.

1.3 Constraints in Commercial Horticultural Crop Production and Possible Remedies

Horticultural crop production plays a vital role in ensuring food security, improving nutrition, and enhancing income for farmers. However, the sector faces several challenges that hinder its growth and profitability. These constraints range from environmental and technological issues to economic, infrastructural, and social barriers. Addressing these challenges requires a holistic approach involving modern technologies, policy support, and innovative farming practices. The major constraints and their possible remedies:

Constraints in Commercial Horticultural Crop Production

- Natural and Climatic Challenges like Unpredictable weather and monsoon dependency, Impact of climate change on crop yields.
- Poor-quality seeds and planting materials.

- Scarcity and high cost of fertilizers and pesticides.
- Inadequate infrastructure leads post-harvest losses due to lack of storage and cold stores.
- Poor irrigation systems and road connectivity.
- Limited technical knowledge of modern farming techniques.
- Insufficient agricultural extension services.
- Difficulty accessing bank loan and high-interest rates.
- Market price fluctuations and high production costs.
- Fragmented landholdings limiting large scale production.
- Weak policy implementation and limited research and development investment.
- Labor shortages due to migration.
- Weak market linkages and unfair involvement of middlemen.
- Underdeveloped processing and export facilities.
- Cheaper imported products reducing domestic competitiveness.

Possible Remedies for Constraints in Commercial Horticultural Crop Production in Nepal

- Promote climate suitable and drought-tolerant crop varieties.
- Develop and implement crop insurance schemes to mitigate risks.
- Strengthen supply chains for fertilizers and pesticides to ensure availability.
- Provide subsidies or financial support for agricultural inputs.
- Develop cold storage, processing facilities, and cold chain networks.
- Expand irrigation systems through community-managed projects.
- Improve road connectivity to facilitate access to markets.
- Strengthen agricultural extension services with more field staff and training programs.

- Introduce farmer field schools and demonstration farms for hands-on learning.
- Promote the use of modern technologies like drip irrigation and greenhouse farming.
- Simplify loan procedures and provide low-interest loan for farmers.
- Stabilize market prices by establishing minimum support price policies.
- Implement land consolidation programs to enable commercial farming.
- Invest in agricultural research for region-specific crops and technologies.
- Strengthen policies promoting public-private partnerships in horticulture.
- Establish farmer markets, collection centers, and e-commerce platforms.
- Promote value addition through training on processing and packaging.
- Provide export support by ensuring compliance with international standards.
- Promote organic and high-quality Nepali products in local and export markets.

Exercises

Choose the correct answer from the given alternatives.

1. Which region in Nepal is suitable for growing mango, banana, and guava?

   a. High hills
   b. Mid-hills
   c. Terai
   d. Eastern Nepal

1. Which region in Nepal is known for tea plantation?

   a. Western Nepal
   b. Eastern Nepal
   c. Mid Nepal
   d. Terai

3. What is a significant potential of horticultural crop production in Nepal?

   a. Dependency on imports
   b. Climatic diversity supporting diverse crops
   c. Decline in market demand
   d. High cost of production

4. What is a major constraint faced by Nepal's horticultural sector?

   a. Availability of land for large-scale farming
   b. Overproduction of crops
   c. Post-harvest losses due to inadequate infrastructure
   d. High literacy rates among farmers

5. Which remedy can help mitigate post-harvest losses?

   a. Using traditional farming methods
   b. Promoting subsistence farming
   c. Developing cold storage and processing facilities
   d. Reducing crop diversity

6. How can Nepal promote export of its horticultural products?

   a. By focusing only on domestic markets

b. Encouraging compliance with international standards

c. Reducing research in high-value crops

d. Avoiding investment in value addition

7. Which horticultural product attracts agritourism in Mustang?

a. Tea

b. Apples

c. Bananas

d. Citrus fruits

8. What is the main climatic characteristic of Nepal's high hills?

a. Tropical

b. Alpine

c. Sub-tropical

d. Temperate

9. What is a critical challenge for Nepal's horticulture sector due to fragmented landholdings?

a. Reduced labor costs

b. Limited large-scale farming

c. Increased access to irrigation

d. Higher export potential

10. What technology can improve productivity in Nepal's horticulture sector?

a. Manual irrigation

b. Traditional pest control

c. Drip irrigation and greenhouse farming

d. Slash and burn farming

11. How can Nepal's horticulture sector address labor shortages?

a. Increase migration opportunities

b. Promote mechanization and modern technologies

c. Ban women from participating in farming

d. Focus on subsistence farming

Write short answer to the following questions.

1. List five tropical horticultural crops grown in the Terai region of Nepal.

Mention one district where each crop is grown.

2. Explain two factors that make Nepal suitable for cultivating a wide variety of horticultural crops. Give examples.
3. What are three major constraints in commercial horticultural crop production in Nepal? Suggest one remedy for each.
4. Why is import substitution important in horticultural crop production? Explain with two examples from Nepal.
5. Describe how agritourism can support horticultural crop production in Nepal. Mention two places where this is practiced.

Write long answer to the following questions.

1. "The diverse topography of Nepal supports different types of horticultural crops." Explain this statement by describing the crops grown in the Terai, mid-hills, and high hills. Give examples of specific crops and districts for each region.
2. Discuss the potential and challenges of horticultural crop production in Nepal. Include at least three potentials and three constraints, along with possible remedies for the constraints.

Project Work

1. Prepare a district-wise horticultural crop map of Nepal showing:
   a. Major tropical, sub-tropical, and temperate horticultural crops.
   b. At least 5 Super Zones and Zones mentioned in the Prime Minister Agriculture Modernization Project (PMAMP).
   c. A short description (2–3 sentences) for each region explaining why the crop is grown there.
   d. You may draw the map by hand or use a digital tool.

Cultivation of Tropical Fruit Crops

Unit 2

2.1 Mango

Introduction

Mango cultivation is done in Nepal in different regions. From the point of view of climate, its cultivation can be done from the lowlands of the country to the central hills. The growth of mango plants planted in the hot areas of the hilly areas is less than the growth in the Terai region and the quantity of the production and quality of fruit is also lower. Among tropical fruits, mango is considered as the main fruit. That is why it is also called the king of fruits. Ripe mango fruits consist of vitamin 'A' and 'C'.

Scientific Name: ***Mangifera indica***
Family: **Anacardiaceae**

Origin

Indo-Burma Region (Southeast Asia)

Present Situation of Mango Production in Nepal

Total cultivation area: 51,681 hectares

Total productive area: 43,688

Total production: 466,266 metric tons

Yield: 10.67 mt/ha

Madhesh Pradesh: Highest mango producing province: 357,150 metric ton

Saptari district: Highest mango producing district: 114,898 metric ton

(Statistical information on Nepalese Agriculture, 2077/78)

Uses

- Unripe mangoes are used to prepare pickles.
- Fresh and ripe fruits are consumed directly and by making juice.
- Mangoes are also used to make jam and jelly.

Nutrition

Mango are highly nutritious fruits. It is rich in carbohydrates, protein, fibre, iron, calcium, phosphorus, vitamin A, vitamin B, and vitamin C.

Varieties

1. Bombay Green
2. Bombay yellow
3. Dashahari
4. Maldah
5. Alfonso
6. Amrapali
7. Mallika
8. Ratna
9. Chausa
10. Culcuttia
11. Neelam

Propagation of Mango

1. Sexual Method

It is the oldest, cheapest, and easiest method of propagation where plants are propagated by the use of seed. Trees propagated through seed live more than the trees propagated by asexual method. But fruiting occurs later in the plants propagated by this method than in the plants propagated through asexual method.

2. Asexual Method (Vegetative Method)

The method of propagation of plants other than by using seed is called the asexual method. There are different methods of vegetative propagation:

a. Inarching Or Approach Grafting

It is one of the most used methods of grafting. It involves joining a branch or shoot from one mango tree (scion) with a stem of another mango tree (rootstock) without separating them from their parent plants until the graft union is well-established.

Process

1. Preparing the Stock

Rootstocks are prepared by sowing the seeds of mango in plastic bag in nursery. Thus, sowed seeds get germinated within 20-25 days and get ready for grafting after 10 months.

2. Preparing the Scion

The scion of the desired quality and variety to be produced is selected. Selected scion should be healthy and well grown. The thickness of scion should be similar to the thickness of rootstock.

3. Joining the Scion and Stock

- Firstly, the rootstock developed in plastic bags should be taken near to the parent plant whose scion is to be used.
- The Scion branch should be bent down to the rootstock. Slanting cut should be made in the rootstock and scion.
- Then, the cut end of the scion should be inserted into the cut end of the rootstock, ensuring the cambium layers of both the scion and stock align.

4. Securing the Graft

To secure the graft, grafting tape or similar material should be used to

tightly bind the graft union. This helps to keep the scion and stock in close contact, allowing for the formation of new tissue connections.

5. Supporting the Scion

The scion branch should be supported by tying to a stake, to prevent movement and damage during the initial stages.

b. Veneer Grafting

- In this type of grafting 8-10 months old rootstock prepared from seed can be used. A slanted 'V' shaped cut should be done in the rootstock 30 cm above the ground level.
- Scion of 3-4 cm diameter and 8-10 cm length should be selected by removing all the leaves from it, keeping the small buds intact.
- Thus, prepared scion should be cut in its lower part in 'V' shape in a way that fits into the rootstock.
- Then, the scion should be inserted into the rootstock and should be tied with grafting tape.
- The scion and rootstock successfully joined in 60-75 days. Regular irrigation should be given until the scion and rootstock get joined successfully.

c. Stone/Epicotyl Grafting

Stone/ Epicotyl grafting is another important, easy, and quick method of propagation in mango that is used for commercial purposes. In this method, young rootstocks are grafted with scion of desirable variety of mango.

Process

- Plantlets present in nursery which are healthy, straight, and have good growth are selected and uprooted.
- Those uprooted plantlets are transplanted into plastic bags. They are given regular irrigation and kept in shade areas.

- The scion of 8-10 cm length, 2-3 months old with 3-4 buds are selected.
- A slanted cut of 3-4 cm should be given at the end of the scion.
- Rootstock should be cut 3-4 cm up from the ground level.
- Then the rootstock should be cut from the top making equal halves for 3-4cm.
- Scion should be inserted into the rootstock and tied tightly using grafting tape.
- Thus, prepared grafting should be irrigated regularly as per the need.

Other Methods of Propagation

- Tongue grafting
- Side grafting
- Budding
- Tissue culture

Climate

Mango is one of the important tropical evergreen fruits. It can be commercially grown from 200-600 masl. It cannot tolerate frost and drought. Average yearly rainfall requirement is 1500-1800 mm and average annual temperature requirement is 20-30°C.

Soil

Mango plants have deep root system going up to 4-5 metre below the ground. So, land should be selected where hard pan of rock are not present just below the ground. Loamy and fertile soil is good for mango cultivation. The p^H of 5.5-7 is considered appropriate for the cultivation of mango.

Layout of Orchard

The layout of an orchard for mango cultivation can vary depending on factors such as the size of the land, soil conditions, climate, and specific management practices.

Systems of Layout

1. Square system
2. Rectangular system
3. Hexagonal system
4. Contour system

Spacing

Spacing in mango cultivation depends on several factors, including the mango variety, desired tree size, soil fertility, and management practices. It is important to consider local conditions and the specific mango variety's characteristics while planting.

Generally, varieties which grow tall are planted in space of 12-14metre. Varieties such as Chausa, Fajali, and Alfonso which get dense vegetation are planted maintaining the space of 14metre. And the varieties such as Amrapali and Mallika that are dwarf are planted maintaining the spacing of 6-8 metre.

Planting

After completing the layout, the orchard should be well cleaned. In the marked spot after laying out the orchard, the planting hole should be digged 1 month before plantation. The planting hole should be 1m depth, 1m width, and 1m length.

While digging the hole, upper surface soil and lower surface soil should be kept separately. Thus, digged hole should be kept open for 1 month. This increases the heat inside the hole and decreases the prone to diseases and insects.

The pit should be filled with

- well rotten FYM or compost manure @ 30-40 kg/pit
- bone powder 2kg/pit
- chemical fertilizers (Urea, DAP, and MoP)

The upper surface soil should be kept at the bottom of the pit by mixing with FYM and fertilizers and the lower surface soil should be kept at the upper part of the pit.

Planting Time

The appropriate time of planting mango plant is rainy season (Jestha-Shrawan). In those areas where high rainfall occurs, planting should be done at the end of rainy season and in those areas where low rainfall occurs, planting should be done at the beginning of the rainy season.

Planting should be done in the evening.

Irrigation

Mango plants may not require irrigation all around the year. But it should be irrigated at different growth stages. Irrigation should be done frequently in the areas where sandy soil is present, and frequency of irrigation may be less where the soil is clayey and loamy.

Ring method of irrigation is one of the best methods to irrigate mango plants.

Fertilizers

Application of fertilizers in mango orchard should be done right from the starting year. Being a perennial plant, application of fertilizer in mango plant should be done yearly. Amount of fertilizer to be applied depends upon the type and fertility of soil.

Age of plant (year)	Amount of fertilizer to be applied per plant			
	FYM/Compost (kg)	Nitrogen (gram)	Phosphorus (gram)	Potassium (gram)
1	10	100	75	100
2	20	200	150	200
3	30	300	225	300
4	40	400	300	400

5	50	500	375	500
6	60	600	450	600
7	70	700	525	700
8	80	800	600	800
9	90	900	675	900
10 or more	100	1000	750	1000

Fertilizers should always be applied at the beginning of rainy season.

Technique to apply fertilizer: Fertilizer should be applied 60cm far around the bottom of the plant and 15cm deep.

Training and Pruning

As mango plant is an evergreen plant, it does not require frequent training and pruning. However, removal of suckers, flowers and fruits, diseased branches should be done regularly in the initial years after plantation. The branches coming out below the graft joint should be removed in the initial years.

Weeding and Intercultural Operation

To keep the orchard clean, weeding should be conducted regularly. Tilling around the plant should be done regularly to keep the orchard clean. Different herbicides can also

Intercropping can be done at the initial year of plantation. Crops like chili, pea, cauliflower, cabbage, etc. can be planted at the initial years. While crops like ginger and turmeric can be planted later years when the trees of mango become tall.

Flowering and fruiting

After 4-5 years of planting grafted plant, mango plant starts to give fruits. In Terai and inner Terai, flowering occurs in Poush-Magh. Fruiting time depends upon the type of varieties cultivated. Generally, fruiting occurs during Baisakh-

Jestha. Ripe fruits are available in the market during Asaar-Shrawan.

(Only 0.1% of total flowers get converted into ripe fruits.)

Production

Production and productivity of mango depends upon the type of soil on which mango is cultivated, local climate, variety, age of the plant, and orchard management practices. It also depends upon the prone to diseases and insects and their management approaches applied. Generally, 5-6 years plants give 20-30 fruits/plant, while 10-12 years plant give 500-600 fruits. And later on, 20 years and older plants can give 2000-4000 fruits/plant. The average productivity of mango in Nepal is 8-10 mt/ha.

Major Insects of Mango

1. Mango Hopper

- **Scientific Name**
  - Amritodus atkinsoni (hopper insect)
- **Symptoms:**
  - Yellowing and drying of leaves
  - Stunted growth
  - Honeydew secretions, sooty mold growth on leaves
  - Reduced fruit yield.
- **Control Mechanisms**
  - Prune and remove affected branches
  - Use insecticides (neem-based or synthetic) to control the population
  - Encourage natural predators like spiders and ladybugs, and
  - Maintain proper orchard hygiene.

2. **Mango Mealy Bug**

- **Scientific Name: *Drosicha mangiferae* (mealybug insect)**
- **Symptoms:**
  - White cottony masses on leaves, shoots, and fruits
  - Honeydew secretions, sooty mold growth, distorted growth
  - Premature fruit drop.
- **Control Mechanisms**
  - Remove and destroy heavily infested plant parts,
  - Use horticultural oil or insecticidal soap to suffocate and kill the mealybugs,
  - Introducing natural enemies like Cryptolaemus montrouzieri (mealybug destroyer),
  - Maintain good orchard sanitation.

3. **Stone Weevil (*Sternochetus mangiferae* (weevil insect)**

- **Symptoms**

  Small holes are seen on the fruit surface Larvae feed inside the fruit. Fruit rotting and premature fruit drop are common symptoms at the later stage.
- **Control Mechanisms**
  - Handpick and destroy infested fruits, maintain orchard cleanliness, avoid waterlogging in the orchard,
  - Use pheromone traps to monitor and control weevil populations,
  - Apply insecticides when necessary.

4. **Stem Borer**

- **Causal Organism: *Batocera rufomaculata* (beetle insect)**
- **Symptoms:**
  - Entry and exit holes on the trunk and branches,

- Sawdust-like frass, gum oozing, wilting of shoots,
- Stunted growth, and tree decline.

- Control mechanisms
  - Prune and destroy infested branches,
  - Plug entry holes with mud or insecticide,
  - Maintain tree vigor through proper nutrition and irrigation, and
  - Use pheromone traps for monitoring and control.
  - Apply insecticides to the trunk and branches. Malathion, Spinosad, Chlorantraniliprole, etc. can be used as chemical insecticides.

Other Major Insects

Shoot borer, Bark eating caterpillar, Leaf Webber, and Fruit fly

Major Diseases

1. Anthracnose

Fungal disease

Causal Organism: *Colletotrichum gloeosporioides*

Symptoms

Symptoms of this disease are seen in tender leaves, tender stems, flowers, and fruits. Initially several dry gray spots are seen on the surface of leaves. In the high humid conditions those spots gradually increase in size and merge. Similarly, in fruits the disease starts with tiny black spots which gradually get larger later on and big black patches are formed. Diseased fruits and leaves fall apart from the tree. Fruit just below the black patches gets hard.

Control

- Application of fertilizer and irrigation at an appropriate time and appropriate amount can keep mango trees healthy. This helps young plants to be away from this disease.
- Diseased branches should be removed and destroyed safely.

- After pruning those infected branches, pesticides such as Bordeaux mixture, Blitox-50 or Captan should be sprayed at appropriate amount.

2. Powdery Mildew

Among all the fungal diseases, powdery mildew is one of the most prominent diseases in mango.

Causal Organism: *Oidium mangiferae*

Symptoms of Damage

- Symptoms are seen in leaves, flower buds, pedicels, flowers, and fruitlets. Brown-white coloured powder like fungus is seen as symptom in different parts of the plant.
- Initially the symptoms are seen on the upper flowers and then gradually seen on the lower parts of the plant.
- White or gray powdery growth appears on young leaves. Leaves may curl, turn brown, and fall early.
- At later stage, the infected parts get black colour and affect fruiting.
- On young fruits, small fruits may show white spots, dry up, and fall off.
- It can cause flower drops, poor fruit set, and even total crop failure in severe cases.

Management Methods

- Clean cultivation: Infected plant parts should be removed effectively and destroyed.
- Fungicide application:
  - Carbendazim (Bavistin) should be applied @ 0.5-1 ml/liter water before flowering.
  - Carothen should be applied @ 2ml/liter water in every 15 days interval after flowering.

3. Sooty Mold Disease

Causal Organism: *Cladosporium spp., Capnodium spp.,*

Sooty mold is a fungal disease that looks like black powder or soot on the surface of leaves, stems, and fruits. It does not infect the plant directly but grows on the honeydew (sticky substance) released by insects like aphids, mealybugs, whiteflies, and scale insects.

So, it is a secondary problem caused by insect pests.

Physiological Disorders of Mango

Physiological disorders in mango are problems in growth, development, or fruit quality caused by weather conditions, nutritional imbalance, or hormonal changes, not by insects or fungi or bacteria. The major physiological disorders of mango are Fruit Drop, Malformation, Black Tip, Jelly Seed, Spongy Tissue, and Biennial Bearing (Alternate Bearing).

1. Mango Malformation

Causes: Mostly due to hormonal imbalance and mite attack. It is also linked to Fusarium fungus, but mainly in physiological condition.

Symptoms of Damage

- The most common symptom is the formation of deformed and distorted flowers. They can appear thickened, discoloured, and twisted.
- Leaves and fruits also get deformed
- Stunted growth
- Premature flowering

Management Methods

- Pruning of infected tender branches, malformed flowers/shoots and destroying them.
- Spraying NAA (200 ppm) in October and November.
- Maintaining orchard sanitation.

2. Black Tip

Cause:

- This disease is caused by the pollution of brick kilns.
- Deficiency of boron

Symptoms of Damage

- The tip of the mango fruit shows yellowish symptoms at initial stage. At later stage, the yellowish patches get black and cover the whole fruit.

Management Methods

- Application of borax 3 kg/400-liter water.
- Orchard should be made away from the brick kilns.

3. Biennial Bearing (Alternate Bearing)

Biennial bearing is a condition where trees of mango give heavy yield for one year, and very little or no yield next year.

Causes: Nutrient exhaustion from previous heavy crops and poor pruning and management.

Management Methods

- Regular pruning and balanced fertilizer application
- Spray Paclobutrazol (PP333) in September–October

2.2 Papaya

Introduction

Papaya cultivation is done in Nepal in different regions. From the point of view of climate, its cultivation can be done from the lowlands of the country to the central hills. It is a tropical fruit that is native to Mexico and Central America. It is widely cultivated in tropical and subtropical regions around the world. They are an excellent source of vitamins C and A, as well as folate, fiber, and antioxidants.

In Nepal, Parsa, Morang, Rautahat, Udayapur, Rupandehi, Kanchanpur, Bardiya, Chitwan, Nawalparashi, Jhapa, etc. are the major papaya producing districts. Commercial production of papaya has not much flourished till now in the Nepalese agricultural sector. It is confined to a kitchen garden and small-scale production.

Scientific Name: *Carica papaya*

Family: Caricaceae

Origin: Mexico and Central America

Uses

- It can be consumed fresh as salad.
- It can be used to make smoothies and juices.
- Papaya has medicinal uses such as skincare, digestive health, immune system support, etc.
- Jam, Jelly, Candy, etc. can also be prepared from papaya.

Nutrition

Papaya is rich in different vitamins and minerals. Vitamin C is one of the major vitamins that we can get from this fruit. Carotenoids, lycopene, etc. pigments help to keep our eyes healthy. Minerals like calcium, phosphorus, potassium, magnesium, etc. are found in large amounts in papaya.

Climate

Papaya is a tropical fruit, so it can be successfully cultivated in warm and humid climatic conditions. It cannot thrive if the temperature goes below 15°C for longer time. For commercial papaya cultivation, optimum temperature range is between 21-32°C. Yearly rainfall of 350-2500 mm is considered appropriate for commercial papaya production.

Soil

- Loamy soil, rich in organic matter, having good drainage capacity is good for papaya cultivation.
- pH range of 6-7 is appropriate.

Varieties

Washington, Honeydew, Pusa Delicious, Pusa Dwarf, Pusa Giant, and Pusa Majesty

Propagation

Propagation of papaya is done by seed. For the propagation purpose of papaya, certified seed from reliable source should be acquired. Thus, acquired healthy seeds should be sowed in the nursery bed.

Nursery bed management

For the preparation of plantlets, initially the nursery should be prepared by ploughing thoroughly. Fertilizers should be applied as per the recommendation in thus prepared nursery bed. Also, formalin should be applied to prevent the papaya plantlets from rotting diseases.

In the nursery, line sowing of papaya seed should be done at about 10 cm depth. Regular irrigation of the nursery bed should be done as per the requirement.

Seed rate: 20-25 gram per ropani

Plantlets of papaya can also be prepared in polybags.

Planting and Spacing

For planting, as in the other tropical fruits, pits should be dug of size 0.5 m × 0.5 m × 0.5 m. Thus, dug pit should be filled with soil, chemical fertilizers, and FYM. In one pit, 3 plantlets should be planted carefully without damaging the roots.

Time of planting and spacing of papaya plant depends on the varieties.
Generally, papaya should be planted during Asaar and Ashoj.

Spacing

Tall varieties: 2 m × 2 m Dwarf varieties: 1.5 m × 1.5 m

Fertilizers

Nitrogen: 300 g/plant/year

Nitrogen should be applied in split doses. The first half should be applied during plantation and the second half should be applied after four months of planting.

Phosphorus: 250 g/plant/year
Potassium: 400 g/plant/year
FYM: 25 kg/plant/year
Additionally, micronutrients such as boron, magnesium, copper, etc. should be applied by the foliar spray method.

Harvesting

Papayas should be harvested when the fruits get mature green in colour. They should be harvested when the fruits start getting lighter green and yellow from dark green colour. As it is a climacteric fruit, it should not be harvested when it is fully ripened.

Storage

Fruits harvested at mature green stage can be stored for up to 1 month at 10-12°C and 85-95% relative humidity.

Production

Production and productivity depend upon the varieties cultivated. Generally, 55-60 kg per plant can be produced.

Major Insects of Papaya

Aphids, Red Spider Mite, Whiteflies, Mealybugs, Fruit Fly, Papaya Stem Borer, Grasshoppers, etc. are the major insects that affect and reduce the production of papaya.

1. Red Spider Mite *(Tetranychus urticae)*

Red Spider Mite is a very small pest that attacks the leaves of papaya plants. It is not a insect, but a tiny arachnid, like a spider.

Symptoms of damage

- Tiny yellow or white spots appear on leaves.
- The underside of leaves shows fine webbing like spider's web.
- Leaves become yellow, dry, and fall off.
- Heavy infestation leads to weak plant growth and poor fruiting.

Management Methods

- In the early infestation stage, spraying water to wash mites from leaves can work for small farms.
- Spraying neem oil (5 ml/litre) or soap water.
- In severe cases, applying miticides like dicofol or abamectin is good.

2. Papaya Stem Borer *(Dasyneura papaya)*

The papaya stem borer is a damaging caterpillar that bores into the stem of the papaya plant.

Symptoms of Damage

- Small holes on the stem or near the leaf stalk (petiole) are seen.
- Sap oozing is observable outside the hole.
- The plant becomes weak, wilted, and may collapse.

- In severe cases, fruit production stops or the plant dies.

Management Methods

- Regularly inspect stems for boreholes. Insert metal wire into the hole to kill the larva (in small farms).
- Plug holes with cotton soaked in neem oil or kerosene, then seal with mud.
- Spray insecticides like Spinosad or Chlorantraniliprole if the infestation is high.
- Avoid water stress and keep plants healthy to resist attack.

Major Diseases of Papaya

Papaya Ring Spot Virus, Powdery Mildew, Anthracnose, Damping Off (in seedlings), Root Rot, Stem Rot/ Foot Rot, Leaf Curl, etc. are some important diseases of papaya.

1. Damping off *(Pythium spp. and Rhizoctonia spp.)*

Damping off is a fungal disease that attacks young seedlings, especially in the nursery. This disease more often occurs when there is excess water or poor drainage in the nursery and when there is a high amount of moisture in the air (high relative humidity).

Symptoms of Damage

- Seedlings rot at the base (near the soil line).
- The plants fall over and die quickly.
- Sometimes seeds fail to germinate properly.

Management Methods

- Use well-drained nursery soil.
- Avoid overwatering. Maintain proper drainage system in the nursery.
- Treat seeds with fungicide before sowing. (e.g. Captan or Thiram)
- Drench nursery with fungicide solution if symptoms appear.

2. Ring Spot

It is a viral disease of papaya, spread by aphids.

Symptoms of Damage

- On leaves and fruits, yellow ring-shaped spots on leaves and fruits.
- Yellow-green patches are seen on leaves.
- Leaves become distorted.
- Fruits are deformed and have poor market value.
- Plants become stunted and stop growing properly.

Management Methods

- Use virus-free seedlings.
- Remove and destroy infected plants early.
- Control aphids using neem oil or recommended insecticides.
- Use barrier crops (e.g., maize) to reduce aphid spread.

3. Leaf Curl

It is a viral disease of papaya, spread by whiteflies. It affects plant growth and reduces fruit production.

Symptoms of Damage

- Leaves become small, thick, and curled upward.
- Plants show a bushy appearance.
- New growth is deformed.
- Plants remain dwarf and give little or no fruit.

Management Methods

- Remove and destroy affected plants immediately.
- Control whiteflies using neem oil or insecticidal soap.
- Use yellow sticky traps to monitor whiteflies.
- Avoid planting papayas near infected fields.

2.3 Litchi

Introduction

It is an important tropical fruit. In Nepal litchi is mainly produced in terai region. It is highly valued for its sweet and juicy flesh. It is small to medium sized, roughly spherical in shape, and covered with thin, rough, and reddish-brown skin. The skin is peeled away to reveal the translucent white or pinkish flesh, which surrounds a single large seed.

In Nepal litchi is mainly cultivated in the terai, inner terai, and mid-hills. Siraha, Saptari, Udayapur, Sarlahi, Mahottari, Dhanusa, Bara, Parsa, Rautahat, Dhading, Nawalparasi, Kapilvastu, Rupandehi, etc. are the major litchi producing districts.

Scientific Name: ***Litchi chinensis***
Family: **Sapindaceae**
Origin: **China**

Major producers: India, Taiwan, Thailand, South Africa, Indonesia, Mexico, etc.

Uses

- Fully ripe fruit can be directly consumed.
- It can be used to prepare jelly, wine, ice cream, juice, flavor, etc.
- Litchi plant can be used to increase the aesthetic value of house in the garden.

Varieties

Muzaffarpur, Rose scented, Culcuttia, Shahi, Early Seedless, Late seedless, Dehradun, China

Climate

Litchi can be cultivated commercially from sea level to 800 masl. For successful litchi cultivation a place which has high relative humidity and temperature is appropriate. Litchi plant cannot tolerate frost and cooler environment.

Soil

Litchi can be cultivated in a variety of soil. Generally, it can be commercially cultivated in the sandy loam soil with high organic matter, and good drainage facility. Soil pH of 5.5-7 is considered appropriate.

Propagation of Litchi

Mainly, litchi is propagated by vegetative method. However, it is propagated through both vegetative and sexual method (by seed). Growth and development of plants get slow in the plants propagating through seed. So, the vegetative method of propagation is preferred than seed propagation.

Vegetative Propagation Methods

- Layering
  - Air layering

Air layering can be an effective propagation method for litchi.

Process of air layering in litchi:

1. **Selection of Healthy and Mature Branches on the Litchi Tree**

   The branch should be at least pencil-thick and ideally without any side shoots or leaves along the selected portion. Also, the selected branch should be healthy and mature branch.

2. **Removing the Bark**

   The bark of the branch should be slightly cut to remove it. About 8-10cm bark should be removed. After removing the bark, rooting hormone (rootex) should be applied on the exposed cambium layer of the branch.

3. **Preparing the Media**

   For the preparation of media sphagnum moss, soil, and compost should be thoroughly mixed. Adding some water on the media makes the media dough.

4. Wrapping the Cambium Layer by the Media

The media dough is then applied on the exposed cambium layer. The bark removed portion should be completely covered by the media.

5. Covering the Layering

The media should be tightly covered by a thin plastic sheet.

Thus, prepared layering produces roots around the media in about 3 months. And then it can be cut from the base and used for plantation either in polybag or in main field.

Grafting (side-veneer grafting and cleft grafting) is also another method that can be used to propagate litchi. But air layering is the most common method of vegetative propagation.

Planting Time, Spacing, and Technique

Generally, plantlets of litchi are planted during the month of Jestha and Asaar.
Pit size: 1m×1m×1m
The pits should be dug at least 1 month prior to planting. Before planting the pit should be filled with chemical fertilizers, FYM, micronutrients, etc. mixed with the soil. The plantlets planted should be tied and supported with small sticks. Immediate irrigation is required after planting and should be done regularly until the plantlets stand still.

Spacing

The spacing requirements of litchi depends upon the varieties to be planted. General spacing for tall varieties and dwarf varieties are given below.
Tall varieties: 10m×10m
Dwarf varieties: 8m×8m

Fertilizers

The amount of fertilizers required entirely depends up on the type of soil. Organic fertilizer is preferred in litchi cultivation. Especially, the major nutrient requirements are nitrogen, phosphorus, and potassium.

Table: Fertilizer Requirement for Litchi

Year	Amount per plant per year						
	Kg		Gram				
	Compost	Oil cakes	Nitrogen	Phosphorus	Potassium	Zinc	Boron
1	10	1	50	25	25	25	
2	15	1.5	100	50	50	50	
3	20	2	150	125	75	75	
4	25	2.5	200	150	100	100	
5	30	3	250	200	125	125	125
6	35	3.5	300	250	150	150	150
7	40	4	350	300	175	175	175
8.	45	4.5	400	350	200	200	200
9.	50	5	500	400	250	250	225
10.	60	5	600	600	250	250	250

Chemical fertilizers should not be applied more than recommended dose. Fertilizers can be applied in two split doses in a year. First time, as soon as the completion of harvesting and second one during Asoj and Kartik. Irrigation should be given immediately after the application of fertilizer. It should be applied in the ring method.

Irrigation

Litchi is an evergreen tree. So, irrigation at regular intervals must keep the soil moist. For irrigation, the drip irrigation method is considered one of the best methods. This method seems costly at the initial phase, but it is actually less costly in the long term. So, drip irrigation can be applied in the orchard to provide regular irrigation, and it can also be used to apply fertilizers through water.

Flooding and ring methods can also be applied to apply irrigation in litchi plants. Irrigation is much required during the fruiting and fruit development stage.

Intercultural Operation

We have to maintain a clean orchard to increase the yield. So, to keep the orchard clean, regular weeding should be done either manually or by applying different herbicides.

The space between trees can be utilized by planting shallow rooted crops like legumes, ginger, turmeric, etc.

Litchi trees should be trained carefully in the initial years to build a strong framework. Regular removal of diseased, insect infected, and unproductive branches should be done to increase the production.

Harvesting

Litchi is non-climacteric in nature. So, it should be well ripened in the tree before harvesting. Litchi fruit is considered to be ripened when the fruits turn into pinkish colour from green colour and finally into red colour. Also, the sharp spines on the fruits start getting blunt when the fruit ripens. Firm skin, sweet flavor, and TSS of 18-22 % is considered appropriate to harvest litchi.

Production

Total production and productivity of litchi depends upon the climate, soil, variety, management practices, and many other things. A well developed and matured tree (14-16 years) can produce 80-150 kg. Beekeeping, if done near the orchard, can enhance the production up to 15-20%.

Physiological Disorders in Litchi

1. **Fruit Cracking**

   Fruit cracking is generally seen in early varieties. This disorder is seen when the temperature is very high, relative humidity is low, and low moisture in soil during the time of fruit development and fruit maturing stage.

Management Methods

- Regular irrigation at the time of fruiting and fruit development.

- Application of NAA @ 100 ppm (20 mg), and gibberellin @ 20 ppm.
- Application of 2 gram borax per liter

2. Fruit Drop

High temperature, low relative humidity, heat waves, hormonal imbalance, lack of proper fertilization, etc. are the major causes of this disorder.

Management Methods

- Beekeeping in the litchi orchard.
- Application of borax @ 2 gram/liter water.
- Application of NAA @ 20-30 ppm, gibberellin @ 20-25 ppm, and 2,4 -D @ 10-20 ppm.
- Application of fertilizer should be at the recommended dose.

Major Insects of Litchi

Litchi fruit borer, litchi leaf folder, litchi mite, fruit fly, aphids, etc. are the important insects of litchi.

1. Litchi fruit borer (*Conopomorpha sinensis)*

Litchi fruit borer is a serious insect pest of litchi that damages the fruits from inside. The larvae (caterpillars) enter the fruits, feed the pulp, and cause the fruit to rot and drop early. Poor orchard hygiene, and warm and humid weather during fruit development stage promotes the infestation of this insect.

Symptoms of Damage:

- Small entry holes are seen near the stem end of the fruit.
- Brown or black frass (insect waste) may be visible at the hole.
- Fruits become soft, brown inside, and may rot early.
- Many fruits drop before harvest.
- Sometimes, you may find a small caterpillar inside the fruit.

Management Methods

- Collect and destroy infested fruits regularly. Remove fallen fruits from the orchard.
- Use pheromone traps to monitor adult moths.
- Spray neem oil (5 ml/ litre) on fruits during fruit development.
- Apply Spinosad during the fruit formation stage, if the infestation is found high.

2. Litchi Leaf Folder (*Platypepla aprobola*)

Litchi leaf folder is a leaf-eating caterpillar that folds the litchi leaves and feeds from inside. It mainly attacks young and tender leaves, which reduces photosynthesis and weakens the plant.

Symptoms of Damage

- Leaves are folded or rolled along the midrib.
- Caterpillars live inside the folded leaf and feed on the green tissue.
- The affected area becomes brown and dry.
- In severe cases, the tree looks burnt or scorched due to drying of leaves.
- Plant growth slows down, especially in young trees

Management Methods

- Prune crowded branches to improve sunlight and airflow.
- Remove and destroy folded leaves that contain larvae.
- Spray neem oil (5 ml/litre) to repel caterpillars.
- If the infestation is high, spray Spinosad, and Quinalphos as chemical treatment.

3. Litchi mite (*Aceria litchii*)

Litchi mite is a tiny insect-like pest that attacks the leaves, twigs, and flower buds of the litchi tree. It is so small that it cannot be seen easily with the naked eye. It causes the formation of hairy, reddish or brown patches on the leaves called erineum.

Symptoms of Damage

- Reddish-brown hairy patches (called erineum) appear on the underside of leaves.
- Leaves may become thick, curled, and deformed.
- In severe cases, the whole leaf dries and falls off.
- Young shoots and flower buds may also be affected by reducing fruit yield.
- The tree may appear stunted and unhealthy.

Management Methods

- Prune and destroy affected leaves and shoots early.
- Spray neem oil (5 ml per litre) to repel mites.
- Spray sulfur-based miticides or Dicofol if the infestation seems high.

Major Diseases of Litchi

Anthracnose, leaf blight, red rot / fruit rot, stem canker / dieback, etc. are the important diseases of litchi.

1. Anthracnose *(Colletotrichum gloeosporiodes)*

Anthracnose is a fungal disease that affects the leaves, twigs, flowers, and fruits of litchi trees. It is one of the most common diseases of litchi, especially in areas with high humidity and frequent rainfall.

Symptoms of Damage

- Small dark brown to black spots appears on the leaf surface.
- Spots may join, causing large dead patches.
- Leaves may turn yellow and drop early.
- Small black sunken spots appear on the fruit surface.
- Infected fruits may rot and fall before ripening.

Management Methods

- Remove and destroy infected leaves, twigs, and fruits.

- Maintain orchard cleanliness.
- Spray fungicides during flowering and fruiting stages:
    - Copper oxychloride (0.3%)
    - Carbendazim (0.1%)
    - Mancozeb (0.2%)

2. Leaf blight *(Alternaria spp. or Pestalotiopsis spp.)*

Leaf blight is a fungal disease that affects the leaves of the litchi tree, causing them to dry, turn brown, and fall off. It mostly appears during hot and humid weather, especially in poorly managed orchards.

Symptoms of Damage

- Brown or dark spots appear on the tip or edge of older leaves.
- The spots enlarge, forming irregular dry patches.
- Leaf edges become scorched, as if burnt.
- Infected leaves may curl, dry up, and fall early.
- In severe cases, branches may appear leafless, and the tree looks weak.

Management Methods

- Prune the tree regularly to improve sunlight and air flow.
- Collect and destroy dried or infected leaves.
- Avoid excess watering and overcrowding.
- Spray fungicides like:
    - Mancozeb (0.2%)
    - Copper oxychloride (0.3%)
    - Chlorothalonil

3. Stem Canker *(Phomopsis spp.)*

Stem canker is a fungal disease that attacks the branches and trunks of litchi trees. It causes cracks, sunken patches, and gum oozing on the bark. If not treated, it can lead to branch dieback and tree decline.

Symptoms of Damage

- Sunken, dark patches on the stem or branches (called cankers).
- Cracks develop in the bark.
- Brown or dark gum oozes out from the infected area (gummosis).
- The area around the canker may dry, rot, or split.
- Affected branches may wilt, dry back, or break off.
- In severe cases, the main trunk gets infected, and the tree may die.

Management Methods

- Avoid injuries to the tree during pruning or harvesting.
- Prune and remove infected branches early.
- Apply Bordeaux paste or fungicide paste or cut or wounded areas.
- Apply fungicides like Carbendazim or Mancozeb sprays to prevent spreading.

2.4 Pineapple

Introduction

The pineapple plant is an herbaceous perennial that grows in tropical and subtropical climates. It is a good source of vitamins, particularly vitamin C, manganese, and vitamin B6. It is known for its high fiber content and can contribute to a healthy digestive system.

Pineapple has a rich history and has been cultivated and enjoyed for centuries. Indigenous peoples of South America were the first to discover and cultivated pineapples, which were later introduced to other parts of the world through exploration and trade.

In Nepal, Jhapa, Morang, Udayapur, Chitwan, Dhading, and Nuwakot are the major districts where pineapple cultivation is done successfully.

Scientific Name: ***Ananas comosus***

Family: **Brommeliaceae**

Uses

- Well ripened fruits can be consumed directly.
- Also, ripened fruits can be used to produce juice, candy, alcohol, etc.
- The fibers of pineapple leaves can be used to make cloths, bags, etc.
- In pineapple, an enzyme named bromilin is present which can be used to make medicine.

Nutrition

- It is very rich in vitamin C, manganese, and vitamin B6.
- It is also rich in fibre, which can improve the digestive system.

Varieties

Giant Q, Queen, Mauritius, Spanish

Climate

Pineapple is a tropical fruit that can be successfully cultivated in a warm and humid climate. It can be cultivated from sea level to 1500 masl. This fruit cannot tolerate frost and cold environment for long time. The rainfall of 100-150 cm per year is considered appropriate. This fruit can tolerate drought. The temperature range for optimum production is 21-23°C.

Soil

Sandy loam soil, which is rich in organic matter and good drainage capacity, is best for pineapple cultivation.

p^H range: 5.5-6.5

Propagation

Generally, pineapple is propagated by vegetative method.

Propagating materials

- **Crowns**

  The leafy top portion of a mature pineapple fruit is known as crown, which can be planted to generate a new plant. This part of the pineapple can be used for the propagation, but is not used for commercial cultivation.

- **Slips**

  Slips are small offshoots that emerge from the base of the pineapple fruit. They are the new shoots that develop around the stem of the plant. Slips are the most common and commercially used propagation material of pineapple.

- **Suckers**

  Suckers are also known as ratoons or side shoots. They are lateral shoots that grow from the base of the pineapple plant, usually at the ground level or slightly above it.

  Among all these, slips are the most used propagating materials. Generally, plants propagated through crown give fruits in 22-24 months, slip give

fruits in 20-22 months, and sucker gives fruits in 16-20 months.

Land Preparation

The land must be prepared thoroughly. It should be plowed thoroughly and harrowed 2 to 3 times until a fine tilth is attained, modify soil structure, control weeds, incorporate organic matter, and evenly distribute lime. Ridges should be made where the planting materials are to be planted. Drainage canals are necessary in areas with heavy rainfall or with poor drainage.

Planting Time, Spacing, and Technique

Time

Pineapple can be successfully cultivated in the beginning of the rainy season or at the end of the rainy season. But it can be cultivated at any time of the year when the temperature is warm, and the soil is moist.

Spacing

Plant - Plant distance: 25-30 cm

Row – Row distance: 60 cm

Planting technique

Pineapples can be planted using either crown or slip or sucker.

- **Slip method**
  - Look for healthy slips that are about 8-12 inches long and have developed roots. Slips should be gently twisted or cut from the mother plant.
  - Remove the lower leaves from the slips, leaving a few intact at the top.
  - Allow the slips to dry for a few days in a shaded area to reduce the risk of rotting.
  - Place the slips into the planting holes or trenches, ensuring that the roots are well-covered with soil and the top leaves remain above the surface.

- Gently press the soil around the slips to provide stability.
- Irrigation should be regularly provided after plantation of slips until the plants develop their roots in the soil.

- **Crown method**
  - Cut off the leafy top of a mature pineapple, ensuring that some flesh is attached to the base.
  - Allow the crown to dry for a few days to prevent rotting.
  - Plant the crown in the field, burying it about an inch deep.

- **Sucker method**
  - Remove suckers, which are shoots growing from the base of the pineapple plant.
  - Ensure that the suckers are at least 35-55 cm long and have developed roots.
  - Plant the suckers directly into the field.

Fertilizers

- Compost: 10-15 kg per plant per year
- Nitrogen: 16 gram per plant per year
- Phosphorus: 5 gram per plant per year
- Potassium: 12 gram per plant per year

Irrigation

Pineapple can tolerate drought. However, in the summer season, irrigation should be given for at least 4-6 times.

Intercropping

Pineapple is itself the crop that can be used for intercropping in mango, litchi, and other fruit orchard. It can also be used as a crop for mixed cropping with banana, coffee, papaya, coconut, etc.

Orchard management

Weed management is the main challenge in the pineapple orchard. As it is cultivated during the rainy season, weed growth is prominent at that time. So, weed should be effectively managed in different ways.

- By using mulching materials such as plastics, straw, etc.
- Drip irrigation can minimize the weed infestation in the orchard.

Pineapple is a shade-loving plant. So, some other fruit crops that can provide shade to pineapple plants can be cultivated in the middle of the orchard. Those crops can be banana, coconut, mango, etc.

Harvesting and Production

Fruits get ready to harvest only after 5-6 months of flowering. Depending upon the variety and climatic condition, pineapple plants take around 12-20 months to mature and produce fruit.

For distant markets, the fruits should be harvested when the fruits get a light colour from dark green. Whereas the fruits for nearest market can be harvested when the bottom of the fruits start getting yellow – orange colour.

A well-managed orchard can give productivity of up to 50-60 metric ton per hectare.

Major Insects of Pineapple

Mealybug, Fruit borer, Scale insects, Termites, Root Grubs, etc. are some of the important insects of pineapple crop.

1. Mealybug *(Dysmicoccus brevipes)*

Mealybug is a sap-sucking insect that attacks the roots, bases, and leaves of pineapple plants. It weakens the plant and also helps spread a disease called mealybug wilt.

Symptoms of Damage

- Mealybugs look like small white cottony insects. They are found

around the base of leaves, in the crown, and sometimes on roots.

- Leaves turn yellow or reddish-purple.
- Plants show stunted growth and may wilt or die.
- Sticky substances (honeydew) attract ants and causes sooty mold to grow.

Management Methods

- Use clean planting materials.
- Spray neem oil (5 ml/litre) or soap solution to control mild infestations.
- For severe infestation, spray Imidacloprid or other recommended systemic insecticides.
- Control ants, as they protect and spread mealybugs.
- Remove and destroy heavily infested plants.

2. Fruit borer *(Thecla Basilides)*

Fruit borer is an insect pest that bores into the pineapple fruit and damages the pulp. It reduces fruit quality and makes the fruit unfit for eating or selling.

Symptoms of damage

- Small holes on the surface of the fruit (often near the eyes).
- Inside the fruit, the larva (caterpillar) feeds on the pulp.
- Brown or black rotten areas develop inside.
- Sometimes you may see insect waste (frass) near the entry hole.
- The fruit may rot early or fall before ripening.

Management Methods

- Use clean and healthy planting suckers.
- Remove and destroy infested fruits from the field.
- Use light traps to attract and kill adult moths.
- Spray neem oil (5 ml/litre) or Spinosad during fruiting stage to kill

caterpillars.

- Maintain clean and weed-free fields to reduce hiding spots for pests.

Major Diseases of Pineapple

Heart Rot/Base Rot, Fusariosis (Fruit Rot), Black Rot, Yellow Spot Virus, Mealybug Wilt, etc. are some of the important diseases of pineapple.

1. Heart Rot *(Phytophthora spp.)*

Heart rot is a fungal disease that affects the central part of the pineapple. It causes rotting of the growing point (heart), which leads to the death of the plant.

Symptoms of Damage

- Central young leaves become soft, yellow, and pull out easily when touched.
- The base of the leaves is watery and foul-smelling.
- The plant stops growing, wilts, and eventually dies.
- The disease may spread quickly during the rainy season or in waterlogged soil.

Management Methods

- Use well-drained soil and avoid waterlogging.
- Plant in raised beds or ridges during rainy season.
- Before planting, treat suckers with fungicide (e.g., Mancozeb or Metalaxyl).
- At the first sign of disease, drench the plant base with fungicide solution.
- Remove and destroy severely affected plants to stop spreading.

2. Fruit Rot *(Fusarium subglutinans)*

It is a fungal disease of pineapple, also called Fusariosis. It affects the fruit, causing it to rot before or after harvest.

Symptoms of damage

- Water-soaked soft spots appear on the fruit surface.
- Spots become brown or pinkish and later rot.
- When cut open, the inside of the fruit is discoloured and smells bad.
- Infected fruits are unmarketable and may rot during transport or storage.

Management Methods

- Handle fruits carefully during harvest and transport.
- Avoid fruit injuries from pests or tools.
- Spray fungicides like Mancozeb or Copper oxychloride at fruiting stage.
- Use clean and healthy suckers for planting.
- Ensure good drainage to avoid fungal buildup.

2.5 Banana

Introduction

Banana is an herbaceous, tropical fruit that thrives well in warm climatic conditions. The major banana producing countries around the world are Mexico, Brazil, Cuba, Guatemala, African nations, India, Indonesia, Philippines, and Thailand.

In Nepal it is successfully being cultivated from Terai to mid-hill regions. The total production on banana is the highest in Lumbini province with 92,231 mt being produced in the fiscal year 2079/80. Chitwan and Nawalparasi west are the major banana producing districts of Nepal producing more the 54,000 mt per year in each of them (Statistical Information on Nepalese Agriculture, 2022/23).

Family: **Musaceae**

Scientific name:

1. *Musa cavendishi* (dwarf varieties)
2. *Musa sapientum* (Tall varieties)
3. *Musa paradisiaca* (cooking type)

Uses

1. The immature fruits of banana can be used as vegetables. The most common use of banana is fresh and ripe fruits, which are eaten directly. The fresh and ripe fruits can also be used to prepare flavor, lassi, wine, confectionary, jelly, and banana chips. The leaves of banana plant can be utilized as wrapping materials in seed bed, mulching materials, paper board, and tissue paper. The trunks of banana can also be used to prepare different types of papers. Also the fibers from banana plant can be used to prepare cloths and bags.

Propagation

Bananas are propagated by vegetative method. It is propagated by suckers, rhizomes, tissue culture, etc. Sexual propagation is not possible in banana due to parthenocarpy nature of fruits.

Vegetative Propagation Through Suckers

Mother plants of banana produce small new plants around it called suckers. Suckers are small shoots or baby plants that grow from the base or underground stem (rhizome) of a banana plant. These suckers are the important vegetative part that can be used to propagate banana. There are different types of suckers that can be used to propagate.

1. **Water Suckers**

   These suckers have broad, soft leaves from an early stage. They are weakly attached to the mother plant and have a small base. They usually produce weaker plants with poor fruit quality. They are not recommended for commercial cultivation because they do not grow well and give lower yields. They are called water suckers because they usually develop especially during the rainy season, when there is excessive water available for the plant.

2. **Sword Suckers**

   Sword suckers have long, narrow, sword-shaped leaves from their young stage. They grow close to the mother plant and are strongly attached to the rhizome. They develop into strong, healthy plants that produce good fruit. They are the most preferred type of sucker for the commercial propagation of banana because they give better yields and healthier plants.

3. **Maidenhead suckers**

   These suckers are large, non-fruiting shoots that look like adult banana plants but have not yet produced fruit. They are sometimes used for propagation, but not as common as sword suckers.

Tissue Culture in Banana

Besides the use of suckers in the process of propagation of banana plants, there is a newly developed and mostly used technique called tissue culture technique to propagate plants.

Tissue culture is a commonly used technique for propagating bananas. It involves the growth of banana plants from small tissue samples taken from the mother plant, which are then placed in a nutrient rich culture medium in a laboratory. Thus, small tissues grow inside the test tube or petri dish. And then, they are planted in the main field.

The advantages of this method of propagation are:

- It helps to produce disease-free plants.
- We can perform rapid multiplication of desired varieties.
- It can help in the commercial production of bananas.
- The plantlets are easier to store and transport in comparison to other methods.

Varieties

The common varieties of banana that are being cultivated in Nepal are as follows.

1. Dwarf Cavendish
2. Robusta
3. William Hybrid
4. Malvog
5. Dhusre
6. Mungre

Climate

For banana cultivation, warm and humid climates are suitable. It requires yearly average rainfall of 200-500 cm. Also, the place which has good irrigation facility can be suitable for banana cultivation although the area is dry.

For vegetative growth and fruit development, 25-27°C temperature is considered appropriate. It cannot thrive in the place where frost and cool temperature is prominent. Growth and development of plants get slow where the temperature is lower than 18°C.

Soil

Bananas thrive best in well-drained soils that are rich in organic matter. Good drainage is crucial for banana plants, as they are sensitive to waterlogged conditions. Excessive water can lead to root rot and other diseases.

Bananas prefer a slightly acidic to neutral pH range of 5.5 to 7.0.

Bananas can grow in a range of soil textures; loamy soils are generally considered ideal. Loamy soils can provide good drainage while retaining moisture and nutrients.

Planting Time, Spacing and Techniques

Time

Banana can be planted in all months except Mangsir, Poush and Magh. While planting bananas, we should consider the time of fruiting. If the fruiting occurs after Bhadra, the quality fruits are not produced. Fruiting starts in 15-24 months after planting depending on the varieties.

Spacing

Spacing of banana plants depends upon different factors such as varieties, soil type, and soil fertility. Suckers of tall varieties are planted by maintaining 2.5 m × 3 m whereas dwarf varieties can be planted in the space of 1.8 m × 1.8 m.

Technique of Planting

While uprooting the suckers from mother plant, holes should be dug around the mother plant and suckers should be removed carefully with rhizome intact in it.

Pit size: 60 cm × 60 cm × 60 cm

Banana sucker should be planted up to 30 cm below the level of ground. For planting the plant, well rotten FYM should be kept mixing with the soil of the pit.

Fertilizers

Nitrogen: 200 g/plant

Phosphorus: 110 g/plant

Potassium: 250 g/plant

FYM: 25 kg/plant

Irrigation

Generally local varieties are cultivated with very little amount of irrigation, but improved varieties require more amount and frequency of irrigation.

Weekly irrigation is required in dry and hot regions while irrigation should be given every 14-15 days in the region which is moist.

Intercropping

The roots of bananas do not go deeper. So, the space between the plants can be utilized by cropping different other crops. Crops which have short lifecycles and do not require much nutrient should be selected for intercropping. They can be radish, brinjal, cauliflower, chili, cabbage, ginger, turmeric, etc.

Harvesting

Harvesting index and methods of harvesting depend upon the varieties of banana. Banana varieties which are used for cooking purpose are harvested earlier than other varieties.

Varieties that are used for fresh fruit consumption, flavor, lassi, etc. are harvested when they get mature. Dwarf varieties of bananas get mature faster than tall varieties. Generally, those varieties of banana are harvested when they get dark green.

Farmers judge fruit maturity by assessing the yellowness of leaves and spadix. When the spadix starts to dry, it is considered that the fruit is ready to be harvested.

While harvesting bananas, it should be done carefully by not making a great impact on the ground.

Storage and Ripening

Bananas are sensitive to chilling injury. So, it cannot be stored at a very low temperature. For the storage of banana 11-13°C and 86-90% relative humidity is appropriate. If bananas are stored in the temperature less than 11°C, due to chilling injury they show black spots and cannot get ripened.

This is why bananas should not be stored in refrigerator.

For ripening banana requires temperature higher than 20°C. For ripening bananas, ethylene gas is used. Also, calcium carbide and ethrel are used to ripen bananas. These chemicals produce ethylene gas, which are essential for ripening bananas. The natural way of ripening is healthier and more beneficial than the methods that use chemicals for ripening of banana.

Insect of Banana

1. Banana Stem Weevil

Scientific name: ***Odoiporus longicollis***

Symptoms of Damage:

- Larvae of this insect gets inside the trunk by making tunnel. It feeds inside the trunk of banana plant. If the young plants get highly infected by this insect, then the plant may die soon.

Management Methods

- Sanitation: Orchard should be kept clean. All the infected plant parts should be removed and destroyed effectively.
- If highly affected plants are found, they should be removed and destroyed immediately.
- Application of chlorpyriphos and malathion 2ml/liter water in the pit where banana is to be planted.
- Application of furadon @ 10-12 grams in the corm if there is any initial signal of insect infestation.

2. Aphids

This insect is black and brownish in colour. Insects get accumulated at the corms, tender leaves, fruits, and trunks and suck the sap from those parts.

Scientific Name: ***Pentalonnia nigronervosa***

Symptoms of Damage

- The infected plant parts seem to be colonized, and thousands of aphids are seen crowded in the same part. They suck sap from the plant parts.
- Infected plant parts get yellowish and wilt. The growth and development of the plant has stopped.

Management Methods

- **Sanitation:** Orchard should be kept clean. Infected plant parts and other plant debris should be removed and destroyed.
- Use of predator insects such as lady bird beetles to control aphid population.
- Application of cow urine and water in 1:4 ratio.
- **Chemical control:** Application of insecticides such as dimethoate and Imidacloprid @ 1ml/liter water.

3. Fruit and Leaf Scaring Beetle

The adult of this insect is black in colour. It lays eggs at the bottom of the banana plant. And the larvae grow inside the root of the banana plant.

Scientific Name: *Nodostoma viridipnnis*

Symptoms of Damage

- Symptoms are seen more in the rainy season.
- Larvae of this insect feed on the tender fruits and leaves by scaring on them. Adults of this insect also feed on tender parts of plants and make scares on them. Those scaring symptoms make the fruits unmarketable.

Management Methods

- Sanitation: Orchard should be kept clean regularly.
- Chemical control: Application of cypermethrin @ 1.5-2ml/liter water on the corms of banana.

Diseases of Banana

1. Panama Wilt

It is the most severe and important disease of banana. It is serious in poorly drained soil.

Causal Organism: ***Fusarium oxysporium*** f sp. cubense

Symptoms of Damage:

- The disease starts by infecting the roots of the banana plant. Initially plants may show stunted growth and yellowing of older leaves.
- As the disease progresses further, the entire plant may exhibit wilting symptoms, starting from the lower leaves and moving upward.
- The affected leaves become completely dry, crispy, and necrotic, often remaining attached to the plant. Eventually, the entire plant may die.

Management Methods:

- **Use of resistant varieties:** Robusta and Dwarf Cavendish
- **Sanitation:** Good sanitation practices are essential to prevent the spread of disease. Remove and destroy infected plant debris, including diseased banana plants, leaves, and pseudostems.
- **Chemical control:** Application of fungicides such as propiconazole and tebuconazole can be done to control panama wilt in banana.

2. Anthracnose

It is one of the fungal diseases that survives in dead and decaying leaves and fruits. It affects various parts of the banana plant, including the leaves, pseudostem, and fruit.

Causal Organism: ***Colletotrichum musae***

Symptoms of Damage

- Small, dark brown to black lesions appear on the leaves. These lesions may have a water-soaked appearance and gradually enlarge, often merging together. In severe cases, the leaves may become distorted, turn yellow, and eventually die.
- This disease also affects the fruits of bananas. It infects both developing and mature fruit. Initially, small, dark brown to black spots appear on the fruit surface. As the disease progresses, the spots may enlarge, coalesce, and develop sunken centers. The fruits become soft, develop rot, and become unmarketable.

Management Methods

- Sanitation: Good sanitation practices are crucial for managing anthracnose. Removal and destroying infected plant parts help prevent the infestation of the disease.
- Fungicide application: Fungicides such as mancozeb should be applied to control the disease.

3. Sigatoka Leaf Spot

This disease is more dangerous during summer with high temperature and high relative humidity. It is one of the important fungal diseases in which the fungi grow on the lower part of the leaves.

Causal Organism: *Mycospharella musicola*

Symptoms of Damage

- Initially, the upper side of the leaves show slightly yellowish spots. Gradually the spots grow and become elliptical in shape.
- The central part of the spot dries and becomes gray in colour. All these small spots grow and coalesce to show dried leaves in a banana plant.
- This disease directly affects the photosynthesis of the plant.

Management Methods

- Appropriate spacing should be maintained while planting the banana plant. Proper air circulation can prevent disease occurrence.
- Sanitation: Continuous cleaning of the orchard should be done. Removal of infected plant parts and destruction of those plant debris should be done at regular intervals.
- Chemical control: Application of mancozeb (Dithane M-45) @ 2 g/ liter water.

4. Bunchy Top Virus

The dwarf banana varieties are very susceptible to this virus. It is transmitted by aphids.

Causal Organism: ***Pentalonia nigronervosa.***

Symptoms of Damage

- The leaves of banana get bunched together like a rosette at the top and the margins are wavy and slightly rolled upward.
- The plants get stunted and do not produce a bunch of commercial value.
- Leaves seem to curl upward.
- Main vein of the leaves shows interrupted dark green streaks.

Management Methods

- Sanitation: Continuous cleaning of the orchard should be done. Removal of infected plant parts and destruction of those plant debris should be done at regular intervals.
- As this disease is transmitted by aphids, aphid control is the major task that can manage the bunchy top virus.
- Use of healthy and quality plantlets while planting.

Exercise

Choose the correct answer from the given alternatives.

1. Which province of Nepal produces the highest quantity of mango?
   a. Bagmati Province
   b. Madhesh Province
   c. Gandaki Province
   d. Karnali Province

2. Which vitamin is found in high amount in ripe mangoes?
   a. Vitamin D
   b. Vitamin A
   c. Vitamin K
   d. Vitamin E

3. Which propagation method is commonly used for mango?
   a. Air layering
   b. Seed sowing
   c. Inarching
   d. Tissue culture

4. Which of the following is a fungal disease of mango?
   a. Powdery mildew
   b. Bunchy top
   c. Panama wilt
   d. Ring spot

6. Which of the following banana variety is dwarf?
   a. Robusta
   b. Dwarf Cavendish
   c. Mungre
   d. Malvog

7. How is banana mainly propagated?
   a. By seed
   b. By grafting
   c. By suckers
   d. By air layering

8. Which insect spreads bunchy top virus in banana?
   a. Aphids
   b. Mealybug
   c. Fruit borer
   d. Stem weevil

9. Which is the most suitable temperature range for banana growth?

a. 10-15°C b. 25-27°C

c. 30-35°C d. 15-20°C

11. Which is a viral disease of papaya?

a. Anthracnose b. Ring Spot

c. Panama wilt d. Powdery mildew

12. Which propagation method is most common in litchi?

a. Air layering b. Seed sowing

c. Suckers d. Crown planting

13. What is the major physiological disorder in litchi causing fruit cracking?

a. Low sunlight b. Excess water

c. High temperature and low humidity

d. Boron deficiency

Write short answer to the following questions.

1. List four major uses of banana and describe its nutritional benefits in simple words.
2. Explain the process of inarching (approach grafting) in mango propagation.
3. What are the major symptoms and management practices of Panama Wilt in banana?
4. Compare biennial bearing in mango and fruit cracking in litchi in terms of causes and control.

Write long answer to the following questions.

1. Discuss the cultivation practices of mango, including soil requirements, climate, propagation, and pest management.
2. Explain the propagation methods and cultivation practices of papaya, focusing on irrigation, manuring, and harvesting.

3. What are the common diseases affecting tropical fruits like mango and papaya? Suggest management practices for each.

Project Work

1. Prepare a short report (2-3 pages) on:
   - Common disease of fruit crops in your locality and their management practices.
   - Include name of crops, diseases observed, symptoms, and how farmers are managing them.
   - You can use photos/drawings if possible.

Unit 3

Cultivation of Sub tropical fruit crops

3.1 Citrus Fruits (Mandarin Orange, Sweet Orange, Lime)

Introduction

Citrus is the collective generic term which includes several species and varieties of fruits that belong to the Rutaceae family. These fruits are rich in vitamins, especially vitamin C, and are good for health. They grow well in warm and sub-tropical climates and are widely grown in many countries, including Nepal.

Different Species of Citrus Fruits

a. Mandarin (*Citrus reticulata)*

Mandarin is very popular citrus fruit because it gives tasty and high-quality fruits. The juice of this fruit has a good balance of sour and sweet taste. It is also full of vitamins and other nutrients, which makes it a healthy and good food for us.

b. Sweet Orange (*Citrus sinensis)*

Sweet orange is tight skinned with solid control core pulp juicy and sour sweet. Seeds are within whitish cotyledons. This is of great importance for its excellent quality and its rootstock value is limited to some extent.

c. Lime (*Citrus aurantifolia)*

Lime is oval or round, having a diameter of one to two inches with green flesh and skin. They can be either sour or sweet depending on the variety. Sour limes contain citric acid giving them an acidic and tart taste, while sweet limes lack citric acid and are sweeter in flavor.

d. Lemon (*Citrus limon)*

Lemons are oval and feature a yellow, texturized outer peel. Like other citrus fruits, their inner flesh is encased in eight to ten segments.

e. Pomelo (*Citrus maxima)*

Pomelo belongs to the citrus race and is closely related to grapefruit. It is a very large, round to pear-shaped, yellowish orange fruit with very thick skin. The texture is fleshy and has more membrane than many other types of citrus fruit.

f. Grapefruit (*Citrus paradisi)*

It has a unique flavor and numerous health benefits. It is believed to be a cross between a pomelo and an orange. They are round or slightly oval, with a thick, yellow-orange rind that can be smooth or slightly pebbled.

Origin and Distribution

Citruses are native to the tropical and sub-tropical regions of Asia such as Southern Asia and the Philippines. The major citrus producing countries in the world are Brazil, USA, China, India, Mexico, Spain, etc.

In Nepal, citrus fruits have been cultivated in the mid-hill regions. Now it is being cultivated in some parts of terai districts as well. Ramechhap, Salyan, Sindhuli, Syangja, Tanahu, Gulmi, Gorkha, etc. are the major citrus producing districts.

Present Situation of Citrus Production in Nepal

- Total cultivation area: 50,235 hectares
- Total Productive area: 32,188 hectares
- Total Production: 311,188 metric ton
- Yield: 9.67 mt/ha

(Statistical information on Nepalese Agriculture, 2077/78)

Uses

Citrus fruits have a wide range of uses depending upon the species and varieties.

1. **Consumption as Fresh Fruit**

   Citrus fruits are commonly consumed fresh, either by peeling and eating the segments or by squeezing the juice.

2. **Juice Froduction**

   Citrus fruits are widely used for juice extraction. Mandarins, sweet oranges, Lemons, limes, and grapefruits are frequently juiced to make refreshing beverages.

3. **Culinary Fpplication**

   Citrus fruits are valued for their flavor and taste enhancing properties in cooking. Especially limes are being used for marinading purpose.

4. **Marmalades and Preserves**

   Citrus fruits, particularly oranges and lemons, are commonly used to make marmalades and preserves. The zest (outermost layer of peel/coloured portion of peel) and juice are combined with sugar to create sweet spreads with a tangy flavor.

5. **Essential Fils and Fragrances**

   Citrus fruits are a source of essential oils that are used in perfumes, cosmetics, and aromatherapy.

Nutritional Value

Citrus fruits are well known for their high Vitamin C content. Vitamin C is an antioxidant that supports the immune system. Citrus fruits when consumed with pulp contain dietary fiber. Additionally, it is rich in folate (Vitamin B9), potassium, Vitamin A, limonoids (have anticancer properties), and flavonoids (antioxidant and anti-inflammatory properties).

Varieties

Table: Varieties of Different Citrus Species

	S.N.	MANDARIN (सुन्तला)	SWEET ORANGE (मौसमरजुनार)	LIME (कागती)	LEMON (निबुवा)
VARIETIES	1.	Pokhara Local	Nobel orange	Local Sun kagati	Nepali Amilo
	2.	Kinno	Washington Noble	Terhathum local	Eureka Round
	3.	Dhankuta Local	Yoshida Noble	Mexican	Eureka Oblong
	4.	Yoshida Pongkan	Tarakko Nucellar	Vanarashi	Lisbon
	5.	Sutusma		N.C.R.P 55	Panta-1
	6.	Khoku Local		N.C.R.P 49	
	7.	Thai Tangerine		N.C.R.P 53	
	8.			Sunkagati-1	
	9.			Sunkagati-2	

Propagation Methods

Both seeds and vegetative propagation methods can be used for propagating citrus fruits.

1. By seed

Propagation of citrus fruits by seed is a common way to grow new plants, especially for making rootstocks. Seeds are planted in nurseries, and after they grow into seedlings, these young plants are used as rootstocks. Citrus seeds often produce many seedlings from one seed, which helps in getting strong and healthy plants. However, plants grown directly form seeds take a long time to bear fruits, and may not be exactly like the parent plant. That is why farmers usually graft or bud a good fruit variety onto the seedling rootstock. This method helps produce healthy trees that grow well and

give good quality fruits. So, seed propagation is mainly used to grow rootstocks, and grafting is done to get the desired fruit.

Process of preparing plantlets from seed.

- Extract seed from fully developed, matured fruits, wash them and dry under shade.
- Treat seeds with Thiram @1gm/kg seed, sow within 7 days in plastic trays(60cm×40cm×12 cm).
- Fill trays with potting mixtures of soil, sand and FYM @1:1:1 ratio after sterilization by solarization or by fumigaiton.
- Tray should have 6-10 holes at the bottom for good drainage.
- Shade dried, bold seeds treated with Thiram@ 3g/kg seed before sowing.
- Sow seeds at a depth of 1-1.5 cm with a spacing of 2.5-3 cm in rows kept 10 cm apart.
- Seeds germinate in 10-15 days interval at 25-30 degree celsius and cover them by plastics.
- Transplant them in polybags (15-20×20-25 cm) when they are 4-6” tall and 8-10 leaves.
- Discard seedlings that grow too slow(about 20% are rejected)
- Selected seedlings are treated with Ridomil Gold (2.75 g/litre water) for 10 min.
- Seedlings are transplanted either in Nursery bed at spacing of 15cm×30 cm.
- Give light irrigation after transplanting, after that irrigate as and when necessary.
- Spray Bavistin(1g/l water) to control disease and confider(0.5ml/lit) for insects at monthly interval.

2. Budding

Shield or T-Budding

In this method of propagation, a bud from desired variety (scion) is transferred on the rootstock with an objective of utilizing the vigorous root system of the rootstock and combining the best characters of both.

Process

- A bud is selected from the middle section of the scion shoot. It is removed by making a cut around the bud with the help of a sharp budding knife.
- On the selected rootstock T-shaped incision is made just enough to insert the bud.
- The bud is inserted in the incision and tied with a strip of plastic film in such a way that the tip of the eye remains open.

Budding should be preferably done as low as possible on the rootstock. It takes three to four weeks for the bud to unite when the new shoot from the grafted bud is about 10cm long the top portion of the stalk above the union is cut off and the plastic film is removed.

Important varieties that can be used to prepare rootstocks for the propagation of citrus are listed below.

1. Rough Lemon
2. Sour Orange
3. Cleopatra mandarin
4. Trifoliate orange
5. Sweet Lime
6. Sour lime

Climate and Soil

Citruses are sub-tropical fruits. They can be cultivated up to an altitude of 700-

1500 masl. The ideal temperature is 15-25℃. They require 1200-1500 mm annual rainfall. Citrus plants cannot tolerate frost and extreme cold.

Sandy loam and loamy soil rich in organic matter and with good drainage facility is good for citrus cultivation. The pH should be 5-6.5.

Altitude range for commercial cultivation of different citrus species

1. Mandarin: 1000-1200 masl
2. Sweet Orange: 1000-1200 masl
3. Lime: 500-1400 masl

Planting Time, Spacing, and Technique

Time

The appropriate time of planting citrus plant is rainy season (Jestha-Shrawan). In those areas where high rainfall occurs, planting should be done at the end of rainy season and in those areas where low rainfall occurs, planting should be done at the beginning of the rainy season.

Planting should be done in the evening.

Spacing

1. Mandarin
   - 5-6 m × 5-6 m
2. Sweet Orange
   - 5-6 m × 5-6 m
3. Lime
   - 4-5 m × 4-5 m

Planting Technique

In citrus, square and rectangular planting systems are generally practiced. The planting density usually varies from 200-400 plants per hectare, but density planting is also followed using modified agro-techniques. In the square system,

spacing of 5 m × 5 m (400 plants/ha) and in rectangular system the spacing of 3 m × 5 m (667 plants/ha) can be maintained. In a well-prepared land, sapling should be planted in a pit size of 1 m × 1 m × 1 m.

Fertilizers

FYM: 50kg/plant/year

Urea: 543 g/plant/year

Diammonium phosphate (DAP): 874 g/plant/year

Muriate of Potassium: 833 g/plant/year

Irrigation

Irrigation is especially important during flowering and fruiting stages. Sudden heavy irrigation during flowering and fruiting may cause flower and fruit drop. It requires irrigation at 7-10 days interval in summer and at 15-20 days interval in winter.

Training and Pruning

An ideal citrus tree should be low headed with a roof like a crown. This can be achieved by pruning young trees. Modified center leader training system is best suited for citrus trees. Trees, if trained to single stem with 4-6 well-spaced branches for making the basic framework can produce a good number of fruits. The lowermost branches should be allowed not to grow below the height of 75 cm from the soil surface. The bearing trees require little or no pruning.

Pruning of bearing trees though differs with variety but chiefly consists of removal of dead, diseased, crisscross and weak branches. Removal of water sprouts and sucker of rootstock is also highly essential. Pruning non-bearing trees can be done at any time of the year. But for bearing trees the best time is after harvesting, during late winter or early spring when these are in somewhat dormant stage.

Weeding and Intercultural Operation

Major weeds can be controlled by hand pulling, hoeing, burning and tillage. However, frequent tillage may destroy the surface structure of soil, thus lowering the water holding capacity and permeability of soil. So, a better way to eradicate weeds is to use weedicides.

- Pre-emergence application of Diuron (5kg/ha) or Terbacil (4.5kg/ha).
- Post-emergence herbicide: Atrazine (5-6kg/ha) for dicot weeds
- Bromocil (6kg/ha) for controlling both monocot and dicot weeds.

Harvesting and Production

Harvesting should be done carefully without causing damage to the fruit. Slight bruising or injury to the rind leads to quick decay of fruits. Harvesting can be done by shaking the branches with a pole and by hand using a ladder. Mechanical harvesting systems consisting of abscission chemical and trunk shakers, pick up machines and automatic robotic fruit picking is also done in advanced citrus orchard.

Productivity of citrus fruits entirely depends upon the species and varieties of fruits.

1. Mandarin – 10.80 mt/ha
2. Sweet Orange – 10.82 mt/ha
3. Lime – 6.38 mt/ha

Physiological Disorders in Citrus

1. Fruit Drop

It is a common type of physiological disorders seen in citrus fruits. When there is alteration in climate, improper soil and nutrient management, hormonal imbalance, and incidence of insects and diseases, fruit drop in citrus can be seen. The alteration in climatic factors like fluctuating temperature and low atmospheric humidity promote fruit drop. Similarly,

imbalance of soil moisture and lack of proper nutrition are the other causes of fruit drop.

Management Methods

- Maintenance of appropriate soil moisture level during fruit development can decrease fruit drop problem.
- Application of growth regulators 2,4-D (10 ppm), NAA (5 ppm)

2. Granulation

It is a physiological disorder of juice sacs of citrus including mandarins wherein they become comparatively hard and become somewhat enlarged. Young, vigorous trees are more likely to develop granulated fruits than older ones. Similarly, large fruits have more granulation than small ones.

Management Methods

Spraying lime reduces the extent of granulation.

- Application of 2,4-D (@12ppm
- Application of zinc and copper can also reduce the incidence of granulation considerably.

3. Citrus Decline

After fruitful production for about 15 years, citrus orchards start bearing little fruit and become uneconomical. They show symptoms of ill health and decline. The affected trees do not die completely but remain in a state of unproductiveness for a number of years. Initially, only a few limbs of the plants are involved but later the whole tree is affected.

Symptoms of Damage

- The leaves start falling and foliage become sparse. The sparse foliage condition leads to the low photosynthesis, which eventually results into the stunted growth of the plants.
- The leaves show diffused yellow colour in mid-rib, lateral veins and

inter-venal area.

Major Insects of Citrus

1. Aphids

The adults and nymphs suck the sap from tender parts of the plant such as leaves, flowers and fruits. It causes the stunted growth of plants and reduction in yield.

Management Methods

- In the initial infestation condition, we can adopt clean cultivation by removing the infected plant parts. Such infected parts should be burnt or buried immediately.
- Biological control methods can also be used to control aphids. The predators like lady bird beetles can be used.
- If the infestation seem serious spraying different insecticides like imidacloprid and thiamethoxam @ 0.3ml/liter of water can control aphids.

2. Scale Insect

They suck the sap from tender parts of the plant, leaves, flowers and fruits. The affected part gets damage which results in premature fruit drop and defoliation.

Management Methods

- We should keep the orchard clean by removing all the insect infected parts from the plant and destroy them.
- In the severe infested condition, chemical insecticides like dimethoate @ 1-2 ml/liter of water can be applied in foliage.

3. Citrus Psylla

They suck the sap from tender parts of the plant, leaves, flowers and fruits. They create honey dew on the leaves in which sooty mold is developed.

Management Methods

- Establish nursery at about 1300masl.
- Destroy the secondary host i.e. Kamini flower.
- Spray dimethoate @ 2-3ml/liter of water.

4. Leaf Miner

Very small larvae bore in the tissue of the leaves and make zig-zag tunnel. Feed on the chlorophyll internally due to which the tunnel looks silver colour.

Management Methods

- Spray tobacco-based pesticide.
  - Example: Soak 250 g tobacco in 400 liters of water and mix with 30 g surf. Keep it the whole night and filter it. Now add one part of this solution in a pot of water and spray at 10 days interval.
- Apply 0.06% solution of Thiamethoxam 25 wg

5. Stem Borer

The larva feed on the stem and trunk of the plant. They make tunnels internally. Leaves fall on severe condition.

Management Methods

- We should keep the orchard clean. For this, we should regularly remove the stem borer infected plant parts and destroy them.
- When there is no severe infestation, we can manually use wire to kill the insects inside the tunnel.
- Use malathion-soaked cotton to plug in the tunnels. And close the holes with the help of mud or cow dung.

Major Diseases of Citrus

1. Die-back

Causal organism: ***Colletotrichum gloeospoiriodes***

Symptoms of Damage

- The leaves become yellow in the initial stage and turn into dark colours and start to fall with the beginning of summer.
- Die-back of twigs starts leading to dryness and finally the plant dies.

Management Methods

- Remove dead twigs or affected parts from the plant. After the removal, we should also destroy the affected parts completely either by burning or burying.
- Application of Bordeaux mixture @ 2:2:250 in April, July-August and September can reduce the infestation of die-back.
- In the severely infected condition, spraying carbendazim can manage the disease.

2. Phytophthora Rot

Causal organism: ***Phytophthora parasitica***

Symptoms of Damage

- Dark discolouration of bark is developed, water-soaked spots develop which cause stem rot, rootlet rot and finally defoliation.
- In advance stage bark cracking and oozing of gums take place.

Management Methods

- Avoid water logging conditions.
- Scrap the affected part and safely destroy it.

3. Citrus Canker

Causal organism: ***Xanthomonas citri***

Symptoms of Damage

- It affects the quality of fruit and reduces market value.
- Water-soaked round spots are seen on the leaves and stems as well as in fruits.
- The spots increase slowly and turn into brownish colour on the leaves, stems, and fruits.

Management Methods

- Remove and destroy the infected part of the plant.
- Spray Bordeaux mixture @ 1% on cut portion.
- Apply streptocyclin @ 1g/l of water.

4. Citrus Greening

Causal organism: ***Libribacter asiaticus***

Symptoms of Damage

- Initially vein and veinlet turn yellow and then interveinal chlorosis is observed.
- Leaves become leathery, small, pair in mass and bend downward of seasonal flowering.
- Die-back symptoms are another major symptom of this disease.
- Division of segments inside the fruits is not in equal proportion and seeds become unviable.
- It is transmitted by citrus psylla.

Management Methods

- The infected parts should be destroyed.
- Spray dimethoate 2-3ml/liter of water to control the vector citrus psylla.

- Apply bordo paste in cut portions.
- Spray streptocyclin @ 1g/liter of water after pruning.

5. Powdery mildew

Causal organism: ***Oidium tingitaninum***

Symptoms of Damage

- White powdery mass appears on the twigs, leaves, and fruits.
- The ends of mildewed leaves can twist and curl upward.
- Young shoots can wither and die back.
- Severe infection causes defoliation.

Management Methods

- Use of healthy propagation material.
- Use good sanitation and hygiene practices.
- Application of fungicides such as propiconazole, and thiophanate-methyl.

6. Tristeza Virus

This virus affects mostly lime trees.

Means of transmission of this disease

- Use of diseased planting materials.
- Aphids

Symptoms of Damage

- In the beginning, the diseased plants become pale, and the plant also appears to be wilting. After that, the leaves fall and become bare, the branches begin to die in extreme cases after being affected by the disease.
- Fruits become small and finally the whole plant dries up and dies.

Management Methods

- Removal and destruction of diseased plant parts.
- Control of aphids by the use of insecticides such as *Imidacloprid* @ 0.3ml/liter of water.
- Use of plant propagation material from reliable and certified sources/ nursery.

3.2 Pomegranate

Introduction

In Nepal, pomegranate can be successfully grown in some districts of Terai and almost all of the mid-hill districts. It can be successfully grown in 500-1600 masl.

The pomegranate trees are about 5-6 meters tall, but it depends upon the varieties. Generally, the fruits are round to oval. The colour of pomegranate can be white, yellow to red depending upon the varieties.

Scientific name: ***Punica granatum***

Family: **Lythraceae**

Origin: **Iran**

Present Situation of Pomegranate Production in Nepal

Total area cultivated: 1443 hectares

Total productive area: 762 hectares

Total Production: 5072 metric tons

Yield: 6.66 mt/ha

Uses

- Fully ripen fruits can be directly consumed.
- Fully ripe fruits can also be used to produce fresh juice and preserved juice.

- Pomegranate fruits also have medicinal use such as cure cancer, reduce blood pressure and cholesterol levels. The high vitamin C content in pomegranates can help boost the immune system.

Nutrition

- Pomegranate fruits are rich in carbohydrate, dietary fiber, fat, protein, vitamin B1, vitamin B2, etc.

Varieties

The common varieties of pomegranate that are being cultivated in Nepal are listed below.

1. Bedana
2. Kandhari
3. Paper Shell
4. Ganesh
5. Mridulla
6. Dholkha
7. Musqat Red

Propagation of Pomegranate

Pomegranate fruit can be propagated both by seed and by cutting. Generally, the propagation of pomegranate is done by seed. Since the pomegranate plants undergo self-pollination as well as cross pollination, the quality of plants is not so good which are propagated through seed. This results in non-uniform fruit production, which is not good for commercial production.

Under vegetative propagation method, cutting is considered the best method. Pomegranate plants easily generate roots, which is why, cutting method of propagation is the most popular method worldwide. This method can give healthy and true to the type plants. The fruits are of good quality.

Process of Cutting in Pomegranate

1. **Selection of plants**
   a. Mother plants which give good number of fruits as well as good quality fruits with true to the type, and which are in healthy state should be selected for cutting.
   b. A mature one year old pencil sized branch should be selected. (branches younger than 6 months and older than 2 years are not good)
   c. This should be done in the month of Magh.
2. **Preparation of cutting**
   a. Pencil sized branches of length 10-12 inches should be cut.
   b. At the base of the cutting, a 1.5-inch slanted cut should be made.
   c. While cutting at least 6 buds should be present in each piece.
3. **Planting in nursery**
   a. For planting in the nursery, a mixture of sand and soil should be prepared, and a bed of size 1 m × 1 m should be made.
   b. The prepared cutting should be planted on the bed with the spacing of 8-10 inches. It should be dipped 4-5 inches under the surface.
   c. While planting, every leaf should be removed from the cutting.
   d. Irrigation should be carried out regularly.
   e. Weeding should be performed as per the requirement.
   f. Plantlets get ready in 9-12 months. But the plantlets of 1-2 years is more appropriate for planting.

Climate

Pomegranate fruits can be successfully cultivated in mid-hill districts of Nepal. To produce good quality fruits, the site should be cold in winter and warm in dry in summer. The appropriate temperature range is between 13-35°C. The average annual rainfall requirement is 50-60 cm. This fruit can tolerate frost to some extent but extremely cold affects the fruits.

Soil

Pomegranate can be cultivated in almost all types of soil. However, clay loam soil is considered best for commercial production of pomegranate. The appropriate range of soil pH is from slightly acidic to slightly alkaline (i.e. 6-8). This fruit can give a good amount of fruit although the soil is less fertile.

Layout of Orchard

Layout is the process of determining the points where the fruit plantlets are to be planted in an orchard. Layout is the most important step to be performed while establishing a commercial orchard. Planting fruit crops in proper layout makes intercultural operation easier. Mostly, hexagonal and square method of layout is preferred in pomegranate cultivation.

Spacing

Spacing of pomegranate depends on the varieties to be planted, climate, soil, and irrigation facilities. However, it can be planted maintaining the spacing of about 3-6 meter.

Planting

For planting, pit should be made 2-3 months of planting. The pit size should be of 1m×1m×1m. The pit should be filled with well decomposed compost, chemical fertilizers (urea, DAP, and Potash) at recommended dose. The fertilizers should be applied in layers.

Planting Time

Planting time depends upon the climatic condition. It should be planted during poush-magh month where irrigation facility is available. And it should be planted in the rainy season where irrigation facility is not available.

Irrigation

Pomegranate can be cultivated in dry areas also. But it requires regular irrigation to get high quality fruits. Frequent but light irrigation is required during dry period.

Fertilizers

The amount of fertilizers to be applied depends upon the fertility status of soil, and soil type.

- FYM: 50 kg/plant/year
- Nitrogen: 250 gram/plant/year
- Phosphorus: 250 gram/plant/year
- Potash: 250 gram/plant/year

Training and Pruning

Training and pruning are required to maintain the good shape of the plants and produce quality fruits. Old, diseased, and insect infected branches and twigs should be removed timely.

Initially after planting the pomegranate plant, the tip of the plant should be cut at 60-70 cm height from the ground level.

Weeding and Intercultural Operation

Pomegranate trees start giving fruit after 3-4 years of planting. Regular cleaning and removal of weeds should be done to keep the diseases and insects away from orchard.

Intercropping

Intercropping can be done in the initial years of planting by cropping non-competing shallow rooted crops such as peas, black gram, green gram, rapeseed, etc.

Flowering and Fruiting

In pomegranate plants, both self-pollination and cross-pollination occur. Hand pollination is also practiced more often in this plant. This can be helpful to get good quality fruits. But it is costly to operate in large orchards.

In tropical areas, pomegranate trees flower all around the year. But in sub-tropics, we find 3 different flowering times. They are:

i. Ambe bahar- Poush/Magh

ii. Mrig bahar- Jestha/Ashad

iii. Hasth bahar- Asoj/Kartik

Harvesting

Generally, fruits become ready to harvest after 5-6 months of flowering. But this can differ depending upon the varieties and place on which it grows. When the fruit starts getting red from green to yellow gradually, it is mature. Harvesting should be carefully done by cutting the peduncle with secateurs.

Production

Production and productivity of any fruit crop depends upon various factors. Orchard management, soil types, variety, and climate are the major factors that can affect the level of production.

In the initial years, 25-30 fruits/plant is generally observed. Average old trees (10-11 years plant) give 100-150 fruits/year. In the mid-hills, its general productivity is 8-10 mt/ha.

Major Insects of Pomegranate

1. Pomegranate Fruit Borer *(Deudorix Isocrates)*

The pomegranate fruit borer is a serious pest that attacks developing fruits, causing internal damage and making them rot or drop early.

Symptoms of Damage

- Small holes on the fruit surface, often near the calyx (fruit crown).
- Larva (caterpillar) enters the fruit and feeds on the pulp and seeds.
- Inside of the fruit becomes brown, wet, and rotten.
- Damaged fruits fall early or become unmarketable.
- You may also see insect droppings (frass) near the hole.

Management Methods

- Collect and destroy infested fruits to stop the spread.
- Cover fruits using fruit bags or netting to prevent egg-laying.
- Use light traps to catch adult moths.
- Spray Neem oil (5 ml/litre) or Spinosad during fruit setting and development.
- Avoid injuries on fruits, as borers enter more easily through wounds.

2. Stem Borer *(Coelosterna spinator)*

The stem borer is a wood-boring insect that attacks the main stem and branches of pomegranate trees, leading to wilting and death of branches.

Symptoms of Damage

- Entry holes seen on the main stem or branches.
- Frass (sawdust-like material) comes out from the holes.
- Branches become weak, dry, or wilted.
- In heavy infestation, the plant may collapse or stop bearing fruits.

Management Methods

- Regularly inspect stems and branches for holes and frass.
- Insert iron wire into the hole to kill the larva inside.
- Inject kerosene or neem oil into the hole and seal with mud.
- Prune and destroy heavily damaged branches.
- Keep the orchard clean and well-managed to reduce pest habitat.

3. Sap Suckers (Aphids, Thrips, Scale Insects, Mealy Bug)

Major Diseases of Pomegranate

1. Colletotrichum Leaf Spot (Anthracnose)

Causal Organism: ***Colletotrichum gloeosporioides***

Symptoms of Damage:

- Small, dark brown or black spots on leaves.

- Spots may be round or irregular and sometimes have a yellow halo.
- Infected leaves may dry and fall off early.
- It can also affect twigs and fruits, causing sunken spots.

Management Methods

- Prune and destroy infected leaves and twigs.
- Spray copper oxychloride (0.3%) or carbendazim (0.1%) at first appearance.
- Maintain good air flow in the orchard by proper pruning.

2. Fusarium Leaf Spot *(Fusarium oxysporium or Fusarium solani)*

Symptoms of Damage

- Yellow to brown spots on leaves, especially on older leaves.
- Spots may become irregular in shape and enlarge over time.
- Infected leaves may wilt or drop early.
- In some cases, leaf veins may turn reddish or brown.

Management Methods

- Improve soil drainage and avoid waterlogging.
- Apply balanced fertilizer to keep plants healthy.
- Spray fungicides like Mancozeb or Carbendazim if needed.

3. Phomopsis Leaf Spot *(Phomopsis spp.)*

Symptoms of Damage

- Small, circular dark brown spots with light centers on leaves.
- Spots may join, forming larger patches.
- Leaf edges may curl, dry, and fall.
- May also infect shoots and twigs, leading to dieback.

Management Methods

- Remove infected leaves and twigs.
- Spray chlorothalonil, mancozeb, or carbendazim at an early stage.
- Prune for better air circulation in the canopy.

3.3 Kiwi

Introduction

Kiwi fruit are a delicious and nutritious fruit originating in China but now grown in various parts of the world. They are small, egg-shaped fruits, typically measuring around 2-3 inches in length. They have a thin, brown, and slightly hairy skin with bright green or golden flesh inside.

Kiwi fruits have a sweet and tangy flavor, often compared to a mix of strawberries, bananas, and pineapple.

Scientific name: ***Actinidia deliciosa***

Family: Actinidiaceae

Origin: China

Present Situation of Kiwi Production in Nepal

In Nepal, Kiwi production is highest in Illam district with 1500kg per year, being cultivated in 200-hectare productive area.

Uses

- Fully mature fruits can be consumed fresh.
- Can be consumed as fruit salads, desserts, and smoothies.
- They can also be used in sauces and marinades.

Nutrition

Kiwi fruits are excellent source of vitamin C, vitamin K, vitamin E, and dietary fiber. They also contain essential minerals like potassium and folate. Additionally, these fruits are rich in antioxidants, which are beneficial for overall health and immune system.

Varieties

Male flower flowering varieties

1. Matua
2. Tomori
3. Khohi

Female flower flowering varieties

1. Bruno
2. Allison
3. Hay-ward
4. Abbott
5. Monty
6. Soyou
7. Theki fal (Nepalese Wild Kiwi)

Propagation of Kiwi

Climate

Kiwi is a warm temperate fruit crop and can be successfully cultivated from 800-2000 masl. For commercial production of kiwi fruit, appropriate temperature range should be between 10°C-25°C. Extreme temperatures, especially frost during the flowering period, can damage the flowers and reduce fruit set.

They require around 1000-1500mm of rainfall per year. However, kiwi plants can somehow tolerate drought.

Soil

Kiwi plants grow well in well-drained, fertile soils that are rich in organic matter. The pH level of the soil should be slightly acidic to neutral, ranging from 6.0 to 6.5. Water logging should be avoided as they can cause root rot and other problems.

Layout of Orchard

A proper layout is always required for successful commercial production of any fruit. To give attractive looks, provide optimum amount of light and air to the plants, make intercultural operations easier, and ultimately get quality fruits, layout of kiwi orchard is must before planting kiwi plants.

Rectangular system of layout is mostly recommended system for kiwi cultivation.

Spacing

Plant-Plant: 6 m

Line-Line: 5 m

For Hay-Ward variety: 6-8 m spacing.

15 plants are required for 1 ropani land.

Planting

Before 2 months of planting, pit should be dug of size 1m×1m×1m. After 2 months, the pit should be filled with soil and mixture of fertilizers. At the center of the filled pit, plants should be planted.

Planting Time

Kiwi is a deciduous plant. So, it should be planted during the winter months i.e. Poush and Magh.

Irrigation

Irrigation is regularly required in dry period. In other times, irrigation should be applied by assessing the soil moisture condition.

Fertilizers

FYM: 3kg for 2-5 years

Nitrogen: 120 gram per plant per year

Phosphorus: 60 gram per plant per year

Potassium: 60 gram per plant per year

The ring method should be applied to apply fertilizers in kiwi plants.

Training and Pruning

Training and pruning in kiwi plants is very important. The branches of kiwi plants grow faster. If pruning is not done at proper time and by proper idea, the branches get uncontrolled growth, which will be difficult to handle at later period.

Summer Pruning

Summer pruning involves selectively removing certain parts of the plant during the active growing season, usually from late spring to early summer. The primary goals of summer pruning in kiwi plants are to:

- Remove excess vegetative growth to promote better sunlight penetration into the canopy.
- Enhance fruit production
- Improve air circulation

Winter Pruning

Winter pruning is done during the dormant season, typically in late winter or early spring, before the plant starts its active growth in the spring. Its main purpose is to

- Remove dead and diseased branches
- Remove unwanted branches
- Shape the plant

Management of Vines/Branches in Kiwi Fruit

1. **T-Bar System**

   In this system, the English 'T' shaped iron or cement poles are placed in the orchard. Five steel wires are placed above the pole in parallel. Plants are planted in between the two poles. Only one main stem is kept until it grows up to 5-6feet. Then, the top is cut down when two branches are clearly seen. The two branches are distributed to two different sides on the bar. These branches are fruiting branches which are given to develop freely on the two sides of the trellis.

2. **Double Pole System**

   In this system, two six feet poles are placed in 2 m distance. Above of the two poles, an iron rod is placed. In the iron rod placed horizontally over the

two poles, 5 steel wires are stretched in the space of 40 cm.

This system is considered more durable and stronger than T-bar system.

Weeding and Intercultural Operation

When the orchard is highly infested by weed, it affects air circulation, nutrient uptake, and light penetration in the kiwi plants. These weeds can be the habitat for different diseases and insects. So, the removal of weed is a must to prevent the kiwi orchard from facing such challenges.

Weeding can be done both manually and chemically. Glyphosate is the most effective herbicide to control weeds in kiwi orchard.

Rate of glyphosate application: 5-8 ml per liter water

Flowering

Kiwifruit is a dioecious plant. In kiwifruit both male and female flowers are not found in same plant. There are male plants that flower male flowers only and female plants that flower only female flowers. Therefore, both male and female plants should be planted in effective proportion in kiwi orchard. Generally, 1 male plant should be planted for 5 female plants for effective pollination of kiwi plants. This ratio helps attain good amount and quality fruit. Insect pollination occurs in kiwi plants.

Harvesting

Kiwi fruits should be harvested when the fruits get fully mature but firm while feeling. Fruits should be harvested carefully with the use of fruit clippers.

Production

As in all other fruits, production and productivity depends upon the varieties and practice of management applied in the orchard. In a 7-8 years mature kiwi plant, 50-100 kg fruits can be harvested.

Average productivity in general varieties is estimated to be 25 mt/ha. However, in Hay-ward variety productivity can reach up to 50 mt/ha.

Major Insects of Kiwi

Leaf roller caterpillars, Spider mites, Thrips, Boxelder bugs, Japanese beetles, Scale insects, Aphids, etc. are some important insects that affect the production of Kiwi in Nepal.

1. Leaf Roller Caterpillars

Leaf rollers are the larvae (caterpillars) of small moths. They roll or fold leaves using silk threads and feed them inside the rolled area. They are commonly found in Kiwi, Guava, Citrus, and other fruit crops.

Symptoms of Damage

- Leaves are rolled, folded, or tied together.
- Caterpillars live inside the roll and feed on leaf tissues.
- Damaged leaves become dry and brown.
- Reduced photosynthesis, leading to poor plant growth.

Management Methods

- Hand-pick and destroy rolled leaves in early stages.
- Use light traps to catch adult moths.
- Spray neem oil (5 ml/litre) or Spinosad if infestation is high.
- Maintain clean and well-pruned orchards.

2. Japanese Beetles *(Popillia japonica)*

Japanese beetles are metallic green and bronze-coloured insects that feed on leaves, flowers, and fruits. Adults of these insects are active during warm weather and feed in groups.

Symptoms of Damage

- Skeletonized leaves – only leaf veins are left.
- Chewing damage on flowers and soft fruit skin.
- Plants look shredded or burnt in severe attacks.

Management Methods

- Handpick beetles early in the morning when they are less active.
- Use trap crops or pheromone traps to attract and kill beetles.
- Apply botanical insecticides or carbaryl if population is high.
- Encourage natural enemies like birds and parasitic wasps.

3. Spider Mites *(Tetranychus urticae)*

Spider mites are tiny pests related to spiders. They suck sap from the underside of leaves and cause yellowing and drying.

Symptoms of Damage

- Yellow or white dots on leaves (stippling).
- Fine webbing on the lower side of leaves.
- Leaves may become bronzed, curled, and dry.
- Plants become weak and stressed.

Management Methods

- Spray water to wash mites off leaves.
- Use neem oil, soap solution, or wettable sulfur.
- In severe cases, spray acaricides like abamectin or dicofol.
- Keep the field moist and dust-free.

Major Diseases of Kiwi

Phytophthora crown or root rot, Botrytis fruit rot, Crown gall, Bleeding canker, Bacterial blight, Powdery Mildew, Leaf Spot, etc. are some of the major diseases of Kiwi in Nepal.

1. Phytophthora Crow or Root Rot (Phytophthora or Pythium spp.)

Root rot is a common and harmful disease in kiwi that affects the underground roots. It is usually caused by soil-borne fungi like *Phytophthora* or *Pythium* species. The disease mostly occurs in waterlogged or poorly drained soils and causes the plant to become weak or die.

Symptoms of Damage

- Leaves turn yellow and become droopy.
- Slow growth and reduced fruit production.
- Roots appear brown, soft, and rotten.
- In severe cases, the whole plant wilts and dies.

Management Methods

- Plant kiwi in well-drained soil or on raised beds.
- Avoid overwatering and waterlogging.
- Use disease-free planting material.
- Apply fungicides like metalaxyl or mancozeb as a soil drench.

2. Botrytis Fruit Rot

Botrytis fruit rot, also known as gray mold, is caused by the fungus *Botrytis cinerea*. It mostly affects kiwi fruits during ripening, harvesting, or storage, especially in cool and moist conditions. The fungus causes soft rot and destroys fruit quality.

Symptoms of Damage

- Brown or soft watery spots on fruits.
- Affected areas covered with gray fuzzy mold.
- Fruit may become soft, shriveled, and smelly.
- Problem worsens during high humidity or poor ventilation.

Management

- Handle fruits carefully during harvest to avoid injury.
- Harvest at proper maturity stage and store in cool, dry places.
- Avoid excessive irrigation during fruit maturity.
- Spray fungicides like chlorothalonil or mancozeb before harvest.

3. Crown Gall

Crown gall is a bacterial disease caused by *Agrobacterium tumefaciens*. It forms tumor-like swellings or galls at the base (crown) of the kiwi stem or on the roots. It enters through wounds and reduces plant vigor and growth.

Symptoms of Damage

- Swollen, rough galls near the base of stem or on roots.
- Galls may be hard at first, later become cracked and decayed.
- Infected plants show stunted growth and reduced fruit yield.
- Severe infection may lead to plant death.

Management Methods

- Avoid injury during planting or pruning.
- Use disease-free planting material.
- Remove and destroy infected plants.
- Apply copper-based bactericide on wounds or infected areas.
- Practice crop rotation and avoid planting in infected soil.

4. Bleeding Canker

Bleeding canker is a fungal disease that affects the trunk and branches of kiwi vines. It is caused by fungi like *Phytophthora* or *Botryosphaeria*. The disease causes dark-coloured sap (gum) to ooze from cracks in the bark, making the plant weak or die back.

Symptoms of Damage

- Dark, wet patches on bark or stem.
- Oozing of reddish-brown or dark sap (called bleeding).
- Bark becomes cracked, sunken, or dead.
- In severe cases, the affected branch may wilt or dry.

Management Methods

- Avoid trunk injuries during field operations.
- Prune and destroy infected branches.
- Improve drainage and air circulation in the orchard.
- Apply fungicide paste (copper oxychloride) on the affected area.

Exercise

Choose the correct answer from the given alternatives.

1. What is the scientific name of sweet orange?

   a. Citrus aurantifolia b. Citrus sinensis

   c. Citrus limon d. Citrus paradisi

2. Which rootstock is commonly used for citrus propagation?

   a. Rough Lemon b. Paper Shell

   c. Bruno d. Matua

3. In pomegranate propagation, which method is considered best for commercial production?

   a. Seed propagation b. Grafting

   c. Cutting method d. Tissue culture

4. Kiwi is a _____ plant.

   a. Monoecious b. Dioecious

   c. Self-pollinated d. Wind-pollinated

5. What is the ideal temperature range for citrus cultivation?

   a. 5–15°C b. 10–20°C

   c. 15–25°C d. 20–30°C

6. Which disease in citrus causes water-soaked round spots on leaves and fruits?

   a. Citrus Greening b. Citrus canker

   c. Die-back d. Powdery mildew

7. Which training system is recommended for kiwi plants?

   a. Single pole b. T-bar system

   c. Espalier system d. Bush system

8. What is the pH range suitable for pomegranate cultivation?

a. 3.5–5.0 b. 6.0–8.0

c. 8.0–10.0 d. 4.0–5.0

9. Granulation disorder in citrus affects which part of the fruit?

a. Skin b. Juice sacs

c. Seeds d. Stem

10. Which insect pest makes tunnels inside kiwi leaves?

a. Aphids b. Leaf miner

c. Stem borer d. Leaf roller caterpillar

Write short answer to the following questions.

1. Describe any three uses of citrus fruits and explain why they are rich in vitamin C.
2. Write the steps of shield (T) budding in citrus propagation.
3. What are the symptoms and management practices of pomegranate fruit borer?
4. Compare the T-bar system and Double pole system of kiwi training. Which one is more durable? Why?
5. What are the causes of fruit drop in citrus plants? Suggest any two management practices.

Write long answer to the following questions.

1. Explain the propagation methods of pomegranate and kiwi. Which method is best for each and why?
2. Write detailed notes on major insect pests and diseases of citrus, pomegranate, and kiwi. Include their symptoms and two management practices for each.
3. Discuss the role of training and pruning in kiwi plants. Why is it necessary, and how does it influence fruit production and quality?

Project Work

1. Prepare a short report (2-3 pages) on: "Common sub-tropical fruit crops grown in your locality and their major problems (insects, diseases, or disorders)." Your report should include:
   a. Names of fruit crops
   b. Problems observed (with symptoms)
   c. Local farmers' practices to manage them
   d. Your suggestions for improvement
   e. Include photos/drawings if possible

Unit 4

Cultivation of Temperate Fruit Crops

4.1 Apple

Introduction

Apple (*Malus domestica*), a deciduous fruit tree from the Rosaceae family, is renowned for its crisp texture and sweet palatable flavor. Apple is a commercially the most important temperate fruits and is fourth among the most widely produced fruits in the world after banana, orange, and grape. Often grown in temperate regions, it is one of the most widely consumed fruits globally, valued for its nutritional benefits, including high fiber, vitamins, and antioxidants.

Apple is known as king of temperate fruit.

Uses

Apples are consumed fresh or processed into juices, cider, vinegar, jams, and dried snacks. Its pectin content makes it valuable in the food industry as a gelling agent. Apples are also used in traditional medicine for digestive and cardiovascular health.

Origin and Distribution

Apples are believed to have originated in Central Asia, particularly Kazakhstan, from where they spread to Europe and Asia. Today, apples are cultivated globally in temperate regions, with major producers including China, the USA, India, and Turkey. China is the largest producer in the world. In Nepal, apple cultivation is concentrated in mid-hill and high-altitude regions, such as Mustang and Jumla.

Nutritional Value

Apple is so valuable in the temperate region as the daily human diet. Apples are a nutritious fruit that provides a variety of essential nutrients.

It is rich in carbohydrates, vitamins, and minerals. Vitamin C, K, B6, are the important vitamins that can be acquired by consuming apple. Minerals like calcium, magnesium, and phosphorus are present in apple.

Apple is also rich in antioxidants.

Varieties

- High chilling varieties (They require more than 1000 hours of temperature below 7°C): Royal delicious, Red delicious, Golden delicious, Jonathan, Granny smith
- Mid chilling varieties (They require 600-1000 hours of temperature below 7°C): Crispin, Red June, Cox's Orange pippin, King of pippin
- Low chilling varieties (They require 400-600 hours of temperature below 7°C): Anna, Verid, Tropical beauty

Climatic Requirement

Apple is known as the king of temperate fruit. It can be grown commercially at altitudes ranging from 1500-2500 masl, where trees experience uninterrupted winter rest so as to get minimum chilling period for growth and fruiting.

Chilling period of about 600-1500 hours (no. of hours during which temperature remains at or below 7°C during the winter season) is required for about 3-4 months so as to satisfy the dormancy requirement and ultimate flowering.

For optimum growth and fruiting, apple trees require 100-125 cm of annual rainfall. Excessive rains and fog near the fruit maturity period result in poor fruit quality with improper colour development and fungal spots on its surface.

Soil

Loamy soil rich in organic matter with slightly acidic pH value (5.5 to 6.5) with good depth (at least 1.25m depth) and having proper drainage and aeration facilities are ideal for apple cultivation.

Site Selection

Sloppy sites, preferably south facing, that allow the free drainage are considered most suitable for apple cultivation. The sites should have good air drainage and free from frost pockets.

Propagation Methods

Sexual propagation is rarely used. Seeds are mainly for rootstock development. For the vegetative propagation of apple, bench grafting, in-situ grafting and micropropagation techniques are adopted. In case of apple, most successful method of grafting is tongue grafting/Whip grafting which is done in Magh-Falgun month. *Malus baccata (Mayal), Malus sikkemensis, Malus pumila*, etc. can be used as rootstocks for grafting the scion of desirable cultivars.

Planting technique

1. **System of Planting**

   Hexagonal and square system of orchard establishment is adopted in plain areas whereas contour system is practiced in hilly region with Spacing: 6m to 7.5 m.

2. **Preparation of Pits**

   Pit digging is done during the month of Chaitra / Baisakh. Pit size is 1m x 1m x 1m keeping top and sub soil separately. Mix 20 kg FYM, 50 grams bone meal, inorganic fertilizers, pesticides with top soil and raise the pit above 1-1.5 ft above the surface of ground.

3. **Irrigation**

   Irrigate the seedlings after transplanting and after that do not let lack of moisture in soil with irrigation management. Irrigation from Falgun to Bhadra month is essential in the orchard.

4. **Manuring and Fertilization**

   Fertilizer requirement depend upon soil type, age of tree and fertility status

of soil.The general dose required is mentioned as:

Age (Years)									
Nutrients	2	3	4	5	6	7	8	9	10
Nitrogen (gram/plant)	100	150	200	250	300	350	400	400	400
Phosphorus (gram/plant)	50	75	100	125	150	175	200	200	200
Potassium (gram/plant)	20	30	40	50	60	70	80	80	80
FYM (Kg/plant)	10	20	30	40	50	60	70	70	70

Apply compost manure, DAP and potash during months of Mangsir/Poush. Nitrogen fertilizer is applied in two split doses i.e. during new flushes and next after 1 month of flowering.

High Density Planting in Apple

High density planting in apple means planting more number of trees in a smaller area by reducing the distance between plants. It is done by using dwarf or semi-dwarf varieties and rootstocks. Golden delicious, Fuji, and Gala are some popular varieties being planted through this method in Manang district of Nepal. In this type of planting method, apple trees are planted in close spacing maintaining short row distance and short plant-plant distance. Also, the trees are trained properly to manage their growth. Applying this method of planting provides several benefits to farmers by producing higher amount of fruits in less land area. Early fruits production, better sunlight exposure for all trees, easier harvesting and management, and higher income per unit area are some other benefits that can be gained through this system of planting. However, higher requirement of labors, frequent training and pruning, risk of pest and disease spread, and higher need of proper management are some challenges of this method.

Training and Pruning

Apples have a naturally erect (straight) growth habit and are traditionally trained in a central leader system or modified leader system. As similar to any fruit training system, the goal is to minimize shade and effectively intercept sunlight

to manage vigor, minimize disease pressure and produce high quality fruits.

Pruning is done to maintain a balance between vegetative growth and fruit production. Proper balance is reached when the mature tree makes 25-50cms of extension growth per year. The apple trees should not be pruned so heavily since pruning reduces the production area by eliminating fruit spur.

Intercultural Operations

Interculture crops i.e. cash crops like Rayo, cucurbit crops, beans, pea, cauliflower, Zucchini, pumpkin, radish, carrot are cultivated for short term earning. Plastic and crop debris are being used as mulch in apple orchard field nowadays. Mulch helps in conserving moisture, controlling weeds, and provide nutrient in case of crop mulch.

Irrigation

Irrigation to maintain adequate soil moisture usually results in increased yield, decreases the incidence of resetting and skin cracking where the annual rainfall is less than 55cm. Adequate (Enough) moisture is especially critical during the early growing season and in the period of fruiting. So, in summer months, irrigation should be given at 7-10 days interval and rest at 3-4 weeks interval.

Harvesting

Harvesting is done as soon as fruit matures. If it is supplied to local market, harvest at full maturity however, if it is to be transported to long distance market, pick fruit before full maturity. However, picking at very immature stage will cause wrinkling of fruit during storage. Cut the peduncle at level to fruit surface with help of scissors. Each tree will give @ 30-90 kg fruits at better management practice. Apple trees start fruiting 6-7 years after planting but reach full bearing at 14-15 years. However, trees raised on dwarf rootstocks come into bearing at 3-4 years.

Yield: 8.45 tons per hectare (Statistical Information on Nepalese Agriculture 2021/22)

Physiological Disorders

1. Bitter Pit

Brown sunken spots usually spherical in the shape appear on mature fruit. The tissues beneath the skin becomes corky in nature. This disorder becomes visible just before the harvest or during early storage period. Large fruits and small fruits which are harvested prematurely are susceptible.

The exact cause of this disease is still unknown but calcium application in the form of calcium nitrate spray (2%) has been reported to reduce the bitter pit in apple.

2. Scald

Scald is one of the storage disorders in apple. Light mottling on green surface of fruits is initial symptom of scald. Darkening of mottled surface becomes more severe with passage of time. Scald usually affects skin only but in severe cases it may extend to fruit flesh.

3. Fruit Drop

Fruit drop means the apples fall from the tree before they are ready to harvest. It is a common problem in apple farming. Fruit drop may occur after flowering, during early growth, or even just before maturity. The important causes of fruit drop in apple are moisture stress, poor soil and nutrient management, poor insect and dissease management, high temperature and dry climate, poor pollination, and hormonal imbalance.

For the management of this disorder, management of regular irrigation, proper use of fertilizer, proper management of insects and diseases, use of plant growth regulators such as NAA (Napthalene Acetic Acid), and managing proper pollination can be done.

Other Disorders

Water core, Jonathon Spot, Fruit drop, Cork Spot, and Alternate Bearing

Major Insect Pests

1. **Wooly Aphid (*Eriosoma lanigerum*)**

Woolly aphids are small, soft-bodied, sap-sucking insects covered with white, cotton-like wax. They form dense colonies on the roots, trunks, branches, and twigs of apple trees and sometimes even on leaves. On the aerial parts, it is seen as a wooly mass. This insect is active from April to December but found in large numbers on aerial parts after rains.

These insects suck the sap of apple plant parts, resulting in gall formation and hindering the flow of cell sap.

Symptoms of Damage

- White, cottony masses on trunk, roots, branches, or pruning wounds.
- Twigs and stem swell or develop galls due to feeding.
- Cracked bark or wounds around infested areas.
- Leaves may be curled or distorted if feeding occurs on shoots.
- Infested trees may show reduced vigor and growth.

Management Methods

- Prune and destroy infested shoots and branches.
- Apply lime and maintain good tree vigor with proper fertilization.
- Rub and wash off colonies with soap water or jet sprays in small orchards.
- Using aphid resistant rootstock. MM series such as MM111, MM118, MM119 are wooly aphid resistant.
- Use of predators such as coccinellids and parasitoids like Parasitic wasps (*Aphelinus mali)*
- Apply chemicals such as Malathion 50 EC, Imidacloprid.

2. **San Jose Scale (*Quadraspidiotus perniciosus*)**

This insect severely infest trees with bark covered with grey layers of

overlapping scales, appearing as if sprayed with ash. Underneath the grey dots are lemon-yellow coloured soft bodied insects. It causes damage by sucking sap from the stems, branches, leaves and even fruits.

Symptoms of Damage

- Small, circular gray scales are seen on branches, twigs, leaves, and fruits.
- Reddish or purplish spots on fruit under feeding sites (fruit spotting).
- Yellowing and drying of leaves and twigs due to sap loss.
- Branch dieback, poor fruit set, and general tree weakening.

Management Methods

- Regular inspection of orchard. Prune and destroy infested branches.
- Use sticky bands to trap crawlers.
- Promote natural enemies like: Parasitic wasps and Ladybird beetles.
- Spraying with Chloropyriphos (0.02%) or Dimethoate (0.03%) or imidacloprid to kill crawlers and newly settled scale insects in May. High volume spray is required to have thorough coverage of the trees.

3. **Leaf Roller (*Archips spp.*,)**

Leaf rollers are moth larvae (caterpillars) that feed on leaves and sometimes fruits. They are common pests in apple, pear, plum, and citrus, and are present in mid- to high-hill regions of Nepal.

Symptoms of Damage

- Leaves are found rolled, tied, or folded.
- They eat terminal buds and young shoots.
- On fruits, there may be superficial scars or feeding damage on the surface of young fruits, reducing market value.
- Severe infestations may slow down plant growth by damaging young shoots.

Management Methods

- Handpick and destroy manually the leaves containing larvae.
- Prun and burn the infected branches.
- Encourage parasitic wasps and predatory beetles to control the insect biologically.
- Use light traps or pheromone traps to attract and monitor moths.
- Spray Spinosad, Emamectin benzoate, and Chlorantraniliprole if the infestation is high.

Major Diseases

1. Apple Scab (*Venturia inequalis*)

Light brown or olive green, round spots with a velvety distinct outline appear on either or both sides of the young leaves in spring. These later turn brownish black and margins become distinct but may get obscured when several lesions coalesce. Severe early infestation results in the formation of mis-shapen, cracked, knotty fruits which allow the entry of other organisms causing fruit rot.

Management Methods

- Spray 5% urea shortly before general leaf fall for hastening the decomposition of apple leaf and to reduce the primary inoculums. Collect and burn the fallen leaves during winter.
- Grow resistant varieties such as Sir Prize, Macfree, Red free, Nova, Liberty, and Freedom.
- Spray Mancozeb (0.3%) or Dodine (0.1%) or Captan (0.3%).

2. Pink Disease/ Papery bark (*Pellicularia salmonicolour*)

This is the most serious disease of apple in Nepal. At first, round and pink lesions will appear in the bark. Those lesions get progressively bigger and appear like cracks. Later on thin sheets of bark will become dry and peel off and killing the whole branch.

Management Methods

- By adopting clean cultivation such as cleaning the orchard time to time by removing weeds, removing the disease infected plant parts and totally destroying them by burning can reduce the potentiality of disease attack in the orchard.
- Application of bordeaux paste in the lesions affected by this disease reduce the infestation. Also, in the infested condition, spraying bordeaux mixture can control the disease.

3. Powdery Mildew (*Podosphaera leucotricha*)

Whitish powdery patches on twigs and both sides of leaves appear on the infection of this disease. Leaves curl and wrinkle and finally fall. Infected fruits show sigh of resetting (rough skinned apple of short whitish colour).

Management Methods

- This disease should be controlled in the beginning otherwise the control fails.
- Prune the diseased branches in winter to reduce disease spread.
- Spray with wettable sulphus powder @300g/liter water or Carbendazim @50g/liter water thrice i.e. during flowering, at bud formation and at petal fall stage.

4. Collar Rot (*Phytophthora cactorum*)

Collar region of affected trees near the ground level turns brown, soft, and spongy. Complete girdling of stem leads to killing of trees. Disease spread is maximum in poorly drained soil.

Management Methods

- During dormant period remove the soil around the collar region and expose the affected portion.
- Keep graft union 20-25cm above the soil level while planting.

- Use resistant varieties with clonal rootstocks like M2, M4, M9, M26, M113, and M114.
- Remove the affected bark and apply Copper oxychloride paint.
- Drench 30cm radius area around tree trunk with mancozeb (0.3-0.4%) or copper oxychloride (0.5%) or Metalaxyl (0.3%).

4.2 Pear

Introduction

Pear, a deciduous fruit tree from the Rosaceae family, is valued for its juicy texture and mildly sweet flavor. It is widely consumed as a fresh fruit and is also processed into products like juices, syrups, and jams. Pear is highly adaptable to temperate regions, making it an important commercial fruit crop globally. There are two types of Pear *Pyrus pyrifolia L. (Asian pear)* and *Pyrus communis L. (European pear).*

Uses

- Consumed fresh, dried, or processed into products like juices, jams, syrups, and canned goods.
- Rich in dietary fiber, vitamins C and K, and antioxidants.
- Used in traditional medicine for improving digestion and skin health.

Origin and Distribution

Pear is believed to have originated in the temperate regions of Europe and Asia, particularly in the western China. Today, it is grown in temperate regions worldwide, with major producers including China, Italy, the USA, and Argentina. In Nepal, pear cultivation is prominent in mid-hill regions such as Dhading, Gorkha, and Kavrepalanchok.

Varieties

S.N.	European Varieties	Asian Varieties	Hybrid
1.	Bartlett	Pharping Local	Leconte
2.	Williams	Hosui	Keiffer
3.	Buerre	Kosui	
4.	Hardy	Chojure	
5.	Comice	Havanna	
6.	Conference		

Soil

Generally, pear can survive better in wet soil condition than apple. Well drained, fertile, deep soil with good water retention capacity is considered good for pear cultivation. The optimum p^H range for pear cultivation is 5.5 to 6.5.

Climate

Pear is a warm temperate fruit. It grows little better in warmer condition than apple and is generally less hardy than apple. In general, chilling period of 900-1000 hrs below 7°C temperature is required to induce flowering in pear. European varieties require high chilling than Asian varieties. The altitude requirement of pear is 1200 to 2200 masl.

Propagation Methods

Grafting is the important method of propagating pear plants. Bench grafting, cleft grafting, and bark grafting are the most successful methods of propagating pear plant. Hard wood cutting is also possible in pear. Rootstocks used for pear are wild Himalayan pear (*P. pashia, P. pyrifolia, P. baccata*, Quince). They are highly used as rootstock for the propagation of pear.

Sexual propagation, propagation from seeds, is done to prepare rootstocks.

Planting

1. System of Planting

Generally, for the cultivation of pear, square or rectangular system is used. Pears require less spacing than apple. The spacing requirement is 4-6 m. For high density planting (HDP), dwarf varieties are used and 2-3 m spacing is maintained between trees in this system.

2. Preparation of Pits

Pits measuring 1 m^3 should be prepared, filled with topsoil, FYM 50 kg/pit, urea 100g, DAP 200g, and potash 100g per pit. We should also add wet wood ash 5-6 kg/pit, bone meal 2-3 kg/pit and left exposed for 15–20 days before planting.

3. Planting Time

Late winter season is the best season to plant temperate fruits like apple and pear.

Irrigation

Pear tree needs irrigation at least once a week for 3 months after planting and then 2 or 3 times a week during spring. Irrigation is necessary especially during young stage and during the stage of fruit development. Basins should be made free of weeds around the tree and mulched with straw or dried leaves.

Manuring and Fertilization

Age (Years)									
Nutrients	2	3	4	5	6	7	8	9	10
Nitrogen (gram/plant)	100	150	200	250	300	350	400	400	400
Phosphorus (gram/plant)	50	75	100	125	150	175	200	200	200
Potassium (gram/plant)	10	15	20	25	30	35	40	40	40
FYM (Kg/plant)	20	25	30	35	40	45	50	50	50

Full dose of FYM, phosphorus, potassium and half dose of nitrogen should be applied in winter and remaining nitrogen should be applied after harvesting of the fruits.

Training and Pruning

Pear is trained on modified center leader system. If they are on quince rootstock, they can be trained to form pyramids. Since short spurs on wood two years old or older are needed for cropping, pome fruits are pruned rather lightly to develop such spur system. Pear needs more pruning than apple. After entering into the bearing age, the center leader should be headed back to encourage lateral growth. All the narrow angled branches, diseases and pest affected branches water sprouts and suckers should be removed every year. The time of pruning is in winter (dormant season).

Intercultural Operations

Pear orchard should be managed with clean basin management system. In this system, the basin of the tree is kept clean and free from weeds either by hand weeding, use of mulches and herbicides. Weed control is carried out by 2 or 3 cross ploughing. In the initial years of plantation, the intercrops like peas, beans, cabbage, cauliflower and ginger are grown in the vacant area in between the trees but not in basin area. In bearing orchard, the basin area of trees should be mulched with 10-15 cm thick dry grass mulch. The mulches help to conserve soil moisture and control the weeds in the basin area.

Fruit Thinning

So as to have larger and high quality fruits, fruit thinning should be done in cultivars having heavy fruit set like Bartlett, Beurre Hardy, Anjou. Generally one fruit per 30-40 leaves should be retained.

Harvesting

Harvested anytime between August to October. Harvested manually when maturing has begun but the pear is not yet fully ripe. Fruit weight may increase up to 20% in delayed picking, however, it reduces the storage life. Fully mature fruits are harvested for fresh consumption, while firm and green fruits for canning and distant markets. Yield: 10 – 15 tons per hectare.

Diseases

1. **Pink Disease (*Corticium salmonicolour*)**

   It is a fungal disease which also affects apple and citrus fruits. The infestation of this disease increases with the increase in temperature and relative humidity. Especially, this disease mainly affect the pear trees during Jestha to Bhadra. Initially, the branches infected with this disease show spider net like symptoms. Such fungal appearance steadily grows and covers the whole plant. Splitting of branches is seen. Wilting of plant starts from the top of the plant.

Management Methods

- Management of good aeration and light in the orchard.
- Infected branches should be immediately removed and burned.
- During Jestha to Shrawan, copperoxychloride fungicide should be applied if the disease infestation is seen.

2. Leaf Spot

In Nepal, where pear cultivation has been done, this disease is generally seen. In the initial stage of infestation, small brown spots are seen on the leaves. Those spots gradually increase and become about 1cm diameter. Necrotic symptoms are seen on those parts. This disease disturbs the flowering time of the plant and thus affects fruiting.

Management Methods

- During winter, the diseased leaves should be collected and destroyed.
- During Jestha to Shrawan, copperoxychloride fungicide should be applied if the disease infestation is seen.

Insect Pests

1. Fruit Fly

It is a type of fly from *Dacus* spp. It is generally yellow brown in colour. The female of this insect is more harmful to pear plants. This insect lay eggs just inside of the fruit surface. In some days, those eggs hatch and larvae start feeding the fruit. In this way this insect affect the pear fruits.

Management Methods

- Pheromone trap can be used when the infestation of this insect starts.
- Protein bait can be used to disrupt the reproduction system of this insect.
- Bagging can be done by paper bag during Jestha.
- Dropped fruits should be collected carefully and destroyed.

2. Thrips

These are tiny insects with light yellow and brown colour. They feed on flowers, leaves, and fruits by sucking.

Management Methods

- The host plant of this insect i.e. clover grass should be removed.
- Being a sucking type insect, systemic insecticide Intrapid 0.5ml/liter water should be applied.

4.3 Grapes

Introduction

Family: **Vitaceae**

Origin: **West Asia** (In between Caspian sea and Black Sea)

Grape (*Vitis vinifera*) is an important vine crop of Vitiaceae family found in semi-arid region. It is originated in West Asia (In between Caspian sea and Black Sea). It is one of the oldest cultivated fruits and have been consumed by humans for thousands of years. It is widely grown in temperate regions around the world and are known for its versatility, delicious taste, and nutritional value. Fruits to be consumed in grape is known as berry. In Nepal grapes are mostly grown for table purpose: to consume fresh. But in major grapes growing countries, they are mainly grown for making wine (80%), raisin (10%), canning and juice (2%).

Uses

Grapes are consumed in different forms. They can be consumed fresh, as dry fruit (raisin), as wine and juice. They are also used in different culinary applications such as salads, jam, and jellies.

Nutritive Value

Grapes are relatively low in calories. They are good sources of minerals like Ca, P, Fe, vitamins like B1 and B2, and sugars like glucose and fructose. Grapes are rich in acid like tartaric acid and malic acid. Little amount of citric acid is also present in them.

Climate

Grapes are deciduous, temperate, and sun loving fruits. They require long warm to moderately hot, dry summer, and cool winter. Under humid summer conditions, vines do not grow well and are susceptible to diseases.

Rainfall during fruiting season is unfavorable. This may lead to loss of sweetness, uneven ripening, and cracking of berries.

High humid conditions during the time of ripening cause splitting of berries and may cause fungal diseases.

Soil

Grapes can be grown in a wide range of soil. However, sandy loam soil with a well drainage facility, fairly fertile with good amount of organic matter is considered the best. Grapes should not be cultivated in the soil having salt content more than 0.3% or more. The ideal soil pH for grape cultivation is recommended as 6.5-7.5.

Varieties

Table purpose: Thompson seedless, Perlette, Delight, Cardinal, Anab-e-Shahi, Black Muscat

Raisin group: Thompson seedless, Black Corinth, Pusa seedless, Kismish Beli

Wine grapes: White Riesling, Pinot Noir, Black Champa, Zinfandel, Chardonnay

Juice grapes: Concord, Beauty seedless

Popular variety in Nepal: Thompson seedless, Anab-e-Shahi, Perltlett, Muscat, etc.

Propagation Techniques

The major, important and most successful method of propagating grapes is hard wood cutting.

Hardwood cutting is taken from mature canes of healthy, moderately vigorous and virus free vines obtained after pruning.

Size of cutting: 20-25 cm long and pencil size thickness

Cuttings are generally taken during the month of January.

And, in some case grapes can also be propagated by chip budding and whip grafting.

Planting

To plant grapes, pits of 75 cm × 75 cm × 75 cm size should be dug. While

digging a pit, top soil and sub-soil should be kept separately. The dug pits should be left open for at least 15-20 days. After that the pits should be filled with recommended dose of fertilizers mixed with soil. Then the pits get ready for plantation.

The best time/season for planting grapes is late winter (January), as it is a temperate, deciduous fruit crop.

Spacing:

The spacing requirement for different types of varieties are listed below.

- 2m × 2 m for less vigorous varieties
- 3m × 3 m for semi-vigorous varieties
- 4m × 4 m for vigorous varieties

One year old rooted cuttings are taken for planting. Soon after planting, the plant is headed back to 3-4 buds, keeping the single cane (stem).

Manure and Fertilizers

The farm yard manure requirement per plant per year is 25-30kg. And the recommended dose of synthetic fertilizers, NPK, is 760g: 245g: 416g per plant annually.

Vine Management

It is important to effectively manage vines in grape plants to achieve good quality harvest. There are different methods of managing vines in grape plants. They are:

1. **Pole System**

   In this system, either iron or wood or bamboo can be used as a pole for the support of vines. The height of the pole should be 2 m height from ground level. A pole should be given for each plant.

2. **Telephone System**

   In this system, galvanized wires are placed on the poles, which look like

telephone wires. Pole height should be above 2 m from ground level. Poles can be placed in every 8 metres. Between 2 poles, galvanized wires should be stretched in the spacing of 50 cm. The vines of the grape plants should be managed in those wires. Space between two plants should be 4 m.

3. Kniffin or Nu-Munson System

In this system, poles are placed making Y-shape and wires are placed making V shape. The vines of grape plants are placed on those V shaped wires.

4. Flat Roof System

This is the most common system of managing vines in grape plants. It is costly at initial, but management wise it is cost effective in the long term.

In this system, wires are placed on the top of the poles in the spacing of 50 cm. The vines are managed on the wires placed on the top of the poles. Thus, managed vines get roof shaped after the vines are fully grown.

Fruits produced in this system are of high quality. And productivity is also found high in this method.

Training and Pruning

Training and pruning are much-needed intercultural operation in grape fruits. Without effective training and pruning commercial production of grapes cannot be done.

Training and pruning should be done in every winter season. While pruning 2/3 part of whole vines should be removed. The number of spurs to be kept in the vines depends upon the varieties. In dwarf varieties, 2 spurs can be kept whereas, in vigorous type 6-14 spurs should be kept.

Irrigation

Compared to other fruit crops, grape fruits require less irrigation. However, as the grape roots do not go below, irrigation is important in two stages of growth

of the plants. One is just before flowering, and another is at the stage of fruit development.

Harvesting

Harvesting time depends upon the varieties grown, region of plantation, and crop management practices.

The important thing to be noticed while harvesting grape fruits is that it should be harvested when fully ripe because it is a non-climacteric type of fruit.

Major Insects of Grape Fruits

1. Grape Borer (*Celosterna scabrator*)

Grape borer is a serious insect pest that damages grape vines by boring into their stems and branches. It is commonly found in Nepal, especially in warmer grape-growing regions. The larva of the insect lives inside the stem and feeds on the inner tissues, making the plant weak.

Symptoms of Damage

- Small round holes are seen on the stem or branches.
- Presence of sawdust like powder around the holes.
- Yellowing and drying of leaves.
- Weak and stunted plant growth.

Management Methods

- Prune and destroy infected branches.
- Apply mud or cow dung paste over entry holes.
- Insert a metal wire into the hole to kill the larvae manually.
- Inject neem oil or kerosene into the hole and close it with mud.
- Apply Spinosad and Chlorantranniliprole as chemical control methods if the infestation is severe.

2. Leaf Hopper

Leafhopper is a small, active insect pest that attacks the leaves of grapevine. It is a sucking insect that feeds on the sap of leaves. The scientific name of one common grape leafhopper in Nepal is ***Arboridia viniferta*** They are light green or yellowish, and they jump quickly when disturbed.

Symptoms of Damage:

- White or yellow spots appear on the upper surface of leaves.
- Leaves become pale, dry, or curled after heavy infestation.
- Insects are seen on the underside of leaves.
- Leaves may fall early, causing poor plant growth.
- Fruit size and quality reduce due to loss of leaf function.

Management Methods

- Collect and destroy infested and fallen leaves.
- Avoid overcrowding of vines for better air flow and light.
- Use yellow sticky traps to monitor and reduce the insect population.
- Spray neem oil (3-5 ml per liter of water) on the leaves.
- Spray Imidacloprid or Thiamethoxam if the infestation is high.

Mites, Thrips, Mealybug, Flea beetles, etc. are some other important grapes insects.

Major Diseases of Grape Fruits

1. Anthracnose (*Elsinoe ampelina*)

Anthracnose is a fungal disease of grapevine that causes dark sunken spots on leaves, stems, and fruits. It is also called “Bird’s-eyespot” disease because the spots look like the eye of a bird – dark in the center with a light ring around.

Symptoms of Damage

- Small brown or black circular spots appear on leaves. Infected leaves may dry and drop early.

- Dark, sunken spots with a gray center appear on immature grapes. Affected fruits crack, dry, or rot, reducing the quality.
- Elliptical or sunken lesions appear on young green shoots.
- In severe cases, the shoot may crack or die back.

Management Methods

- Prune and destroy infected branches.
- Apply fungicides like Mancozeb (0.2%), Chlorothalonil or copper-based fungicides if the infestation is severe. Spray the fungicides at 10-14 days interval.

2. Powdery Mildew (*Uncinula necator*)

Powdery mildew is a fungal disease that affects leaves, shoots, flowers, and fruits of the grapevine. It is one of the most common and harmful diseases of grapes in Nepal. The disease is often called "white dust disease" because of its powdery white appearance on leaves and fruits.

Symptoms of Damage

- White or grayish powdery growth on both sides of the leaves.
- Infected leaves may become curled, yellow, or dry.
- Young shoots look white, dusty, and may become twisted or deformed.
- Fruits may crack, harden, or become deformed.

Management Methods

- Prune infected parts and destroy them.
- Avoid overuse of nitrogen fertilizer which promotes soft, susceptible growth.
- Spray fungicides at early stages (especially before flowering):
  - Hexaconazole
  - Myclobutanil

3. Downy Mildew (*Plasmopara viticola*)

Downy mildew is a serious fungal disease of grapevine that mainly affects the leaves, but can also damage shoots, flowers, and fruits. It spreads quickly in wet and humid conditions, especially during the rainy season.

Symptoms of Damage

- On the upper surface of the leaves, yellowish, oily spots appear.
- On the lower side of the leaves, gray cotton like fungal growth appears below the oily spots.
- Shoots and flower cluster become brown and withered.
- Flowers drop and poor fruit set may occur.

Management Methods

- Remove and destroy infected leaves and shoots.
- Plant vines with proper spacing for good air movement.
- Spray fungicides like Mancozeb (0.2%), or Metalaxyl + Mancozeb, if the infestation is severe.

Exercise

Choose the correct answer from the given alternatives.

1. Which one of the following is known as the 'King of Temperate Fruits'?
   a. Pear
   b. Apple
   c. Peach
   d. Grapes
2. What is the ideal soil pH for apple cultivation?
   a. 4.5–5.0
   b. 5.5–6.8
   c. 6.8–7.5
   d. 7.5–8.5
3. Which of the following is a high-chilling variety of apple?
   a. Anna
   b. Granny Smith
   c. Crispin
   d. Tropical Beauty
4. What is the most suitable method of propagation for apples?
   a. Budding
   b. Whip grafting
   c. Layering
   d. Tissue culture
5. What is the primary method of propagation for grapes?
   a. Seed sowing
   b. Hardwood cuttings
   c. Air layering
   d. Micropropagation
6. Which rootstock is commonly used for pear propagation?
   a. Thompson seedless
   b. Quince A
   c. Vitis vinifera
   d. Malus domestica
7. Pear originated from:
   a. Central Asia
   b. Europe and Asia
   c. Mediterranean region
   d. South America
8. Which insect pest causes “cottony masses” on apple branches?
   a. Stem Borer
   b. Woolly Aphid
   c. San Jose Scale
   c. Blossom Thrips

9. Which is the common method of training grape vines?

a. Central leader system
c. T-bar system
b. Modified leader system
d. Flat roof system

Write short answer to the following questions.

1. Explain the climatic and soil requirements for successful apple cultivation.
2. What is high density planting in apple? List its advantages and challenges.
3. Write short notes on the propagation methods used in grapes and pears.
4. Compare European pear and Asian pear based on varieties, chilling requirement, and adaptation.
5. Describe the symptoms and management of Apple scab and Woolly aphid.

Write long answer to the following questions.

1. Describe the training and pruning practices in apple orchards. Discuss the major physiological disorders of apple and their management.
2. Describe the different vine management systems used in grape cultivation. Explain the Telephone system and Flat roof system in detail.
3. Enlist the major insect pests of apple and pear. Describe any two insect pests from each with their symptoms and management.

Project Work

1. Visit a nearby apple, pear, or grape orchard and prepare a report on the following points.
   a. Varieties grown
   b. Propagation methods used
   c. Major insects and diseases observed
   d. Farmers' practices of disease management
   e. Orchard layout and spacing
   f. Farmers' practices for harvesting and storage

Cultivation of Cole Crops

Unit 5

Cole Crops

Cole crops are those plants that basically belong to the mustard family and are all descendants of wild cabbage. As a group, these plants grow better in cool weather which may lead many people to think that word 'cole' is a variation of the word 'cold'. But the word 'cole' is derived from Latin which means stem.

Some important cole crops include:

1. Cauliflower
2. Cabbage
3. Broccoli
4. Knolkhol
5. Brussels sprout
6. Chinese Cabbage

Origin

Cole crops are originated in Western Europe, Cyprus and Northern Mediterranean region.

Table: Important cole crops with their Nepali, English and Scientific Name and Area coverage and its Production in Nepal

S.N.	Nepali Name	English Name	Scientific Name	Family
1.	काउली	Cauliflower	*Brassica oleraceae* var botrytis	Cruciferae/ Brassicaceae
2.	बन्दा	Cabbage	*Brassica oleraceae* var capitata	Cruciferae/ Brassicaceae

3.	ब्रोकाउली	Broccoli	*Brassica oleraceae* var italic	Cruciferae/ Brassicaceae
4.	ग्याठगोभि	Knolkhol	*Brassica oleraceae* var golgylodes	Cruciferae/ Brassicaceae
5.	अन्तरबन्दा	Brussels Sprouts	*Brassica oleraceae* var gongylodes	Cruciferae/ Brassicaceae
6.	चाइनिज बन्दा	Chinese Cabbage	*Brassica pekinensis*	Cruciferae/ Brassicaceae

Cauliflower and cabbage are the most important cole crops of all. Cole crops are cultivated in Terai, Inner Terai, River basins and mid-hills during winter season. In high hills and temperate region, it is being cultivated during summer season and rainy season.

The area of cultivation for broccoli is being increased throughout Nepal, as it has greater scope of export market in India, both during on-season and off-season.

Brussels sprout and Chinese cabbage are not yet been cultivated in commercial scale in Nepal.

5.1 Cauliflower

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis)* is a widely grown vegetable belonging to the Brassicaceae family. It is renowned for its edible white curd, which is rich in vitamins, minerals, and antioxidants. As a versatile vegetable, cauliflower holds immense nutritional and economic value. In Nepal, it is a staple crop in both commercial and subsistence farming, playing a vital role in the livelihoods of farmers and meeting the dietary needs of the population.

Origin and Distribution

Cauliflower is originated in the Mediterranean region and has been cultivated for over 2000 years. It spread to Europe, Asia, and eventually to other parts of the

world. Today, India and China are the leading producers of cauliflower, while it is also extensively cultivated in Nepal. The crop is well-suited to the diverse agro-climatic zones of Nepal, ranging from the Terai plains to the mid-hills, where it is grown both as a winter and an off-season crop.

Uses

In cauliflower, generally the edible part is considered as the immature flower which is also called 'curd'. It can be consumed in different ways i.e. as vegetable, soup, pickle, dried vegetables, *parautha*, etc.

Climate and Soil

Cauliflower can be cultivated in varieties of climatic conditions. It is generally cultivated in cold season during which it gives high quality curds. Leaves of cauliflower can tolerate the frost, but curds are susceptible to frost. The ideal temperature for proper growth and curd formation of cauliflower is 15°C-20°C. High amount of frost induces purple colour in curd.

Land having fertile soil with good facilities of irrigation and drainage should be selected for the cultivation of cauliflower. Land where cruciferous plants were not planted for the last two seasons should be selected. Different varieties may require different types of soil texture.

Table: Cauliflower varieties with their respective soil texture type and p^H.

S.N.	Types of Varieties	Soil type	p^H
1.	Early season varieties	Sandy Loam	6-6.5
2.	Medium season varieties	Loamy	6-6.5
3.	Late season varieties	Clay Loam	6-6.5

Varieties

Several varieties of cauliflower are cultivated in Nepal, categorized into early, mid-season, and late-maturing types based on their growth period. Popular varieties include:

S.N.	Varieties	Days to harvest	Recommended Region	Productivity (MT/Ha)
Early Season Varieties				
	Silver cup 60 (F1)	55-60	Terai and Mid-hills	24-30
	NS 60 N (F1)	55-60	Terai and Hills	26-30
	Snow King (F1)	55-60		
	Himalata (F1)	55-60		
	Snow Crown (F1)	70	Terai and Hills	22-25
	Snow Mystic (F1)	80	Terai and Hills	35-40
	Sarlahi Deepali	55-60	Terai and Mid-hills	8.0
Medium Season Varieties				
	Kathmandu Local	100-110	Terai, Hills and High hills	25.0
	Jyapu Kaauli (Local)	80-110	Mid-hills	30
Late Season Varieties				
	Kibo Giant	120-140		
	Milky Way (F1)	120	Hills and High hills	52.5
	Dolpa Snow Ball	110-120	Terai, Mid-hills and High hills	15.0

The choice of variety depends on the climatic conditions, market demand, and intended planting season.

Nursery Bed Preparation

A well-prepared nursery bed is essential for healthy seedling growth. The nursery bed should be located in a well-drained area with sufficient sunlight. The soil should be tilled finely and mixed with well-decomposed farmyard manure (FYM) or compost at the rate of 5 kg per square meter. Beds of 1-meter width

and convenient length are prepared, with raised edges to prevent waterlogging. Seeds are sown at a depth of 1 cm in rows spaced 5 cm apart and covered with a thin layer of soil or sand. The bed should be mulched with straw or dry grass to maintain moisture and temperature until germination. Regular watering and monitoring for pests or diseases are necessary to ensure healthy seedlings.

Land Preparation

Land should be thoroughly ploughed followed by planking and harrowing to make the soil well pulverized. Weeds, plastics, stones and stubbles of earlier crops should be removed from the field. Farmyard Manure (FYM) should be applied during field preparation. Chemical fertilizers should be applied 1 week prior to seedling transplantation.

For off-season farming during rainy season, a ridge of 20 cm height, 120 cm width and length as per the land availability should be made.

Manures and Fertilizers

Cauliflower requires a large amount of nutrients as it is known as a heavy feeder.

The recommended amount of FYM is 50-60 doka per ropani. And the recommended dose of NPK in Nepal is 10:8:5 kg/ropani i.e. 200:160:100 Kg per hectare.

Among these only half dose of nitrogen and full dose of phosphorus and potassium should be applied during field preparation. The remaining half dose of nitrogen should be applied in two split doses.

- Half of the remaining dose after 3 weeks after transplantation.
- Half of the remaining dose should be applied when curd appears on the plant.

Boron and molybdenum also should be applied during field preparation.

- Borax @ 700 g per ropani (14 kg per hectare)
- Sodium Molybdate @ 75 per ropani (1.5 kg per hectare)

Sowing and Transplanting

Cauliflower seeds are typically sown in nursery beds 4–6 weeks before the desired transplanting time. In Nepal, early-season sowing occurs in August–September, while mid-season sowing is done in October–November. Seedlings are ready for transplanting when they reach a height of 10–15 cm and have 4–5 true leaves. The amount of seed required to plant in a unit area of land depends upon the type of variety. The seed rate and spacing requirement for different types of varieties are given in the table below.

S.N.	Types of varieties	Seed rate	Spacing
1.	Early	25-30	60×50
2.	Medium	20-25	60×60
3.	Late	20-25	75×60

Time of transplantation of seedlings depend upon the type of varieties. Generally, seedlings get ready to transplant in 30-40 days after sowing in nursery bed. Early varieties should be transplanted when the seedling gets 2-3 leaves. Mid-season and late varieties should be planted when the seedlings get 4-5 leaves.

While transplanting seedlings should be hardened by holding the irrigation for at least 7 days before the transplantation. Before 1 hour of transplantation, nursery bed should be irrigated for easy uprooting of the seedlings.

S.N.	Region	Type of varieties	Time of transplantation	Time of harvesting
1.	Terai, Inner Terai, River basins (60-400 masl)	Early Medium Season Late	Asaar-Shrawan Asoj-Kartik Kartik-Mangsir	Asoj-Kartik Poush-Magh Magh-Falgun
2.	Mid-Hills (401-2000 masl)	Early Medium Season Late	Chaitra-Baisakh Shrawan-Bhadra Asoj-Kartik,	Mangsir-Magh Magh-Falgun Chaitra-Baisakh

3.	High Hills (higher than 2000 masl)	Medium Season Late	Chaitra-Asaar Falgun-Baisakh	Shrawan-Asoj Bhadra-Kartik

Irrigation

Water should be applied as soon as the transplantation is done. Irrigation should be given regularly for 7-10 days until the seedling gets established. After proper establishment of seedlings, irrigation should be done in every 5-10 days interval depending upon the amount of moisture present in the soil.

Intercultural Operations

Regular weeding and hoeing are essential to keep the field weed-free and to promote aeration in the root zone. First removal of weeds should be done during 30-45 days after transplanting (DAT). Earthing-up around the base of the plants can help provide support and prevent lodging. Mulching with organic materials such as straw can conserve soil moisture, regulate temperature, and suppress weeds. Regular monitoring for pests and diseases is also an integral part of intercultural operations. If there is any condition of water stagnation, a proper drainage system should be maintained.

Harvesting

Cauliflower should be harvested when the curd reaches full size, is compact, and has a creamy white colour. Delayed harvesting can lead to discolouration and reduced market value. The crop is typically ready for harvest 60–120 days after sowing, depending on the variety and growing conditions. Harvesting can be done manually by cutting the curd along with a few wrapper leaves to protect it during handling and transportation. Generally, harvesting should be done during the late morning and early evening to escape the due. Thus, harvested crops should not be kept in direct contact with the heat of the sun. When it is harvested during sunny days, the products get easily wilted.

After harvesting, cauliflower can be stored in room storage (at ambient

temperature) for 2-3 days. In cold storage having 0°C temperature and 85-90% relative humidity, it can be stored for 1 month.

Physiological Disorders

1. Buttoning

Symptoms of Damage

- Curds of cauliflower get small, like buttons.
- Small curds are formed very early when the vegetative parts have not grown well.

Causes

- Transplanting early varieties late
- Transplanting over aged seedlings
- Low moisture content in field
- Low nitrogen content in field

Management Methods

- Cultivating seedlings at appropriate age
- Cultivating appropriate varieties in appropriate season

2. Riceyness

It is a premature initiation of floral buds or elongation of peduncle stalk of inflorescence. Curds are considered as poor quality for marketing.

Causes

- Higher or lower temperature during curd formation may cause riceyness.
- High application of nitrogenous fertilizer may also cause riceyness.

Management Methods

- Apply optimum amount of nitrogenous fertilizer
- Manage proper soil moisture and fertility during development stage

3. Browning

Symptoms of Damage

- Water soaked spots are seen on the surface of cauliflower initially. Later it gets brown colour.

Causes

- It is caused due to the deficiency of boron in soil.

Management Methods

- Application of borax or sodium borate (boron containing fertilizer) during field preparation @ 500-700 gram per ropani
- Also, can be applied by spraying borax on the field @ 0.25-0.5%

4. Whiptail

Symptoms of Damage

- Deficiency of molybdenum causes 'whiptail' especially, in highly acidic soils
- Cauliflower having this disorder have tail like shrinked leaves

Management Methods

- Application of micronutrients in appropriate amounts especially molybdenum containing fertilizer (Sodium molybdate).
- Application of lime in the soil during field preparation to increase the p^H

5. Leafy curds

Symptoms of Damage

- Leaves come out from the middle of the curd and make cauliflower unmarketable

Causes

- Rise in temperature during the development of curds

Management Methodds

- Appropriate variety at appropriate season should be cultivated

6. Hollow stem

Causes

- Caused by deficiency of boron in soil

Symptoms of Damage

- Appearance of water-soaked areas and discolouration of tissues
- Deficiency of boron also causes browning or brown rot in cauliflower
- In severe cases, the curd becomes dark brown and black. And the whole curd gets rotten.

Management Methods

- Application of borax @0.3-0.4%
- Reduce the dose of nitrogenous fertilizer
- Transplant the crop at closer spacing

5.2 Broccoli

Introduction

Broccoli (*Brassica oleracea* var. *italica*) is a nutrient-rich vegetable that belongs to the Brassicaceae family. Known for its vibrant green flower heads and rich antioxidant properties, broccoli has gained immense popularity as a superfood. It is a relatively new introduction in Nepal compared to cauliflower but has shown great potential due to its adaptability and high market demand. Rich in vitamins A, C, and K, and minerals like calcium and iron, broccoli is highly valued for its health benefits and is increasingly being cultivated by farmers in various regions of Nepal.

Origin and Distribution

Broccoli originated in the Mediterranean region, specifically Italy, where it has been cultivated for thousands of years. From Italy, broccoli spread to other parts of Europe and eventually to North America and Asia. In Nepal, broccoli cultivation began in the late 20th century and has since expanded to mid-hills and Terai regions due to its favorable climatic adaptability and growing consumer demand.

Varieties

There are several broccoli varieties suitable for cultivation in Nepal. Popular varieties include:

S.N.	Varieties	Days to Harvest	Recommended region	Productivity (MT/Ha)
Early Season Varieties				
	DiCicco	50-60		
	Centauro (F1)	68	Terai and Hills	22-25
	Early You (F1)	60-65	Terai and Mid-hills	12-18

Medium Season Varieties				
	Green Piya (F1)	85	Terai and Hills	16-17
	King Dome	85-90	Terai and Mid-hills	16-24
	Calabrese	90	Terai and Hills	

Climate and Soil

Broccoli is a cool-season crop and grows best in temperatures between 18°C and 24°C. High temperatures can cause bolting and poor head formation, while frost can damage the plant. In Nepal, broccoli is typically grown during the winter season in the Terai and mid-hills and during the summer in high-altitude regions.

Broccoli thrives in well-drained, sandy loam soil rich in organic matter. The ideal soil p^H for broccoli cultivation ranges between 6.0 and 7.0. Proper soil preparation, including plowing and adding compost or farmyard manure, is essential to ensure good growth and high yields. Avoid soils prone to waterlogging, as broccoli is sensitive to excess moisture.

Nursery Bed Preparation

1. Site Selection: Choose a location with ample sunlight and good drainage.
2. Soil Preparation: Prepare raised nursery beds 1 meter wide and 15-20 cm high to prevent waterlogging. Add well-decomposed compost and mix thoroughly.
3. Seed Sowing: Sow seeds 1-1.5 cm deep and 5 cm apart in rows. Cover lightly with fine soil.
4. Irrigation: Water the nursery bed regularly to maintain moisture but avoid overwatering.

Land Preparation

Land should be thoroughly ploughed followed by planking and harrowing to make the soil well pulverized. Weeds, plastics, stones and stubbles of earlier

crops should be removed from the field. Farmyard Manure (FYM) should be applied during field preparation. Chemical fertilizers should be applied 1 week prior to seedling transplantation.

For off-season farming during rainy season, a ridge of 20 cm height, 120 cm width and length as per the land availability should be made.

Sowing/Transplanting

- **Time:** In Nepal, sowing is typically done from September to November for winter cultivation and from March to April for summer cultivation in higher altitudes. Time of plantation for different types of varieties varies.

S.N.	Region	Time of transplantation	Time of harvesting
1.	High Hills	Falgun-Baisakh	Asaar-Bhadra
2.	Mid-hills	Bhadra-Kartik	Mangsir-Falgun
3.	Terai and River Basin	Bhadra-Asoj	Mangsir-Magh

- **Spacing:** Maintain a spacing of 45-60 cm between rows and 30-45 cm between plants to ensure proper air circulation and growth. The spacing and seed rate requirement vary with the types of varieties. Generally, early varieties require lower seed amount per unit area and lower spaces between the plants.

S.N.	Types of varieties	Seed rate	Spacing
1.	Early	20-25	45×30
2.	Medium	20-25	50×50
3.	Late	20-25	75×30

- **Method:** Transplant seedlings carefully to avoid root damage. Plant at the same depth as they were in the nursery. While transplanting seedlings should be hardened by holding the irrigation for at least 7 days before the transplantation. Before 1 hour of transplantation, nursery bed should be irrigated for easy uprooting of the seedlings.

Manuring and Fertilization

Organic Fertilizers: Incorporate 15-20 tons of farmyard manure or compost per hectare during land preparation.

Chemical Fertilizers:

- **Basal dose:** Apply 60 kg of nitrogen (N), 80 kg of phosphorus (P), and 60 kg of potassium (K) per hectare at the time of planting.
- **Topdressing:** Apply an additional 40 kg of nitrogen per hectare in two split doses—once 3 weeks after transplanting and again during head formation.

Irrigation

Broccoli requires consistent moisture for optimal growth. Irrigate immediately after transplanting and then at intervals of 7-10 days, depending on soil moisture. Avoid waterlogging, especially during head formation, as it can lead to fungal diseases.

Intercultural Operations

- **Weeding:** Perform regular weeding to reduce competition for nutrients and prevent pests and diseases.
- **Mulching:** Use organic mulches like straw or dry leaves to conserve soil moisture and regulate temperature.
- **Earthing up:** Weeding and earthing up should be done simultaneously by lifting up the soil of furrow to the ridge. One of the split doses of nitrogen can be applied at this intercultural operation.

Harvesting

Broccoli heads are ready for harvesting 70-90 days after transplanting, depending on the variety. Harvest when the heads are fully developed but before the flower buds start opening. Use a sharp knife to cut the main head along with 10-15 cm of stem. After harvesting the central head, side shoots can continue to produce smaller heads for several weeks, extending the harvest period. Broccoli gets degraded earlier than cauliflower and cabbage due to the presence of green pigment (chlorophyll).

5.3 Cabbage

Introduction

Cabbage (*Brassica oleracea* var. *capitata*) is a leafy green or purple biennial vegetable grown as an annual crop for its dense-leaved heads. It is one of the most popular vegetables cultivated globally, including Nepal, due to its adaptability to a wide range of climates and its nutritional value. Cabbage is rich in vitamins C and K, dietary fiber, and various antioxidants, making it a staple in many diets. The crop is economically significant for small-scale and commercial farmers in Nepal, contributing to both domestic consumption and export markets.

Origin and Distribution

Cabbage is believed to have originated in the Mediterranean region, where wild varieties were cultivated by ancient civilizations such as the Greeks and Romans. Over centuries, it spread to other parts of Europe and Asia, eventually becoming a global crop. In Nepal, cabbage is widely cultivated in the mid-hills, Terai plains, and some high-altitude regions, where favorable climatic conditions support its growth. Major cabbage-producing districts in Nepal include Kathmandu, Bhaktapur, Lalitpur, Kavrepalanchok, Chitwan, and Dhading.

Varieties

Numerous cabbage varieties are available, and their selection depends on the local climatic conditions, market demand, and intended use. Commonly grown varieties in Nepal include:

S.N.	Varieties	Days to Harvest	Recommended Region	Productivity (MT/Ha)
Early Season Varieties				
	Golden Ball	48-53	Terai and Hills	45-60
	Summer Cross	53-58	Terai and Hills	45-60
	Green Hero	53-58	Terai and Hills	45-60
	Nepa Magic	60-65	Terai and Hills	45-60

	Golden Acre	65-75		20-24
Mid-Season Varieties				
	Copenhagen Market	70-90	Terai and Mid-hills	35
	Nepa Green	85-90	Terai and Mid-hills	75
	Big Son 171 (F1)	95-100	High Hills	80
	Super Green (F1)	90-100	Terai, Hills and High hills	40-50
	Green Coronet	75-80	Terai and Hills	35-38
Late Season Varieties				
	Green Top (F1)	110	Terai and Hills	48
	Nepa Dream	120	Terai and Hills	25

Climate and Soil

Cabbage is a cool-season crop, preferring temperatures between 15°C and 20°C. Excessive heat can cause bolting or head splitting, while frost may damage the leaves. In Nepal, cabbage is commonly cultivated during the winter season in the Terai and throughout the year in the mid-hills, where the climate remains moderate.

Cabbage thrives in well-drained, fertile soils with a pH range of 6.0–6.8. Loamy soils rich in organic matter are ideal for its growth. The crop is moderately tolerant of different soil types but performs best in soils with good water retention and aeration.

Nursery Bed Preparation

A well-prepared nursery bed is essential for producing healthy cabbage seedlings. The nursery bed should be located in a well-drained area with sufficient sunlight. Fine tilth is achieved by plowing and leveling the soil. Organic manure or compost

is mixed into the soil to enhance fertility. The seeds are sown in rows, spaced 10–15 cm apart, and covered lightly with soil. Regular watering is necessary to maintain moisture for germination. Mulching can be applied to protect the seedlings and conserve soil moisture.

Land Preparation

Land should be thoroughly ploughed followed by planking and harrowing to make the soil well pulverized. Weeds, plastics, stones and stubbles of earlier crops should be removed from the field. Farmyard Manure (FYM) should be applied during field preparation. Chemical fertilizers should be applied 1 week prior to seedling transplantation.

For off-season farming during rainy season, a ridge of 20 cm height, 120 cm width and length as per the land availability should be made.

Manures and Fertilizers

Cabbage is a heavy feeder and requires a large amount of nutrients than some other vegetable crops. The FYM requirement is 50-60 doka per ropani and NPK requirement is 10:8:5 kg/ropani i.e. 200:160:100 Kg per hectare.

Among these only half dose of nitrogen and full dose of phosphorus and potassium should be applied during field preparation. The remaining half dose of nitrogen should be applied in two split doses.

- Half of the remaining dose after 3 weeks after transplantation.
- Half of the remaining dose should be applied when curd appears on the plant.

Boron and molybdenum also should be applied during field preparation.

- Borax @ 700 g per ropani (14 kg per hectare)
- Sodium Molybdate @ 75 per ropani (1.5 kg per hectare)

Sowing/Transplanting

Cabbage seeds are typically sown in nursery beds, and seedlings are ready for

transplanting within 25–30 days when they have 4–5 true leaves. Transplanting is done during the cool part of the day, such as early morning or late afternoon, to minimize transplant shock. The recommended spacing is 45–60 cm between rows and 30–45 cm between plants, depending on the variety.

Time of transplantation of seedlings depend upon the type of varieties. Generally, seedlings get ready to transplant in 30-40 days after sowing in nursery bed. Early varieties should be transplanted when the seedling gets 2-3 leaves. Mid-season and late varieties should be planted when the seedlings get 4-5 leaves.

While transplanting seedlings should be hardened by holding the irrigation for at least 7 days before the transplantation. Before 1 hour of transplantation, nursery bed should be irrigated for easy uprooting of the seedlings.

S.N.	Region	Time of transplantation	Time of harvesting
1.	High Hills	Falgun-Bhadra	Jestha-Mangsir
2.	Mid-hills	All months	All months
3.	Terai and River Basin	Bhadra-Magh	Mangsir-Chaitra

The seed rate requirement and spacing requirement also differ depending upon the types of varieties.

S.N.	Types of varieties	Seed rate	Spacing
1.	Early	25-30	40×40
2.	Medium	20-25	50×50
3.	Late	20-25	75×30

Irrigation

Consistent moisture is critical for cabbage growth, especially during head formation. Irrigation is provided at regular intervals, depending on the soil type and climatic conditions. Over-irrigation should be avoided to prevent waterlogging, which can lead to root rot. In the Terai region, where winters are

drier, irrigation intervals are shorter compared to the mid-hills.

Intercultural Operations

Weeding and hoeing are necessary to control weeds and improve soil aeration. Mulching with organic materials like straw or plastic helps suppress weeds and conserve soil moisture. Earthing up around the base of the plants is performed to provide support and prevent lodging.

Harvesting

Cabbage is ready for harvesting 70–120 days after transplanting, depending on the variety and growing conditions. Harvesting is done when the heads are firm and compact. Overmature heads may split, reducing market value. The heads are cut with a sharp knife, leaving a few outer leaves to protect them during handling and transport.

Cabbage can be stored for 4-5 days in room storage (at ambient temperature). In cold storage with 0-1°C temperature and 98-100% relative humidity, early season cabbage variety can be stored for 1-2 months whereas late season varieties can be stored for 5-6 months.

Major Diseases of Cole Crops

1. Damping Off

Causes

- Caused by fungus of Pythium species.
- It is soil and seed borne disease.

Symptoms of Damage

- Water-soaked spots are seen initially just above the ground level (collar region) in the seedlings.
- At later stage, the seedlings get wilted and topple down

Management Methods

- Crop rotation

- Nursery bed treatment by formalin
- Nursery bed treatment by thiram and dithane M-45 @ 0.2% and by bavistin @0.1%
- Avoiding water stagnation in both nursery beds and in fields
- Sowing and transplanting should be done by maintaining appropriate spacing. Dense sowing and transplantation may cause damping off.

2. Downy Mildew

Causes

- Caused by fungus named *Peronospora parasitica*

Symptoms of Damage

- Yellow coloured spots are seen on the top of the leaves
- Lower part of the leaves is covered by grey fungal mycelia
- Plants wilt and die at the later stage when the fungal infestation gets high

Management Methods

- Seed treatment should be done by captan and thiram @ 2g per kg
- Application of Dithane M-45 @ 0.3% by spraying on the crop at 10-15 days interval

3. Alternaria Leaf Spot *(Alternaria brassicola)*

Symptoms of Damage

- Small black spots are seen on the surface of the initial leaves. Those small spots coalesce and get larger as the disease progresses and finally the plant dies.

Management Methods

- Seed treatment should be done by fungicide before sowing
- Crop Rotation
- Foliar application of Dithane M-45 or Blitox @ 0.2-0.3%

4. Club Root Disease

Causes

- Caused by fungus called *Plasmodiophora brassicae*
- This disease is mostly prevalent in acidic soils

Symptoms of Damaage

- Roots show large swellings presenting a club shape appearance
- Foliage wilts on sunny days and recovers towards the evening

Management Methods

- Crop rotation with non-cruciferous crops at least for 3-4 years
- Application of lime at appropriate amount to make the soil pH about 7-7.3

5. Sclerotinia Rot

Causes

- Fungus: *Sclerotinia minor*

Symptoms of Damage

- Stem just above the ground gets affected by this fungus. Affected stem gets decayed.
- White fungal appearance is seen on the affected part.

Management Methods

- Crop rotation with rice plant.
- Spraying of bavistin and benlate @ 1g/litre water at 15 days interval should be done.
- Seed treatment should be done with Aureofungin @ 59 ppm and Streptocyclin @ 50 ppm for 30 minutes. Thus, treated seed should be sown only after drying.
- Treatment of seedling with Benlate @ 0.25% for 5-8 minutes.

6. Black Rot

Causes

- It is a bacterial disease caused by bacteria named *Xanthomonas campestris*

Symptoms of Damage

- The symptoms generally appear at the margin of the leaves. Yellowing of margin of leaves and wilting at later stage.
- The veins of leaves get blackish colour

Management Methods

- Crop rotation with crops from other families.
- Hot water treatment of seed for 30 minutes at 50°C temperature water.
- Spraying of blitox (0.2%) and streptocyclin (0.2%) alternately when the disease infestation is seen.

Major Insects in Cole Crops

1. Cabbage butterfly

Scientific Name: *Pieris brassicae*; Family: Lepidoptera: Pieridae

It's a butterfly insect which is found both in terai and hills. The wings of these insects are yellowish white in colour. Larvae are bluish green in colour. Black spots, small fur like structures and three yellow lines are seen on the back of larvae.

Symptoms of Damage

- Larvae feed to all the tender parts of leaves leaving the main veins.
- Larvae make holes in the curds.

Management Methods

- Use botanical materials like garlic, neem solution which act as repellent or anti-feedant.

- Spray commercial formulation of Bacillus thuringiensis@ 2g/liter at primordial stage.
- Spray insecticides like quinalphos 25% EC @ 1000ml, or cypermethrin 25% EC @ 200ml/400 liter water per hectare at initial stage of infestation.

2. Diamond Back Moth

Scientific Name: *Plutella xylostella*; Family: Lepidoptera: Plutellidae

- When at rest the triangular markings of opposite wings give diamond shape, hence it is named as 'Diamond back moth'
- Larva is pale yellowish green
- Pupation takes place on the foliage in a transparent cocoon

Symptoms of Damage

- Young caterpillars cause small yellow lines on leaves.
- Caterpillars (larvae) feed by scraping leaf tissue.
- The infested plant parts get converted into typical white patches. Scrapping of leaf tissues producing typical whitish patches on leaves.

Management Methods

- Pheromone traps with DBM lure @ 12 trap/hectare
- Crop rotation with cucurbits, beans, peas, tomato and melon
- Use larval parasitoid:
  a. *Diadegma semiclausm* @ 100,000/ha
  b. *Cotesia plutellae* @ 20,000/ha
- Apply Bacillus thuringiensis var kurstaki 2g/liter water
- Use neem seed kernel extract 5% or neem based pesticide @ 5ml/liter water
- Spray 0.05% solution of Malathion 50% EC @ 2ml/liter water

3. Cabbage Aphids

It is a small greenish colour aphid which sucks sap from the tender leaves of cole crops. It also transmits viruses from one plant to another.

Symptoms of Damage

- Aphids gather in large amounts in one place and suck the sap from leaves and stems which makes plants dry and finally the plant dies.

Management Methods

- Spray the mixture of water and cattle urine (10:1 ratio) at 3 days interval.
- Apply neem-based pesticide at 7 days interval.

Exercise

Choose the correct answer from the given alternatives.

1. What does the word 'cole' in the cole crop mean?

   a. Cold b. Stem c. Leaf d. Root

2. Which part of broccoli is primarily consumed?

   a. Leaves b. Stems

   c. Flowers d. Roots

3. What pH range is ideal for cabbage cultivation?

   a. 4.5–5.5 b. 6.0–6.8

   c. 7.5–8.0 d. 5.0–6.0

4. Which insect pest is common in cauliflower cultivation?

   a. Aphids b. Armyworms

   c. Cabbage butterfly d. Whitefly

5. In Nepal, cauliflower is typically grown during which season?

   a. Summer b. Monsoon

   c. Winter d. Spring

6. What is the main symptom of clubroot disease in cabbage?

   a. Leaf yellowing b. Swelling of roots

   c. White fungal patches d. Head splitting

7. Which soil condition is unfavorable for cauliflower?

   a. Well-drained soil b. Waterlogged soil

   c. Loamy soil d. Fertile soil

8. Which pest creates holes in cabbage leaves?

   a. Diamondback moth b. Aphids

   c. Thrips d. Beetles

9. What is the main method of controlling black rot in cabbage?

a. Fungicide application b. Crop rotation

c. Use of pheromone traps d. Biological control

Write short answer to the following questions.

1. Describe the ideal climatic and soil requirements for cauliflower cultivation. Why is mulching important in cabbage cultivation?
2. List and describe any two intercultural operations performed in cole crop cultivation.
3. Explain the nursery bed preparation technique for raising seedlings of cole crops. Explain the manures and fertilizer management practices used in cabbage.
4. Why early cole crop varieties require low seed rate and spacing than medium and late varieties?

Write long answer to the following questions.

1. Explain the transplantation process of cauliflower seedlings, including spacing and seed rate. Discuss the symptoms, causes, and management of 'Whiptail' and 'Browning' in cauliflower.
2. Explain the role of micronutrients like boron and molybdenum in cole crop cultivation. Enlist the physiological disorders of cauliflower. Explain the symptoms and management methods of 'Buttoning' in cauliflower.

Project Work

1. Visit a local farmer's vegetable farm and prepare a report covering:
   a. Types of cole crops cultivated
   b. Varieties used
   c. Farmer's practices for nursery bed preparation, seed sowing, transplanting, and irrigation
   d. Major pests/diseases observed and their control measures

Cultivation Practices of Root Crops

Unit 6

6.1. Radish

Introduction

Radish (*Raphanus sativus*) is a root vegetable cultivated worldwide for its edible, crisp, and slightly pungent roots. It is a fast-growing crop with multiple uses, including consumption as a salad, cooked vegetable, or pickled item. Radish is an excellent source of vitamin C, fiber, and antioxidants, making it a healthy addition to diets. In Nepal, radish holds significant cultural and economic importance. Its adaptability to various agro-climatic zones makes it a popular crop among Nepalese farmers.

Origin and Distribution

Radish is believed to have originated in Southeast Asia or the eastern Mediterranean region, with its cultivation dating back thousands of years. The crop spread to Europe and Asia, where it became a staple vegetable in many cuisines. In Nepal, radish is widely cultivated across the country, from the Terai plains to the high-altitude regions of the Himalayas. Major radish-growing districts include Kathmandu, Bhaktapur, Lalitpur, Chitwan, Dhading, and Kavre.

Nutritive Value

Radish is a low-calorie vegetable that offers different types of vitamins and minerals. It is rich in vitamin C, K, B9, B6, B2, etc. It is rich in minerals like potassium and phosphorus. Also, radish contain antioxidants like anthocyanins, quercetin, and catechin. Being a good source of fiber, various antioxidants, it has several health benefits such as prevention of constipation, help in digestion, has cooling effect, etc.

Varieties

Several radish varieties are grown in Nepal, catering to different climatic conditions and consumer preferences. Popular varieties include: White Neck, Mino early, All season white, Mino early Long white, Pyuthane Rato, Tokinasi, chalis dine, Green neck etc.

Climate and Soil

Radish is a cool-season crop that prefers temperatures between 10°C and 20°C. While it can tolerate a range of climates, extreme heat causes bolting, and severe frost damages roots. In Nepal, radish is commonly grown during the winter season in the Terai and mid-hills, while high-altitude areas can produce it in summer.

Radish thrives in well-drained, loose, sandy loam or loamy soils with a pH of 6.0–7.0. Compacted or heavy clay soils can hinder root development, leading to poor-quality produce. Adding organic matter or well-decomposed compost enhances soil fertility and structure, promoting healthy growth.

Manure and Fertilizers

Incorporate 200 q of well rotten FYM per hectare after the first plowing. Make ridges and furrows of convenient length. Keep 20 cm spacing between two ridges and 15 cm between plants. Add fertilizer mixture @ 100 kg N, 60 kg P2O5 and 80 Kg K2O/ha at the bottom of the ridges and cover it with soil. Furrow should be irrigated for one or two days before sowing the seeds.

Seed Rate and Sowing

About 10-15 kg of seed is sufficient to grow in one hectare. Seeds are usually on ridges to facilitate good root production. Shallow furrow of 2 cm depth is prepared on the ridges using a stick. The seeds are thinly sown in the shallow furrows and covered with soil or pulverized manure. Radish can be grown throughout the year, but the main season is from June to July in high hills, September to October in mid hills and September to November in terai area.

Irrigation

Irrigate the crop in 6-7 days depending upon weather condition. Before sowing soil must be moist, a light irrigation is given immediately after sowing.

Inter-Culture and Weed Control

One weeding should be done 15-20 days after sowing. Thinning of plants must be carried out 15-20 days after sowing keeping a distance of 15 cm between plants in a row. Top dress the crop with the N at 25-30 days after sowing and do earthing up which prevents discolouration of roots exposed to the atmosphere and resulted in better quality roots. The pre-emergence application of Fluchloralin (0.5 kg/ha) effectively controls the weeds in the radish field.

Harvesting

Generally, radish varieties are ready to harvest at 50-60 days after sowing but the cultivar Tokinashi is ready to harvest at 30-35 days after sowing. Harvesting should be done when the roots reach their optimal size, as overmature roots become woody and lose their quality. They will become fluffy or pithy (which are unfit for consumption) if kept in the field for a longer period. The crop should be irrigated before the pulling out of roots. The roots should be carefully pulled from the soil, and excess soil should be removed. Proper handling during harvesting minimizes damage to the roots, ensuring good marketability.

The yield of radish varies from 300-400 q/ha.

Diseases of Radish

1. Yellow

This disease is caused by fungus of fusarium species. It generally occurs when the temperature is relatively high. Crop rotation is the best way to minimize the infestation of this disease.

2. Black Rot

Black rot is a fungal disease in radish which is generally caused in the boron deficient soil. Generally, roots do not develop well when this disease attack

radish. Black marks are seen in the innermost part of radish.

Application of borax at appropriate amount is the best way to reduce the infestation of this disease.

3. White Rust

It's a fungal disease caused by *Albugo candida*. The symptoms of this disease seen on the foliage of radish plants. On the inner side of the leaves, white dots are seen. Plants cannot grow well due to this disease.

Insect Pests

1. **Aphids *(Aphis gossypii)*:** These sap-sucking insects weaken plants and spread viral diseases. Neem-based sprays and biological controls, such as ladybird beetles, help manage infestations.
2. **Flea Beetles *(Phyllotreta spp.)*:** They create small holes in leaves, reducing plant vigor. Insecticidal sprays and cultural practices like crop rotation are effective.
3. **Cutworms *(Agrotis ipsilon)*:** These larvae cut seedlings at the base, leading to plant loss. Preventive measures include field sanitation and using traps.

1.2 Carrot

Introduction

Carrot (*Daucus carota* subsp. *sativus*) is a highly nutritious root vegetable widely cultivated for its sweet, crunchy, and vibrant-coloured taproot. It is a rich source of beta-carotene, dietary fiber, vitamins A, K, and C, and essential minerals. Carrots are consumed both fresh and processed, making them an economically valuable crop for farmers in Nepal. Their adaptability to diverse agro-climatic zones has made carrot cultivation popular in the country, both for local consumption and market sale.

Origin and Distribution

Carrots are believed to have originated in Central Asia, specifically in regions of modern-day Afghanistan and Iran. They were initially grown for their aromatic leaves and seeds, their cultivation for roots gained prominence over centuries. The crop spread across Europe, Asia, and the rest of the world through trade and exploration. In Nepal, carrots are cultivated in the Terai, mid-hills, and high-hill regions, with districts like Dhading, Morang, Kavrepalanchok, Chitwan, and Kaski being major producers.

Uses

Carrots are generally used as raw salads in Nepal. Around the world it has different consumption methods. It is cooked as a side dish, soup, carrot puree, etc. Some other important uses of carrot are listed below.

- gajarko haluwa
- cooked vegetable (mixed with other vegetables)
- dried carrots are used in noodles
- vegetable soup

Nutritive Value

Carrots are highly nutritious vegetables, rich in essential vitamins, minerals, and antioxidants. Carrots are rich in carbohydrate, dietary fiber, vitamin A, vitamin K,

vitamin C, vitamin E, vitamin B6, etc. Also, it is rich in minerals like potassium, phosphorus, sodium and many others.

Carrots are rich in beta-carotene, which is a powerful antioxidant and the precursor to vitamin A.

Varieties

Carrot varieties are categorized based on their root shape, colour, and growth duration. Common types grown in Nepal include: New Curoda, Nantes Forte, Nepa Dream, Sigma, Kuroda Mark etc.

Climate

Carrots are predominantly a cool season crop. A temperature range of 7.2-23.9°C is suitable for seed germination and 18.3-23.9°C for better growth of roots. The optimum temperature for better colour development of roots is 15.6-21.1°C.

Soil and Field Preparation

The long, smooth, slender roots desired for fresh market can successfully produce deep, well drained light soils. The optimum soil pH is 6.0-7.0. About 3-4 plowing is required to bring the soil to a fine tilth.

Sowing

Carrots are propagated through seeds, which are directly sown in the field. The ideal sowing time varies depending on the region:

- Terai: October to November
- Mid-hills: August to September
- High hills: March to April

Seed Rate and Time of Sowing

About 8-10 kg healthy seeds are required to grow in one hectare area. The carrot is grown in flat beds as well as on the ridges. Ridges and furrow methods facilitate better root development. The ridges are made at 25-30 cm spacing.

Shallow furrows of 2 cm depth are made on the ridges and seed is sown thinly in these furrows and covered with mixture of soils and well rotten manure. June to July for high hills, October to December for mid hills and October to November for terai is the optimum time for sowing in Nepal. The optimum spacing is 30 cm between the rows and 10 cm between the plants.

Manuring and Fertilization

Carrots require adequate nutrients for optimal growth. Well-rotted farmyard manure (15–20 tons per hectare) is applied during land preparation. Chemical fertilizers are used as follows:

- Basal Dose: 60–80 kg nitrogen, 40–60 kg phosphorus, and 40–60 kg potassium per hectare.
- Top Dressing: Additional nitrogen is applied in split doses during the crop's growth stages to enhance root development.

Irrigation

Regular and uniform moisture is essential for proper root growth. Carrots are irrigated immediately after sowing and at intervals of 7–10 days, depending on soil type and weather conditions. Excessive irrigation should be avoided to prevent cracking of roots.

Intercultural Operations

Weeding and hoeing are necessary to control weeds and aerate the soil. Mulching with straw or plastic reduces weed growth, conserves soil moisture, and maintains soil temperature. Careful thinning ensures proper spacing and avoids competition among plants.

Harvesting

Carrots are ready for harvest 75–120 days after sowing, depending on the variety and growing conditions. Harvesting is done when roots attain the desired size, shape, and colour. Delayed harvesting can result in woody and less palatable roots. Roots are loosened using a fork or spade and pulled gently to avoid

damage. Post-harvest, carrots are washed, sorted, and graded based on size and quality for market sale. The yield of carrot in Nepal is 11.15 mt/ha.

Physiological Disorders

1. Carrot Splitting

It is a major physiological disorder of carrots where roots crack and seem to be controlled by genetic factors but a number of other factors like heavy side dressing, sowing at wide spacing, large size of roots and fluctuation in soil moisture are also found to be responsible for splitting.

Control-

- Grow resistant varieties like Selection-233.
- Sow the seeds at close spacing.
- Maintain optimum moisture in the field.
- Harvest the crop at the right maturity stage.

2. Cavity Spot

It is characterized by the appearance of cavity in the cortex and in most cases the subtending epidermis collapse to form a pitted lesion. The disorder was caused due to Ca deficiency, increased level of K2O and delay in harvesting.

Control-

- Incorporate Calcium containing fertilizers in thed soil.
- Harvest the roots at optimum time.

Insect-Pests

1. Aphid (*Myzus persicae, Liphaphis erysimi*)

Insects suck the sap from the tender parts of plant. In case of heavy infestation leaves become curled, yellowed and finally die. The cloudy and humid conditions are favorable for their rapid multiplication.

Control

Spray crop with Malathion (0.1%) or Endosulfan (0.05%) and repeat the spray after 10 days.

2. Carrot Rust Fly (*Psila rosae*)

The larvae burrows into the roots leading to misshapen and decay of roots to make them unfit for consumption. Wilting and redness of foliage are the main symptoms above the ground.

Control

- Grow resistant Varieties like Nantes
- Sowing should be done at proper spacing to avoid thinning.
- Destroy the thinned plants immediately.
- Fill the holes made due to thinning to avoid the laying of eggs by flies.
- Incorporate Dimethoate (0.1%) in the soil.

Diseases

1. Alternaria Blight (*Alternaria raphani*)

Small, yellowish and slightly raised lesions appear first on the leaves. It also infects the stem, pods and seeds.

Control-

- Adopt crop rotation.
- Use disease free seed.
- Seed treatment with hot water at 50°C for 30 minutes.
- Spray Bavistin (0.2%) or Dithene M 45 (0.2%) at 7-10 days interval.

2. Black Rot (*Alternaria radicina*)

It affects the foliage as well as roots of carrots in both field and storage. The affected roots develop irregular or circular sunken black areas and finally decay.

Control-

- Follow phyto-sanitary measures.
- Follow crop rotation.
- Selected affected roots and destroy them.
- Store the roots at 0-2ºC temperature.

3. Bacterial Soft Rot (*Erwinia carotovora*)

It is a destructive disease of carrots in storage and transport. The infected roots become soft, watery and as the rooting progresses, exude watery substances which give foul odour.

Control-

- Uproot the infected roots and destroy.
- Clean the roots and keep dry.
- Avoid bruising during harvesting, grading, transport, storage and handling.
- Store the roots at 0oC temperature and 90% RH.

4. Radish Mosaic Virus (RMV)

Small, circular to irregular chlorotic lesions develop on the leaves. The virus is transmitted by aphids.

Control-

- Uproot weed hosts.
- Collect seeds from healthy plants.
- Remove affected plants and burn them.
- Spray Dimethoate (0.03%)

Exercise

Choose the correct answer from the given alternatives.

1. Which soil type is most suitable for carrot cultivation?
   a. Heavy clay
   b. Sandy loam
   c. Rocky soil
   d. Peaty soil

2. Radish is primarily cultivated during which season in Nepal?
   a. Summer
   b. Monsoon
   c. Winter
   d. Spring

3. Carrot roots attain their characteristic orange colour due to the presence of...
   a. Chlorophyll
   b. Anthocyanin
   c. Beta-carotene
   d. Lycopene

4. Which method is commonly used for sowing carrot seeds?
   a. Broadcasting
   b. Line sowing
   c. Transplanting
   d. Dibbling

5. The optimum pH range for carrot cultivation is:
   a. 4.5–5.5
   b. 5.5–6.5
   c. 6.0–7.5
   d. 7.5–8.5

Write short answer to the following questions.

1. Why is carrot considered a nutritious vegetable? Mention any two reasons. Explain the ideal climate and soil conditions for growing radish.
2. What are the common insects affecting carrot crops? Write their management methods.
3. Why is irrigation crucial during the root development stage of carrots? Why is irrigation important during harvesting of root crops?

Write long answer to the following questions.

1. Elaborate on the cultivation practices of radish, including soil preparation, sowing, fertilization, irrigation, and pest management. Relate your answer to Nepalese conditions.
2. Compare the radish and carrot based on the following points:
    a. Origin
    b. Edible part
    c. Climatic requirement
    d. Soil type
    e. Major nutrients found
    f. Major insect pests

Project Work

1. Prepare a small report (1-2 pages) by asking local farmers or visiting nearby fields. Include the following points:
    a. Which vegetable (radish or carrot) is more commonly grown in your area?
    b. Which varieties are planted?
    c. What is the sowing and harvesting time?
    d. What fertilizers and manure do farmers use?
    e. What problems (insects, diseases, disorders) do farmers face in these crops?
    f. What solutions are they using for these problems?

Cultivation Practices of Leafy Vegetable

Unit 7

7.1. Broad leaf Mustard

Introduction

Broad Leaf Mustard (*Brassica juncea var. rugosa*) is a leafy vegetable widely cultivated for its tender leaves, stems, and flowers. It is a member of the Brassicaceae family and is highly valued for its culinary versatility, nutritional benefits, and adaptability to various agro-climatic conditions. Rich in vitamins A, C, and K, as well as minerals like calcium and iron, broad leaf mustard is a staple in traditional Nepalese diets as *Gundruk* and is used in dishes like pickles, soups, and stir-fries.

Origin and Distribution

The origin of broad leaf mustard can be traced to the Himalayan region and parts of Central Asia over centuries, it spread to other parts of Asia, Europe, and the Americas. In Nepal, it is one of the most important winter vegetables, cultivated predominantly in the mid-hills, high hills, and Terai regions. Popular districts for its cultivation include Kathmandu, Bhaktapur, Lalitpur, Kavrepalanchok, Dhankuta, and Ilam.

Nutritive Value

Rich in Vitamins, minerals, and dietary fiber.

- Vitamins like vitamin A, B, C, and E are the major vitamins found in broadleaf mustard.
- In minerals, iron, phosphorus, and calcium are the major ones.
- Protein is also available at some extent in this vegetable.

Varieties

Broad leaf mustard is available in various local and improved varieties, catering to diverse culinary and market preferences. Commonly grown varieties in Nepal include: Marpha Broad Leaf, Khumal Broad Leaf, Tangkhuwa, Khumal red leaf, Gujmuje rayo, Mustard 101, Saili, Champa Dude Rayo, Manakamana Rayo, Mike Giant, Red Giant etc.

Climate and Soil

Mustard is a cool season crop and is cultivated in the tropical as well as in the temperate zones. In temperate zones, it grows in summer season and in tropical zones, it is grown in winter season. Short days, dry weather with low humidity, and low temperatures are the most favorable type of climatic condition for better growth and development of leaves.

Soil rich in organic matter, well drained, and fertile is preferred for the cultivation of mustard. It can be cultivated in a wide range of soil from sandy loam to clay loam. Mustard performs best in the soil with a neutral pH but will tolerate slightly alkaline soil above pH

Nursery Bed Preparation

A well-prepared nursery bed is crucial for healthy seedling production. The nursery bed should be located in a sunny, well-drained area. The soil should be thoroughly plowed and enriched with decomposed farmyard manure or compost at the rate of 5–10 tons per hectare. Seeds should be sown in shallow furrows spaced 2-3 cm apart and covered lightly with soil. Mulching with straw or dry leaves can help retain soil moisture and protect seedlings from temperature

fluctuations. Regular irrigation should be given to ensure the presence of enough moisture in the soil for germination. We should avoid over irrigation and water stagnation to keep the seedlings away from damping off disease.

Mustard seeds are very small in size. So, a smaller number of seeds can be enough to cultivate a large amount of field. The seed required to cultivate broad leaf mustard in one ropani land is 30 grams.

Manure and Fertilizers

- FYM: 2000 kg/ropani
- NPK: 6:4:3 kg/ropani

Application of urea (nitrogenous fertilizer) should be done at split doses.

First half – at field preparation

Second half – At 25-30 Days after transplantation and at 45-50 DAT

Transplantation

Seedlings become ready to transplant 30 days after sowing. Transplantation can be done on the ridges.

Spacing: Row to Row: 45 cm

Plant to plant: 30 cm

Irrigation

Irrigation should be given regularly as soon as the transplantation of seedlings are done until the seedlings get well established in the main field. Manual irrigation can be done at the initial days to make seedlings well established in the field. Drip irrigation can also be done for efficient utilization of time and resources.

When the plants get well established after several days of transplantation, irrigation can be given at certain day's interval depending upon the moisture present in soil.

Intercultural Operations

Weeding and hoeing are necessary to control weeds and improve soil aeration.

Mulching with organic materials helps conserve soil moisture and suppress weed growth. Thinning may be required to maintain appropriate plant spacing and ensure healthy development.

Harvesting

Leaves of broad leaf mustard can be harvested for multiple times. The first harvesting can be done at 25-30 DAT and can be continued for more than 50 DAT. Timely harvesting ensures tender leaves with optimal flavor and market value. Delay in harvesting can lead to tough, fibrous leaves. Harvesting should be done by detaching leaves gently from the plant.

Insects/Pests

1. Mustard Aphids (*Lipaphis erysimi*)

Mustard aphids are sucking type insects, which are small, green to grey soft-bodied insects; found in clusters on young shoots and leaves.

Symptoms of Damage

- Suck sap from tender parts, causing leaf curling, yellowing, and stunted growth.
- Secrete honeydew, which attracts sooty mold.
- Transmit viral diseases.

Management Methods

- Use yellow sticky traps.
- Apply jholmal at every 7 days interval if the infestation is seen.
- Spray neem-based insecticide or systemic insecticide like Imidacloprid if needed.

2. Mustard Sawfly (*Athalia lugens proxima*)

Mustard sawflies are defoliating pest (leaf feeder), which are black when adult. The larvae look greenish with black spots. They are active during early plant growth stage (November-January)

Symptoms of Damage

- Larvae feed on leaves, leaving only veins (skeletonized leaves).
- Heavy infestation can lead to complete defoliation.

Management Methods

- Handpick larvae in small fields.
- Spray chemical insecticide Malathion in severe cases.

3. Flea Beetle (*Phyllotreta spp.*)

Flea beetles, leaf-chewing beetles, are small, shiny black beetles that jump like fleas. They are found during early crop stages, especially in dry and sunny weather.

Symptoms of Damage

- Create shot holes in leaves.
- Damage is more severe in seedlings, leading to poor establishment.

Management Methods

- Use ash or sand dusting on plants.
- Seed treatment with insecticides (e.g., Imidacloprid).
- Spray spinosad or other low-toxic insecticides.

3. Diamondback Moth (*Plutella xylostella*)

Diamondback moth is a lepidopteran insect, which look small and brown with a diamond-shaped white mark on wings when they are at adult stage.

Symptoms of Damage

- Larvae feed on the underside of leaves, causing irregular holes.
- It can also bore into stems in heavy infestations.

Management Methods

- Use pheromone traps.

- Introduce biocontrol agents like Trichogramma.
- Apply Bt (Bacillus thuringiensis) or neem extract.
- Apply chemical insecticides such as Emamectin benzoate (5g/10 l water), Spinosad (1.5ml/l water), and Chlorantraniliprole (0.5 ml/l water) if the infestation is seen high.

Diseases

1. Alternaria Leaf Spot

Alternaria leaf spot, also known as Alternaria blight, is a common and destructive fungal disease of mustard in Nepal, especially in cool and moist weather. It is caused by fungi such as:

- Alternaria brassicae
- Alternaria brassicola

Symptoms of Damage

- Small circular spots with dark brown to black margins and concentric rings (target-like pattern) are seen on the leaves. Spots grow and merge, causing leaf blight (burning).
- Dark brown to black elongated lesions is seen in the stems, which lead to weakening and breaking of the stems.
- Leaves fall early, stunted growth occurs, and yield is reduced.

Management Methods

- Crop rotation: Do not cultivate broad leaf mustard continuously for several years in the same field.
- Remove and destroy the infected plant parts as soon as possible.
- Use disease free seeds: Fungicide treated seeds can be used.
- Treatment of seed bed with fungicide can be done.
- Use neem-based bio-fungicides.
- If the infestation is seen and is getting severe apply chemical fungicides such as Mancozeb 75% WP, Chlorothalonil 75% WP, etc.

2. White Rust *(Albugo candida)*

It is one of the most common and damaging fungal diseases of mustard crops in Nepal, especially during cool and moist conditions in the winter growing seasons. Dense crop canopy and poor air circulation promotes the fungus's growth.

Symptoms of Damage

- On the underside of the leaves, we can see white to creamy pustules (raised spots). At the same time, the upper side of the leaves show yellow patches corresponding to the pustule's underneath. Such pustules break and release white powdery spores.
- Infected leaves may curl, distort, or dry up early.

Management Methods

- Use disease-free seeds.
- Remove and destroy plant debris after harvest.
- Maintain proper spacing while planting.
- Apply fungicides like Mancozeb, Metalaxyl, or Ridomil Gold at early stages of infection.

7.2 Spinach

Introduction

Spinach (*Spinacia oleracea*) is a highly nutritious leafy green vegetable widely consumed for its rich content of vitamins A, C, and K, as well as iron, calcium, and fiber. It is a fast-growing crop known for its adaptability to different climates and cultivation conditions. In Nepal, it is cultivated in all types of agro-climatic zones. Generally, spinach in Nepal is of two types. One is generally found in mid-hills with spiky seeds. And the next one is generally cultivated in terai region, which is less spiky than the mid-hills one.

Origin and Distribution

Spinach is believed to have originated in ancient Persia (modern-day Iran), from where it spread to other parts of Asia and Europe via trade routes. The vegetable gained popularity in the Mediterranean region and later across the world. In Nepal, spinach is grown in various regions, including the Terai, mid-hills, and high-altitude areas. Its cultivation is prevalent throughout the year, particularly during the cooler seasons in the Terai and year-round in the mid-hills where moderate climates prevail.

Nutritive Value

In Nepal, spinach holds significance in the diet due to its health benefits and versatility in various culinary preparations, including salads, soups, and curries. Its relatively short growing cycle makes it a popular choice for farmers looking for quick returns.

Climate and Soil

It prefers cool weather conditions, making it a winter crop in lowland regions like the Terai and a year-round crop in cooler highlands. Temperatures between 10°C and 24°C are optimal for germination and growth. Excessive heat can cause

bolting, while frost can damage the foliage. Proper soil preparation, including plowing and adding organic manure, enhances spinach growth and productivity. In cooler climatic conditions, the vegetative growth of spinach is good. It can be successfully cultivated in the winter season in Terai. In hilly areas, it can be cultivated throughout the year if we can save crops from continuous heavy rain.

Spinach thrives in well-drained, fertile soils with a pH range of 6.0 to 7.5. Sandy loam or loamy soils rich in organic matter are ideal for its growth.

Varieties

Several spinach varieties are cultivated, varying in their growth habits, leaf texture, and tolerance to climatic conditions. Commonly grown varieties in Nepal include: Patane, Haripate, All green, Pusa Jyoti, W King, Asia Dong Cho etc.

Field Preparation

Field should be irrigated before the cultivation of spinach if there is not enough moisture to support the germination of seeds. After irrigation, the field should be thoroughly plowed to fine tilth. After plowing, the field should be harrowed and planked.

Manures and Fertilizers

The recommended dose of farm yard manure is 2000 kg per ropani and that of NPK is 6:4:3 kg per ropani.

Nitrogenous fertilizers (Urea) should be applied in split doses while other fertilizers should be applied during field preparation. Half of the recommended dose should be applied during the field preparation and the remaining half at 45 DAS.

Sowing

Spinach seeds are typically sown by broadcasting method, directly in the field at a depth of 1–2 cm. Seeds should be uniformly broadcasted in the field.

The recommended seed rate for broadcasting of spinach is 1.5 kg per ropani. Line sowing of seeds can also be done as an alternative method maintaining appropriate spacing. The spacing varies depending on the variety but generally follows a row-to-row spacing of 20–25 cm and plant-to-plant spacing of 5–10 cm. Sowing or broadcasting should be followed by thinning to maintain proper plant density.

Irrigation

As the crop is generally grown during dry weather, frequent irrigation may be required for the successful growth of spinach. If the first irrigation is given just before the tillage, the second irrigation should be given after 25-30 days. Time and frequency of irrigation also depend upon the amount of moisture present in soil and type of soil.

Intercultural Operations

Regular weeding is essential to minimize competition for nutrients, water, and sunlight. Hoeing helps aerate the soil and promote healthy root development. Mulching with organic materials like straw or plastic sheets can reduce weed growth and retain soil moisture. Thinning is performed to maintain optimal plant spacing for proper growth and airflow.

Harvesting

Spinach is ready for harvest 30–45 days after sowing, depending on the variety and growing conditions. Harvesting is done when the leaves are tender and reach a suitable size for consumption. The outer leaves can be picked selectively, allowing the inner leaves to grow, or the entire plant can be harvested at once. Timely harvesting is crucial to prevent bolting and ensure optimal quality and taste. The harvested leaves are washed, sorted, and packed for market or storage.

Common Insect Pests and Diseases

Insect Pests

i. **Aphids (*Aphis spp.*):**

These sap-sucking insects weaken the plants and may transmit viral diseases. They suck sap from the underside of leaves using their piercing-sucking mouthparts. Smaller clusters of aphids are seen on the infected area. Due to the sap loss, yellowing of leaves are seen due to sap loss. This reduces the photosynthesis by distorting and curling the leaves. A sugary substance, honeydew, is excreted by aphids, which encourages sooty mold growth. This blocks the sunlight and affects leaf quality.

Management Methods

- Remove and destroy infested leaves or entire plants if severely damaged.
- Avoid application of excessive nitrogen, as soft leaves attract aphids.
- Encourage natural enemies like ladybird beetles, lacewings, parasitic wasps, etc.
- Use yellow sticky traps to monitor and reduce aphid populations.
- In severe cases, we should use imidacloprid, thiamethoxam, acetamiprid, etc.

ii. White flies

Whiteflies are small, soft-bodied, flying insects that are related to aphids and mealybugs. In spinach, they are commonly found on the underside of leaves and can cause serious damage by sucking plant sap and transmitting plant viruses.

Symptoms of Damage

- Presence of tiny white insects on the underside of leaves.
- Yellowing or curling of leaves due to sap sucking.
- Sticky honeydew secretion on leaves, which may lead to sooty mold

growth.

- Reduced plant growth and vigor, sometimes leading to wilting.

Management Methods

- Remove and destroy heavily infested plants.
- Avoid planting spinach near whitefly-susceptible crops (like tomato or beans)
- Use yellow sticky traps to monitor and reduce whitefly population.
- Promote beneficial insects like lady beetles and lacewings.
- In severe cases, use recommended systemic insecticides such as:
  - Imidacloprid
  - Thiamethoxam

Diseases

i. Downy Mildew (*Peronospora farinosa*)

Downy mildew is a fungal disease, causing yellow patches on leaves and a white, powdery growth on the underside. It thrives in cool, moist conditions, especially when there is heavy dew or prolonged leaf wetness.

Small, yellowish spots appear on the upper surface of older leaves. Spots are angular because they are limited by leaf veins. On the underside of leaves, a purple to greyish fuzzy fungal growth develops (this is the "downy" appearance). Severely infected leaves wilt, shrivel, and drop prematurely.

Management Methods

- Avoid overhead irrigation to reduce leaf wetness. Reducing leaf wetness reduces the propagation of fungus.
- Destroy infected plant debris after harvest to reduce fungal spores in the field.
- Apply bio-fungicides like Trichoderma spp. as a preventive measure.
- If the infestation is severe, apply fungicides like metalaxyl + mancozeb (systemic + contact), chlorothalonil, etc. in 7 days interval.

ii. Bacterial Leaf Spot

Bacterial leaf spot of spinach is a disease caused mainly by the bacterium *Pseudomonas syringae*. The disease is commonly seen when plants are irrigated and watered overhead.

Symptoms of Damage

- Small, water-soaked spots on leaves that later turn dark brown to black.
- Spots may be circular or irregular in shape.
- In severe cases, many spots join, leading to leaf blight (browning and death of large leaf areas).
- The affected leaves may dry out, become brittle, and fall off.
- Overall plant growth is reduced.

Management Methods

- Use disease-free seeds or treat seeds with hot water (50 ºC for 30 minutes).
- Avoid overhead irrigation to reduce leaf wetness.
- Apply beneficial microbes like Bacillus subtilis as foliar sprays to reduce bacterial growth.

Exercise

Choose the correct answer from the given alternatives.

1. Which nutrient is most responsible for green leaf growth in broadleaf mustard and spinach?

   a. Phosphorus b. Potassium

   c. Nitrogen d. Calcium

2. Which disease in spinach is caused by bacteria and leads to dark brown spots on leaves?

   a. White rust b. Bacterial leaf spot

   c. Downy mildew d. Alternaria leaf spot

3. What soil pH range is ideal for Broad Leaf Mustard cultivation?

   a. 5.0–5.5 b. 6.0–6.8

   c. 7.0–7.5 d. 8.0–8.5

4. Spinach prefers which type of soil for optimal growth?

   a. Sandy b. Clayey

   c. Loamy d. Peaty

5. Spinach is primarily cultivated during which season in Nepal?

   a. Summer b. Monsoon

   c. Winter d. Spring

6. What is the main nutrient requirement for Spinach growth?

   a. Nitrogen b. Potassium

   c. Phosphorus d. Calcium

7. How long does it take for Broad Leaf Mustard to be ready for first harvesting after sowing?

   a. 25-30 DAT b. 50–60 DAT

   c. 60–75 DAT d. 80–90 DAT

Write short answer to the following questions.

1. Write the steps for nursery bed preparation for Broad Leaf Mustard. Why is it important?
2. Describe the field preparation and sowing methods for spinach cultivation.
3. Explain the symptoms, causes, and management of Alternaria leaf spot in mustard.

Write long answer to the following questions.

1. Discuss the detailed cultivation practices of Broad Leaf Mustard, including nursery bed preparation, manuring, irrigation, and pest management. Relate your explanation to Nepalese agricultural practices.
2. Elaborate on the common insect pests and diseases affecting Spinach and the integrated pest management (IPM) strategies used to control them, with a focus on sustainable farming techniques in Nepal.

Project work

Growth Comparison Experiment

Title: Effect of organic and chemical fertilizers on growth of broad leaf mustard or spinach.

To do:

a. Grow spinach/mustard plants in two small plots
b. Use organic manure (FYM/compost) in one plot and chemical fertilizers (NPK) in another.
c. Record observations weekly: germination rate, leaf size, plant height, and overall health.

After 4-6 weeks, compare the result

Outcome: A report comparing growth, showing photos/drawings, and suggesting which fertilizer works best for small-scale farmers.

Unit 8

Cultivation Practices of Solanaceous Crops

8.1 Chili/Capsicum

Introduction

Chili (*Capsicum frustescens.*) and capsicum (*Capsicum annuum*, bell pepper) are essential vegetables grown for their culinary and commercial importance. Chilies are valued for their pungency and spiciness, while capsicums are known for their sweet flavor and vibrant colours. Spiciness in chilly is due to the compound called capsaicin. Capsaicin may have potential health benefits, including anti-inflammatory properties. Both crops are rich in vitamins A, C, and E, antioxidants, and minerals, making them a staple in diets worldwide. They contain minerals such as potassium, magnesium, and iron. In Nepal, these crops are cultivated for domestic consumption and export, supporting the livelihoods of numerous farmers.

Origin and Distribution

Chilies and capsicums are native to Central and South America and were introduced to Asia by Portuguese explorers in the 15th century. Over time, these crops adapted to diverse climates and became integral to various cuisines. In Nepal, they are widely grown in the Terai plains, mid-hills, and urban fringes. Districts such as Chitwan, Makwanpur, Kathmandu, and Dhading are significant producers. Capsicum, in particular, is also cultivated in controlled environments like polyhouses for higher yields.

Uses

Chilly is cultivated for vegetables, spices and pickles. Green fruits are good sources of vitamin A and C.

Capsicum or sweet pepper or simla mirch or bell pepper bears bell shaped, non-pungent, mild and thick fleshed fruits. Green fruits are used as vegetables because they are less pungent.

The pungency in chilly is due to crystalline volatile alkaloid capsaicin, which has good export potential. The red colours of chilies are due to the presence of pigment capsanthin.

Varieties

Several chili and capsicum varieties are cultivated in Nepal, depending on climatic suitability and market demand:

- Chili Varieties: Jwala, Karma 777, Anna 3, Big mama 3, Omega, Super tara, Marshal, Karma 747, Nepa Hot, Aakash, Premium, Fire Camp, Hot Shot etc.
- Capsicum Varieties: California Wonder well, Sagar, NS 632 F1

Soil and Climate

Chilly is very sensitive to frost. The optimum temperature for fruit set is 24°C. When night temperature goes below 10°C, the fruit set is restricted. Comparatively milder climatic conditions are preferred for sweet pepper cultivation as compared to hot pepper. Temperature above 23.5°C affects the development of fruit adversely. Fruit weight, length, girth, pericarp thickness and number of seeds per fruits were high at 25°C/18°C day and night temperature. In Nepal, these crops are grown during summer in the mid-hills and year-round in controlled environments like polyhouses Rainy season is the main season for chilly cultivation while it might be cultivated in summer and winter season also. Rainy crops are planted in the month of Ashar to Shrawan, winter crop in the month of Ashwin to Kartik and summer crop in the month of Magh to Falgun.

Chilly can be grown on all types of soils from light sandy to heavy clay. The optimum soil pH is 5.8-6.5. Chilly crops are very sensitive to waterlogging.

Nursery Raising

The sandy loam and loam soils rich in organic matter are suitable for the nursery. In soil with good tilth 10-12 beds of 15 cm raised nursery beds of 3m length and 1 m width are prepared. 15 kg FYM and 500g of N:P:K (15:15:15) complex fertilizer along with 7.5g carbofuran per bed is incorporated. The beds are drenched with captan or any systemic fungicide @ 2-3 g/liter of water. Seeds are sown thinly in rows 6 cm apart and 2.5 mm deep. The beds are covered thinly with straw or grass layer and irrigate with rose-cane. On germination (10-12 days) the beds are again drenched. After the appearance of first true life seedlings are thinned out. On the 20th day Monocrotophos or any systemic insecticide (1.5-2 ml) and on 25th day mancozeb are sprayed. During the last week of nursery, the seedlings may be hardened by slightly withholding water for better establishment of seedlings. The seedlings with 5-6 true leaves are transplanted after 30 days. About 1.0-1.5 kg seed is sufficient for one hectare area.

Transplanting

When seedlings attain the height of 8-12 cm having 5-6 true leaves, these are ready to transplant in the already prepared field. Normally transplanting is done in the evening hours. The field should be irrigated immediately after transplanting and then frequent irrigations are made until the establishment of seedlings. Spacing depends upon the type of variety and season. The optimum spacing is 60 X 45 cm. Spacing should be increased and decreased as per the fertility status of the soil, favorability of the environment.

Manure and Fertilizer

The entire quantity of FYM or compost (200-250 q/ha) is incorporated at the time of first plowings. 25 kg Carbofuran per hectare is also applied. Generally, 80-100 kg N, 40-50 kg P and 40-50 kg K are required for one hectare area. Half dose of N and full dose of P and K is applied as basal, and the remaining half dose of N is applied as top dressing at 30 days after transplanting.

Irrigation

Chili requires frequent irrigation. However, excess irrigation may lead to more vegetative growth and less fruiting while water deficiency leads to reduction in fruit setting. The first irrigation is applied soon after transplanting. The subsequent irrigations are made at 8-10 days interval or as per requirement of the crop.

Inter-Cultural Operation and Weed Control

For raising a successful crop, gap filling, hoeing and mulching is required. Generally during summer and rainy season 6-8 DAT there is mortality of seedlings. In order to maintain adequate plant population, gap filling is essential. Gap filling is done in the evening and soon after the field is irrigated. Pre-transplant surface application of Alachlor (1-1.5 kg) or Oxadiazon (1.0 kg) and post-transplant spraying of Metribuzine (0.5 kg) controls the weed very effectively.

Harvesting

Chilies and capsicums are harvested at different stages, depending on their use. Chilies can be picked green or red, while capsicums are harvested when they attain full size and desired colour (green, yellow, or red). Multiple pickings are required due to uneven fruit ripening. Harvesting is done carefully to avoid damaging the plants.

The yield of green chillies in Nepal is 50-60 quintal/ha in rainfed and 200-300 quintal/ha in irrigated land. For dry chillies, the yield is 5-6 quintal/ha (rainfed) and 20-30 quintal/ha in irrigated land.

Storage and Marketing Pre- and Post-Harvest Handling

Green chili and capsicum should be harvested at full maturity stage. Green chili and capsicum are usually tight filled in gunny bags and sent to the local wholesale markets and also transported to long distance markets.

When chilly is used as dry red chili, harvesting the crop when the pods are well ripened and partially withered in the plant itself gives superior produce with

better pungency and colour retention properties. The ideal thing to do would be to keep the harvested pods in heaps either indoors or in shade ways from direct sunlight for 2-3 days so as develop uniform red colour.

To get uniform and quick drying pods must be spread out in the drying yard in layer of 8-10 cm. Frequent strings should be practiced avoiding mold growth and discolouration. Unless the pods are dried properly, they may lose their colour, glossiness and pungency. To avoid microbial activity and aflatoxins, the moisture in the dried pods should be less than 10%. Sun drying takes about 5-15 days depending on the day temperature and humidity. Improved drying system includes drying using air blow drier at 44-46 ºC and to dry very solar drier. However, it is extremely difficult to dry very large quantities of chilies through these methods.

Common Insect Pests and Diseases

Insect-Pests

1. Fruit Borer (*Helicoverpa ormigera*)

The fruit borer is a common insect pest that damages chili fruits by boring holes and feeding inside. The most common fruit borer in chili is Helicoverpa armigera. It causes loss in yield and reduces the market value of the chilies.

Symptoms of Damage

The main symptom of fruit borer damage in chili is the presence of holes on the fruit surface, often with excreta (waste) around the entry point. The larvae of this insect feed inside the fruit, causing rotting, drying, or premature fruit drop. Damaged fruits become unfit for sale or consumption. They also feed on flowers, flower buds, and young tender fruits.

Management Methods

- Grow tall varieties of marigold as intercrop in a row after every 14 rows of tomato to attract the insects.
- Spray Spinosad (0.05%) at 10 days interval starting from flowering stage.

Diseases

A. Fungal Diseases

1. Damping Off (*Pythium sp., Rhizoctonia sp., Fusarium sp., Phuotophthora parasitica*)

Damping off is a fungal disease, which attacks plants at their seedling stage.

Symptoms of Damage

It affects the collar region of seedlings. The rapid shrinking and rotting of collar region is the main symptom that we see in the seedlings affected by this disease. In the later stage, the seedlings affected by this disease, topple down.

Management Methods

- Provide proper drainage facility to avoid stagnant of water.
- Deep ploughings during summer.
- Thin sowing of seeds to avoid overcrowding.
- Seed treatment with Bavistin @ 2g/kg of seed.

2. Fruit Rot, Dieback and Anthracnose (*Colletotrichum capsici*)

Fruit rot of chili is a common fungal disease that causes the decay and rotting of chili fruits, especially during the rainy season. It is mainly caused by fungi like *Colletotrichum capsici* and *Phytophthora* spp. The disease leads to soft, sunken, and dark spots on fruits, making them unfit for market and reducing yield.

Symptoms of Damage

Black water-soaked spots appear on the leaves which gradually turn brown to black in colour. Dieback is usually observed after the rains have stopped and prolonged deposition of dew of the plants.

Management Methods

- Use disease-free seeds.
- Treat the seed with Bavistin 2g/kg of seed.

- Spray the crop with dithane M-45 @ 0.25% at 15 days interval starting from the appearance of disease.

B. Bacterial diseases

3. Bacterial Leaf Spot (*Xanthomonas campestris pv. vesicatoria*)

Bacterial leaf spot is an important bacterial disease that affects chili plants, especially in warm and humid conditions. It can spread quickly in the field and impact chili production.

Symptoms of Damage

The important characteristics of the disease is the development of small dark and greasy spots on the leaves, petioles and stems and water-soaked spots on the green fruits. Spot remain light brown and slightly sunken towards the center.

Management Methods

- Use disease free seeds
- Seed treatment with hot water at 50 ºC for 25 minutes.
- Remove the affected plants.
- Spray Streptocyclin 200 ppm + copper oxychloride (0.03%) thrice during

Ashwin-Kartik.

C. Viral Diseases

4. Leaf Curl

Leaf curl virus is a major viral disease of chili that affects plants mainly in warm climates. The occurrence of this disease is favored by high temperature and low humidity. It is commonly spread by insects like whiteflies. The disease can lead to poor plant growth and a significant reduction in yield.

Symptoms of Damage

The major symptoms of this disease are curling of leaves and crowding together.

Stunted growth of plants, infected leaves turn pale are other symptoms of this disease. The infected plants produce more stunted lateral branches resulting in bushy growth.

Management Methods

- Rouge out infected plants.
- Uproot the weeds.
- Raise nurseries in disease free areas.
- Treat the nursery beds before sowing with furadan @ 1 kg/ha.
- Spray Dimethoate (0.05%) at 10 days interval.
- Spray border crops like maize about 2 months before transplanting.

5. Mosaic Virus

The mottling of leaves and formation of dark green patches on the leaves are the characteristic symptoms. The growth of infected plants is stunted and bears very few fruits. The virus is sap transmitted and seed borne.

Management Methods

- Follow clean cultivation.
- Select virus free seeds.
- Follow crop rotation excluding potato, brinjal, chilly etc.
- Give hot water treatment at 50 ºC at 30 minutes to the seed.

1.2 Tomato

Introduction

Tomato (***Solanum lycopersicum***) is one of the most important vegetable crops of the world being cultivated in tropical, sub-tropical and temperate climatic regions. It is an annual crop being cultivated in the winter season. It is being cultivated in all 77 districts of Nepal. It has a great economic importance among Nepali farmers as it can be produced both as on-season and off-season vegetables.

Origin and Distribution

The tomato originated in South America, and was domesticated by ancient civilizations in Central and South America. In Nepal, tomatoes are cultivated across various agro-climatic zones, from the Terai plains to the mid-hills and even high-altitude regions under protected cultivation. Districts like Dhading, Kavre, Chitwan, and Makwanpur are among the major tomato-producing areas.

Uses

Tomatoes can be eaten as ketchup, pickle, powder soup, raw as salad, etc. Its powder can also be used as a colouring pigment in different food items. It can also be cooked by mixing it in different vegetables.

Nutrition

Tomato is very rich in vitamin C. It contains a pigment called lycopene which is very useful for human beings to prevent cancer. It also contains carbohydrates, protein, minerals and different other vitamins.

Climate and Soil

Tomatoes grow well in warm and dry weather. Ideal temperature for its successful growth and development is 20-24°C.

Day and night temperature affect the seed germination, growth and development of plants, flowering and productivity. High numbers and quality of fruits are produced if the day temperature is 25°C and night temperature is 15-20°C. If

the temperature is more than 32°C, fruit is reduced. Also, lycopene formation is reduced at this temperature.

Tomatoes can be successfully grown in sandy to clayey soil. But fertile loamy soil with a high amount of organic manure is ideal for tomato cultivation. Soil pH 6.0-7.0 is ideal. If the soil has less pH, calcium deficiency may be seen in fruits.

Varieties

Based on growth and flowering type, tomato varieties are classified into two types.

Determinate varieties	Indeterminate varieties
– Determinate varieties are shorter in height than indeterminate varieties. – Generally, they are early season varieties. – Synchronized flowering occurs which helps to harvest fruits at one time. – Varieties Roma Pusa Early Dwarf NS 2535 NS 815, etc.	– Indeterminate varieties are taller than determinate varieties. So, it requires staking. – Generally, they are late season varieties. – Flowering and fruiting occurs continuously until the plant dies. – Varieties Srijana F1 Bishesh Nabin 2000

The important varieties of tomato that are being cultivated in Nepal are listed below.

– Pusa Ruby
– Roma
– NS 2535 F_1
– Minto F_1

– Monprecos
– Bhim
– NCL 1
– Sriana, F1
– Gaurav 555, F1
– Surya 111 F_1
– Nova F_1
– Sworaksha F_1
– Amita F_1
– NS 815, F_1

Planting Time for Seasonal and Off-Seasonal Tomato Farming

Planting time is affected by climatic conditions of any particular place and the variety of tomato to be cultivated. Depending upon the climatic condition and variety, planting time for tomatoes differs from region to region.

S.N.	Region	Planting Time	Harvesting time
1.	High hills	Chaitra-Baisakh	Asaar-Bhadra
2.	Mid hills	Magh-Falgun	Baishak-Asaar
3.	Terai	Bhadra-Asoj	Mangsir-Falgun

Seed Bed Preparation

For the seed bed preparation, the field should be thoroughly plowed, harrowed and planked. Soil should be made fine. Then, application of well rotten FYM, compost and synthetic fertilizers should be applied at appropriate amounts. The bed should be raised up to 15-25 cm, width should be 1 m and length should be made as per the requirement. To keep the seedlings away from fungal diseases, seed beds should be treated with 2-3 grams per liter of bavistin or blitox. Also, to keep the bacterial diseases away streptomycin should be applied in the seedbed.

Seed sowing should be done at appropriate depth and spacing (Depth: 2cm, Spacing 5cm×5cm). After that, the seeds should be covered by soil slightly. Then, the seed bed should be covered by mulching material (paddy straw or any other organic mulching material). Irrigation should be done right after mulching and should be done regularly until the seedlings are well established in the seed bed.

Generally, seedlings are ready to transplant in 20-22 days when they produce 3-4 leaves if they are given proper care.

Field Preparation

Thorough plowing of land to the depth of around 25-30 cm should be done. After plowing, harrowing and planking should be done to pulverize the soil and level it. Fertilizer applications should be done at the time of field preparation. Ridges on the field should be made with a height of 25-30 cm, width of 120 cm, and length as per the requirement.

Manuring

FYM: 50-60 doka per ropani

NPK:- 10:6:5 kg per ropani

FYM with full dose of DAP and Potash and half dose of Urea should be applied during the field preparation. All the manures should be thoroughly mixed in the soil. The remaining half dose of Urea should be further splitted into two doses and should be applied after 25 DAT (Days after Transplantation) and 45 DAT in ring shape. Thus, applied urea should be covered by soil and then irrigation should be given.

Seed Rate and Transplantation

For one ropani field, it requires about 1000 plants. For 1000 plants, we just need 5g seed to be sown in a nursery. During seed sowing in a nursery, seed should not be sown dense. In 21 days after sowing, seedlings get ready to transplant. Healthy seedlings with 3-4 leaves are best to transplant in the main field.

For off-season tomato farming, it is better to prepare seedlings in a polybag rather than in a nursery bed.

Transplanting should be generally done in the early evening. Irrigation should be immediately given on the transplanted seedling. Also, irrigation should be followed regularly until the seedling stands still in the main field.

Irrigation

Initial irrigation should be given regularly to transplanted seedlings until the seedlings stand still on the field. After that, irrigation should be given at a certain day's interval depending upon the amount of moisture present in the soil.

Irrigation also depends upon the type of tomato farming. If the tomato is farmed under a plastic tunnel, it requires regular and less irrigation than the tomato farmed in open condition. Also, irrigation depends upon the season. In winter irrigation should be given in 10-15 days interval while in summer irrigation should be given in 3-4 days interval.

Staking

Staking is important for both determinate and indeterminate types of tomato varieties to stay upright. It supports tall tomato plants to grow to optimum height and helps in increasing yield.

For tall and indeterminate varieties staking stick should be of height about 2 m and for dwarf varieties staking stick should be of height of about 1 m. Staking sticks are tied with 3-4 layers of horizontal sticks depending upon the height. Generally, bamboo sticks are used for staking in open fields and plastic tunnels. In high tech tunnels we can use different nylon strings for staking tomatoes.

Pruning

Pruning helps tomato plants to acquire the required amount of sunlight and also helps in air circulation. This makes plants healthy and helps in producing fruits of good quality, shape and colour. Pruning is a must for indeterminate tomato varieties to get good yield.

Proper Pruning Techniques

1. Remove all the suckers and their leaves below the first flower cluster.
2. Leave the thicker shoots/suckers.
3. Remove yellow leaves
4. Top the plant.

Maximum of two main branches can be kept for growing. First training should be generally done when the plant has 6-8 leaves and should be continued until the plant stops its growth.

Weeding and Manuring

After 10-15 days of transplanting, if the soil is not so loose around the plant, it should be made loose by slightly harrowing the soil about 5cm deep. Loosening soil also removes weed from the field.

After 20-25 DAT split dose of urea should be applied to tomato plants by ring method. The remaining split dose of urea should be applied after 40-45 DAT, when flowering in the plants starts. Apart from it, *jholmal* can be applied (@1part *jholmal* : 5 parts water) after each round of harvesting.

Micro-Nutrients and Hormones

Application of micro-nutrients and hormones starting from the sowing of tomato seed is essential for the proper growth, flowering and fruiting of tomato.

In nursery bed, application of Puma 555 when the seedling acquires 2 leaves @ 2g/liter water with Zitlex or Multiplex or Agromin @ 2g/liter water in mixed solution helps in proper growth of seedlings. Also, application of Etonic @ 1ml/ 5liter water or H.B. 101 @ 2 drops/liter water in seedlings increases the capacity of seedlings to withstand the transplanting shock.

After transplanting, application of Vegimax @ 1ml/ 3 liter water in a 15 days interval increases the tomato yield.

During the flowering period, application of Miraculin @ 1ml/ liter water in a 15 days interval increases flowering and quality of fruits.

Harvesting

The harvesting stage of tomato depends on several things such as uses and market.

Different harvesting stages of tomato.

1. **Mature Green Stage**

   At this stage, the tomato is fully grown, but it is still green and firm. These tomatoes are not yet ripe and should not be harvested until they have reached their mature stage.

2. **Breaker Stage**

   At this stage, the tomato begins to change colour from green to light pink or yellow. The fruit is still firm but has started to soften slightly. Tomatoes at this stage are usually harvested for long-distance shipping, as they can ripen during transportation.

3. **Turning Stage**

   At this stage, the tomato has turned completely from green to its final colour. Tomatoes at this stage are usually harvested for local markets or for processing.

4. **Pink Stage**

   At this stage, the tomato is fully ripe and has a deep, rich colour. The fruit is soft and has a high sugar content, making it ideal for fresh eating. Tomatoes at this stage are typically picked and sold at farmers' markets or harvested for home use.

5. **Red Stage**

   At this stage, the tomato is fully ripe and has a bright red colour. The fruit is very soft and has a very high sugar content, making it ideal for fresh eating. Tomatoes at this stage should be picked up and used immediately, as they will not last long before spoiling.

Yield

Open pollinated varieties- 1500-2500 Kg/ ropani

Hybrid varieties – 4000 kg/ropani

Diseases of Tomato

1. Damping off

Causal Organism: ***Pythium*** spp, ***Fusarium*** spp, and ***Rhizoctonia*** spp.

Damping off typically occurs in the early stages of tomato seedling growth, either when seeds are germinating or shortly after germination.

Symptoms of Damage

Pre-emergence damping off occurs when seedlings fail to emerge from the soil, or they emerge weak and spindly before collapsing.

Post-emergence damping off occurs when seedlings that have already emerged may display symptoms such as thinning of stems, wilting, and a water soaked appearance at the base of the stem. As the disease progresses, seedlings may become discoloured, shriveled, and eventually die. A common symptom is the presence of a thin, white or brown fungal mycelium on the affected seedlings.

Management Methods

- Seed treatment with bavistin, captan or thiram.
- Seed-bed treatment with bavistin.
- Raising of seed-bed high if there is high presence of moisture in soil.
- Proper spacing should be maintained while sowing seed.

2. Early Blight

Causal Organism: *Alternaria solani* (fungus)

Symptoms of Damage

- Circular, dark brown lesions with concentric rings on leaves. Often starts at the bottom of the plant.
- Dark lesions on leaves, stems, and fruit. Leaves may be yellow and wither.

Management Methods

- Crop rotation

- Pruning lower leaves
- Maintaining good plant hygiene.
- Fungicide applications such as spraying of Blitox-50 or Dithane M-45 at 10 days interval.

3. Late Blight

Causal Organism: *Phytophthora infestans* (fungus)

This disease is more likely to occur when there is a high amount of relative humidity in the environment. The growth of this fungus can easily start if there are 2-3 days of foggy weather.

Symptoms of Damage

- Brown lesions on leaves with a white, fuzzy growth on the underside.
- Rapid leaf yellowing, wilting, and fruit rot. Can spread quickly.

Management Methods

- Clean cultivation techniques: Removal and destroyal of weed, crop residue, etc.
- Crop rotation
- Fungicide application: Application of fungicides such as Blitox-50 or dithane M-45 should be done at 10 day's interval if there is any sign of blight is seen.

4. Bacterial Wilt

Bacterial wilt is a serious and destructive disease of tomato that commonly occurs in warm and moist conditions. It spreads through soil and water, affecting the plant's ability to transport water. This disease can cause major losses in tomato production, especially in tropical regions.

Causal Organism: *Ralstonia solanacearum*

Symptoms of Damage

- Wilting and yellowing of lower leaves, often on one side of the plant.

- As the disease progresses, wilting spreads upwards from the lower leaves, and the entire plant may collapse and die within a short period.
- When the stem is cut near the base, a milky, viscous substance may ooze out, which is a diagnostic symptom of bacterial wilt.

Management Methods

- Use disease free seeds
- Crop rotation
- Use disease resistant varieties
- Clean cultivation
- Chemical treatments are not available for bacterial wilt, so some soil drenches with copper-based compounds may help protect healthy plants from infection in high-risk areas.

5. Tomato mosaic virus (ToMV)

The Tomato mosaic virus is a plant virus that primarily infects tomato plants, but it can also affect other plants in the Solanaceae family.

Causal organism: Tomato mosaic Virus (ToMV)

Symptoms of Damage

- Mosaic-like patterns on leaves, which are often light and dark green or yellow-green in colour.
- Leaf distortion, curling, and puckering.
- Reduced plant growth and stunted development.
- Irregular ripening and smaller fruit with uneven colouring.
- Death of infected tissue in severe cases.

Management Methods

- Clean cultivation
- Control of insects like aphids and whitefly should be done as these insects carry and transfer the disease from one plant to other plants.

- Remove and destroy infected plants as soon as symptoms appear to prevent the spread of the virus.

Insects of Tomato

1. White Fly

Whiteflies are tiny, white insects that feed on the undersides of tomato leaves.

Symptoms of Damage

- Yellowing of leaves.
- Reduced plant growth and vigor.
- Distorted or curling leaves.
- In severe infestation, whiteflies can transmit plant viruses, leading to disease symptoms.

Management Methods

- Yellow sticky traps can help monitor and trap adult whiteflies.
- Neem based pesticides such as Margosom and Econeem @ 0.003% can be applied at the initial stages when the insect infestation is not severe. Also, any other neem based insecticides can be applied @ 3-5ml/ liter water solution.
- If the infestation of white fly is high, chemical insecticides such as Emamectin benzoate can be applied @ 1ml/liter.

2. Aphids (*Myzus persicae*)

Aphids are small, soft-bodied insects that feed on the sap of tomato plants. These insects transmit viral diseases from one plant to the other.

Symptoms of Damage

- Curling leaves
- Yellowing of leaves
- Stunted growth
- Distorted fruits

Management Methods

- Use of natural predators such as ladybugs, lacewings, parasitic wasps, and predatory beetles.
- Use of insecticidal soaps or neem oil to directly spray aphids.
- Use of jholmal.
- Planting companion plants like marigolds near the tomato plants.
- Chemical pesticides: Spraying of Imidacloprid.

3. Leaf Miner

The tomato leaf miner (*Tuta absoluta*), also known as the South American tomato moth, is a destructive pest that primarily affects tomato plants and can cause significant damage to both leaves and fruit. Originally native to South America, it has spread to various parts of the world and has become a major concern for tomato growers.

Symptoms of Damage

- Larva bore tunnels in the tomato fruits.
- Serpentine mines are formed in tomato leaves.
- Yellowing of leaves.

Management Methods

- Regularly inspecting tomato plants for signs of infestation, such as winding tunnels and yellowing leaves.
- Crop rotation with non-solanaceous crops such as maize, beans, and cole crops.
- Clean cultivation.
- Use of microbial pesticides such as Bacillus thuringiensis var. kurstaki, Beauvaria bassiana, Heterorhabiditis bacteriophora, and Metarhizium anisopilae.
- Pheromone traps can be used for mass trapping or prevent reproduction which helps in reduction of pest population.

- Apply plant-based insecticide, such as neem oil.
- Apply chemical insecticide, such as spinosad.

4. Thrips

Thrips are tiny, slender insects that feed on tomato leaves and fruit, causing silvering, scarring, and distortion.

Symptoms of Damage

- Fruits, leaves, flowers, all are attacked by thrips.
- Attacked fruits show small necrotic patches on the surface affecting fruit quality.
- Distorted and curled leaves.
- Fruits may become deformed.
- Thrips feed on tomatoes at all stages, but their feeding on seedlings is particularly damaging.

Management Methods

- Use of predators such as ladybird beetles, and lacewings.
- Use of blue or yellow sticky traps.
- Spray jholmal.
- Spray insecticides such as Spinosad, Imidacloprid, etc. at appropriate concentration.

5. Leafhopper

Leafhoppers are small insects that can transmit diseases to tomato plants while feeding on their sap. They may cause yellowing and reduced growth.

Leafhoppers also transfer different plant diseases.

Symptoms of Damage

- White spots on leaves are seen by the removal of plant sap by insects.
- Curling, yellowing, or browning of leaf edges or tips.
- Reduced plant growth and vigor.

Management Methods

- Promote clean cultivation.
- Natural predators, such as ladybugs, lacewings, parasitic wasps, etc. can be used to help control leafhopper population.
- Insecticidal soaps and neem oil can be sprayed.
- For chemical control, malathion, spinosad, and imadicloprid can be sprayed.

6. Tomato Fruit Borer

Scientific Name: *Helicoverpa armigera*

The tomato fruit borer is a caterpillar or larval stage of a moth.

Symptoms of Damage

- Larvae bore holes in the tomato fruits.
- Larvae also feed on leaves and stems.
- Damaged fruits are unsuitable for consumption.

Management of Methods

- Regularly inspect tomato plants for signs of tomato fruit borer damage.
- Remove and destroy infested fruit to reduce the population.
- Practice crop rotation with non-solanaceous crops.
- Use of natural predators and parasitoids, such as parasitic wasps, to help control caterpillar population.
- Chemical control can be done by applying insecticides such as spinosad, cypermethrin, etc.

Physiological Disorders in Tomato

1. Blossom End Rot

It is a very common problem with green and ripe tomatoes. It appears as water-soaked spots on the blossom end of the fruit, which later enlarge and become black.

Causes

- Deficiency of calcium.
- High soil moisture and high temperature.
- Application of nitrogen in abundant quantities.

Management Methods

- Application of nitrogen fertilizer at appropriate dose.
- Give light and frequent irrigation to maintain optimum soil moisture.
- Spray crops with calcium chloride (0.5%) at the fruit development stage.

2. Cat-facing

The fruits get distorted and develop ridge, furrow indentations and blotches.

Causes

- Unfavorable climatic conditions during flowering cause distortion of growth of the pistil cells.

Management methods

- Cultivation should be done at an appropriate time.

3. Sunscald

The fruits exposed to intense sunlight develop yellow or brown patches. The affected tissue has blistered water soaked areas.

Management Methods

- Raise the crop with high density.
- Control defoliating diseases and pests timely.
- Avoid excessive training and pruning especially during summer months.

4. Fruit Cracking

The surface of mature green and ripe fruits cracks at the stem end. It is commonly observed during the rainy season.

Causes

- Long dry spell during the rainy season.
- Exposure of fruit to sunlight.
- Boron deficiency in soil.

Management Methods

- Maintain optimum soil moisture through light irrigation.
- Grow resistant varieties like Pusa ruby, Roma, etc.
- Spray borax @ 0.3 to 0.4% two to three times.
- Harvest the fruits before they ripe fully.

5. Puffiness

When the fruit attends about two thirds of the normal size, the growth of internal tissue retards whereas the outer wall develops normally. The affected fruits are light in weight, lack firmness and are partially filled. The disorder is common in the winter season.

Causes

- Lack of fertilization.
- Abortion of embryos after fertilization.
- High temperature and high soil moisture.

Management Methods

- Avoid over watering to crops.
- Applied recommended dose of nitrogen.

1.3 Potato

Introduction

Potato (*Solanum tuberosum*) is one of the most important vegetable crops worldwide and a staple food for millions. It is a widely consumed vegetable that plays an important role in the global food supply.In Nepal, potato cultivation holds significant economic importance, serving as a primary food crop and a cash crop in many regions, particularly in the mid-hills and high-altitude areas.

Origin and Distribution

The potato originated in the Andean region of South America, where it was domesticated by ancient civilizations over 8,000 years ago. Spanish explorers introduced it to Europe in the 16th century, and it spread globally as a vital food crop. In Nepal, potatoes are cultivated extensively across the Terai, mid-hills, and high mountains, with major production areas including districts like Kavrepalanchok, Ramechhap, Dolakha, and Mustang. The crop is cultivated year-round in the mid-hills and as a summer crop in high-altitude areas.

Uses

Potatoes are the king of vegetables. It is mainly used as curry. Preserved potatoes are very popular in the market as aalu chips, aalu bhujiya. It is highly consumed as aalu chop, aalu dam etc.

Nutritive value

Potatoes are a rich source of carbohydrates (22.6 g) while other nutrients like protein (1.6 g) and vitamin C (17 mg) are also present in the edible part of the potato.

Varieties

Several varieties of potatoes are grown in Nepal, depending on the region, altitude, and intended use. Commonly cultivated varieties include: Khumal Seto-1, Janakdev, Cardinal, Kufri Sindhuri, Desire, Khumal Rato -2, Khumal Laxmi, IPY 8, Khumal Ujjwal, Khumal Upahar, Khumal bikash, TPS 1, TPS -2, etc.

Climatic and soil requirement-

Potatoes are a cool season crop and require low temperature, low humidity and bright sunny days. The temperature for germination of tubers and satisfactory tuber growth is 25°C and 17-19°C respectively. A temperature above 30°C completely stops the tuber formation.

Potatoes can be grown on a variety of soil but well drained sandy loam to clay loam soils rich in organic matter having pH 5.5-7.5 are found best.

Manuring

Potato is a heavy feeder and thus needs a high dose of nutrients. Well rotten FYM @ 200-250 q/ha in the soil 3-4 weeks before planting is incorporated. Besides 100 kg N, 100 kg P, 60 kg K depending upon type of soil and fertility status should be supplied. 2/3 quantity of N and whole quantities of P and K should be applied at the time of planting. Apply the remaining dose of N at 30-35 days after planting *i.e.* at the time of first earthing up.

Time of Planting- The planting time of potatoes varies considerably from region to region. The main time of planting in high hills is falgun to chaitra, poush to magh for mid hills and asoj to mangsir for terai.

Method of Planting- The commonly used methods of potato planting are as follows:

1. Flatbed Method- It is commonly adopted in areas that have light sandy soil. The tubers are planted in flat beds in very shallow furrows. The method requires two earthing up. First at 30-35 DAS and second 25-30 days after first earthing up.
2. Furrow Planting- In this method tubers are planted in furrows (5-7 cm deep) and adopted in irrigated areas having light sandy soil. It needs ridging to 10-15 cm height soon after planting and then at 30-35 DAP.
3. Planting on Ridges- The ridges of 30 cm height are made at 70 cm spacing and tubers are planted opposite in these ridges.

Seed Size, Spacing and Seed Rate

Tubers, which have 25 g weight and 2.5-3.0 cm diameter are considered ideal for main crop planting. The seed rate depends upon the size of seed tubers and spacing. A medium size of tuber can be planted at 75 cm from row to row and 25 cm from plant to plant. Generally, 15-20 q seed tubers are required for one hectare area.

Cutting of Seed

Cut the large sized tubers into small pieces with the help of a disinfected knife. The main objective of cutting the seeds is to lower the cost of seed. During cutting keep 2-3 healthy eyes on the cut pieces. The average weight of the cut seed piece should be 30-40 g.

Irrigation

Being a shallow rooted crop, potatoes require light irrigation frequently. In general light soil should be irrigated at an interval of 8-10 days whereas heavy soils at 12-15 days. Light irrigation should be carried out when frost is expected. The critical stages for irrigation are germination, tuber formation followed by earthing up and tuber bulking appears at 10-12, 30-35 and 55-60 DAP respectively.

Weeding

Two manual weeding first at 15-20 DAP and second weeding-cum-hoeing at 30-35 DAP. The first weeding may be replaced by the use of herbicide but second weeding and hoeing at earthing is a must. The most common herbicide used to control weeds in potato are Fluchloralin (1.0 kg/ha) and Pendimethalin (0.5 kg/ha) used as pre-planting while Simazine (0.5 Kg/ha), Alchlor (1.0-1.5 kg/ha) applied as early preemergence and Paraquat (0.5 kg/ha) applied at early post emergence *i.e.* when more than 5% potato plants have just emerged from the soil.

Earthing Up

If potato tubers are exposed to sunlight, they will start to synthesize anthocyanin

and chlorophyll. The chlorophyll formation in tubers checks the accumulation of starch which results in small sized tubers with bitter in taste due to the presence of *Solanin.* Generally, two earthing is sufficient in flat bed planting. First at 30-35 DAP and second at 25-30 days after first earthing up. Irrigate the field lightly just after earthing.

Harvesting

The time of harvesting of potatoes depends on a number of factors, *viz.* variety, market price, weather condition, purpose for which crop is grown etc. Early varieties mature in 80 days, medium in 90-100 days and late in 100-120 days. Sometimes, the crops are harvested early to fetch high market prices and to facilitate the sowing of succeeding crops. Potatoes harvested at full maturity stage will have a better shelf life. Withholding irrigation about 15 days before the harvesting will harden the skin of tubers. The harvested tubers are allowed to dry in the open under shade.

Post-harvest Handling and Storage

Nearly one fifth of the total potato production in the country is used as planting material in the following season. Therefore, postharvest handling, particularly seed stocks, has become very important. After harvesting potatoes are kept in heaps in cool places for another 10-15 days for drying and curing skin. Heaps 3-4 meters long, wide at the base and 1 meter in the central height are the best. In hills the harvested potatoes are spread in well-ventilated rooms for drying. Before grading all the cut, damaged and rotted tubers are removed. The tubers are then graded and packed in gunny bags according to sizes preferably in 4 sizes, e.g. small (below 25 g), medium (25-50 g), large (50-75 g) and extra-large (above 75g). After grading potatoes meant for use as seed next year are treated with 3% boric acid solution for 30 minutes for protecting against soil-pathogens, e.g. black scurf, common scab etc. before storing them in the bags.

In plains the seed potatoes after drying, curing and grading are stored in cold stores where temperature is maintained at 2-4 ºC with high relative humidity.

The low temperature checks sprouting and rottage and high relative humidity reduces weight loss in tubers.

Value Added Products of Potato

Potatoes can be easily processed into dehydrated and canned products like-chips, french fries, finger chips, granules, disc, cubes, flour etc.

Marketing

Potatoes are semi-perishable and bulky therefore their transport over long distances is a problem. Often potatoes rot during transit because of high temperatures at the time of transportation. The problem is compounded further due to the shortage of transport wagons. The total cold storage capacity in the country is very low. The markets in potato producing belts in plains are also not properly integrated. Because of these factors marketing of potato is a complicated process and potato prices are prone to high fluctuations and often glut situations.

Insect Pests

1. Aphids (*Aphis gossypii* and *Myzus persicae*)

The nymph and adults suck the sap from tender parts of the plant. They also act as vectors for several viral diseases like potato mosaic, leaf roll virus etc.

Management Methods

- Use yellow sticky traps to monitor and reduce aphid populations.
- Remove heavily infested leaves or shoots.
- Avoid excessive use of nitrogen fertilizers.
- Encourage natural predators like ladybird beetles and lacewings.
- Spray neem oil (5 ml per liter) or soap solution (5 ml per liter) or jhol mal.
- If the infestation is severe, spray Imidacloprid or Thiamethoxam at recommended doses.

2. Potato Tuber Moth (*Gnorimoschema operculella*):

It is a serious pest of potato both in the field and storage. After hatching, the caterpillar bores and makes tunnels into the tubers.

Management Methods

- Select healthy and insect free tubers for planting.
- Cover the stored potato with Titepati plant.
- Proper earthing should be done so that tubers are not exposed to ovipositing female moth.
- Treat the gunny bags used for storage with Neem karnel extract at 10%.
- Spray the crop with Chlorantraniliprole, Flubendiamide, etc. if the infestation is found high.

3. Cutworms (*Agrotis ipsilon*)

Among the different spices of cutworm, the *Agrotis ipsilon* is the most common and devastating one. The caterpillars cut the young seedlings at the base near the soil.

Management Methods

- Practice deep ploughing before planting to expose larvae.
- Use light traps to attracts and kill adult moths.
- Collect and kill caterpillars manually in small fields.
- Apply neem cake in soil before planting.
- Spray or apply by drenching Cypermethrin or Deltamethrin.

4. White Grub (*Holotrichia insularis*)

The grub feeds on the roots and developing tubers and makes large holes. The adults feed on the foliage of trees and lay eggs in the soil.

Management Methods

- Follow clean cultivation. Plough the soil after the first rain to expose grubs and eggs.

- Rotate crops with non-host crops like pulses.
- Use light traps to control adult population.
- Use Metarhizium anisopliae (a fungus) to infect and kill grubs.
- Mix neem cake or neem powder in soil during field preparation.
- Spray Chlorantraniliprole 0.4% if the infestation is high.

Diseases (Fungal diseases)

1. Early Blight (c.o.- *Alternaria solani*)

The disease is characterized by the appearance of dead spots with concentric rings on the leaves. The fungus is soil borne and warm moist weather is favorable for the development and spread of disease.

Symptoms of Damage

The symptoms of early blight disease in potato begin with the appearance of small, dark brown to black spots on the lower, older leaves. These spots gradually enlarge and develop concentric rings, giving them a "target-like" appearance. As the disease progresses, the affected leaves turn yellow and dry up, starting from the bottom of the plant and moving upward. In severe cases, the disease can also affect stems and tubers, reducing the plant's vigor and overall yield.

Management Methods

- Grow resistant varieties like kufri sinduri, kufri jeevan etc
- Follow crop rotation
- Adopt phytosanitary measures
- Spray dithane M-45(Mancozeb), Dimethomorph etc. @ 0.25% at 10 days interval.

2. Late Blight (*Phytophthora infestans*)

Late blight is a devastating and the most common disease of potato that spreads rapidly under cool, moist, and cloudy conditions. It is caused by a fungus and is responsible for major crop losses worldwide. The disease can affect both leaves

and tubers, making it a serious threat to potato production. Late blight outbreaks can destroy entire fields if not controlled in time.

Symptoms of Damage

Circular or irregular water soaked spots appear on the leaves which soon turn to brownish black lesions. The lesions enlarge and coalesce, killing the entire leaves. Decayed leaves emit an offensive odor. This disease also affects tubers of potato. The tubers show irregular, sunker, and dark brown to purplish patches on the skin. When the infected tubers are cut open, the flesh underneath the spots shows brown, reddish, or grayish discolouration. In the advanced stages, the affected parts become soft and may rot due to secondary infections.

Control-

- Use healthy, disese free and certified seed tubers for planting.
- Locate resistant varieties like- Kufri jeevan, kufri alankar etc.
- Make four prophylactic sprays of Blitox-50 or dithane M-45 at 7 days interval.
- Spray the crop with dithane M-45 @ 0.25% at 15 days interval starting from the appearance of disease.

3. Wart (*Synchytrium endobioticum*)

It is a serious soil disease but restricted to only Darjelling hills and surrounding areas. The disease attacks all underground parts except roots. It is caused by a fungus that can survive in the soil for many years without a host plant. The disease mainly affects the growing parts of the plant, especially tubers.

Symptoms of Damage

The symptoms of wart disease in potato appear as irregular, cauliflower-like warty growths on the eyes, buds, and surface of tubers. These warts are whitish to green at first, but later turn brown or black as they decay. The affected parts become spongy and rotten, making the tubers unmarketable. In severe cases, the entire tuber may be deformed and destroyed, leading to significant yield loss.

Management Methods

- Follow quarantine measures
- Avoid potato cultivation on wart affected soil.
- Grow wart resistant varieties like Kufri jyoti, kufri jeevan.
- Soil sterilization should be done by copper sulphate or formaline before planting.

Bacterial Diseases

4. Bacterial Wilt (*Pseodomonas solanacearum*)

Bacterial wilt of potato is a harmful disease that lives in the soil and spreads easily in warm and wet weather. It is common in many parts of Nepal where potatoes are grown. The disease spreads through dirty tools, water, soil, and infected seed potatoes. It can cause a big loss in potato production and is hard to control once it starts.

Symptoms of Damage

Bacterial wilt is characterized by the appearance of wilting, stunting and yellowing of foliage followed by collapse of the plant. Browning of the xylem in the vascular bundles occurs. The infected tubers are discoloured. The pathogen is soil borne.

Management Methods

- Use healthy, disease free and certified seed tubers for planting.
- Follow at least 3 years of crop rotation with maize, cowpea, French bean etc.
- Treat the seed tubers with streptocycline solution @ 0.02% for 30 minutes before planting.

5. Soft Rot (*Erwinia carotovora* spp. *atroseptica*)

Soft rot of potato is a common and damaging disease that mostly affects potato tubers during storage or in the field. It is caused by bacteria that enter through cuts, wounds, or cracks on the tuber surface. The disease spreads quickly in warm

and wet conditions. Soft rot can cause heavy losses by making the potatoes soft, watery, and unfit for use.

Symptoms of Damage

The infected plants remain dwarfed and stunted. Leaves turned yellow and curled. Brown, black rotten areas develop on the base of the stem called black leg. The affected tubers become dark both inside and outside. The internal tissues become soft resulting in disintegration of the whole tuber. The pathogen is also prevalent in storage.

Management Methods

- Select disease free seed tubers for planting.
- Follow long term crop rotation.
- Uproot affected plants and destroy them.
- Treat the seed tubers in streptocyclin solution @ 0.01% before planting.

Viral diseases

6. Leaf Roll

It is affected by leaf roll viruses. The leaves of affected plants roll upward, turn light green in colour and become leathery in texture. It is transmitted through several species of aphids (*Myzus persicae*).

7. Mosaic Virus

Symptoms of Damage

The potatoes infected by this virus show mild mottling or light green colours. It is transmitted mechanically by the contact of disease plants and other farm implements.

Management Methods

- Select disease free seed tubers for planting.
- Uproot affected plants and destroy them.
- Before using tools, wash them with a 3% solution of tri-sodium phosphate.

Exercise

Choose the correct answer from the given alternatives.

1. Which nutrient is present in high amount in potatoes?
   a. Protein
   b. Carbohydrate
   c. Vitamin A
   d. Iron

2. Which is an example of indeterminate tomato variety?
   a. Roma
   b. Srijana F1
   c. Pusa Early Dwarf
   d. NS 2535

3. Which method of planting is commonly used for potatoes in sandy soil?
   a. Ridge planting
   b. Furrow planting
   c. Flat bed method
   d. Transplantation

4. Which pigment in tomatoes helps prevent cancer?
   a. Capsaicin
   b. Anthocyanin
   c. Lycopene
   d. Chlorophyll

5. Which potato disease shows concentric rings on leaves?
   a. Late blight
   b. Early blight
   c. Wart
   d. Bacterial wilt

6. What is the cause of blossom end rot in tomatoes?
   a. Nitrogen deficiency
   b. Calcium deficiency
   c. Iron deficiency
   d. Phosphorus deficiency

7. Which is a sucking pest of potato?
   a. Aphid
   b. Cutworm
   c. White grub
   d. Tuber moth

8. Which fertilizer management is done in split doses for potato?

a. Phosphorus
b. Nitrogen
c. Potassium
d. Calcium

9. Which disease of chilli shows small dark greasy spots on leaves?
a. Mosaic
b. Bacterial leaf spot
c. Damping off
d. Early blight

10. Which variety of chilli is commonly grown in Nepal?
a. Roma
b. Jwala
c. Srijana
d. Kufri Jyoti

11. What is the main cause of fruit cracking in tomatoes?
a. Excess nitrogen
b. Boron deficiency
c. Lack of sunlight
d. Calcium toxicity

Write short answer to the following questions.

1. What are the uses of potato and tomato as value-added products?
2. Differentiate between determinate and indeterminate tomato varieties with examples. Why is staking important in tomato?
3. Discuss the steps involved in nursery management and transplanting of tomato seedlings.
4. Explain the common physiological disorders of tomato and their management practices.

Write long answer to the following questions.

1. Discuss in detail the cultivation practices of Capsicum/chili, including nursery preparation, transplanting, irrigation, and pest management.
2. Describe the climatic and soil requirements for potato cultivation. Also, explain the suitable time of planting in high hills, mid-hills, and Terai region of Nepal.
3. Explain the common diseases and pests affecting solanaceous plants, their

symptoms, and integrated management strategies.

Project Work

Title: Identify Vegetable Pests

Instruction

Visit your school field or a nearby vegetable field. Observe any one insect pest (like aphid, whitefly, or fruit borer) attacking tomato, potato, or chilli. Task

a. Draw a simple diagram of the insect.

b. Write 3 points about the damage it causes.

c. Write 2 methods to control it.

Cultivation Practices of Bulb Crops

Unit 9

9.1 Onion

Introduction

Onion (*Allium cepa*), a crop from Amyrallidaceae family, is one of the most widely cultivated and consumed vegetables worldwide. It is valued for its pungent bulbs, which are used as a culinary ingredient in various dishes. Onions are rich in antioxidants, vitamins (such as C and B6), and minerals, making them a nutritious addition to diets. In Nepal, onions are a key cash crop, supporting both domestic consumption and local markets.

Origin and Distribution

Onion is believed to have originated in Central Asia, particularly in regions near modern-day Iran and Pakistan. From there, its cultivation spread to other parts of the world through trade and migration. Today, onions are grown in almost all regions with suitable climates. In Nepal, onion cultivation is concentrated in the Terai region and some mid-hill areas, where the climate and soil conditions favor their growth. Major onion-producing districts include Banke, Bardiya, Kailali, and Jhapa.

Uses

Onions are fundamental ingredients in many cuisines around the world. It can be consumed raw as salad. It can be pickled and can be powdered to be used as flavor.

Varieties

Several onion varieties are grown in Nepal, Some common are : Red Creole,

Suparex, TI 172, Venus F_1, Winter silver F_1, Nasik red (N-53), Baitadi Local, superex, etc.

Climate and Soil

Onion is a cool season crop, but it can perform well in mild climate without extreme heat and cold. It does not perform well in excessive rainfall regions. Before bulbing, temperature between 12.8℃-21℃ for at least 10 hours/day is required for proper bulb development. About 70% relative humidity is good for crops. Very low temperature in the beginning favors bolting.

In general, sandy-loam to clay-loam soils is recommended for this crop. Sandy soils need more and frequent irrigation and favor early maturity whereas; heavy soils give rise to misshapen bulbs. For good yield of quality bulbs deep, friable, well drained alluvial and loamy soils which are slightly acidic (pH 5.8 to 6.5) are considered best.

Sowing

Onion crops are raised through seeds or sets (small bulbs).

i. Raising Through Seed

In this method, sowing seeds is done in nursery bed. The nursery bed should be prepared well by plowing well, harrowing, and planking to make soil fine and levelled. It should be treated with Thiram or Captan at an effective dose. Application of fertilizers at recommended dose is very important during field preparation.

Seeds should be sown at a spacing of 5 cm between seeds and 2cm below the soil surface. Regular light irrigation is required for proper growth and development of seedlings.

The seedling become ready for transplantation within 6-7 weeks.

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The seedling become ready for transplantation within 6-7 weeks.

Field Preparation

Three to four plowing followed by harrowing and planking is required to make soil finely tilth before transplanting onion seedlings. Application of manures and fertilizers at recommended dose is also important during field preparation.

For onion transplantation, it is important to make plots of width 1m and length as per requirement.

Transplanting

Before plucking off the seedlings for transplantation, the nursery beds should be well irrigated. This makes easier to pluck off the seedlings without any injury.

Spacing for Transplantation:

Row to row: 15cm

Plant to plant: 10cm

Gap filling should be done one week after transplanting as some seedlings may die because of transplanting shock.

Light irrigation is required immediately after transplantation and should be continued daily until the seedlings get well established in the field.

Seed Rate: 500g/ropani

ii. Raising Through Sets (Small Bulbs)

This is generally done in case of a rainy season crop. In this method ridges and furrows are made at 40 cm spacing. The sets should be planted on the ridges at 15cm apart.

The onions planted through this method are ready to harvest earlier than through seedling method.

Manures and Fertilizers

FYM: 1500 kg/ropani

NPK: 12:9:4 kg/ropani

Nitrogenous fertilizer (Urea) should be applied in split doses.

Micronutrients such as sulphur, zinc, and copper are also essential for good harvest of the product.

Irrigation

In general, onion crops are irrigated at 10-15 days interval in winter and 6-7 days interval in summer. Withhold irrigation 15-20 days prior to maturity.

Onions when cropped in sandy loam soil require more frequent irrigation.

Weed control

- Different herbicides like Fluchloralin and Alachlor may be used to control the weeds.
- Weeding can also be done manually by shallow hoeing at 20-25 DAT and 40-45 DAT.

Harvesting and Yield

Raising through seedlings: 110 – 150 days after transplantation depending upon the varieties. Raising through sets: 60 – 70 days after transplantation. The crops are ready to harvest when the leaves turn yellow. For winter crop neck fall is another symptom of maturity. The mature bulbs are uprooted and left in the field as such for 2-3 days for curing. About 200-300 q/ha bulb yield may be obtained

from one hectare area.

Curing in Onions

Curing is the process of drying harvested onions to remove moisture from the neck (top part) and outer skin. Curing dries the skin of the onion protecting the onion from decay. This helps the onion to last longer during storage by preventing diseases like bacterial soft rot and neck rot.

Benefits of curing

1. It prevents rot and diseases. Drying necks and outer skin block entry of bacteria and fungi.
2. It improves storage life. Well cured onions can be stored for several months without spoiling.
3. It improves bulb appearance. The outer layers become dry and papery, giving onions a neat look for market sales.
4. It reduces weight loss during storage. The moisture loss during storage is minimized after curing.

Steps of Onion Curing Process

1. Harvesting

- Gently pull-out onions from the soil.
- Avoid bruising, cutting, or damaging the bulbs.
- Do not wash the bulbs with water.

2. Field Curing (if the weather is dry)

- Lay onions in the field with bulbs exposed and leaves covering the bulbs.
- Let them dry in sunlight for 3 to 5 days.
- Turn them occasionally to dry all sides.
- Cover with straw or cloth in case of rain.

3. Shed Curing / Indoor Curing

- If the weather is rainy or humid, cure onions in a well-ventilated shed or room.
- Place them on mesh racks or hang them in bunches.
- Use fans or heaters (not too hot – around 25–30°C) to speed up drying.

4. Trimming

- After drying, cut the necks about 1 inch above the bulb.
- Also remove the roots and lose outer skin if needed.
- Be gentle to avoid opening the bulb to infection.

Note: Curing typically takes 7 to 14 days, depending on humidity, temperature, and bulb size. While curing we should avoid stacking the un-cured onions in bags or heaps. Also, we should avoid washing onions with water after harvesting. We should avoid curing in closed, humid rooms.

Physiological Disorders

1. Sprouting of Bulbs

It is the premature growth of green shoots from stored or field-matured bulbs. It is an undesirable physiological disorder especially when onions are stored for longer periods. Sprouting reduces the quality, shelf-life, and marketability of onions.

Causes of Sprouting:

- High moisture and humidity during storage.
- Higher storage temperatures (above 10-12 ºC)
- Immature harvesting of bulbs
- Improper curing of bulbs before storage
- Varietal susceptibility (some varieties sprout easily)
- Hormonal changes within the bulb during dormancy breakdown.

- Mechanical injuries that stimulate sprouting

Symptoms of sprouting

- Appearance of green shoots emerging from the neck region of the bulb.
- Progressive elongation of shoots reduces bulb compactness
- Softening of bulbs due to loss of storage reserves.
- Weight loss and shriveling of bulbs
- In advanced stages, bulbs become spongy and start to rot.
- Reduction in pungency and quality of onions.

Control Measures of Sprouting

- Select Sprout-resistant varieties, which are known for longer dormancy and storage ability (e.g. Pusa Red, Agrifound Light Red).
- Harvest onions when necks are fully bent and tops are dry.
- Avoid application of excessive nitrogen.
- After harvesting onions, proper curing should be done for 10-15 days in well ventilated, dry, shaded places.
- Ensure complete drying of the neck portion to seal off sprouting pathways.
- Maintain proper storage by keeping the temperature around 0-2 ºC for long term and 10-12 ºC with low relative humidity for short term storage.
- Application of Maleic Hydrazide (MH) at 2000-2500 ppm concentration 10-15 days before harvesting to inhibit sprouting.

2. Bolting

Bolting is the premature formation of flowering stalk in onions before the bulbs have matured. It is a physiological disorder caused by stress factors that induce the onion plant to switch from vegetative to reproductive phase early. It reduces bulb size, quality, and marketability.

Causes of bolting

- Higher exposure to prolonged low temperatures (10-15 ºC) at early growth stages induces flowering.
- Transplanting older seedlings. (i.e. greater than 8 weeks old)
- Sudden temperature fluctuations (warm to cold)
- Longer daylight hours after cold exposure.
- Some varieties are more prone to bolting.

Symptoms of bolting

- Premature elongation of the flower stalk from the center of the plant.
- Hard, woody stalk grows taller than the leaves.
- Reduction in bulb development as the plant diverts energy to flower production.
- Bulbs become small, hard, and fibrous.

For seed production purposes, bolting is desirable, but for bulb crops, it is a serious problem.

Management Methods

- Use bolting resistant varieties: e.g. Pusa Red, Arka Niketan, Agrifound Light Red, etc.
- Timely Planting: Adjust sowing/transplanting time to avoid vernalization period.
- Harden seedlings gradually before transplanting.
- Apply growth regulators like GA3 (Gibberellic Acid) at appropriate stages can reduce bolting tendency.

Diseases

1. Purple Blotch

It is a fungal disease of onion caused by *Alternaria porri*. It is one of the most destructive diseases which affect the foliar parts of onion. This disease especially

affects onion crops especially in warm and humid regions.

Symptoms of Damage

- Small, wet-looking spots appear on the older leaves first. These spots are oval or long in shape.
- The spots turn purple or dark brown in the middle with yellow edges.
- The spots grow bigger, and the leaf may bend, dry, or fall.
- Due to damaged leaves, photosynthesis reduces and ultimately the bulbs become small and weak.

Management Methods

- Give enough space between plants so the air can move easily.
- Crop Rotation: Do not grow onions in the same field every year.
- Avoid over irrigation.
- Remove and burn old, infected onion leaves after harvest.

2. Basal rot

Basal rot is a fungal disease in onion caused by *Fusarium oxysporum*. It affects the base (bottom part) of the onion plant, where the roots and bulb join.

Symptoms of Damage

a. The leaves turn yellow from the tip downward. Later, the leaves become dry and fall off.

b. The bottom of the bulb becomes soft and brown. If the bulb is cut open, the inside is brown and rotten.

Management Methods

- Maintain proper drainage system in the field to avoid water logging.
- Use healthy seeds and bulbs for plantation.
- Use Trichoderma viride or Pseudomonas fluorescens in the soil. This stops the fungus growth.

- The treatment of seeds and bulbs should be done before planting. For the treatment, fungicides like Carbendazim or Thiram can be used.
- Drench soil with Carbendazim 0.1% solution around infected plants.

3. Downy Mildew

Downy mildew is a fungal disease that mainly affects onions, garlic, and other related crops. It spreads easily in cool, wet, and humid conditions. The disease damages leaves, reduces bulb size, and lowers crop yield.

Symptoms of Damage

- Pale green to yellow spots appears on leaves.
- A gray fuzzy growth can be seen on the underside of the leaves.
- Leaves become curled, soft, and eventually die.
- Bulb growth is stunted or poor.

Management Methods

- Remove and destroy infected plants.
- Avoid waterlogging in the field by managing well-drainage system.
- Avoid using overhead irrigation.
- Avoid dense planting to improve air flow.
- Crop rotation: Do not plant onion in the same field every year.
- Spray fungicides such as metalaxyl, mancozeb, chlorothalonil, etc. if the plants are seen infected.

4. Bacterial Soft Rot

Bacterial soft rot is a common post-harvest disease in onions. It causes the bulbs to become soft, watery, and foul-smelling. The disease usually starts when onions are damaged during harvest or stored in wet, warm, and poor ventilation conditions.

Symptoms of Damage

- Soft, mushy tissue at the neck or bottom of onion bulbs.
- Foul smell from the rotting bulbs.
- Bulbs may look water-soaked and slimy inside.
- Infected bulbs collapse easily under pressure.

Management Methods

- Avoid injuring onions during harvest.
- Do not irrigate before harvest.
- Ensure good drainage in the field.
- Control insect pests (like onion maggot)
- Cure the bulbs properly after harvest.
- Remove infected or damaged bulbs before storage.
- Store in cool, dry, and well-ventilated areas.
- Avoid piling onions in large heaps.

9.2 Garlic

Introduction

Garlic (*Allium sativum*), a crop from Alliaceae family, is a popular bulbous vegetable and spice crop known for its pungent flavor and medicinal properties. It is widely used in culinary preparations, traditional medicine, and as a natural pesticide. Rich in sulfur compounds such as allicin, garlic is renowned for its antimicrobial, antioxidant, and immune-boosting properties. In Nepal, garlic is a staple ingredient in many dishes and holds significant cultural and economic importance, being cultivated extensively in various regions.

Origin and Distribution

Garlic is believed to have originated in Central Asia, particularly in regions encompassing modern-day Iran and Turkmenistan. Its cultivation spread to the Mediterranean and eventually across the globe through trade and migration. Today, garlic is grown worldwide in temperate and subtropical climates. In Nepal, garlic cultivation is prominent in the mid-hills and Terai regions, where climatic conditions favor its growth. Key garlic-producing districts include Dhading, Kavrepalanchok, Nuwakot, Chitwan, and Rupandehi.

Uses

- It is used as a flavoring agent.
- It can be used to make pickles.
- It has several medicinal uses.
- It is also used as a spice in different cuisines.

Varieties

Several garlic varieties are cultivated, differing in size, flavor, and adaptability: Indigenous garlic varieties such as Lekali are popular in Nepal for their strong flavor and adaptability to local conditions. Some improved cultivars like Rajikot Lasun-1, Rajikot Lasun-2, G-1, Agrifound white, Yamuna Safed, and G-282 are preferred for their higher yields and disease resistance.

Climatic and soil

It is a cool season crop. In high hills it is cultivated in spring season and in mid-hills and terai region it is cultivated in winter season. For the proper growth and development of this crop, 15-25 ℃ temperature is considered optimum. It can tolerate frost.

As it is underground crops, sandy loam soil is the best one for the proper development of bulbs. However, it can be successfully cultivated in a wide range of soil textures. It can be cultivated well in the soil with pH 5.0-7.0. While selecting the field for garlic cultivation, the field should have a good drainage facility.

Field Preparation

For field preparation, the field should be plowed 4-5 times to make soil fine. After plowing and harrowing, planking is required to level the field. Application of recommended dose of fertilizers is also essential while preparing field.

The field should be separated into different plots to make intercultural operations easy. Sunken plots are generally made to make the irrigation effective as it is cultivated in winter.

Manures and Fertilizers

The recommended dose of FYM is 1500 kg/ropani and NPK is 12:12:4 kg/ropani. Manures and fertilizers should be applied during field preparation.

Important Insects of Garlic

1. Onion Thrips (*Thrips tabaci*)

Onion thrips are tiny, slender insects (about 1 mm long) that suck the sap from garlic leaves. They are pale yellow or brown and move quickly when disturbed. These pests are very common in garlic fields, especially during dry, hot weather.

Symptoms of Damage

- Silvery or white streaks on leaves.

- Curling, drying, and stunted leaves.
- Small bulbs due to reduced photosynthesis.

Management Methods

- Keep fields weed-free and remove plant debris.
- Spray neem oil (5 ml per liter of water).
- Use insecticides like spinosad or acetamiprid in severe cases.

2. Onion Maggot (*Delia antiqua*)

Onion maggots are small white larvae (maggots) of a fly that lays eggs near garlic plants. The larvae feed on the roots and bulbs of garlic, causing plants to rot and die. They are a big problem in cool, moist soils.

Symptoms of Damage

- Plants turn yellow and wilt.
- Soft, rotten bulbs with foul smell.
- Plants are easily pulled out from the soil.

Management Methods

- Rotate crops with non-host plants.
- Use net covers to block adult flies.
- Destroy infected plants.
- Apply soil insecticide like chlorpyrifos if needed.

3. Cutworms (*Agrotis* spp.)

Cutworms are fat, grayish caterpillars that hide in soil during the day and feed at night. They cut young garlic plants at the base, making them dry up and die.

Symptoms of Damage

- Young seedlings cut off near soil surface.
- Wilted and dried plants.

Management Methods

- Handpick cutworms during evening.
- Clean field borders and weeds.
- Use light traps to catch adult moths.
- Spray cypermethrin if attack is severe.

Important Diseases of Garlic

1. White Rot (*Sclerotium cepivorum*)

White rot is a fungal disease that attacks garlic bulbs and roots. It survives in soil for many years and spreads rapidly in cool, wet conditions.

Symptoms of Damage

- Yellowing and wilting of leaves from tips.
- White, fluffy fungal growth at plant base.
- Tiny black sclerotia (fungal resting bodies) on bulbs.

Management Methods

- Rotate crops for 3–4 years.
- Use healthy, disease-free garlic cloves.
- Apply carbendazim or thiophanate-methyl as soil drench.
- Remove and destroy infected plants.

2. Purple Blotch (*Alternaria porri*)

Purple blotch is caused by a fungus that infects garlic leaves. It is common in warm, humid conditions and weakens plants by killing leaves.

Symptoms of Damage

- Purple spots with yellow borders on leaves.
- Spots enlarge, causing leaves to dry and die.
- Poor bulb development due to leaf damage.

Management Methods

- Provide proper spacing for good air flow.
- Avoid overhead irrigation.
- Spray mancozeb or chlorothalonil when symptoms appear.

3. Downy Mildew (*Peronospora destructor*)

Downy mildew is a fungal-like disease that attacks garlic during cool and wet weather. It spreads quickly and causes large yield losses if not managed.

Symptoms of Damage

- Pale green or yellow patches on leaves.
- Greyish-purple fungal growth on the underside of leaves.
- Leaves turn brown and die.

Management Methods

- Grow garlic in well-drained soil.
- Rotate crops and avoid planting garlic after onion.
- Spray metalaxyl + mancozeb as a preventive

Exercise

Choose the correct answer from the given alternatives.

1. Which pigment is most responsible for the pungent smell and taste of garlic?

   a. Capsaicin
   b. Lycopene
   c. Allicin
   d. Chlorophyll

2. What is the recommended spacing for onion transplanting?

   a. 45 cm × 30 cm
   b. 15 cm × 10 cm
   c. 30 cm × 10 cm
   d. 10 cm × 5 cm

3. Which of the following is a symptom of bolting in onions?

   a. Yellowing leaves
   b. Formation of flower stalk before bulb maturity
   c. Purple blotch on leaves
   d. Neck rot after harvesting

4. Which soil type is best for garlic cultivation?

   a. Sandy loam
   b. Heavy clay
   c. Waterlogged soil
   d. Rocky soil

5. Which of the following is a fungal disease of onion?

   a. Purple blotch
   b. Bacterial soft rot
   c. Downy mildew
   d. Both a and c

6. What is the primary symptom of purple blotch in onions?

   a. Yellowing of leaves
   b. Purple lesions with yellow halos on leaves
   c. Wilting of the plant
   d. Black rot of bulb

7. What is the main propagation method for garlic?

a. Seeds
b. Bulblets
c. Cloves
d. Tissue culture

Write short answer to the following questions.

1. Explain the steps and importance of curing in onions.
2. Differentiate between raising onion crops through seeds and through sets.
3. Write the climate and soil requirement for the cultivation of onion and garlic.

Write long answer to the following questions.

1. Explain in detail the nursery preparation, field preparation, and transplanting process of onions. Write about the recommended manures and fertilizers for onions and their application method.
2. Explain the harvesting methods of onions and garlic. What are the post-harvest activities that you will adopt after harvesting the bulb crops? Explain.

Project Work

Title: Comparative study of onion and garlic storage practices

Instruction: Conduct a Small Storage Experiment at Home/School:

a. Take 1 kg onions and 1 kg garlic bulbs.
b. Divide them into two groups for each crop (half kg each): Group A (Without Curing): Directly store after purchase or harvest. Group B (With Curing): Keep them under sunlight or well-ventilated place for 5-7 days before storing.
c. Keep both groups in the same place for observation (room temperature and dry place).
d. Observe the condition of both groups for at least 15 days.
e. Prepare an observation table like this:

	Group A					
Day	**Onion Condition**			**Garlic Condition**		
	Weight	**Rotting or Decay**	**Shrinkage /Drying**	**Weight**	**Rotting or Decay**	**Shrinkage /Drying**
1						
5						
10						
15						

	Group B					
Day	**Onion Condition**			**Garlic Condition**		
	Weight	**Rotting or Decay**	**Shrinkage /Drying**	**Weight**	**Rotting or Decay**	**Shrinkage /Drying**
1						
5						
10						
15						

– Prepare a final report of the project including

- Introduction to curing and storage of onion and garlic.
- Your experiment explaining steps and observation table.
- Result, explaining which group stored better and why?
- Conclusion and recommendation: What storage method do you suggest for small farmers in Nepal?

Unit 10

Cultivation Practices of Cucurbitaceous Vegetable

10.1 Bitter Gourd

Introduction

Bitter gourd (*Momordica charantia*), also known as bitter melon or "karela," is a tropical and subtropical vine widely grown for its edible fruit, which is known for its distinctive bitter taste. The crop is valued for its nutritional and medicinal properties, being rich in vitamins A and C, iron, and various antioxidants. It is often recommended for its role in managing blood sugar levels and blood pressure. It is especially prized in Nepalese cuisine for its health benefits, including its role in managing diabetes, improving digestion, and boosting immunity. It is eaten as cooked vegetable and can also be used to make pickles.

Origin and Distribution

Bitter gourd is believed to have originated in Southeast Asia, where wild forms of the plant are still found. Over centuries, its cultivation spread to Africa, the Caribbean, and other tropical regions. Today, bitter gourd is cultivated widely across Asia, including Nepal, where it is grown in both home gardens and commercial farms. In Nepal, the Terai and mid-hill regions are the primary cultivation areas due to their favorable climatic conditions.

Varieties

Several varieties of bitter gourd are cultivated. Some common types include: Hariyo Karela, Chandra, NS 454, NS 1024, NS424, Keshav777, Laxmi 555, Palee, Samridhdi, Komal, Peepal, Raman, Heera, CG-01, CG-02 etc.

Climate and Soil

Bitter gourd is a warm-season crop, requiring temperatures between 24°C and 30°C for optimal growth. It cannot tolerate frost and thrives in areas with adequate sunlight and moderate humidity. In Nepal, it is commonly grown during the summer and rainy seasons, though with irrigation and protection, it can also be cultivated in the spring.

Bitter gourd thrives in well-drained, fertile soils with a pH range of 6.0–7.5. Loamy or sandy-loam soils enriched with organic matter are ideal. The crop is sensitive to waterlogging, so proper drainage is essential.

Raising of Seedling

Seedlings of bitter gourd can be raised in poly-trays and polybags. For this, a proper media proper is essential by mixing appropriate amounts of peat moss or coco peat with soil and organic manure. One or two seeds can be placed into the media filled with poly-trays or polybags. Those seeds sown polybags or poly-trays should immediately be irrigated lightly to provide enough moisture in the media.

Seedlings get ready to transplant when the seedlings become around 1 month old.

Field Preparation

Field where bitter gourd is to be cultivated should be deeply plowed for 2-3 times. Plowing should be followed by harrowing and planking. After that ridges should be made of 250 cm width and length as per requirement. Within the ridges, pit should be made of size 30cm×30cm×30cm. Recommended dose of fertilizers should be applied into the pits and then covered with soil.

Manuring and Fertilization

Bitter gourd requires a nutrient-rich soil for healthy growth. Organic manure or compost at the rate of 20–25 tons per hectare is applied during land preparation. Basal doses of fertilizers such as urea, DAP, and MOP are incorporated into the

soil. The recommended NPK requirement for bitter gourd in Nepal is 100:50:50 kg per hectare. Additional nitrogen is supplied in split doses during the plant's vegetative and flowering stages. Organic options, such as vermicompost, are also effective.

Transplantation

For transplantation, seedlings get ready when the seedlings are at 2-3 true leaf stage or about one month old. In the ridge of 250 cm, seedlings should be transplanted in two rows maintaining the spacing of 150 cm between the rows and the spacing of 100cm between the plants.

Seedlings should be transplanted on the pit. Thus, planted seedlings should be irrigated immediately after transplantation. Also, irrigation should be done regularly until the seedlings get well established in the soil.

Irrigation

Requirement of irrigation depends upon the soil type, climatic condition, etc. Bitter gourd when cultivated as a rainy season crop does not require extra irrigation manually. But as a spring crop, it requires frequent irrigation at the interval of 7 days depending upon the soil moisture level.

Intercultural Operations

Weeding and hoeing are carried out regularly to remove weeds and improve soil aeration. Mulching with organic materials like straw helps retain soil moisture and suppress weed growth.

Staking

Staking is one of the most important intercultural operations. Staking should be given immediately when the plant height becomes more than half a meter. Bamboo sticks and plastic ropes can be used as staking materials to support the bitter gourd plants. The height of bamboo sticks should be 1.5 to 2 meters. Rope should be tied in the spacing of 30 cm.

Pruning

Pruning is another important intercultural operation. Non-fruiting old branches, old and diseased leaves, deformed and diseased fruits should be regularly pruned to get good quality fruits.

Harvesting

Bitter gourd is ready for harvest 60–70 days after sowing, depending on the variety. Fruits should be harvested when they are green and tender, as overripe fruits become too bitter and lose market value. Harvesting is done every 2–3 days by cutting the fruit pedicel slightly with the help of clean knife or scissors. Harvested products should be handled carefully because a slight injury to a fruit can damage the whole lot of fruits kept together.

Depending upon the variety, season of cultivation, and management skill, 1000-2500 kg bitter gourd fruits can be harvested from 1 ropani field.

Insects

1. Red Pumpkin Beetle *(Aulacophora foveicollis)*

Red Pumpkin Beetle is a reddish-orange beetle that attacks cucurbits, especially pumpkin and squash.

Symptoms of Damage

- Adult beetles feed on leaves, flowers, and tender shoots, creating round holes.
- Grubs feed on roots and underground parts.
- Seedlings may wilt and die.

Management Methods

- Handpick and destroy beetles early morning.
- Use neem-based insecticides.
- Apply Carbaryl or Malathion (if permitted).
- Practice crop rotation and remove weeds.

2. Spotted Cucumber Beetle *(Diabrotica undecimpunctata)*

It is a greenish-yellow beetle with black spots that attack cucumbers and other cucurbits.

Symptoms of Damage

- Adults chew leaves and flowers.
- Larvae feed on roots, reducing plant vigor.
- Can transmit bacterial wilt disease.

Management Methods

- Use yellow sticky traps.
- Spray Neem oil or Pyrethrin-based insecticides.

3. Aphid *(Aphis gossypii)*

Aphids are small, soft-bodied insects that attack cucurbit crops like bitter gourd, cucumber, pumpkin, bottle gourd, and others.

They are usually green, black, or brown in colour and are found in large groups on the underside of leaves, stems, and tender shoots. Aphids suck the plant sap, which weakens the plants and reduces yield. They also produce a sticky substance called honeydew which leads to the growth of a black fungus called sooty mold. They can also spread plant viruses like Cucumber Mosaic Virus (CMV).

Symptoms of Damage

- Curled and twisted young leaves are seen due to sap sucking.
- Sticky substance (honeydew) are seen on leaves and fruits.
- Growth of black and sooty mold are seen on sticky leaves and fruits.
- In the severe case, the plants get fully yellowed and stunted. This leads to poor flowering and fruit setting.
- If viruses are transmitted in the plants, the plants show yellow-green patches on the leaves. Also the fruits are found distorted with uneven colour or shape.

Management Methods

- Avoid use of excess nitrogen fertilizer, as it promotes soft growth attractive to aphids.
- Encourage natural enemies like lady bird beetles, lacewings, and parasitic wasps.
- Spray neem oil (5ml per liter of water) as an organic option.
- Spray jholmal @ 1:5 mixing with water in 7 days interval.
- If the infestation is severe, apply insecticides like imidacloprid, thiamethoxam, etc.

4. Fruit Fly *(Bactrocera cucurbitae)*

The cucurbit fruit fly is a harmful insect that attacks cucurbit crops like cucumber, pumpkin, bitter gourd, bottle gourd, and sponge gourd. It is most active in warm and humid weather.

Symptoms of Damage:

- Female flies lay eggs inside young fruits.
- Small holes or brown spots appear where the eggs are laid.
- Fruits become soft and rotten inside.
- Fruits become soft, yellow, or rotten from inside.
- Brown or black marks where flies laid eggs.
- Larvae (maggots) are found inside fruits.
- The fruits drop early and become unfit to eat or sell.

Management Methods

- Collect and destroy infected fruits.
- Encourage natural enemies like parasitic wasps.
- Use fruit fly traps (e.g., pheromone or protein bait traps).
- Spray organic insecticides (e.g., malathion bait spray).

5. Bugs

Bugs are a group of insects that have piercing and sucking mouthparts. They are different from chewing insects. In horticultural crops, bugs like stink bugs and leaf-footed bugs are common. They are medium sized insects that pierce plant parts and suck juice. These bugs attack fruits and vegetables by sucking the plant's juice.

Symptoms of Damage

- Fruits become deformed or scarred.
- Yellow spots on leaves and fruit.
- Bad smell (if stink bug).
- Premature fruit drop.

Management Methods

- Keep the field clean by removing weeds and old plants.
- Use light traps at night to attract and catch bugs.
- If infestation is high, spray botanical insecticides like neem oil.
- Apply Imidacloprid if the infestation is severe.

6. Root knot nematode *(Meloidogyne spp.)*

Root knot nematode are microscopic worms (too small to see with naked eyes) that live in the soil. They attack the roots of many vegetables, fruits, and other horticultural crops. Tomato, brinjal, chili, cucumber, pumpkin, gourds, beans, okra, spinach, flowers, and different fruit crops are affected by this pest.

They are called "root knot" nematodes because they cause swellings or knots on the roots. These knots stop the roots from absorbing enough water and nutrients.

Symptoms of Damage

- Roots have small knots or galls (swellings).
- Plants look yellow, weak, and stunted (do not grow properly).
- Leaves may wilt, even if the soil is wet.

- Poor fruit or vegetable production.
- Plants may easily fall over due to weak roots.

Management Methods

- Rotate crops with non-hosts like maize or wheat.
- Practice mixed-cropping marigold with the main crop.
- Use resistant or tolerant varieties.
- Practice deep plowing and drying of soil under the sun (soil solarization).
- Mix neem cake or mustard cake into the soil before planting.
- Use beneficial organisms like Paecilomyces lilacinus (a fungus that attacks nematodes)
- Apply chemical named Fosthiozate 500 SL (1 ml/liter water) in the soil before planting crops.

Diseases

1. Powdery Mildew (*Podosphaera xanthii* or *Erysiphe cichoracearum*)

Powdery mildew is a common fungal disease that affects the leaves and stems of bitter gourd. It occurs mainly in dry and warm weather.

Symptoms of Damage

- White powdery spots on leaves, stems, and young fruits.
- Leaves may turn yellow, dry, and fall off.
- Poor fruit development in severe cases.

Management Methods

- Grow resistant varieties if available.
- Provide good air circulation by proper spacing.
- Spray sulfur-based fungicides or neem oil.
- Use systemic fungicides like hexaconazole if the infection is severe.

2. Downy Mildew (*Pseudoperonospora cubensis*)

Downy mildew is a fungal-like disease that spreads rapidly in cool, moist conditions. It affects leaves and reduces photosynthesis.

Symptoms of Damage

- Yellow angular spots on the upper side of leaves.
- Greyish-purple fungal growth on the underside of leaves.
- Leaves dry and die early.

Management Methods

- Avoid overhead irrigation.
- Grow in well-drained soil.
- Spray fungicides like mancozeb or metalaxyl + mancozeb when symptoms appear.

3. Fusarium Wilt (*Fusarium oxysporium*)

Fusarium wilt is a soil-borne fungal disease that blocks water transport in plants. It thrives in warm, moist soils.

Symptoms of Damage

- Yellowing and wilting of leaves, starting from the bottom.
- Brown discolouration of stem tissues.
- Plants eventually die.

Management Methods

- Rotate crops for 3–4 years.
- Grow resistant varieties if available.
- Drench soil with fungicides like carbendazim.

4. Root Rot and Collar Rot (*Pythium* spp., *Rhizoctonia solani*)

These soil-borne fungal diseases attack the base of the stem and roots, especially in poorly drained soils.

Symptoms of Damage

- Soft, rotten tissues at stem base.
- Plants wilt and fall over.
- Roots are blackened and decayed.

Management Methods

- Plant in well-drained soil.
- Avoid overwatering.
- Apply Trichoderma-based bio-fungicides as a preventive measure.

5. Cucumber Mosaic Virus

Mosaic virus is a viral disease spread by aphids. It causes mottling and distortion of leaves and fruits.

Symptoms of Damage

- Mosaic or patchy light and dark green patterns on leaves.
- Distorted and twisted leaves and fruits.
- Poor flowering and fruit set.

Management Methods

- Control aphids using neem oil or insecticides.
- Uproot and destroy infected plants.
- Use virus-free seeds and resistant varieties if available.

10.2 Bottle Gourd

Introduction

Bottle gourd (*Lagenaria siceraria*), also known as "lauka," is a popular warm-season vegetable cultivated for its tender, edible fruits. Its elongated shape and light green skin are characteristic features, and it is highly valued for its culinary versatility and health benefits. Bottle gourd is low in calories and rich in water content, making it a favored vegetable in Nepalese households for its cooling and digestive properties.

Origin and Distribution

Bottle gourd is believed to have originated in Africa and spread to Asia and other tropical regions over centuries. It has been a staple crop in many cultures, with its use extending beyond food, such as making containers and musical instruments from dried gourds. In Nepal, bottle gourd is grown extensively in the Terai, mid-hills, and some high-altitude regions where suitable climatic conditions prevail.

Varieties

Various local and hybrid varieties of bottle gourd are cultivated in Nepal. Some common include: Anmol, NS421, Kaberi, NS443 etc.

Soil and Climate

Bottle gourd thrives in well-drained, fertile soils with a pH range of 6.0–7.5. Loamy soils enriched with organic matter are ideal for its cultivation. The crop is sensitive to waterlogging, so proper drainage is essential.

As a warm-season crop, bottle gourd requires temperatures between 20°C and 30°C for optimal growth. It is frost-sensitive and grows best in regions with adequate sunlight and moderate humidity. In Nepal, it is typically cultivated during the spring and summer seasons, although with proper irrigation and management, it can also be grown year-round.

Nursery Bed Preparation

For bottle gourd, seeds are sown directly in the main field or raised in nursery beds before transplanting. In the case of nursery-raised plants, beds are prepared by loosening the soil and enriching it with well-decomposed organic manure. Seeds are soaked overnight or treated with fungicides to improve germination. They are then sown at a depth of 2–3 cm and kept moist until germination.

Cultivation Practices

1. Sowing/Transplanting

Seeds are sown directly in the field or transplanted after 2–3 weeks when seedlings are strong enough. A spacing of 1.5–2 meters between rows and 1–1.5 meters between plants is maintained for optimal growth and aeration. Climbing varieties require trellises or stakes to support vine growth and improve fruit quality.

2. Manuring and Fertilization

Bottle gourd is a nutrient-demanding crop and requires ample organic and inorganic fertilizers. Organic manure or compost is applied at 20–25 tons per hectare during land preparation. Basal doses of urea, DAP, and MOP are incorporated into the soil, and additional nitrogen is supplied in split doses during vegetative and flowering stages. The recommended NPK ratio for bottle gourd in Nepal is 120:60:60 kg per hectare. Organic options like vermicompost and biofertilizers can also be used to enhance soil fertility.

3. Irrigation

Regular irrigation is necessary to maintain consistent soil moisture, especially during flowering and fruiting stages. However, care must be taken to avoid over-irrigation, as waterlogging can lead to root diseases. In Nepal, irrigation frequency depends on the season, with more frequent watering required during the dry summer months.

4. Intercultural Operations

Weeding and hoeing are essential to keep the field free of weeds and to improve soil aeration. Mulching with organic materials helps retain soil moisture and suppress weeds. Trellising or staking is vital for climbing varieties, which improves fruit quality and facilitates harvesting.

Harvesting

Bottle gourd is ready for harvest 50–60 days after sowing, depending on the variety. Fruits should be harvested while tender and green, as overmature fruits become fibrous and lose their market value. Regular harvesting every 3–4 days ensures continuous production. Fruits are cut using sharp tools to avoid damaging the vines.

Insects

1. Red Pumpkin Beetle *(Aulacophora foveicollis)*

Red Pumpkin Beetle is a reddish-orange beetle that attacks cucurbits, especially pumpkin and squash.

Symptoms of Damage

- Adult beetles feed on leaves, flowers, and tender shoots, creating round holes.
- Grubs feed on roots and underground parts.
- Seedlings may wilt and die.

Management Methods

- Handpick and destroy beetles early morning.
- Use neem-based insecticides.
- Apply Carbaryl or Malathion (if permitted).
- Practice crop rotation and remove weeds.

2. Spotted Cucumber Beetle *(Diabrotica undecimpunctata)*

It is a greenish-yellow beetle with black spots that attack cucumbers and other cucurbits.

Symptoms of Damage:

- Adults chew leaves and flowers.
- Larvae feed on roots, reducing plant vigor.
- Can transmit bacterial wilt disease.

Management Methods

- Use yellow sticky traps.
- Spray Neem oil or Pyrethrin-based insecticides.

3. Aphid *(Aphis gossypii)*

Aphids are small, soft-bodied insects that attack cucurbit crops like bitter gourd, cucumber, pumpkin, bottle gourd, and others.

They are usually green, black, or brown in colour and are found in large groups on the underside of leaves, stems, and tender shoots. Aphids suck the plant sap, which weakens the plants and reduces yield. They also produce a sticky substance called honeydew which leads to the growth of a black fungus called sooty mold. They can also spread plant viruses like Cucumber Mosaic Virus (CMV).

Symptoms of Damage

- Curled and twisted young leaves are seen due to sap sucking.
- Sticky substance (honeydew) are seen on leaves and fruits.
- Growth of black and sooty mold are seen on sticky leaves and fruits.
- In the severe case, the plants get fully yellowed and stunted. This leads to poor flowering and fruit setting.
- If viruses are transmitted in the plants, the plants show yellow-green patches on the leaves. Also the fruits are found distorted with uneven colour or shape.

Management Methods

- Avoid use of excess nitrogen fertilizer, as it promotes soft growth attractive to aphids.

- Encourage natural enemies like lady bird beetles, lacewings, and parasitic wasps.
- Spray neem oil (5ml per liter of water) as an organic option.
- Spray jholmal @ 1:5 mixing with water in 7 days interval.
- If the infestation is severe, apply insecticides like imidacloprid, thiamethoxam, etc.

4. Fruit fly *(Bactrocera cucurbitae)*

The cucurbit fruit fly is a harmful insect that attacks cucurbit crops like cucumber, pumpkin, bitter gourd, bottle gourd, and sponge gourd. It is most active in warm and humid weather.

Symptoms of Damage

- Female flies lay eggs inside young fruits.
- Small holes or brown spots appear where the eggs are laid.
- Fruits become soft and rotten inside.
- Fruits become soft, yellow, or rotten from inside.
- Brown or black marks where flies laid eggs.
- Larvae (maggots) are found inside fruits.
- The fruits drop early and become unfit to eat or sell.

Management Methods

- Collect and destroy infected fruits.
- Encourage natural enemies like parasitic wasps.
- Use fruit fly traps (e.g., pheromone or protein bait traps).
- Spray organic insecticides (e.g., malathion bait spray).

5. Bugs

Bugs are a group of insects that have piercing and sucking mouthparts. They are different from chewing insects. In horticultural crops, bugs like stink bugs and

leaf-footed bugs are common. They are medium sized insects that pierce plant parts and suck juice. These bugs attack fruits and vegetables by sucking the plant's juice.

Symptoms of Damage:

- Fruits become deformed or scarred.
- Yellow spots on leaves and fruit.
- Bad smell (if stink bug).
- Premature fruit drop.

Management Methods

- Keep the field clean by removing weeds and old plants.
- Use light traps at night to attract and catch bugs.
- If infestation is high, spray botanical insecticides like neem oil.
- Apply Imidacloprid if the infestation is severe.

6. Root Knot Nematode *(Meloidogyne spp.)*

Root knot nematode are microscopic worms (too small to see with naked eyes) that live in the soil. They attack the roots of many vegetables, fruits, and other horticultural crops. Tomato, brinjal, chili, cucumber, pumpkin, gourds, beans, okra, spinach, flowers, and different fruit crops are affected by this pest.

They are called "root knot" nematodes because they cause swellings or knots on the roots. These knots stop the roots from absorbing enough water and nutrients.

Symptoms of Damage

- Roots have small knots or galls (swellings).
- Plants look yellow, weak, and stunted (do not grow properly).
- Leaves may wilt, even if the soil is wet.
- Poor fruit or vegetable production.
- Plants may easily fall over due to weak roots.

Management Methods

- Rotate crops with non-hosts like maize or wheat.
- Practice mixed-cropping marigold with the main crop.
- Use resistant or tolerant varieties.
- Practice deep plowing and drying of soil under the sun (soil solarization).
- Mix neem cake or mustard cake into the soil before planting.
- Use beneficial organisms like Paecilomyces lilacinus (a fungus that attacks nematodes)
- Apply chemical named Fosthiozate 500 SL (1 ml/liter water) in the soil before planting crops.

Diseases

1. Powdery Mildew (*Podosphaera xanthii*)

Powdery mildew is a common fungal disease that affects the leaves and stems of bitter gourd. It occurs mainly in dry and warm weather.

Symptoms of Damage

- White powdery spots on leaves, stems, and young fruits.
- Leaves may turn yellow, dry, and fall off.
- Poor fruit development in severe cases.

Management Methods

- Grow resistant varieties if available.
- Provide good air circulation by proper spacing.
- Spray sulfur-based fungicides or neem oil.
- Use systemic fungicides like hexaconazole if the infection is severe.

2. Downy Mildew (*Pseudoperonospora cubensis*)

Downy mildew is a fungal-like disease that spreads rapidly in cool, moist conditions. It affects leaves and reduces photosynthesis.

Symptoms of Damage

- Yellow angular spots on the upper side of leaves.
- Greyish-purple fungal growth on the underside of leaves.
- Leaves dry and die early.

Management Methods

- Avoid overhead irrigation.
- Grow in well-drained soil.
- Spray fungicides like mancozeb or metalaxyl + mancozeb when symptoms appear.

3. Fusarium Wilt (*Fusarium oxysporium*)

Fusarium wilt is a soil-borne fungal disease that blocks water transport in plants. It thrives in warm, moist soils.

Symptoms of Damage

- Yellowing and wilting of leaves, starting from the bottom.
- Brown discolouration of stem tissues.
- Plants eventually die.

Management Methods

- Rotate crops for 3–4 years.
- Grow resistant varieties if available.
- Drench soil with fungicides like carbendazim.

4. Root Rot and Collar Rot (*Pythium* spp., *Rhizoctonia solani*)

These soil-borne fungal diseases attack the base of the stem and roots, especially in poorly drained soils.

Symptoms of Damage

- Soft, rotten tissues at stem base.
- Plants wilt and fall over.

- Roots are blackened and decayed.

Management Methods

- Plant in well-drained soil.
- Avoid overwatering.
- Apply Trichoderma-based bio-fungicides as a preventive measure.

5. Cucumber Mosaic Virus

Mosaic virus is a viral disease spread by aphids. It causes mottling and distortion of leaves and fruits.

Symptoms of Damage

- Mosaic or patchy light and dark green patterns on leaves.
- Distorted and twisted leaves and fruits.
- Poor flowering and fruit set.

Management Methods

- Control aphids using neem oil or insecticides.
- Uproot and destroy infected plants.
- Use virus-free seeds and resistant varieties if available.

10.3 Cucumber

Introduction

Cucumber (*Cucumis sativus*), known as "kakro," is a widely cultivated vegetable valued for its crisp texture and refreshing taste. Rich in water content, vitamins, and minerals, cucumbers are an essential ingredient in salads, pickles, and culinary preparations worldwide. They also offer various health benefits, such as hydration, aiding digestion, and providing antioxidants. Cucumber is a staple crop in Nepal, particularly during the summer and rainy seasons.

Origin and Distribution

Cucumber is believed to have originated in India, where wild forms of the plant can still be found. Over time, it spread to other parts of Asia, Africa, and Europe, becoming a globally popular crop. In Nepal, cucumbers are cultivated across the Terai plains, mid-hills, and high-altitude regions, with variations adapted to different agro-climatic zones.

Varieties

A range of cucumber varieties is cultivated based on their growth habits, fruit characteristics, and regional preferences. These include: Bhaktapur Local, Shahini 1, Shahini 2, Raja, Brishma, Gorkha, NS404, NS408, Kopila, Katma, Chandani, Simran, Himal etc.

Soil and Climate

Cucumber thrives in well-drained, fertile soils with a pH of 5.5–6.8. Loamy or sandy-loam soils rich in organic matter are ideal. Waterlogging must be avoided as it can lead to root diseases.

Cucumber is a warm-season crop requiring temperatures between 20°C and 30°C for optimal growth. It is highly sensitive to frost but thrives in sunny and moderately humid conditions. In Nepal, cucumbers are grown during the summer, monsoon, and spring seasons, with greenhouse cultivation enabling year-round production in some areas.

Nursery Bed Preparation

For raising cucumber seedlings, nursery beds are prepared by plowing the soil to fine tilth and enriching it with decomposed organic manure. Seeds are soaked in water or treated with fungicides to ensure better germination and disease prevention. They are sown 2–3 cm deep, and the beds are kept moist. Germinated seedlings are transplanted into the main field after 2–3 weeks.

Cultivation Practices

1. Sowing/Transplanting

Cucumber seeds are often sown directly in the field. Alternatively, nursery-raised seedlings are transplanted after reaching 2–3 true leaves. A spacing of 1.5–2 meters between rows and 50–70 cm between plants is maintained for adequate growth and aeration. Trellising is recommended for climbing varieties to enhance yield and fruit quality.

2. Manuring and Fertilization

Cucumber demands fertile soil enriched with organic and inorganic nutrients. Organic manure or compost is applied at the rate of 20–25 tons per hectare during land preparation. The recommended NPK ratio for cucumber in Nepal is 120:80:60 kg per hectare. Basal doses of fertilizers like DAP, MOP, and urea are applied, with additional nitrogen supplied during vegetative and flowering stages. Organic options, such as vermicompost and biofertilizers, can also enhance crop growth.

3. Irrigation

Cucumber requires consistent soil moisture, especially during flowering and fruiting stages. Drip irrigation or light but frequent watering is ideal to maintain moisture levels without over-saturating the soil. In Nepal, irrigation schedules vary depending on the season, with reduced need during the monsoon and more frequent watering in dry periods.

4. Intercultural Operations

Regular weeding and hoeing help maintain a weed-free field and improve soil aeration. Mulching with organic materials like straw conserves moisture and suppresses weed growth. Climbing varieties are supported with trellises or stakes, improving fruit quality and facilitating easy harvesting.

Harvesting

Cucumber is ready for harvest 40–60 days after sowing, depending on the variety. Fruits should be harvested while tender, with smooth skin and no signs of over-maturity, as older fruits become tough and seedy. Harvesting is done every 2–3 days using sharp tools to avoid vine damage. Proper handling and packaging ensure the freshness and market value of the produce.

Insects

1. Red Pumpkin Beetle *(Aulacophora foveicollis)*

Red Pumpkin Beetle is a reddish-orange beetle that attacks cucurbits, especially pumpkin and squash.

Symptoms of damage

- Adult beetles feed on leaves, flowers, and tender shoots, creating round holes.
- Grubs feed on roots and underground parts.
- Seedlings may wilt and die.

Management Methods

- Handpick and destroy beetles early morning.
- Use neem-based insecticides.
- Apply Carbaryl or Malathion (if permitted).
- Practice crop rotation and remove weeds.

2. Spotted Cucumber Beetle *(Diabrotica undecimpunctata)*

It is a greenish-yellow beetle with black spots that attack cucumbers and other cucurbits.

Symptoms of Damage:

- Adults chew leaves and flowers.
- Larvae feed on roots, reducing plant vigor.
- Can transmit bacterial wilt disease.

Management Methods

- Use yellow sticky traps.
- Spray Neem oil or Pyrethrin-based insecticides.

3. Aphid *(Aphis gossypii)*

Aphids are small, soft-bodied insects that attack cucurbit crops like bitter gourd, cucumber, pumpkin, bottle gourd, and others.

They are usually green, black, or brown in colour and are found in large groups on the underside of leaves, stems, and tender shoots. Aphids suck the plant sap, which weakens the plants and reduces yield. They also produce a sticky substance called honeydew which leads to the growth of a black fungus called sooty mold. They can also spread plant viruses like Cucumber Mosaic Virus (CMV).

Symptoms of damage

- Curled and twisted young leaves are seen due to sap sucking.
- Sticky substance (honeydew) are seen on leaves and fruits.
- Growth of black and sooty mold are seen on sticky leaves and fruits.
- In the severe case, the plants get fully yellowed and stunted. This leads to poor flowering and fruit setting.
- If viruses are transmitted in the plants, the plants show yellow-green patches on the leaves. Also the fruits are found distorted with uneven colour or shape.

Management

- Avoid use of excess nitrogen fertilizer, as it promotes soft growth attractive to aphids.
- Encourage natural enemies like lady bird beetles, lacewings, and parasitic wasps.
- Spray neem oil (5ml per liter of water) as an organic option.
- Spray jholmal @ 1:5 mixing with water in 7 days interval.
- If the infestation is severe, apply insecticides like imidacloprid, thiamethoxam, etc.

4. Fruit fly *(Bactrocera cucurbitae)*

The cucurbit fruit fly is a harmful insect that attacks cucurbit crops like cucumber, pumpkin, bitter gourd, bottle gourd, and sponge gourd. It is most active in warm and humid weather.

Symptoms of Damage

- Female flies lay eggs inside young fruits.
- Small holes or brown spots appear where the eggs are laid.
- Fruits become soft and rotten inside.
- Fruits become soft, yellow, or rotten from inside.
- Brown or black marks where flies laid eggs.
- Larvae (maggots) are found inside fruits.
- The fruits drop early and become unfit to eat or sell.

Management Methods

- Collect and destroy infected fruits.
- Encourage natural enemies like parasitic wasps.
- Use fruit fly traps (e.g., pheromone or protein bait traps).
- Spray organic insecticides (e.g., malathion bait spray).

5. Bugs

Bugs are a group of insects that have piercing and sucking mouthparts. They are different from chewing insects. In horticultural crops, bugs like stink bugs and leaf-footed bugs are common. They are medium sized insects that pierce plant parts and suck juice. These bugs attack fruits and vegetables by sucking the plant's juice.

Symptoms of Damage

- Fruits become deformed or scarred.
- Yellow spots on leaves and fruit.
- Bad smell (if stink bug).
- Premature fruit drop.

Management Methods

- Keep the field clean by removing weeds and old plants.
- Use light traps at night to attract and catch bugs.
- If infestation is high, spray botanical insecticides like neem oil.
- Apply Imidacloprid if the infestation is severe.

6. Root knot nematode *(Meloidogyne spp.)*

Root knot nematode are microscopic worms (too small to see with naked eyes) that live in the soil. They attack the roots of many vegetables, fruits, and other horticultural crops. Tomato, brinjal, chili, cucumber, pumpkin, gourds, beans, okra, spinach, flowers, and different fruit crops are affected by this pest.

They are called "root knot" nematodes because they cause swellings or knots on the roots. These knots stop the roots from absorbing enough water and nutrients.

Symptoms of damage

- Roots have small knots or galls (swellings).
- Plants look yellow, weak, and stunted (do not grow properly).
- Leaves may wilt, even if the soil is wet.

- Poor fruit or vegetable production.
- Plants may easily fall over due to weak roots.

Management Methods

- Rotate crops with non-hosts like maize or wheat.
- Practice mixed-cropping marigold with the main crop.
- Use resistant or tolerant varieties.
- Practice deep plowing and drying of soil under the sun (soil solarization).
- Mix neem cake or mustard cake into the soil before planting.
- Use beneficial organisms like Paecilomyces lilacinus (a fungus that attacks nematodes)
- Apply chemical named Fosthiozate 500 SL (1 ml/liter water) in the soil before planting crops.

Diseases

1. Powdery mildew (*Podosphaera xanthii*)

Powdery mildew is a common fungal disease that affects the leaves and stems of bitter gourd. It occurs mainly in dry and warm weather.

Symptoms

- White powdery spots on leaves, stems, and young fruits.
- Leaves may turn yellow, dry, and fall off.
- Poor fruit development in severe cases.

Management

- Grow resistant varieties if available.
- Provide good air circulation by proper spacing.
- Spray sulfur-based fungicides or neem oil.
- Use systemic fungicides like hexaconazole if the infection is severe.

2. Downy mildew (*Pseudoperonospora cubensis*)

Downy mildew is a fungal-like disease that spreads rapidly in cool, moist conditions. It affects leaves and reduces photosynthesis.

Symptoms

- Yellow angular spots on the upper side of leaves.
- Greyish-purple fungal growth on the underside of leaves.
- Leaves dry and die early.

Management

- Avoid overhead irrigation.
- Grow in well-drained soil.
- Spray fungicides like mancozeb or metalaxyl + mancozeb when symptoms appear.

3. Fusarium wilt (*Fusarium oxysporium*)

Fusarium wilt is a soil-borne fungal disease that blocks water transport in plants. It thrives in warm, moist soils.

Symptoms of Damage

- Yellowing and wilting of leaves, starting from the bottom.
- Brown discolouration of stem tissues.
- Plants eventually die.

Management Methods

- Rotate crops for 3–4 years.
- Grow resistant varieties if available.
- Drench soil with fungicides like carbendazim.

4. Root Rot and Collar Rot

These soil-borne fungal diseases attack the base of the stem and roots, especially in poorly drained soils.

Symptoms of Damage

- Soft, rotten tissues at stem base.
- Plants wilt and fall over.
- Roots are blackened and decayed.

Management Methods

- Plant in well-drained soil.
- Avoid overwatering.
- Apply Trichoderma-based bio-fungicides as a preventive measure.

5. Cucumber Mosaic Virus

Mosaic virus is a viral disease spread by aphids. It causes mottling and distortion of leaves and fruits.

Symptoms of Damage

- Mosaic or patchy light and dark green patterns on leaves.
- Distorted and twisted leaves and fruits.
- Poor flowering and fruit set.

Management Methods

- Control aphids using neem oil or insecticides.
- Uproot and destroy infected plants.
- Use virus-free seeds and resistant varieties if available.

Exercise

Choose the correct answer from the given alternatives.

1. Which of the following is the scientific name of cucumber?

   a. Cucumis melo
   b. Cucumis sativus
   c. Citrullus lanatus
   d. Lagenaria siceraria

2. Which climatic condition is most suitable for pumpkin growth?

   a. Cold and moist
   b. Warm and sunny
   c. Frosty
   d. Extremely dry

3. Which nutrient is mainly responsible for increasing female flowering in cucurbits?

   a. Nitrogen
   b. Potassium
   c. Phosphorus
   d. Zinc

4. Which insect pest makes round holes on cucumber and pumpkin leaves?

   a. Aphid
   b. Red Pumpkin Beetle
   c. Fruit Fly
   d. Root Knot Nematode

5. What is the best method to control root knot nematode in cucurbits?

   a. Spray neem oil on leaves
   b. Rotate crops with maize or wheat
   c. Harvest early
   d. Irrigate daily

6. Which statement about bitter gourd is FALSE?

   a. It is a cool-season crop
   b. It contains momordicin and charantin
   c. It helps manage blood sugar
   d. It grows well at 25-30°C

7. Which insect pest causes sooty mold in cucurbit crops?

a. Fruit fly b. Aphids

c. Red pumpkin beetle d. Cutworms

Write short answer to the following questions.

1. Explain the steps of staking and pruning in bitter gourd cultivation and why they are important.
2. Explain the seedling preparation, field preparation, and transplantation methods of cucumber.

Write long answer to the following questions.

1. Discuss the cultivation practices of bitter gourd, including land preparation, sowing, irrigation, and harvesting in detail. Explain the role of intercultural operations like weeding, staking, and pruning in its yield and quality.
2. Analyze the symptoms and management of Cucumber Mosaic Virus (CMV) and Fruit fly in cucurbits.

Project Work

Title: Study of Pests and Diseases in Cucurbitaceous Crops in Local Farms

Objective: To identify the major insect pests and diseases affecting cucurbitaceous crops (bitter gourd, bottle gourd, cucumber) in your area and learn their management.

Instructions:

a. Visit a local farm or garden growing cucurbitaceous crops.

b. Observe and note down any insect pests or disease symptoms you see.

c. Take photos or draw diagrams of affected plants.

d. Ask farmers about their control methods and challenges.

e. Prepare a report including:

- Names of pests and diseases found
- Symptoms observed

- Management methods used by farmers
- Your suggestions for improvement

f. Submit a 2–**3 page report** with sketches or photographs.

Cultivation Practices of Spices

Unit 11

11.1 Ginger

Introduction

Ginger (*Zingiber officinale*) is a perennial herbaceous plant cultivated for its aromatic rhizomes, which are widely used as a spice, medicine, and flavoring agent. It is highly valued for its pungent compounds like gingerol and shogaol, which have culinary and therapeutic applications. In Nepal, ginger is a significant cash crop, contributing to local and export markets. It is commonly used in Nepalese cuisine, Ayurvedic medicine, and tea preparation.

Origin and Distribution

Ginger is believed to have originated in Southeast Asia, with India being one of its primary centers of diversity. Its cultivation has spread worldwide, particularly in tropical and subtropical regions. Nepal is one of the prominent producers of ginger, with districts like Salyan, Ilam, Palpa, and Dhankuta being major cultivation areas due to favorable agro-climatic conditions.

Varieties

Varieties grown in Nepal include: Kapurkot-1, Kapurkot-2

Soil and Climate

Ginger thrives in well-drained, fertile soils rich in organic matter. Loamy or sandy-loam soils with a pH range of 5.5–6.5 are ideal. Excess water and waterlogging can cause rhizome rot, so proper drainage is essential. Ginger prefers a warm and humid climate, with an optimum temperature of 25°C–30°C. It is grown in areas with an annual rainfall of 1500–2500 mm. In Nepal, it is cultivated during the rainy season in mid-hills and Terai regions.

Nursery Bed Preparation

Healthy rhizomes are critical for successful ginger cultivation. Nursery beds are prepared by loosening the soil and incorporating well-decomposed compost or farmyard manure. Rhizomes are treated with fungicides or biocontrol agents to prevent fungal infections. Seed rhizomes are cut into 3–5 cm pieces, each with at least one viable bud, and then planted in raised beds with proper spacing.

Cultivation Practices

1. **Sowing/Transplanting**

   Ginger is usually propagated through rhizomes. The planting season in Nepal begins in late spring (March–April). Rhizome pieces are sown directly into prepared beds at a spacing of 25–30 cm between rows and 20 cm between plants. Mulching with organic materials like straw is essential to retain soil moisture, suppress weeds, and prevent soil erosion.

2. **Manuring and Fertilization**

   Ginger is a nutrient-demanding crop. Organic manure or compost is applied at 20–25 tons per hectare during land preparation. The recommended NPK dosage for ginger in Nepal is 75:50:50 kg per hectare, applied in split doses. Additional nitrogen is supplied during the vegetative growth phase. Vermicompost and biofertilizers can enhance soil fertility and improve rhizome quality.

3. **Irrigation**

   Regular and moderate irrigation is necessary, especially during dry spells. Overwatering should be avoided as it leads to waterlogging and rhizome rot. In regions with sufficient rainfall, supplemental irrigation may be needed during the early growth stages.

4. **Intercultural Operations**

   Frequent weeding and earthing-up are carried out to promote aeration and rhizome expansion. Mulching is done after planting and during the crop's growth stages to conserve soil moisture and control weeds.

Harvesting

Ginger is ready for harvest 8–10 months after planting when the leaves turn yellow and dry. For fresh consumption, it is harvested earlier at 6–7 months. Rhizomes are carefully dug out to avoid damage, washed, and cured before storage or sale. Proper packaging ensures the rhizomes remain fresh for longer periods.

Common Insect Pests and Diseases

Insect Pests

i. **Shoot borer *(Conogethes punctiferalis)*:** Larvae damage shoots, causing withering. Controlled through pheromone traps and insecticidal sprays.

ii. **Rhizome scale *(Aspidiella hartii)*:** Scales suck sap from rhizomes, leading to stunted growth. Neem oil sprays are effective in controlling them.

Diseases

i. **Rhizome rot *(Pythium spp.)*:** A fungal disease, causing soft rot in rhizomes. Management includes treating rhizomes with fungicides and maintaining proper drainage.

ii. **Bacterial wilt *(Ralstonia solanacearum)*:** Causes yellowing and wilting of plants. Crop rotation and disease-free planting materials are effective prevention measures.

iii. **Leaf spot *(Phyllosticta zingiberi)*:** Fungal spots on leaves that reduce photosynthesis. Controlled through fungicidal sprays and resistant varieties.

11.2 Coriander

Introduction

Coriander (*Coriandrum sativum*), commonly known as "dhania" in Nepal, is an annual herb cultivated for its aromatic leaves and seeds. It is a versatile crop widely used in culinary applications, medicinal preparations, and as a spice. Coriander is cherished in Nepalese cuisine for its flavor-enhancing properties. It also holds traditional medicinal value, aiding in digestion.

Origin and Distribution

Coriander is believed to have originated in the Mediterranean region and Western Asia. It has been cultivated for thousands of years and has spread globally due to its culinary and medicinal importance. In Nepal, coriander is grown across various agro-climatic zones, from the Terai to mid-hill regions, often in kitchen gardens and commercial farms.

Varieties

Several varieties of coriander are cultivated, including: Lotus, XMLNO, American Long Standing, Ramases etc.

Soil and Climate

Coriander thrives in well-drained loamy or sandy-loam soils with a pH range of 6.0–7.5. The soil should be rich in organic matter to support healthy growth. It is sensitive to waterlogging, so proper drainage is necessary.

Coriander prefers cool and dry conditions. The optimal temperature for growth is between 15°C and 25°C. Excessive heat or frost adversely affects plant development. In Nepal, coriander is grown during the winter season, from October to February, in plains and mid-hills.

Cultivation Practices

1. **Sowing/Transplanting**

   Coriander can be cultivated as a direct-seeded crop. Seeds are soaked in

water overnight to improve germination. Seeds are sown at a depth of 1–2 cm with a spacing of 20–25 cm between rows and 8–10 cm between plants. A seed rate of 15–20 kg per hectare is recommended. In some cases, seedlings are transplanted after 3–4 weeks of growth.

2. Manuring and Fertilization

Organic manure or compost is applied at the rate of 10–15 tons per hectare during land preparation. The recommended NPK dosage for coriander in Nepal is 40:30:30 kg per hectare. Nitrogen is applied in two split doses, one at sowing and the other during vegetative growth. Organic fertilizers, such as vermicompost, also enhance plant health and yield.

3. Irrigation

Coriander requires consistent soil moisture, especially during germination and early vegetative stages. However, overwatering can lead to root diseases. Light irrigation is provided as needed, depending on the soil type and climatic conditions. In Nepal, irrigation is often necessary during dry spells in the winter season.

4. Intercultural Operations

Weeding is carried out regularly to eliminate competition for nutrients and sunlight. Hoeing improves soil aeration and promotes better root growth. Mulching with organic materials helps conserve soil moisture and control weed growth.

Harvesting

Coriander is harvested at different stages depending on the intended use:

- For leaves: Harvesting begins 30–40 days after sowing when the plants are young and tender.
- For seeds: Plants are allowed to mature fully, which takes about 90–120 days. Seeds are harvested when they turn light brown and are dried further before storage.

Timely harvesting is crucial to retain the desired flavor and aroma in both leaves and seeds.

Common Insect Pests and Diseases

Insect Pests

i. **Aphids *(Aphis spp.)*:** These sap-sucking pests weaken plants and spread viral diseases. Neem oil sprays and natural predators like ladybirds are effective in controlling them.

ii. **Coriander Caterpillar *(Helicoverpa spp.)*:** Larvae feed on leaves, reducing yield. Biological control agents or safe insecticides can be used.

Diseases

i. **Powdery Mildew *(Erysiphe spp.)*:** White powdery spots on leaves reduce photosynthesis. Managed using sulfur-based fungicides and resistant varieties.

ii. **Wilt *(Fusarium spp.)*:** Causes yellowing and wilting of plants. Crop rotation and disease-free seeds help in management.

iii. **Blight *(Alternaria spp.)*:** Causes dark spots on leaves, stems, and seeds. Proper plant spacing and fungicides are effective control measures.

11.3 Cumin

Introduction

Cumin (*Cuminum cyminum*) is an aromatic spice belonging to the Apiaceae family, cultivated primarily for its seeds. It is valued for its distinctive flavor, which enhances the taste of various cuisines, and for its medicinal properties, such as aiding digestion and boosting immunity. In Nepal, cumin is an essential component of spice blends like garam masala and curry powders, making it a significant crop for both home consumption and commercial purposes.

Origin and Distribution

Cumin is believed to have originated in the Eastern Mediterranean region or Southwest Asia. It has been cultivated for thousands of years and is widely grown in India, the Middle East, and the Mediterranean. In Nepal, cumin cultivation is concentrated in the Terai and lower hill regions, where the dry climate is suitable for its growth.

Varieties

Common cumin varieties are cultivated, including: RZ-19, GC-1

Soil and Climate

Cumin thrives in well-drained sandy loam or loamy soils with a pH range of 6.5–7.5. The soil should be rich in organic matter to support optimal growth. Waterlogging must be avoided, as cumin is sensitive to excessive moisture.

Cumin is a winter season crop that requires cool, dry weather during its vegetative phase and warm, dry weather during seed maturation. The ideal temperature range for its growth is 20°C to 30°C. In Nepal, cumin is sown in October–November and harvested in March–April.

Cultivation Practices

1. Sowing

Cumin is usually grown directly from seeds. The field is prepared by plowing and mixing it with organic manure, such as compost or

farmyard manure, at a rate of 10–15 tons per hectare. A fine tilth is essential for proper seed sowing and germination. Seeds are treated with fungicides or biopesticides to prevent seed-borne diseases. Cumin seeds are sown directly in the field at a depth of 1–2 cm, with a spacing of 20–25 cm between rows and 10–15 cm between plants. A seed rate of 10–12 kg per hectare is recommended. Seeds should be lightly covered with soil and irrigated immediately after sowing.

2. Manuring and Fertilization

Cumin responds well to organic and inorganic fertilizers.

- **Organic Manure:** Compost or farmyard manure at 10–15 tons per hectare during land preparation.
- **Chemical Fertilizers:** Recommended NPK dose for cumin in Nepal is 25:25:15 kg per hectare. Nitrogen is applied in two split doses, one at sowing and the other during the early vegetative stage.

3. Irrigation

Cumin requires careful irrigation management.

- The first irrigation is provided immediately after sowing.
- Subsequent irrigations are given at critical stages, such as flowering and seed formation.
- Excessive watering should be avoided to prevent fungal diseases.

4. Intercultural Operations

Regular weeding is necessary to reduce competition for nutrients and sunlight. Light hoeing improves soil aeration and promotes healthy root development. Mulching with organic materials helps conserve soil moisture and suppress weeds.

Harvesting

Cumin is ready for harvest about 100–120 days after sowing when the plants

turn yellowish-brown, and the seeds are fully mature. Harvesting is done by uprooting the plants or cutting them close to the ground. The harvested plants are dried in the sun for 7–10 days before threshing to separate the seeds. Proper drying and storage are essential to maintain seed quality.

Common Insect Pests and Diseases

Insect Pests

i. **Aphids *(Aphis spp.)*:** These sap-sucking pests cause stunted growth and transmit viral diseases. Neem oil sprays and biological control using ladybird beetles are effective.

ii. **Cumin Seed Bug *(Nysius spp.)*:** Feeds on seeds, reducing yield. Controlled using pheromone traps and safe insecticides.

Diseases

i. **Wilt *(Fusarium oxysporum)*:** Causes yellowing and wilting of plants. Crop rotation and seed treatment are effective management strategies.

ii. **Powdery Mildew *(Erysiphe polygoni)*:** White powdery growth on leaves and stems reduces photosynthesis. Sulfur-based fungicides and resistant varieties are used for control.

iii. **Blight *(Alternaria spp.)*:** Leads to brown spots on leaves and seeds. Controlled using fungicides and proper field sanitation.

11.4 Large Cardamom

Introduction

Large cardamom (*Amomum subulatum*), commonly referred to as "Alaichi" in Nepal, is a perennial herbaceous plant that belongs to the Zingiberaceae family. It is one of the most valuable spices grown in Nepal, celebrated for its aromatic seeds, which are used in culinary, medicinal, and industrial applications. Large cardamom is a key cash crop, particularly in the eastern and mid-hill regions of Nepal, contributing significantly to rural livelihoods and the national economy.

Origin and Distribution

Large cardamom is believed to have originated in the Eastern Himalayan region, encompassing parts of Nepal, India, and Bhutan. In Nepal, its cultivation is concentrated in the eastern districts such as Ilam, Panchthar, Taplejung, and Sankhuwasabha, where the agro-climatic conditions are favorable. Nepal is one of the largest producers of large cardamom globally, with significant exports to India, Pakistan, and Gulf countries.

Uses

Cardamom has multiple uses in cooking, medicine, cosmetics, beverages, etc.

- It is used to flavor curries, biryanis, soups, etc.
- It is used to prepare garam masala, which is used in most of the culinaries in Nepal and India.
- It adds aroma to food, desserts, cakes, bread, etc.
- It has been used as an ayurvedic and traditional medicine to cure asthma, bronchitis, improve kidney health, etc.
- In modern medicine it has been used as an antioxidant.
- It is also used in perfumes and essential oils for warm and spicy fragrance.

Nutritional Benefits

- It contains variety of minerals like calcium, iron, magnesium,

phosphorus, potassium, vitamin C and vitamin B6. Also, we can get fiber, fats, protein, and carbohydrate from cardamom.

Varieties

Several varieties of large cardamom are cultivated in Nepal, including:

- Ramsai: Early-maturing variety, preferred for its higher productivity.
- Golsai: Medium-duration variety with bold capsules and high oil content.
- Sawney: Late-maturing variety that performs well under marginal conditions.
- Bharlange, Dambarsai

Soil and Climate

Large cardamom thrives in deep, well-drained, and loamy soils rich in organic matter. The soil pH should be slightly acidic, ranging from 5.5 to 6.5. Proper drainage is essential, as waterlogging can lead to root diseases.

Large cardamom grows well in a cool, humid climate under partial shade. The ideal temperature range is 10°C to 25°C, with an annual rainfall of 1500–3000 mm. It is typically cultivated at altitudes between 600 and 2000 meters above sea level in Nepal, where the forest canopy provides the necessary shade.

Nursery Bed Preparation

Healthy seedlings are crucial for successful large cardamom cultivation. A nursery bed is prepared by mixing well-decomposed organic manure with the soil. Seeds are extracted from mature capsules, cleaned, and treated with fungicides to prevent seed-borne diseases. The seeds are sown in the nursery at a depth of 1–2 cm and covered with a thin layer of compost. Regular watering and shading ensure healthy seedling growth. Seedlings are ready for transplanting after 10–12 months.

Propagation

There are three types of propagation techniques that can be used to plant cardamom. They are

a. Propagation through seed
b. Propagation through suckers
c. Micro propagation

The mostly dependable propagating material is seedlings prepared from seeds. For the preparation of seedlings, nursery beds should be made.

1. Primary Nursery

Primary nursery is that where seeds are sown for the first time, where seedlings grow to 3-4 leaves stage and are plucked to transplant in secondary nursery.

- Height of seed bed: 15-20 cm
- Width: 1 meter
- Length: As per requirement and convenience
- Seed spacing: 10 cm while sowing
- Germination of seed in 25-30 days

2. Secondary Nursery

The nursery where the seedlings prepared in primary nursery (3-4 leaves) are transplanted for further preparation of robust seedlings to be planted in the main field.

Height: 15cm

Width: 1 meter

Length: As per convenience

Spacing of 3-4 leaved seedlings: 15cm

Seedlings are ready when they attain a growth of 45-60 cm in height and 2-3 tillers.

Land Preparation

Before planting, the land should be cleared of all weeds, and old plants. Pit size of 30×30×30 cm should be made on the contour line of the hill at spacing of 1.5×1.5 meter. The pits should be filled with FYM, compost, and synthetic fertilizers. Then they should be covered and left for 1 month before planting the seedlings.

Planting

Planting of cardamom seedlings is done generally during June-July. Three seedlings should be planted over one pit making a triangular shape to ensure the maintenance of optimum plant population in the orchard.

Mulching

It is an important cultural practice in cardamom. The fallen leaves of the shade trees are utilized for mulching. It adds organic matter in the soil and reduces the ill effects of drought.

Weeding

Weed infestation is high particularly during and just after the rainy season. So, it is very important to reduce and remove the weeds to ensure cardamom plants utilize the optimum amount of nutrient present in the soil. Weeds should be manually removed, and the removed weed can be utilized as mulch material to prevent the growth of further weed. During weed removal, the removal of unproductive pseudo-stem also should be done.

Harvesting

Cardamom plants normally start bearing capsules two years after planting. In most of the areas the peak period of harvest is during October-November (Asoj-Kartik). Ripe capsules are harvested to get maximum green colour during curing.

Curing

After harvesting, capsules should be dried either in a fuel kiln or in an electrical

drier or in the sun. While drying it should be dried at the temperature range between 45-50 ºC for 14 to 18 hours. Tail cutting is also required after drying to get the good quality cardamom.

Grading the cardamom according to size and colour, and storing in polythene bags to retain the green colour during storage enhances the quality to fetch good price in market.

Major Diseases of Cardamom

1. Rhizome Rot

Rhizome rot is a serious fungal disease of cardamom caused by Pythium, Fusarium, and Rhizoctonia species. It attacks the rhizomes and roots, leading to severe plant damage.

Symptoms of Damage

- Yellowing and wilting of leaves.
- Soft, water-soaked rhizomes with foul smell.
- Roots rot and plants topple over easily.

Management Methods

- Use disease-free planting materials.
- Ensure proper drainage in fields to avoid waterlogging.
- Treat rhizomes with fungicides like carbendazim before planting.
- Apply Trichoderma-based bio-fungicides to the soil.

2. Blight

Blight is caused by the fungus Colletotrichum gloeosporioides and affects cardamom leaves and capsules. It spreads quickly in wet and humid conditions.

Symptoms of Damage

- Brown spots on leaves with yellow halos.
- Spots enlarge and cause leaf drying.
- Capsules may also develop lesions and rot.

Management Methods

- Remove and destroy infected leaves and capsules.
- Spray fungicides like mancozeb or copper oxychloride.
- Avoid dense planting to improve air circulation.

3. Chirkey and Furkey Disease

Chirkey and Furkey are viral diseases of cardamom transmitted by aphids. Chirkey causes streaking on leaves, while Furkey causes severe stunting.

Symptoms of Damage

- Chirkey: Yellow streaks along veins of leaves.
- Furkey: Stunted plants with small, twisted leaves.
- Both diseases reduce flowering and capsule production.

Management Methods

- Uproot and destroy infected plants.
- Control aphid populations using neem oil or insecticides.
- Plant virus-free seedlings.

Major Insects of Cardamom

1. Leaf Caterpillar (Artona chorista)

Leaf caterpillars are larvae of moths that feed on cardamom leaves and reduce photosynthesis.

Symptoms of Damage

- Holes are seen on the infected leaves.
- Severe infestation causes defoliation.

Management Methods

- Handpick and destroy caterpillars.
- Encourage natural predators like birds.
- Spray neem oil or Bacillus thuringiensis (Bt) for control.

2. Shoot Fly (Merochlorops dimorphus)

Shoot flies lay eggs on young shoots, and their larvae damage tender shoots of cardamom.

Symptoms of Damage

- Drying of central shoots (dead heart symptoms).
- Reduced tillering and stunted plants.

Management Methods

- Remove and destroy infested shoots.
- Spray insecticides like dimethoate for severe infestations.

3. Stem Borer (*Glyphipterix* spp.)

Stem borers are small caterpillars that bore into stems and suckers of cardamom plants.

Symptoms of Damage

- Boreholes on stems with frass (insect waste).
- Yellowing and wilting of shoots.
- Drying of entire tillers in severe cases.

Management Methods

- Cut and destroy infested shoots.
- Apply neem cake to the soil.
- Use systemic insecticides if necessary.

4. White Grub (*Holotrichia* spp.)

White grubs are larvae of beetles that feed on the roots of cardamom plants.

Symptoms of Damage

- Wilting and yellowing of plants due to root damage.
- Plants may be easily uprooted.

Management Methods

- Plow fields to expose grubs to predators.
- Apply neem cake or entomopathogenic fungi like Metarhizium.
- Use soil insecticides for heavy infestations.

5. Aphids (*Mollitrichosiphum* spp.)

Aphids are small, soft-bodied insects that suck sap from young shoots and leaves. They also spread viral diseases like Chirkey and Furkey.

Symptoms of Damage

- Curled and twisted young leaves.
- Sticky honeydew on leaves leading to sooty mold.
- Stunted plant growth and reduced flowering.

Management Methods

- Spray neem oil or insecticidal soap.
- Encourage natural predators like ladybugs.
- Use systemic insecticides if infestation is severe.

6. Capsule Borer

Capsule borers are caterpillars that bore into cardamom capsules and damage seeds.

Symptoms of Damage

- Boreholes on capsules with frass.
- Damaged capsules dry and fall off.
- Reduced yield and poor quality of seeds.

Management Methods

- Remove and destroy infested capsules.
- Spray neem oil or Bt formulations.
- Use insecticides like spinosad if necessary.

11.5 Turmeric

Introduction

Turmeric (*Curcuma longa*), known as "Besar" in Nepal, is a perennial herbaceous plant belonging to the Zingiberaceae family. Renowned for its vibrant yellow rhizomes, turmeric is a significant spice crop, widely used for culinary, medicinal, and industrial purposes. It is rich in curcumin, an active compound with anti-inflammatory, antioxidant, and antimicrobial properties. In Nepal, turmeric is integral to traditional medicine and cuisine, making it a valuable crop for both subsistence and commercial farming.

Origin and Distribution

Turmeric is believed to have originated in South Asia, with India being its primary center of origin. Over time, it spread to Southeast Asia, China, and Africa. In Nepal, turmeric is cultivated across the Terai, mid-hill, and inner Terai regions, with significant production in districts such as Jhapa, Morang, Chitwan, and Dang. Its cultivation thrives in areas with warm temperatures and fertile soils.

Varieties

In Nepal, Kapurkot Haledo -1 and Kapurkot Haledo -2 varieties are cultivated.

Soil and Climate

Turmeric grows best in well-drained, loamy soils enriched with organic matter. The soil pH should range between 5.5 and 7.0. It is sensitive to waterlogging, so fields should have adequate drainage.

Turmeric is a tropical crop that requires warm and humid conditions for optimal growth. The ideal temperature range is 20°C–30°C, and annual rainfall of 1500–2000 mm is suitable. In Nepal, turmeric is grown as a rainfed crop, typically in the monsoon season.

Cultivation Practices

1. Sowing/Planting

Turmeric is propagated through rhizomes rather than seeds. For nursery bed preparation, healthy mother rhizomes are cut into 2.5–4 cm pieces, each with at least one bud. These pieces are treated with fungicides or cow dung slurry to prevent rot and promote early sprouting. The treated rhizomes are planted in raised beds with well-mixed compost, ensuring adequate moisture for germination.

Turmeric is planted at the onset of the monsoon (May–June). Rhizomes are sown in furrows at a spacing of 25–30 cm between rows and 15–20 cm between plants. A planting depth of 5–7 cm ensures proper establishment. Mulching with organic materials like straw or dried leaves helps retain moisture and suppress weeds.

2. Manuring and Fertilization

Turmeric is a nutrient-demanding crop and thrives in soils rich in organic matter. Organic manure such as farmyard manure (20–25 tons/ha) is applied during land preparation.

- Recommended NPK dose in Nepal: 120:60:80 kg per hectare.
- Nitrogen is applied in split doses—50% at planting and the remaining during the vegetative phase. Potassium and phosphorus are applied as basal doses. Vermicompost and biofertilizers also enhance soil fertility and crop growth.

3. Irrigation

Although turmeric is primarily grown as a rainfed crop, supplemental irrigation is necessary during dry spells to maintain soil moisture. Irrigation is crucial at critical stages such as sprouting, rhizome formation, and development. Proper drainage is essential to prevent waterlogging and rhizome rot.

4. Intercultural Operations

Weeding is done 2–3 times during the growing season to reduce competition and ensure healthy growth. Mulching not only helps suppress weeds but also maintains soil moisture. Earthing up is carried out to support rhizome development and prevent exposure.

Harvesting

Turmeric is ready for harvest 7–9 months after planting when the leaves and stems turn yellow and start drying. Harvesting is done manually by digging out the rhizomes carefully to avoid damage. The harvested rhizomes are washed, boiled, and cured to enhance their colour and shelf life. Proper drying ensures the rhizomes retain their quality for storage and marketing.

Major Diseases of Turmeric

1. Rhizome Rot (***Pythium*** spp., ***Fusarium*** spp., ***Rhizoctonia solani***) Rhizome rot is the most serious disease of turmeric caused by soil-borne fungi. It spreads easily in waterlogged and poorly drained soils.

Symptoms of Damage

- Yellowing and drooping of leaves starting from the tips.
- Soft, rotten rhizomes with foul smell.
- Plants wilt and die prematurely.

Management Methods

- Use healthy and disease-free rhizomes for planting.
- Ensure proper drainage to avoid waterlogging.
- Treat rhizomes with fungicides like mancozeb before planting.
- Apply Trichoderma-based bio-fungicides to the soil.

2. Leaf Spot (*Taphrina maculans*)

Leaf spot is a fungal disease that attacks the leaves of turmeric, especially during wet and humid weather.

Symptoms of Damage

- Small brown spots on leaves with yellow halos.
- Spots enlarge, merge, and cause drying of leaves.
- Severe infection reduces photosynthesis and yield.

Management Methods

- Remove and destroy affected leaves.
- Provide good spacing to improve air flow.
- Spray fungicides like copper oxychloride or mancozeb at first appearance of symptoms.

Major Insects of Turmeric

1. Shoot Borer (*Conogethes punctiferalis*)

Shoot borers are caterpillars that bore into the central shoots of turmeric plants and cause significant damage.

Symptoms of Damage

- Central shoot dries up (dead heart symptom).
- Presence of holes and frass (insect waste) on shoots.
- Reduced tillering and rhizome development.

Management Methods

- Remove and destroy affected shoots.
- Spray neem oil or Bacillus thuringiensis (Bt) for control.
- For severe infestations, use insecticides like dimethoate or chlorpyrifos.

2. Rhizome Scale (*Aspidiella hartii*)

Rhizome scales are small insects that suck sap from turmeric rhizomes, weakening the plants and reducing rhizome quality.

Symptoms of Damage

- Presence of small, brownish scale insects on rhizomes.

- Shrivelled and poorly developed rhizomes.
- Reduced plant vigor and yield.

Management Methods

- Use clean and healthy planting material.
- Dip rhizomes in insecticidal solution (like dimethoate) before planting.
- Apply neem cake to soil to suppress scale population.

3. Leaf Roller (*Udaspes folus*)

Leaf rollers are caterpillars that roll and feed on turmeric leaves, reducing the leaf area available for photosynthesis.

Symptoms of Damage

- Leaves roll up with caterpillars feeding inside.
- Holes are seen on leaves.
- The plants show reduced growth and yield in severe infestation.

Management Methods

- Handpick and destroy rolled leaves with caterpillars.
- Encourage natural predators like birds.
- Spray neem oil or Bt formulations for control.

Exercise

Choose the correct answer from the given alternatives.

1. Which part of the ginger plant is used for cultivation?
   a. Leaves b. Stem
   c. Rhizome d. Flowers
2. Which district of Nepal is a major producer of large cardamom?
   a. Jhapa b. Illam
   c. Dang d. Kailali
3. Large cardamom thrives best in which type of soil?
   a. Sandy b. Clayey
   c. Loamy with rich organic matter d. Saline
4. What is the main bioactive compound found in turmeric?
   a. Pectin b. Curcumin
   c. Saponin d. Tannin
5. What is the recommended NPK dose for turmeric in Nepal?
   a. 120:80:80 kg/ha b. 100:50:50 kg/ha
   c. 60:40:40 kg/ha d. 90:45:45 kg/ha
6. What is the scientific name of large cardamom?
   a. Curcuma longa b. Elettaria cardamomum
   c. Amomum subulatum d. Cuminum cyminum
7. Which method is used for sowing cumin seeds?
   a. Broadcast method b. Line sowing
   c. Transplanting d. Dibbling
8. The main pest of large cardamom is……..
   a. Shoot borer b. Aphids
   c. Red pumpkin beetle d. Fruit fly

9. The curing process for turmeric involves……..

a. Sun-drying only
b. Boiling and sun-drying
c. Washing and air-drying
d. None of the above

Write short answer to the following questions.

1. Write briefly about the cultivation practices of turmeric (nursery preparation, planting, manuring, and intercultural operations).
2. Discuss how mulching and proper drainage help in improving yield and reducing diseases in ginger and turmeric cultivation.
3. Explain the symptoms and management of Rhizome rot in ginger, turmeric, and cardamom.

Write long answer to the following questions.

1. Describe the steps of cardamom cultivation from nursery preparation to harvesting. Evaluate how intercultural practices like mulching, weeding, and shade management increase yield and prevent diseases in cardamom.
2. Explain in detail the pest and disease management of turmeric and ginger. Prepare an integrated disease management plan for these crops suitable for a mid-hill region of Nepal.

Project Work

Title: Study how farmers in your area grow any one of the spice crops (ginger, coriander, cumin, cardamom, or turmeric).

Tasks

a. Visit 2-3 farms and ask farmers about their cultivation methods.
b. Record data on land size, varieties grown, fertilizer use, irrigation practices, and pest/diseases problems.
c. Suggest improvements based on what you learned in class.
d. Prepare a report comparing traditional and improved farming practices.

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