Plant Science

Food Crop Production

Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur

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Grade 10

Technical and Vocational Stream
Learning Resource Material

Food 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, Dayamand Pokharel the subject matter of the materials, was edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala and language was edited by Mr. Binod Raj Bhatta. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

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

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Curriculum Development Centre
Sanothimi, Bhaktapur

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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.

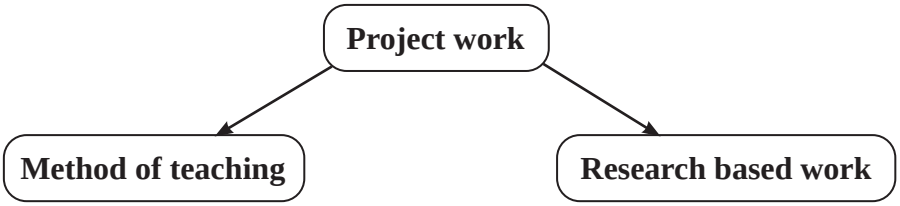
Interaction

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 Definition of Food Security and Sustainable Agriculture

1.1.1 Definition of Food Security

Food security is the backbone of a healthy society. It ensures that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food. It helps to meet their dietary needs and preferences for an active and healthy life. Food security is based on different four pillars: i) availability (enough food is produced within a country or imported), ii). accessibility (people can access food physically and affordably), iii). utilization (proper nutrition and food safety), and iv). stability (resilience to climate disasters or economic crises). In Nepal, food security is known as both a challenge and an opportunity due to the different geographical regions and climates. The Terai region produces plenty of grains. The mountain areas often struggle with food shortages due to lack of proper infrastructures. Sustainable farming methods like growing native crops, organic farming can lead to food security. It helps to protect the environment and ensure food to consume now and also for future.

Food security is defined as, every people have enough food that is safe, healthy, and nutritious at all times, so they can live active and healthy lives. Some of the widely accepted definitions of food security are as follows;

According to the Food and Agriculture Organization (FAO), 1983: Food security involves ensuring that "all people at all times have both physical and economic access to the basic food that they need."

According to the World Food Summit, 1996: Food security exists "when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life."

1.1.2 Definition of Sustainable Agriculture

Sustainable agriculture refers to farming practices designed to meet current needs of agricultural products without compromising the ability of future generations to meet their own needs.

According to the Food and Agriculture Organization (FAO): Sustainable agriculture ensures that farming practices conserve land, water, and biodiversity while enhancing productivity and profitability. It also emphasizes minimizing negative environmental impacts and improving the quality of life for farmers and society as a whole.

1.1.3. Difference Between Subsistence and Commercial Agriculture

S.N.	Subsistence agriculture	S.N.	Commercial agriculture
1.	Subsistence agriculture refers to growing of crops and rearing livestock mainly for personal consumption, not for sale.	1.	Commercial agriculture referes to growing crops and rearing livestock for sale in the market, aiming to generate profit.
2.	Small scale farming primariliy with the involvement of family members.	2.	Large scale farming with the use of different types of labours and machines.

3.	More use of traditional farming methods	3.	Use of advanced machinery and technology.
4.	Growing a variety of crops for household needs.	4.	Focusing on one or a few crops as demand of market.
5.	Minimal or no market involvement.	5.	Linked to local, national, or international markets.
6.	Low negative impact to environment	6.	High negative impact to environment

The production of food along with protecting environment could be a best practice to ensure food security. This can be achieved with combining the strengths of both subsistence and commercial agriculture**.** Subsistence farming plays a key role in providing local environment friendly practices that preserve biodiversity. The commercial farming, with its advanced technology, techniques, and machinery, plays a crucial role in scaling production to meet the global demand for food. We can produce enough food for all by preserving the environment for future generation by integrating traditional knowledge from subsistence farming with commercial cultivation practices. This approach ensures long-term food security, supports sustainable agriculture, and maintains agricultural productivity and conservation of environment.

1.2 Concept of Food Security and its Importance

12.1 Concept of Food Security

The concept of food security has changed over time. In the 1940s, it focused on producing enough food for everyone in the world. By the 1970s, people started thinking about how to keep food prices stable and make sure food reached everyone. In the 1980s, the idea expanded to include not just having food but also being able to afford it and use it properly. In the 1990s, it also included eating safe and healthy food that people prefer. Today, food security also considers protecting the environment and preparing for problems like climate change.

The concept of food security includes four main aspects/pillars which are described below:

1. Availability

Availability means having enough food produced or supplied to meet the needs of a population. It focuses on the physical presence of food through:

- **Local Production:** Growing crops and raising animals within the country or region.
- **Imports:** Bringing in food from other places to meet demand.
- **Food Reserves:** Storing food to use during shortages or emergencies.

2. Accessibility

Accessibility refers to people's ability to obtain the food they need for a healthy and active life. It focuses on ensuring that food is not just available but also within reach of all individuals, regardless of their economic, physical, or social situation. This pillar is influenced by several key factors:

a. Economic Access

- Food must be affordable for people. If food prices are too high or incomes are too low, even if food is available, people cannot access it.
- Economic access is affected by employment, wages, poverty levels, and social protection systems like subsidies or food assistance programs.

b. Physical Access

People need to be able to physically reach food markets or distribution centers. This depends on infrastructure like roads, transport, and storage facilities and geographic factors, such as whether people live in remote or urban areas.

c. Social Access

- Food distribution must consider fairness and equity. Marginalized groups, such as women, children, the elderly, or people with disabilities, often face barriers to accessing food.

- Social systems, cultural norms, and discrimination can also affect who has access to food within communities or households.

d. Policy and Governance

- Effective government policies and market systems are crucial in ensuring access to food.
- Policies that improve wages, provide subsidies, or reduce taxes on essential food items can enhance accessibility.

3. Utilization

Utilization refers to how food is used by individuals to achieve proper nutrition and maintain good health. Even if food is available and accessible, food security cannot be achieved unless people can effectively utilize it. This pillar focuses on the quality of food, how it is prepared and consumed, and whether the body can absorb its nutrients.

Key Aspects of Utilization

a. Nutritional Quality

- Food must be safe, diverse, and nutritious to provide the necessary energy, vitamins, and minerals for a healthy life.
- Diets lacking essential nutrients can lead to malnutrition, even when enough food is consumed.

b. Food Safety

- Food should be free from contamination, such as bacteria, toxins, or harmful chemicals. Unsafe food can cause diseases and reduce its nutritional value.
- Clean water and proper sanitation are essential for safe food preparation and consumption.

c. Food Preparation and Cooking:

Proper cooking methods are necessary to preserve nutrients and make food

safe to eat. For example, boiling water kills harmful microorganisms, and balanced cooking avoids over-processing, which can reduce nutrients.

d. Health and Sanitation

- The body's ability to use nutrients from food depends on overall health. Illnesses like diarrhea, caused by poor sanitation, can prevent nutrient absorption.
- Access to healthcare, clean water, and hygienic living conditions supports effective utilization.

e. Cultural Preferences

Food must align with people's cultural and personal preferences to be consumed regularly and contribute to nutrition. For example, certain communities prefer specific staples or preparation styles.

4. Stability

Stability refers to ensuring consistent availability, access, and utilization of food over time. It emphasizes that food security is not just about having enough food today but also being able to maintain these conditions in the future, even during disruptions or crises.

Key Aspects of Stability

a. Long-Term Food Supply

- Food production and supply systems must be resilient and sustainable to avoid shortages.
- This involves addressing challenges like climate change, soil degradation, and resource depletion.

b. Economic Stability

- Stable income levels and food prices are crucial. Sudden economic downturns or inflation can make food unaffordable for many.
- Policies like social safety nets, subsidies, and minimum wage regulations help stabilize access to food.

c. Environmental Stability

- Sustainable farming practices are necessary to maintain the natural resources (e.g., water, soil, biodiversity) required for future food production.
- Protecting ecosystems ensures that environmental shocks, such as droughts or floods, have less impact on food systems.

d. Resilience to Shocks

- Stability requires the ability to withstand short-term disruptions like natural disasters, pandemics, economic crises, or conflicts.
- Food systems must include strategies like emergency food reserves, international aid, and resilient supply chains.

e. Market and Trade Stability

- Global and local markets play a key role in ensuring food stability. Disruptions in trade routes or export bans by major food producers can lead to instability.
- Diversifying food sources and maintaining trade agreements can minimize such risks.

1.2.2 Importance of Food Security

Food security is essential for the well-being of individuals, communities, and nations. Its importance can be understood through the following points:

i. Ensures Survival and Health

- Access to adequate and nutritious food is necessary for human survival and good health.
- Prevents malnutrition, starvation, and diet-related diseases like stunting, anemia, or obesity.

ii. Supports Economic Growth

- Well-nourished populations are healthier and more productive,

contributing to economic development.

- Reduces healthcare costs by preventing food-related illnesses.

iii. Reduces Poverty

- Ensuring food security can break the cycle of poverty by allowing individuals to focus on education, work, and entrepreneurship instead of worrying about daily food needs.

iv. Promotes Social Stability

- Food insecurity often leads to social unrest, migration, or conflicts. Ensuring food security promotes peace and stability within and between nations.

v. Strengthens Resilience to Crises

- A secure food system helps communities recover from natural disasters, economic downturns, or conflicts more quickly.
- Reduces dependency on emergency aid during crises.

vi. Encourages Sustainable Development

Sustainable food security practices protect natural resources, reduce environmental degradation, and support long-term agricultural productivity.

1.2.3 Classify Cereals, Oilseeds, Grain Legumes, Cash and Industrial Crops

Food security is closely linked to the different crops we cultivate. Cereals**,** oilseeds, and grain legumes crops are essential for the nutrition and energy needed for proper growth and development of a human body. Cash crops and industrial crops help farmers to earn more income and improves access to food. A good production of these crops ensures that we have enough nutritious food and better income. These crops are defined with examples as follows:

i. Cereal Crops

Those crops which are cultivated for their edible grains or seeds which are staple for humans is called cereal crops. These grains are rich in carbohydrates.

Examples: Rice, Wheat, Maize, Barley, Millet, Buckwheat etc.

ii. Oilseed Crops

Those crops which are grown for their seeds, which are processed to extract oils used in cooking, industry, and biodiesel is called oilseed crops. Examples: Rapeseed, Mustard, Sunflower, Groundnut e.t.c.

iii. Grain Legume Crops

Those crops which are grown for for their protein rich seeds which are mostly consumed as Dal is known as Grain legume crops. These crops also can fix atmospheric nitrogen. Examples:Lentil, Chickpea, Pigeon pea e.t.c.

1.3 Geographical Distribution of Agronomical Crops in Nepal

Nepal is a beautiful landlocked country, situated in the majestic foothills of the Himalayas. It stretches from 26°20' to 30°10' North latitude and 80°15' to 88°19' East longitude. To the north, it borders the Tibetan region of China, while to the south, east, and west, it shares its boundaries with India. Nepal is shaped like a long rectangle, about 128 kilometers wide and 880 kilometers long, with a total land area of 147,181 square kilometers. The climate of Nepal is divided in to five types and distributed according to ethe elevation of the country. The different agronomical crops are grown according to the climatic requirement of the cops in different geographical regions of Nepal. The distribution of agronomical crops according to the required climate are described below:

The Subtropical Monsoon Climate, which ranges from 1200 to 4000 feet in elevation and has temperatures of 38-42°C in summer with mild winters. It is found in the Terai region of Nepal (e.g., Jhapa, Chitwan, Bara, Parsa, Rupandehi). This warm and wet climate is ideal for rice cultivation, making the Terai the main rice-producing area of Nepal. Wheat is grown in areas like Lumbini and parts of Chitwan, while maize is a staple crop in the Terai and also in parts of the mid-hills. The warm temperature of the Terai is also suitable for groundnut farming, and mustard is grown primarily in the central and western Terai. Sunflower is cultivated in areas like Chitwan and Rupandehi.

The Warm Temperate Climate, which ranges from 1200 to 2100 meters in elevation and experiences temperatures of 24-31°C in summer, reaching zero degrees during winter. It is found in the middle hill regions of Nepal, such as Kavre, Makwanpur, and parts of Kathmandu. Maize is widely cultivated in areas like Rasuwa, Nuwakot, and other middle hills, while millet is grown in regions like Ramechhap, Dolakha. The middle hills like Dhading and Makwanpur, are also suitable for rapeseed farming. Sunflower grows well in the central hill regions where there is adequate sunlight, and buckwheat is commonly cultivated in Rasuwa and Sindhupalchowk.

The Cold Temperate Climate, which ranges from 2100 to 3350 meters in elevation and experiences temperatures of 15-20°C in summer, with the possibility of dropping to zero degrees during winter. It is found in the higher hill regions of Nepal, such as Solukhumbu, Mustang, and Manang. This climate is ideal for barley, a crop well-suited for the cold temperate zone. It is commonly grown in areas like Manang and Mustang. Buckwheat is also cultivated in regions like Manang and Dolpa.

The Alpine Climate, which ranges from 3350 to 5000 meters in elevation and has an average temperature of 10°C, can stay below freezing for up to 9 months a year It is found in the high-altitude regions of Nepal such as Manang, Mustang, and Dolpa. This harsh climate is ideal for barley, the primary crop in these alpine regions due to its resilience to cold temperatures. Buckwheat is also grown in the high-altitude villages of Mustang and Manang.

The Tundra Climate, found above 5000 meters in elevation, remains below freezing throughout most of the year and is located in the highest peaks of the Himalayas, such as Mount Everest and other areas above 5000 meters. Due to the extreme cold and harsh conditions, very little agriculture is possible in this zone. The area is primarily used as pasture for grazing animals rather than for crop cultivation.

1.3.1 Importance and Scope of Agronomical Crops in Nepal

Importance of Agronomical Crops in Nepal

The importance and scope of agronomical crops are closely tied with the diverse geographical distribution of the Nepal. Lowland Terai to the mid-hills and mountains, support various agronomical crops like cereals, legumes and oil seed cultivation. These crops are crucial for food security and economic stability of the Nepalese people. There are various importance and scope of agronomical crops in Nepal. The different importance of agronomical crops are described below:

i. **Food Security:** Agronomical crops like rice, maize, and wheat are staple foods in Nepal. Growing of these crops helps to ensure the food security by providing nutritious food for the population.

ii. **Economic Stability:** Agronomical crops are a major source of income for Nepali farmers. `Farmers grow different cereal, cash and Industrial crops which help to generate stable income for the farmers by selling them.

iii. **Livelihood for People:** Cultivation of agronomical crops support farming, runnig related industries. It help to ensure the employment,income of the farmer which supports the livelihoods of the people.

v. **Enhance Soil Fertility:** Cultivation of agronomical crops like legumes (e.g., Lentil, Pigeonpea) help to fix atmospheric nitrogen in the soil. This helps to improve soil health and productivity.

vi. **Cultural Significance:** Agronomical crop like rice, have deep cultural importance in Nepal. It is an integral part of local festivals, rituals, and traditional dishes.

Scopes of Agronomical Crops in Nepal

There are different scope of agronomical crops in Nepal which are described bellow:

i. **Increase in Production:** Nepalese farmers have been growing different agronomical crops from ancient time. They have better knowledge about soil type, climate, weather pattern, crops suitable for their micro climate.

By combining these traditional knowledge and experience with the modern technology, improved farming techniques, and better seed varieties, there is significant potential to enhance crop production.

ii. **Export Opportunities:** Nepal is located between two large countries China and India. There is high demand of agronomical crops in these neighbour countries and global market. For an example, there is rising demand for soybeans in different countries for animal feed and biofuels by producing it in large quantity can be exported to the foreign countries.

iii. **Organic Farming:** Most of the cultivable land lacks access to chemical fertilizers and pesticides in Nepal. It can be a best opportunity for **organic farming**. By focusing on agricultural practices like crop rotation, FYM, Compost, Green manure, organic pesticides can improve soil health, and production of the crops. It helps to reduce dependence on chemicals, and promote a more eco-friendly approach to farming. This is benefit for both the environment and farmers.

iv. **Innovation of Machines and Technology:** The cultivation of agronomical crops requires specialized machines and advanced technology. Nepal has the potential to develop and innovate its own machinery and technologies which helps in the production of these crops. This innovation can enhance farming efficiency, increase productivity, and support sustainable agricultural practices. It ultimately benefit agricultural sector of the country.

v. **Development of Disease and Drought Resistance Varieties:** Developing disease and drought-resistant crop varieties can greatly benefit agriculture of Nepal. These crops can thrive disease prone or water shortages area. It ensures stable food production. Disease-resistant varieties reduce the need for chemical pesticides. The drought-resistant varieties help farmers cope with changing weather patterns. By focusing on these innovations, Nepal can improve food security, boost farm productivity, and build a resilient agricultural system.

Exercise

Choose the correct answer from the given alternatives.

1. According to the FAO (1983), food security involves.....
   a. Ensuring all people have physical access to food
   b. Ensuring all people have economic access to food
   c. Ensuring all people have both physical and economic access to food
   d. Ensuring all people have access to sufficient, safe, and nutritious food

2. Which of the following is NOT a pillar of food security?
   a. Availability
   b. Accessibility
   c. Utilization
   d. Sustainability

3. Economic access to food is primarily influenced by.....
   a. Climate change and natural disasters
   b. Employment, wages, and poverty levels
   c. Transportation infrastructure and geographical location
   d. Cultural preferences and dietary habits

4. Which region in Nepal is known as the "breadbasket"?
   a. Mountain region
   b. Terai region
   c. Hill region
   d. Kathmandu Valley

5. What is the primary agricultural challenge in the Mountain region of Nepal?
   a. Lack of fertile land
   c. Harsh climate and limited accessibility
   b. High population density
   d. Excessive rainfall and soil erosion.

6. Which of the following crops is most likely to be cultivated in the Hill region of Nepal?

   a. Paddy
   c. Coffee
   b. Sugarcane
   d. Wheat

7. What is the main focus of food utilization in the context of food security?

   a. Ensuring food is produced sustainably

   b. Making sure food is available in sufficient quantities

   c. Ensuring people can effectively use food for proper nutrition

   d. Maintaining stable food prices in the market.

8. What is the primary purpose of food security?

   a. To ensure economic growth for a nation

   b. To prevent environmental degradation

   c. To ensure all people have access to sufficient, safe, and nutritious food

   d. To promote international trade and cooperation.

Write short answer to the following questions.

1. What do you mean by food security? Mention the four pillars of food security.
2. Write any five differences between subsistence agriculture and commercial agriculture.
3. Make of table of cereal crops grown in different geographical regions of Nepal according to different seasons.
4. Explain the importance of agronomical crops in Nepal.

Write long answer to the following questions.

1. Explain the four pillars of food security with suitable examples.
2. What are the different climatic regions of Nepal? Describe how they support the cultivation of different agronomical crops with examples.

Project Work

1. Visit any local farm or consult with your parents or elders. Make a short report describing what types of crops are grown in your area. Mention: The name of the crops
   a. Whether they are cereal, oilseed, or legume crops
   b. Which climatic region your area belongs to
   c. Whether the farming is contributing to food security or not
   d. Conclude the report with the findings whether the farming is subsistence or commercial

Unit 2

Cultivation of Cereal Crops

2.1 Rice/Paddy

Rice is one of the most important staple food in the world. It is cultivated in waterlogged fields called paddies. Rice is cultivated especially in tropical and subtropical regions, where there is sufficient water and warm climates. It plays a crucial role in food security and supports the livelihoods of millions of people globally. There are different types of rice cultivated globally which are listed below;

Indica Rice (*Oryza sativa indica)*: This rice is long-grained and non-sticky. It is commonly grown in tropical and subtropical regions.

Japonica Rice (*Oryza sativa japonica*): This rice is short-grained and sticky when cooked and popular in East Asia. It is used for making sushi and rice balls.

Aromatic Rice (*Oryza sativa var. indica*): This rice Possesses a fragrant aroma due to natural aromatic compounds, such as 2-acetyl-1-pyrroline. Examples include Basmati and Jasmine rice.

Glutinous Rice (*Oryza sativa var. glutinosa*): This rice is sticky and starchy, often used in desserts and traditional dishes in Southeast Asia. It is gluten-free despite its name.

Wild Rice (*Zizania spp.*): This is not a true rice but a grass seed. It is known for its nutty flavor and dark, long grains. Native to North America and China

African Rice (*Oryzaglaberrima*): This rice is known as drought and pest-resistant. It is cultivated in West Africa.

Among all of them Rice (*Oryza sativa indica*) is widely cultivated in Nepal. This rice is well-suited to diverse agro-climatic zones, ranging from the terai plains to hilly regions of Nepal.

Botanical Description

Rice *(Oryza sativa indica)* is a short-day, annual plant.It grows 80-150 cm tall with long narrow leaves and a hollow stem.It containsaerenchyma tissue for gas exchange in flooded fields. The plant has fibrous roots, and the topmost "flag leaf" supports photosynthesis for grain filling. Flowers grow in a loose panicle and plant can thrive in warm, humid climates.

History and Origin

It is believed to have originated in Southeast Asia. The domestication of rice is thought to have occurred around 8,000 to 10,000 years ago in regions such as the Yangtze River valley of China. From China, rice farming slowly spread to India, Southeast Asia, and later to other parts of the world. In South Asia, rice became popular during the time of the later Indus Valley Civilization. In the modern world, rice is one of the important foods, feeding more than half of the word's people. Countries like China, India, and Indonesia are the largest producers of rice today. Modern machines and improved seeds have helped increase rice production and made it easier for farmers to grow more rice.

In Nepal, the cultivation of *Oryza sativa indica* has a long history, dating back thousands of years. The fertile plains of the terai and the hilly terraces of the mid-hills provided ideal environments for growing rice. Gradually it became a staple crop and is integral to Nepalese agriculture, culture, and cuisine.

Area, Distribution and Production

Crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Paddy	1,447,789	5,486,472	3.79

China, India, Indonesia, Bangladesh, Vietnam are the major producer of paddy. Nepal also produces significant amount of paddy. Paddy is grown all over parts of Nepal except high Himalayan regions. According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23);

Varieties

Paddy is cultivated in Nepal during two main seasons: the monsoon and the autumn (Chaite) season. The autumn season varieties, commonly known as Chaite Dhan, are primarily recommended for cultivation in the Terai belt due to their suitability to the region's climatic conditions. Major autumn varieties include Chaite 2, Chaite 5, Chaite 6, and Hardinath 1, which are widely grown for their adaptability and good yield performance during the autumn season.

During the monsoon season, various paddy varieties known as Barkhe Dhan are cultivated across Nepal. Hardinath 4 and Ghaiya 3 are well-suited for rainfed conditions and are commonly grown up to elevations of 700 meters above sea level. Meanwhile, varieties such as Khumal 4, 10, 11, 12, and 14 are predominantly cultivated around the Kathmandu Valley and other areas with similar climatic conditions, offering good adaptability and yield in these regions.

Climate and Temperature

Paddy is a warm-season crop that thrives in warm and humid climates. It is best suited to subtropical or tropical regions with distinct wet and dry seasons.

Adequate rainfall of 1000 to 1500 mm throughout the growing season is essential for healthy growth. The optimal average temperature range for paddy cultivation is between 21°C and 35°C. Warm temperatures of around 25–30°C are ideal for seed germination and early growth. During the vegetative stage, moderate temperatures between 21°C and 28°C favor healthy development. The grain filling stage benefits from slightly warmer temperatures, approximately 26–30°C, which support proper grain formation.

Soil Requirement

Paddy grows well in fertile clayey loam soil that holds water effectively. The soil should drain well but also hold enough water for the plants. Ideally, the soil pH should be slightly acidic to neutral, ranging from 5.5 to 7.

Land Preparation

Land preparation is a very important step in paddy cultivation that involves several crucial processes. First, land clearing and initial tillage are performed by removing residues of previous crops and controlling weeds either manually or by applying herbicides. Irrigation is usually applied a few days after herbicide application to enhance its effectiveness. The field may be flooded for 1–2 days before plowing to loosen the soil, making it easier to work. One deep plowing followed by 2–3 shallow plowings is recommended to prepare the soil adequately. Next, leveling the field is essential to ensure uniform water distribution; this can be done manually or with laser leveling machines. Finally, puddling is performed by maintaining a shallow water depth of 2–3 cm while tilling the soil to create a mud-like consistency. Puddling helps control weeds, reduces water infiltration, and provides a suitable medium for transplanting. Before flooding, farmyard manure (FYM) is often incorporated to enrich the soil.

Method of Nursery Raising of Rice Seedling

There are three major types of nursery for raising paddy seedlings. They are : Dry bed method, wet bed method and dapog method.

Wet Bed Method

Wet nurseries are used in irrigated areas. About 800 m² of nursery area is sufficient to raise seedlings for 1 hectare of land. The soil is puddled 2-3 times with a puddler or ploughed 3-4 times. After 1-2 days, the nursery is divided into narrow beds 1.25 meters wide, with drainage channels 30 cm wide between them. Fertilizers are applied at the rate of 225 g urea, 500 g ammonium sulphate, and 500 g single super phosphate per 10 m². For 800 m², this means applying 18 kg urea, 40 kg ammonium sulphate, and 40 kg single super phosphate. Keep the beds saturated with water for 5 days, then gradually raise water to 5 cm as seedlings grow. Drain excess water during heavy rains. If nitrogen is low, top dress with 50 g urea per m². For zinc deficiency, spray zinc sulphate twice (5 kg zinc sulphate + 2.5 kg calcium hydroxide mixed in 1000 litres of water per hectare), once 10 days after sowing and again 20 days after sowing. For iron deficiency, spray 0.5% ferrous sulphate solution. Seedlings are ready for transplanting after 20–25 days.

Dry Bed Method

This method is used in areas with low rainfall or insufficient irrigation where wet nurseries are not possible. About 800 m² of nursery area is sufficient to raise seedlings for one hectare of land. The land is ploughed 5–6 times until the soil becomes fine and well-tilled. Beds about 1 to 1.5 meters long (length may vary with land size) and 15 cm high are prepared, with 30 cm wide channels between them. Seeds are sown in rows 10 cm apart in dry or moist soil and covered immediately with sand or a thin layer of well-decomposed compost. Frequent irrigation is necessary until seeds germinate, keeping the topsoil moist but avoiding overwatering. Water is allowed to flow through the channels first, then gradually moistening the beds without flooding. Maintain a thin film of water after 5 days of sowing. Follow the same care and management as wet nurseries.

Dapog Method (Mat Nursery)

This method requires less space to raise seedlings—about 25 to 30 m² is enough for one hectare of land. Seedlings grow faster but are delicate and last only about

two weeks. Beds are prepared on a flat, slightly raised surface or cement floor, about 1.5 meters wide. The soil surface is covered with banana leaves or plastic sheets to protect seeds. Well-decomposed farmyard manure (1-2 kg per m^2) and balanced NPK fertilizer (15:15:15) at 20-30 g per m^2 are applied to provide necessary nutrients. Pre-germinated seeds are evenly broadcast at 3 kg per m^2, covered lightly, and watered several times daily to keep moist. Seedlings are ready for transplanting in 11–14 days and can be rolled like a carpet for easy transport. Transplant 3–4 seedlings per hill.

Difference Between Dry and Wet Bed Method

Feature	**Dry Bed Method**	**Wet Bed Method**
Soil Consistency	Well- pulverized, fine tilth	Soupy, mud like consistency
Water Management	Less water required throughout the nursery stage	Requires maintaining a shallow layer of water throughout
Seedling Development	Seedlings develop slower initially, but establish stronger root systems later	Seedlings emerge faster due to moist conditions
Weed Control	Easier to control weeds	Weeding can be challenging due to wet and muddy environment
Labor Intensity	Generally considered less labor intensive	Requires more labor for puddling the soil and maintaining water levels

Seed Rate Estimates

The recommended seed rate varies by nursery method. For wet and dry bed nurseries, sow seeds at 2 to 3 handfuls (about 90–135 grams) per square meter, requiring roughly 72 to 108 kilograms of seed for 800 m^2 of nursery area. In the dapog method, pre-germinated seeds are broadcast at 3 kilograms per square

meter, so about 75 to 90 kilograms of seed is needed for 25 to 30 m² of nursery which are sufficient for one hectare of land.

Seed Treatment and Seed Quality

Healthy and vigorous seedlings are essential for better crop growth and higher yield. Strong seedlings raised in the nursery are more resistant to pest attacks in the main field. For wet seed treatment, soak seeds in carbendazim at 2 g per liter of water for 1 kg of seeds for 10 hours, then drain the excess water. For biological control, treat seeds with *Pseudomonas fluorescens* at 10 g per kg of seed, soak in 1 liter of water, drain, and allow the seeds to sprout for 24 hours. *Pseudomonas fluorescens* produces antibiotic compounds that protect against rice blast and sheath blight. Seeds can also be treated with fungicides like captan or thiram at 4 g per kg of seed.

Time and Method of Transplanting

The primary paddy sowing season in Nepal occurs between mid-June and July, coinciding with the monsoon season that provides adequate rainfall for seed germination and early growth.

Typical Spacing

Row spacing should be 20–30 cm (8–12 inches), and plant spacing within a row should be 10–20 cm (4–8 inches).

Transplanting is done either manually or mechanically. Manual transplanting is the traditional method, where 30-day-old seedlings are uprooted and planted in puddled fields, with 2–3 seedlings per hill. Mechanical transplanting uses a transplanter, and seedlings are typically raised in a mat nursery.

Manure and Fertilizer

The amount of manure and fertilizer needed for paddy cultivation depends on factors such as soil fertility, rice variety, weather, and farming practices. Generally, 5 to 10 tons of organic manure like compost or farmyard manure is applied to improve soil structure, moisture retention, and nutrient content. For chemical fertilizers, nitrogen (N), phosphorus (P), and potassium (K) are essential. Paddy

requires a substantial amount of nitrogen for vegetative growth, applied in split doses: about 50% as a basal dose before transplanting, 25% at tillering, and 25% at panicle initiation, totaling 80-120 kg N per hectare. Phosphorus, vital for root development, flowering, and grain formation, is applied as a basal dose at 40-60 kg P per hectare. Potassium enhances disease resistance and grain quality, applied similarly as a basal dose at 40-60 kg K per hectare**.**

Irrigation

Traditional flooding method is found to efficient method of irrigation in paddy cultivation. It helps to suppress weed, provides a good habitat for beneficial organisms and helps controls pests and diseases. Flooding is gradually reduced or stopped after panicle initiation stage. Excessive water after panicle initiation can hinder grain filling. Stagnant water can increase risk of certain fungal diseases. Reduced flooding enhances good aeration around root.

Weed Management

Weeds compete with rice for nutrients, water, and sunlight, reducing yield if not controlled. Effective management includes proper field preparation, water management, crop rotation, hand weeding at 45 days, mechanical weeding, and using herbicides. Pre-emergence herbicides like Pretilachlor and Butachlor are applied 3–4 days after transplanting mixed with sand and watered lightly, avoiding drainage for 2 days. Post-emergence herbicides such as 2,4-D and Propanil control emerging weeds. Biological agents and high-density planting also help. Common weeds include *Echinochloa colona* (sama), *Cyperus difformis* (mothe), and *Cyperus iria* (thulomothe).Post emergence herbicides-2,4-D (2,4-Dichlorophenoxyaceticacid), Quinclorac, Propanil, Bentazon.

Harvesting

Rice maturity is commonly assessed by the color change of both the grains and the plant. Mature grains turn golden yellow or light brown, while the rice plant's leaves and stems change from green to yellowish. Paddy is typically harvested when the grain moisture content reaches about 20% or lower.

Harvesting can be done mechanically or manually. In large-scale paddy production, combine harvesters are commonly used. These machines cut and thresh the plant, separating grains and straw in a single pass. On a smaller scale, paddy may be harvested manually using hand tools such as sickles or knives. Workers cut the rice plants and gather them into bundles for further processing. Threshing is done using a mechanical thresher or a traditional method, such as pounding. After threshing, winnowing is done to remove any remaining straw, chaff, or impurities. After winnowing, drying is done to reduce the excess moisture content to safe storage levels. It is stored in cool and dry air tight container.

Marketing

Rice is a staple crop in Nepal. It is livelihoods of millions of farmers. Growing rice involves various costs like labor, seeds, fertilizers, irrigation e.t.c.. Many farmers in Nepal still rely on traditional farming methods, which are less efficient and more time-consuming than modern techniques.

In terms of trade, Nepal is both an importer and exporter of rice. While the country produces a significant amount of rice but still import different varieties of rice due to varying domestic demand. While Nepal also exports rice to international markets especially aromatic variety like Basmati but the volume is very limited. Nepal has a huge scope of growing rice to meet domestic demand and for export.

In Nepal rice market sector is influenced by a fragmented supply chain. Most of the farmers often lack direct access to larger markets. They often depend on middlemen to sell their products. Due to limited infrastructure and involvement of middlemen are affecting the pricing

and the timely distribution of rice. Involvement of Government for making best policies and granting subsidies to agriculture sector are important to keep rice prices stable and affordable for people.

❖ **SRI (System of Rice Intensification)**

The System of Rice Intensification, known as SRI, is a climate-smart, agroecological methodology for increasing the productivity of rice and, more recently, other crops by changing the management of plants, soil, water, and nutrients. The System of Rice Intensification (SRI) is an innovative method of rice cultivation that originated in Madagascar in the 1980s. SRI was developed by a French Jesuit priest, Fr. Henri de Laulanié, who observed and experimented with different rice cultivation practices in the highlands of Madagascar.

SRI Principles:

SRI methodology is based on four main principles that interact with each other:

- Early, quick and healthy plant establishment
- Reduced plant density
- Improved soil conditions through enrichment with organic matter
- Reduced and controlled water application

Recommended SRI Management Practices for Irrigated Conditions

- Seedlings should be transplanted when they are very young at the 2-leaf stage.
- Seedlings should be transplanted carefully and quickly to prevent damage of roots and minimize transplanting shock.

Insects-Pests of Paddy

As per the weighted average yield loss seed bug, stem borer, rice hispa, brown plant hopper (BPH), and rice armyworm are known to be common rice insects in Nepal. Effective control of these insect pests can be achieved through a well integrated management strategy.

1. Rice Seed Bug (RSB): *Leptocorisa acuta, Leptocorisa oratorius, Leptocorisa chinensis*

Rice seed bugs belong to the Hemiptera order and Alydidae family. These insects have become a significant threat to rice production. They have been causing damage to rice crops for decades. These pests attack rice grains leades to deformities and decrease yield.

Symptoms of Damage

- Affected grains become shriveled and misshapen.

- Grains may become discolored, with a "pecky" appearance.
- Some rice grains may be completely empty.
- The rice panicles may stand upright instead of drooping.
- Small marks or punctures from the bug's feeding are visible on the rice husks.

Management Methods

- Grow late-maturing rice varieties to avoid the infestation.
- Remove weeds around the rice fields to limit bug habitat.
- Trap and destroy bugs early in the morning or late afternoon when they are most active.
- **Protect natural predators** such as spiders, wasps, long-horn grasshoppers, and tiger beetles, which help reduce bug populations.
- When the bug population reaches a threshold of one bug per hill then spray Malathion 50 EC at a dosage of 1.25 ml/litre of water for effective control.

2. Rice Stem Borers (RSBs)

Major Rice Stem Borer Species are Striped Stem Borer: *Chilo suppressalis,* Yellow Stem Borer: *Scirpophaga incertulas,* White Stem Borer: *Scirpophaga innotata,* Dark-Headed Stem Borer: *Chilo polychrysus,* Pink Stem Borer: *Sesamia inferens.*

Rice stem borers are one of the most destructive pests for rice crop. These insects belong to the order Hemiptera and family Crambidae. They damage rice plants at various stages, reducing yields and causing economic losses. These pests have been a major concern for farmers in Nepal from many years.

Symptoms of Damage:

- Due to damage from larvae, the panicles appear white, can be easily pulled out, and contain no rice grains, which is called white head.
- Larvae feeding on the central leaves of young tillers results in the

leaves turning brown, which is called dead heart.

- Larval Waste is seen when white heads show waste left behind by the larvae.
- Severe damage from pests causes heavily infested fields to appear burned or scorched, which is called scorched fields.

Management Methods

- Grow resistant varieties.
- Plant early-maturing varieties to avoid peak pest cycles.
- Remove straw and cut stubbles to eliminate pest habitat.
- Cut the tip of seedlings before transplanting to remove eggs and larvae.
- Apply Bacillus thuringiensis (Bt) at 4g/litre for controlling fresh larvae.
- Protect natural predators such as wasps, spiders, and tiger beetles.
- Use light traps to capture adult moths
- For chemical control of rice stem borers, apply Cartap Hydrochloride (4G) @ 1.5 kg/ropani, Fipronil (0.3G) @ 1.5 kg/ropani, and Chlorantraniliprole @ 5g/ropani, based on pest infestation levels.

3. Rice Hispa

Rice Hispa (*Dicladispa armigera Olivier*) is also one of the major pest of rice crop. It belongs to the Order Coleoptera and the Family Chrysomelidae. It was first collected in Kathmandu in June 1975. It is recognized as a significant pest in the Terai belt of Nepal.

Symptoms of Damage

- The insects feed on the leaves, leaving visible marks on the upper surface of the leaf blades.
- White streaks running parallel to the midrib (central vein) of the leaves can be visible.
- The clear white spots along the veins of the leaves can be observed.
- The affected leaves turn whitish and become thin and fragile which

seems like paper.

Management Methods

- Remove weeds around and within rice cultivation field.
- Crop should be grown early when the monsoon starts.
- Eliminate eggs and larvae by cutting seedling tips before transplanting.
- Remove damaged leaves before the booting stage to reduce pest populations.
- Manually remove adult beetles from plants.
- Soack the rope @ 1:10 kerosene-water solution and tung rope is pulled across the canopy.
- Spray Lambda-Cyhalothrin 5 EC @ 0.75 ml per liter or Malathion 50 EC @ 1.25 ml per liter.

1. Brown Plant Hopper

The Brown Plant Hopper (*Nilaparvata lugens*), belongs to the order Hemiptera. It is one of the important pest in rice cultivation.

Symptoms of Damage

- Browning, and wilting of plants which is called Hopper burn.
- Ring patches of wilting and lodging of mature plants can be seen.
- Nymphs and adults gather at the base of plants above the water level.
- Sooty moulds are often found at the base of infected plants.

Management Methods

- Prefer early-maturing varieties to reduce pest infestation.
- Maintain 2-3 plants per hill for better plant health.
- Avoid overuse of nitrogenous fertilizers.
- Control weeds in and around the rice field to eliminate alternative hosts for the pest.
- Practice water management by increasing and decreasing water levels

at 3-4 day intervals to disrupt the pest's lifecycle.

- Apply systemic pesticides as per the following dosage: Imidacloprid 17.8% SL: 1 ml per 4 liters of water or Fipronil 5% SG: 2-3 ml per 4 liters of water.

2. Rice Armyworm

The Rice Armyworm (*Mythimna separata*), a significant pest from the Noctuidae family, poses a serious threat to rice crops in Nepal. The larvae feed on the leaves, panicles, and grains of rice plants, leading to a substantial reduction in both yield and quality.

Symptoms of Damage

- Seedlings are cut at the seed-bed level.
- Severe defoliation during the vegetative phase.
- Leaves turn yellow and dry out.
- Larvae feed on developing grains and panicles.
- Basal cutting of panicles results in hanging of panicles.

Management Methods

- Keep nursery areas free from weeds and practice deep ploughing.
- Sow rice early and conduct regular pest monitoring.
- Flood fields in areas with suspected outbreaks to control larvae.
- Dig a shallow trench along affected rice rows to trap armyworms.
- When infestations are severe, apply insecticides like **Emamectin Benzoate 5 SG** @ 0.45 g per liter of water or **Fenvalerate 20 EC** @ 1 ml per liter of water.

Diseases of Paddy

1. Bacterial Leaf Blight

Bacterial leaf blight is caused by the bacterium *Xanthomonas oryzae*. It attacks on rice leaves which leads to yellowing and drying of the plants.

Symptoms of Damage

- Yellow to gray stripes appear along the leaf margins.
- Water-soaked areas appear at the edges of the leaves.
- The stripes gradually spread across the entire leaf.
- The leaves begin to dry out, starting from the tip.
- This disease mostly occurs during transplanting or in nursery conditions.

Management Methods

- Use disease resistance variety.
- Use recommended doses of fertilizer.
- Drain out water from the disease infected field.
- treatment of seed with streptomycin sulfate 9%+tetracycline hydrochloride 1% WP 0.25 gm/l of water.

2. Rice Blast

Rice blast is a destructive fungal disease caused by *Pyricularia oryzae*. It leads to significant yield losses if not properly managed. This disease primarily impacts leaves, leaf sheaths, and panicles. The symptoms becomes noticeable during key growth stages.

Symptoms of Damage

- Broad or eye-shaped spots with gray or dark margins appear on leaves or leaf sheaths.
- In severe cases, the spots merge into larger areas of damage.
- At panicle initiation the stand below the ear head dark brown spots are observed.

Management Methods

- Use disease-resistant varieties of rice.
- Treat seeds with carbendazim 50% WP (2-3 g/kg of seed) to prevent infection.

- Apply the recommended dose of nitrogenous fertilizers for balanced growth.
- Use Tricyclazole 75% WP (0.75 g/l of water) for effective control.
- Apply Kasugamycin 3% SL (1.5 ml/l of water) to manage the disease.

3. Brown leaf Spot

Brown leaf spot is a fungal disease caused by *Helminthosporium oryzae*. This affects rice from the seedling stage in the nursery to the milk stage in the main field. It can damage both the leaves and seeds and leads to yield loss.

Symptoms of Damage

- Small, brown dots are visible on leaves during the early disease phase.
- Those dots become cylindrical, oval, or round like sesame seeds.
- Infected leaves have dark brown to black spots.
- Yellow halos appear around the brown lesions.
- Infected seed leads to poor germination of seed and weak plant growth.

Management Methods

- Use disease-resistant varieties to reduce susceptibility to the fungus.
- Apply the recommended dose of fertilizers to promote healthy plant growth and resilience.
- Drain out excess water from the field to prevent a moist environment.
- Treat seeds with Streptomycin sulfate 9% + Tetracycline hydrochloride 1% WP to prevent seed infection.
- Practice proper crop rotation and avoid planting rice in the same field repeatedly to break the disease cycle.

4. Tungro Virus

Tungro Virus is a rice disease that causes stunted growth and poor panicle development, often spread by sucking pests.

Symptom

- Older leaves turn yellow to orange which starts from the tips and margins.
- Plant growth is stunted.
- Flowering is delayed.
- Panicles bear empty glumes.
- Chlorosis appears between veins on the leaves.

Management Methods

- Use certified seeds to prevent infection.
- Uproot and destroy infected plants to stop the spreading of this disease.
- Spray cypermethrin (2 ml/liter of water) to control the vectors.
- Follow the crop ratation to break the life cycle of the vectors.
- Avoid excess irrigation.

4. Khaira Disorder in Rice

Khaira Disorder in rice is caused by zinc deficiency. It primarily affects plants both in the nursery and field.

Symptoms of Damage

- Stunted plant growth.
- Chlorosis between the veins of new leaves.
- Brown spots form on the lower leaves.
- Small brown stripes appear on the leaves.
- Poor tillering and reduced grain formation.

Management Methods

- Spray a mixture of 5kg zinc sulphate + 2.5kg lime in 1000 litre of water & spray at 10 days & 20 days after sowing seed in the nursery.
- In the field condition spray zinc sulphate @ 20-25kg/ hactare.

- 5kg zinc sulphate + 2.5kg calcium oxide in 1000 litre of water for 500m² area (2 times at 7days interval) is used for foliar spray

Critical stages in paddy

Rice plants go through several important growth stages, but some are especially critical because the crop is most vulnerable to stress during these times. Proper care and management during these critical stages like seedling, tillering, panicle initiation, flowering, and grain filling are essential to protect the crop and achieve a good harvest.

- **Seedling Stage:** Ensure proper watering and protection from pests and diseases to establish healthy seedlings.
- **Tillering Stage:** Maintain adequate water and apply balanced fertilizer to promote maximum tiller development.
- **Panicle Initiation Stage:** Avoid water stress and provide necessary nutrients, especially nitrogen, for healthy panicle formation.
- **Flowering (Heading) Stage:** Keep fields well-irrigated and protect from pests to ensure good pollination and grain setting.
- **Grain Filling Stage:** Continue proper irrigation and nutrient supply to ensure full grain development and optimal grain weight.

2.2. Wheat (*Triticum aestivum*)

Introduction

Wheat (*Triticum aestivum*) belongs to the Poaceae family. It is one of the most important cereal crops and consumed as staple food by millions of people in the world. It is commonly used to make chapati, bread, pasta, and many other foods. In Nepal, wheat ranks third position in terms of cultivated area.

History and Origin

There is debate in the exact origin of wheat. However, archaeological evidence suggests its domestication occurred in the Fertile Crescent region of the Middle East. It encompasses present-day Iraq, Syria, and Turkey around 10,000 years ago.

Area and Distribution

Wheat is cultivated across diverse climatic zones worldwide. In Nepal, it is primarily grown in the Terai region, with significant cultivation in the eastern, central, and western parts. According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23);

Crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Wheat	697,762	2,098,462	3.01

Climate

Wheat grows best in cool climates with moderate humidity. The ideal temperature for germination is 20-25°C, 15-25°C during tillering, 18-30°C during booting and heading, and 22-32°C for grain filling stage. Wheat also needs 500-750 mm of well-distributed rainfall throughout the growing season for proper growth and

development.

Soil

Wheat grows best in fertile, loamy, neutral pH (6.5-7.5) and good water-holding capacity soil. This type of soil provides the right balance of aeration, moisture, and nutrients for proper growth and development of the crop.

Varieties

In Nepal different varieties are cultivated according to the different geographical regions which are listed below.

- **Terai Region:** Gautam, BL-1473, RR-21, NL-30, HD-1982, UP-202, Nepal-297, Nepal-251, BL-1022, Cumbizi, Trabani, Vaskar, Rohini, and Achyut.
- **Mid-Hill Region:** Kranti, Lerma-52, Annapurna-2, and Pasang Lhamu.
- **High-Hill Region:** Annapurna-1, Annapurna-2, Annapurna-3, Annapurna-4, and Kanti.

Seed Rate and Spacing

The seed rate of around 100-120 kg per hectare is commonly suggested for the growing of wheat crops. In the case of late planting, the seed rate should be increased by 10-12% to ensure adequate plant population. Adequate spacing is also required to ensure maximum growth and development. R×R 20-25 cm and the P×P 5-10 cm spacing facilitates air circulation, proper sunlight, uptake of nutrients and helps to gain better yield.

Field Preparation

Proper land preparation is essential for wheat cultivation. Deep plowing to a depth of 20-25 cm and followed by 2-3 shallow plowings helps to create a fine seedbed. Leveling the field ensures uniform water distribution. Removing crop residues and controlling weeds before planting are crucial steps to minimize competition and promote better yield.

Manures and Fertilizers

Apply 10-15 tons of farmyard manure (FYM) or compost per hectare to improve the fertility of the soil. The recommended NPK fertilizer dose are 100:50:50 kg/ha for irrigated wheat and 60:40:25 kg/ha for rainfed conditions. Apply half of the Urea along with the full dose of DAP and MOP during land preparation. The remaining Urea should be applied in two equal splits: once at 40-45 days after sowing (DAS) and again at the panicle initiation stage to support optimal crop growth and yield of the crop.

Time and Method of Sowing

The best time to sow wheat is between 10th to 25th November in irrigated areas. For rainfed wheat, sowing is carriedout from mid-October to early November. The short-duration varieties of wheat can be sown in December. The sowing time should ensure temperatures are between 20°C and 22°C for proper germination of seed. Before sowing seed treatment is crucial. Hot water treatment is done Before sowing by soaking them in water for 4 hours, then dipping them in hot water (52°C for 10 minutes or 55°C for 5 minutes). After cooling dried in shade. For fungicide treatment, mix Bevistin or Benlate (2g per kg of seeds) in a sealed container and stir for 8-10 minutes. This helps protect the seeds from diseases like blast and loose smut.There are different methods of sowing wheat which are described below:

- **Behind Local Plough**

  This is the most common method, where seeds are dropped by hand into furrows made by a local plough.

- **Drilling**

  In this method, seeds are sown using a seed drill or ferti-seed drill, ensuring uniform depth for better germination and plant growth. The field should be well-prepared, fine, and level for this method.

- **Dibbling**

  Used when seed supply is limited, seeds are placed one by one in holes

made by a dibbler. This method is time-consuming and not commonly used.

- **Zero Tillage Technique**

  Used in rice-wheat cropping systems, this method involves sowing wheat directly in the rice field without ploughing by broadcasting manually or using a Zero-till-ferti-seed-drill machine. This method helps to saves time. There should be proper moisture, low stubble height, and weed-free condition in field before sowing.

Irrigation

Proper irrigation is crucial for healthy wheat growth and development. It helps to provides the right amount of water at key stages of the crop. Pre-sowing irrigation helps to prepares the soil for planting. Irrigation during these growth stages is crucial for wheat cultivation: crown root initiation (20-25 days after sowing), tillering (40-45 days), jointing (70-75 days), flowering (90-95 days), and milk formation (110-115 days). Proper drainage is also essential to prevent waterlogging condition in the field.

Weeding

Weeds compete with wheat plants for water, nutrients, and sunlight. Infestation of weeds reduce yield of the crop. Timely weed management is crucial for optimal crop production. The first weeding should be done about a month after sowing, during the crown root initiation stage. The second weeding should be done three months after sowing, during the plant elongation stage. Chemical control using herbicides such as Weedone or Tafacid is also can be practiced to manage weeds efficiently.

Harvesting, Yield, and Storage

Harvest wheat when the grains are fully mature. The grains should be harvested when the whole plant turns into golden-brown color, grains becomes hard and grain moisture reaches 12%. Threshing can be done by hand or using machines. After threshing, it is important to dry the grains properly to lower the moisture

content below 12% to avoid spoilage. The dried grains should be stored in a clean, dry, and well-ventilated area, using sacks or airtight containers to protect them from pests, moisture, and mold. The stored grains should be monitored regularly to keep them in good condition until it is consumed or sold.

Insects-Pests

Wheat is affected by different insect pests which can damage the plants at different growth stages and leads to reduced yield and quality. The common pests include White Grub**,** Army Worm**,** Wire Worm**,** Aphids**,** and Cut Worms each have specific symptoms and control measures which are described below:

1. White Grub (*Phyllophaga spp.*)

White Grub is a soil-dwelling pest that feeds on the roots of wheat plants, leading to significant damage.

Symptoms of Damage

- White Grub lives in the soil and feeds on roots.
- It causes plants to wilt.
- The affected plants may eventually die.
- The roots become weak and damaged.
- The plant shows stunted growth and yellowing of leaves.

Management Methods

- Plough the field and manually pick and destroy the white grub.
- Use only well-decomposed FYM or compost.
- Use 2 kg of Meterhizium pesticide per Ropani during the second ploughing if infestations are frequent.

2. Army Worm (*Mythimna separata)*

Army Worm is a destructive pest that feeds on wheat plants at various growth stages, causing significant damage to the crop.

Symptoms of Damage

- Larvae feed on ripe wheat grains, young shoots, leaves, and seeds.
- Leaves are severely damaged and may be eaten entirely, leaving the plant leafless.
- The plant shows signs of stunted growth.
- Affected plants may have chewed or irregularly shaped leaves.
- Larvae damage can lead to reduced grain production.

Management Methods

- Clean and plough the field thoroughly before sowing.
- Burn or bury crop residues from the previous season to remove potential pests.
- Use Dimethoate 30 EC at a rate of 1 ml per litre of water.
- Prepare a solution of 15 litres of water and 15 ml of Dimethoate for 1 Ropani of land.
- Apply the pesticide in the evening when the army worm larvae are usually hiding in the soil.

3. Wire Worm (*Agriotes spp*)

Wire Worm is soil-dwelling pest that damage wheat roots and other parts of the plant, sometimes even affect seeds.

Symptoms of Damage

- Damage to the roots of wheat plants.
- Injury to parts of the plant beneath the soil surface.
- Occasionally, seeds are also damaged.
- Plants may show signs of stunted growth.
- The plant may fail to develop properly due to root damage

Management Methods

- Practice crop rotation to prevent a buildup of pests.

- Ensure proper irrigation during the cultivation period to maintain healthy soil conditions.
- Proper soil preparation before sowing can help reduce infestation.
- Clean the field of debris that may harbor the pests

4. Aphids (*Aphis gossypii*)

Aphids are small insects that feed on the sap of wheat plants, especially during the spike formation stage, and can weaken the plant significantly.

Symptoms of Damage

- Damage is most severe during the spike formation stage.
- Aphids suck sap from the leaves and young spikes, causing them to weaken.
- Affected plants may show stunted growth.
- Leaves may become yellow and curl up.
- Aphids leave behind a sticky substance (honeydew) that may attract mold.

Management Methods

- Regularly monitor the crop to detect early aphid infestations.
- Ensure good field sanitation to reduce the spread of pests.
- Mix 15 ml of Dimethoate in 15 litres of water and spray on the affected area.
- Carryout the control measures as soon as aphids first appear on the plants.

3. **Cut worms**

Cut worms **(***Agrotis spp***.)** are the larvae (young ones) of certain moths that can harm crops. They are most active at night and like to feed on the stems and leaves of plants, especially when the plants are young. Here are some common signs that your plants might have cut worms:

Symptoms of Damage

- The plants might suddenly droop or fall over because their stems are cut at the base.
- The leaves may have irregular holes especially on the edges.
- The stems of plants can have scars or cuts.

Management Methods

- Spray 1 kg of Dorsban granule per Ropani near each plant during the time of vegetative growth stage.
- The weeding and field sanitation should be done for controlling pest in the field.

Diseases

Wheat is susceptible to various diseases that can severely affect the growth and yield of the crop. Common diseases include **Yellow Rust**, **Loose Smut**, and **Bacterial Leaf Blight**.These each disease is caused by specific pathogens and requires different control measures which are described below:

1. Yellow Rust

The Causal organism of this disease is *Puccinia striiformis.* Yellow Rust is a fungal disease that causes yellowing of wheat leaves and leads to reduced yield.

Symptoms of Damage

- Small, long yellow dots appear on the upper side of the leaves.
- The dots merge into yellow lines on the leaves.
- Disease also affects the underside of the leaf, husk of the grain, and ear part.
- High infestation causes yellowing of the wheat of entire field.
- Plants may show stunted growth.

Management Methods

- Grow disease-resistant wheat varieties like W. K. 1204, Gautam, Danphe Munal, and Dhaulagiri.
- Use only the recommended amount of urea.
- Spray Mancozeb fungicide (2.5 gm in 1 litre of water).
- Spray Propiconazole solution (0.75 gm per litre of water).
- Remove and destroy infected plant material from the field.

2. Loose Smut

The Causal organism of this disease is *Ustilago tritici.* Loose Smut is a fungal infection that causes black fungal powder to fill wheat ears and affects grain quality.

Symptoms of Damage

- Wheat ears are filled with black fungal powder.
- The wind may carry away the powder, leaving only the empty spike.
- Infected plants may show incomplete or malformed spikes.
- Grain quality of wheat is reduced.

Management Methods

- Soak seeds in cold water for 4 hours before sowing, then dip in hot water at 52°C for 10 minutes or 50°C for 5 minutes.
- Use disease-resistant varieties like Annapurna-4.
- Treat seeds with fungicides like Vaitavax-2000, Bevistin, or Benlate (2-3 gm per kg of seed).
- Use 7-10 gm of fungicide for 3.5 kg of seeds for 1 Ropani of land.
- Ensure proper field sanitation and remove infected plants.

3. Bacterial Leaf Blight

The causal organism of this disease is *Xanthomonas oryzae.* Bacterial Leaf Blight is a bacterial disease that causes small brown or black spots on wheat

leaves, which eventually burn the leaves.

Symptoms of Damage

- Small brown or black dots appear on the leaves.
- The dots expand into oval shapes with a light brown center and yellow circle around them.
- The spots grow larger and merge into one, causing leaves to look burnt.
- Infected plants may show stunted growth.
- The disease can severely reduce yield if not controlled.

Management Methods

- Grow disease-resistant varieties like Pasang Lhamu, W K 1204, Aaditya, Gautam, and Vijaya.
- Sow seeds early (late October) to help reduce infection.
- Apply recommended amounts of urea, phosphorus, and potash.
- Treat seeds with Vitavax-200 fungicide (2-2.5 gm per kg of seed).
- Maintain proper field hygiene by removing infected plant material.

Marketing

In Nepal, the cultivation of wheat involves growing for both local consumption and trade. Wheat is an important crop of the country and especially grown in the Terai and Mid-Hill regions. The economics of wheat production is impacted by the involvement of middlemen. Middlemen often buy wheat from farmers at lower prices and sell it for a higher price in the market. This practice is hampering to receive the actual value of their crop which reduces their profits. The minimum support price by government for wheat can protect farmers from price fluctuations. Eliminating this problem and ensuring direct access to markets or setting a better fixed price for wheat can help farmers earn more and improve their livelihoods. There is high domestic demand for wheat in Nepal and foreign countries too. By growing enough quality grains, Nepal has the potential to become self-sufficient and good exporter of wheat grains.

Critical Stages of Wheat

Wheat goes through several important growth stages, but some are critical because the crop is most sensitive to stress during these periods. Proper care and management at these stages ensure healthy development and maximize yield. The critical growth stages of wheat include:

- **Germination and Emergence:** Ensure proper soil moisture and seed treatment for healthy seedlings.
- **Tillering:** Apply nitrogen fertilizer and control weeds to promote strong tiller growth.
- **Jointing:** Stem elongates and joints (nodes) become visible. Apply necessary fertilizers and monitor for pests and diseases to support healthy growth.
- **Heading:** The grain-bearing head emerges. Protect plants from diseases and insects, and ensure adequate irrigation to support grain formation.
- **Grain Filling:** Maintain sufficient water and nutrient supply for proper grain development.

2.3 Maize

Introduction

Maize (*Zea Mays*) belongs to the poaceae family. It is also known as corn. It is one of the most important cereal crops in the world. It is the second main food crop in Nepal. Maize is widely used as food, animal feed, biofuel production, and various industrial products. In Nepal, maize cultivation is crucial for food security and the livelihoods.

Botanical Description

Maize is a monocotyledonous, annual plant with a tall, erect stem. It has a unique inflorescence consisting of separate male (tassel) and female (ear) flowers. The female flowers are enclosed within husks eventually develops into the corncob which contains numerous kernels.

History and Origin

Maize is believed to have originated in Central America and Mexico. Archaeological evidence suggests that it was domesticated several thousand years ago by indigenous civilizations.

Area and Distribution

Maize is cultivated worldwide, with major producing countries including the USA, Brazil, China, Mexico, and India. In Nepal, maize is grown extensively across the Terai, inner Terai, mid-hills, and high-hills. According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23);

Crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Maize	940,256	2,976,490	3.17

Climate and Soil

Maize is a warm-season crop that thrives in warm and humid environments. The optimal temperature range for its growth and development lies between 24°C and 32°C, while seed germination is most effective at approximately 21°C. A well-distributed rainfall of 500 to 750 mm throughout the growing season is

ideal to support healthy crop establishment and better yield. Maize can be grown on a wide range of soils. Well-drained, fertile, loamy soils with good aeration and soil pH ranging from 5.5 to 7.5 are generally considered ideal for cultivation of maize.

Varieties

Maize is cultivated across various ecological regions of Nepal, and specific varieties are recommended for each zone to ensure optimal productivity.

- In the Terai region, suitable maize varieties include Janaki, Sarlahi Seto, Hetauda Composite, Rampur Yellow, Rampur Composite, Rampur-2, Arun-1, Arun-2, and Rampur-1.
- For the mid-hill region, recommended varieties are Khumal Yellow, Manakamana-3, Ganesh-2, Manakamana-1, Lumle-2, and Hetauda Composite.
- In the high-hill areas, Ganesh-1 and Kakani Yellow are the most appropriate due to their adaptability to cooler climates and higher altitudes.

Types of Maize

There are different types of maize cultivated in the world. In Nepal, the two main types of maize are grown (i). Dent Corn and (ii). Flint Corn.

(i) **Dent Corn: Dent Corn** is primarily used as **animal feed**. It is used in the foumulation of Farm animals and poultry feed due to its high starch content and low gluten. It produces good yields but contains **lower nutrients** compared to other maize types. Due to its **high yield** makes it a popular choice for animal feed.

(ii) **Flint Corn: It** does not have a dent on its kernels. It contains more **starch**, which makes it ideal for **making flour**. This type of corn is commonly used to prepare **chapati, cakes, bread e.t.c**. Flint corn is also rich in nutrition and **tasty**. It also can be stored safely for long time without being affected by **weevils**.

Seed Rate and Spacing

The recommended seed rate for maize varies by variety type. For hybrid varieties, a seed rate of 20–25 kg per hectare is suitable, while open-pollinated varieties generally require about 20 kg per hectare. Spacing also plays a key role in ensuring proper plant development. A common spacing for composite varieties is 75 cm between rows and 25 cm between plants. Hybrid varieties may require slightly closer spacing depending on the plant architecture and growth conditions.

Field Preparation

Proper land preparation is crucial for achieving good seed-to-soil contact and promoting healthy root development in maize. It is recommended to begin with deep plowing to a depth of 20-25 cm, followed by 2-3 shallow plowings at about 15 cm to break down soil clumps and refine the tilth. Finally, leveling the field ensures uniform water distribution, efficient irrigation, and proper drainage, all of which contribute to better crop establishment and yield.

Manures and Fertilizers

For successful maize cultivation, balanced nutrient management is essential. It is recommended to apply 10-20 tons of farmyard manure (FYM) or compost per hectare to improve soil fertility and structure. The general NPK recommendation is 60:30:40 kg/ha for rainy season crops, while summer season crops require higher doses, 120:90:40 kg/ha. Half of the urea should be applied as a basal dose during field preparation. The remaining half is splited in to two halves and used as two top dressings. First top dressing is done around 40-50 days after sowing (at the tasseling stage) to help proper grow and development of the plant. Second top dressing is done around 60-70 days after sowing (at the silking stage) to help the maize fill the grains properly and increase yield.

Sowing Time and Methods

Maize is generally sown between March to May in most of the part of Nepal. It is a day-neutral plant, which means its growth is not affected by the length

of the day. Whether the day is long or short, maize will grow well as long as other factors like temperature, moisture, and soil are suitable for the crop. Before sowing, soak the maize seeds in water for one night and slightly dry them in the shade. This helps to ensure the seed germination. There are different planting methods of maize which are described below:

- **Behind Local Plough Method:** This is the most common method of sowing maize, where seeds are manually dropped into the furrows made by a local plough. It is a simple and widely used method by farmers in Nepal.
- **Drilling Method:** In this method, a seed drill or ferti-seed drill is used to sow seeds at a uniform depth. This ensures consistent germination and healthy plant growth, as the seeds are evenly distributed and placed at the correct depth.
- **Dibbling Method:** This method is used when seed supply is limited. Seeds are placed one by one in small holes (called dibble holes) made using a tool called a dibbler. This method is more labor-intensive and not commonly used compared to other methods.

Irrigation

For better maize production, the soil should have enough moisture up to 40-45 days after sowing, and during the tasseling and silking stages. Irrigation is needed after the first weeding and during the tassel stage if the field dries out. The most important times for irrigation are during tasseling, silking, and grain filling to prevent water stress, which can reduce yield. However, avoid waterlogging as too much water can cause root rot and harm the plants.

Weeding

Weeding is a vital practice for ensuring optimal growth and yield in maize cultivation. Timely weed control helps to reduce competition for nutrients, water, and sunlight with the crop. Manual weeding is commonly practiced. The use of herbicides can enhance efficiency of weed management. Pre-emergence

herbicides such as atrazine, alachlor, and simazine are effective in controlling weeds before they emerge. Post-emergence herbicides can also be applied but they must be carefully selected to avoid injury to the crop.

Harvesting, Yield, and Storage

Harvesting, yield, and storage are important aspects of maize production that influence overall profitability. Maize should be harvested when the grain moisture content reaches around 27-30%, ensuring optimal quality and ease of processing. After harvesting, the cobs should be husked and thoroughly dried in the sun to reduce moisture content and prevent fungal growth. Proper storage in well-ventilated areas is essential to avoid moisture damage and preserve grain quality. The average yield of maize can vary widely depending on factors such as variety, soil fertility, climate conditions, and management practices.

Insects Pests, and Diseases

Insects and Pests of Maize

1. White Grub (*Phyllophaga* species)

Symptoms of Damage

- White grubs feed on the roots of maize plants. This reduces its ability to absorb nutrients and water.
- Wilting and yellowing of the leaves especially during dry conditions.
- Stunted growth and may appear smaller than healthy plants.
- In severe cases, maize plant can be easily uprooted by wind or pulledout with hand.

Management Methods

- Plow the field properly and manually pick and destroy the white grubs to reduce their numbers.
- Do not use raw Farm Yard Manure (FYM) as it can encourage the growth of white grubs.
- Apply 2 kg of Meterhizium pesticide per Ropani and mix it into the

soil during the second plowing. It can also be applied at the second weeding time for better control.

2. Maize Stem Borer (*Chilo partellus*)

Symptoms of Damage

- The central shoot of young maize plants wilts and dries up which is called dead heart.
- Small holes or tunnels appear in the maize stem as larvae feed inside.
- The leaves near the damaged stem start to yellow and wilt due to nutrient loss.
- The growth of the plant slows down and maize ears may be smaller or undeveloped.

Management Methods

- Rotate maize with non-host crops to break the life cycle of the stem borer.
- Remove and destroy infested plant debris to reduce pest survival for the next season.
- Spray 1.5 liters 2 kg of Carbaryl 50 WP in 1000 liters of water per hectare, about 15 days after sowing.
- Apply 4% Savin granules at 15 kg per hectare, 30 days after sowing.

Diseases of Maize

1. Common Ear Rot Disease (*Fusarium verticillioides)*

Symptoms of Damage

- The kernels of the maize turn pink, red, or reddish-brown as the fungus infects them.
- The infected kernels begin to rot, and the cob starts to decompose,

often with a foul smell.

- A white or pinkish mold appears on the infected kernels, which later turns brown.
- The infected kernels shrink and decay prematurely.

Management Methods

- Use of varieties that are resistant to Fusarium to reduce the risk of ear rot.
- Rotate maize with non-host crops (such as legumes) to break the disease cycle.
- Sow and Harvest maize early and avoid harvesting in wet conditions.
- Remove and destroy infected plant debris after harvest.

2. Black Smut (*Ustilago maydis)*

Symptoms of Damage

- The tassels of the maize plant become black in colour.
- The maize cob is filled with blackish, powdery spores instead of kernels.
- Infected cobs may be malformed, and the usual kernels are replaced by the smut spores.
- Stunted growth and poor development of the plant.

Management Methods

- Remove and destroy infected plants, including their cobs and tassels, to prevent further spread of the disease.
- Ensure that seeds are free from fungal contamination before planting .
- Practice crop rotation with non-host crops (such as legumes) to break the disease cycle.
- Plant maize varieties that are resistant to black smut to reduce the chances of infection.

3. Downy Mildew (*Peronosclerospora sorghi)*

Symptoms of Damage

- Infected maize plants show yellowing, especially in the younger leaves.
- A white, fuzzy growth appears on the underside of the infected leaves.
- The leaves may curl or become distorted in severe condition.
- Stunted growth of plant and produce fewer or no ears.

Management Methods

- Use resistant variety such as Rampur-composite to reduce the chance of infection.
- Spray Bevistine 75% W.P. 3 gram per liter of water during the early stages of the disease.
- **Proper sanize the field before sowing and after harvesting of the crop.**
- Maintain the crop ratation with other crops like legumes.

4. Northern Leaf Blight *(Exserohilum turcicum)*

Symptoms of Damage

- Long water-soaked spots appear on the maize leaves. These spots later turn brown or tan with a yellowish ring around them
- These spots spread and cause the leaves to dry out and die.
- The dried leaves of the plant can't make as much food through photosynthesis.
- The maize ears don't grow properly also leads to fewer grains.

Management Methods

- Rotate maize with other crops (like legumes) to break the cycle of the fungus.
- Use maize varieties that are resistant to Northern Leaf Blight.
- Plant maize with enough space between each plant which helps to

prevent the spread of the disease.

- The infected leaves or plants should be removed and destroyed.

5. Southern Leaf Blight (*Bipolaris maydis)*

Symptoms of Damage

- Narrow linear lesions that are light green at first and then turn into tan or brown. The lesions are often more distinct and angular.
- leaves become damage and die.
- The edges of the infected leaves turn yellow.
- The disease can lower the maize yield.

Management Methods

- Rotate the crops every year.
- Choose resistant varieties to Southern Leaf Blight.
- remove the infected parts of the plant and destroy them.
- Make sure the maize plants are spaced well apart so air can flow easily between them.
- Apply tebuconazole (0.5–1 L/ha) or chlorothalonil (2–3 L/ha) in the early stages of the disease.

Marketing

Maize cultivation is contributing to the agricultural economy of the country. There is a high domestic demand for maize due to variety of uses. It is used for food, animal feed, and industrial purposes. Nepal has the potential to become self-sufficient and even an exporter in maize production by utilizing the fertile land. The involvement of middlemen are hindering the profit of farmers in Nepal in this sector. Ensuring direct access to markets and eliminating intermediaries, better government policies, good agricultural infrastructure can help to earn better prices, boosting the economy and supporting livelihood of the farmers

Critical Stages of Maize

Maize passes through several key growth stages that are critical for a good harvest. Proper care during these stages ensures healthy plants and optimal yields.

- **Germination and Emergence:** Prepare a good seedbed, keep soil moist, and treat seeds to prevent diseases.
- **Vegetative Growth (Knee height stage) :** Apply nitrogen fertilizer and control weeds for strong growth.
- **Tasseling:** Watch for pests and ensure enough water.
- **Silking and Pollination:** Maintain soil moisture and protect from pests to ensure good kernel formation.
- **Grain Filling:** Provide water and nutrients for full grain development and manage plant density to prevent lodging.

2.4 Millet

Millets are a group of small-seeded cereal grains, often called "ancient grains." They are highly nutritious, gluten-free, and drought-resistant, making them a sustainable and healthy food choice.

Millets are often referred to as "nutricereals" because they are highly nutritious. It has been a significant part of Nepal's agriculture for centuries.These hardy grains are well-adapted to diverse climatic conditions, particularly the hilly and mountainous regions of the country. There are different types of millets found in Nepal such as,

i) **Finger Millet (Kodo) (*Eleusine coracana*)**: The most widely grown millet in Nepal, valued for its adaptability to hilly terrains and use in traditional dishes like Dhido and Raksi.

ii) **Foxtail Millet (Kaguno) (*Setaria italica*):** A minor crop in Nepal, cultivated in higher-altitude regions and used as a rice substitute.

iii) **Barnyard Millet (Jhanjhanro) (*Echinochloa spp.*):** Grown in limited

areas, it is often used during fasting and appreciated for its quick cooking time.

iv) **Little Millet (Kutki) (*Panicum sumatrense*):** A drought-resistant crop grown sporadically in Nepal, used in porridges and local snacks.

v) **Kodo Millet (Kodo) (*Paspalum scrobiculatum*):** Rarely grown in Nepal due to its lower yield and specific climatic requirements, though it is known for its nutritional benefits.

vi) **Proso Millet (Chino) (*Panicum miliaceum*):** Cultivated in small quantities, mainly in arid regions, and used as a substitute for rice or in traditional porridges.

2.4.1 Finger Millet

Source:https://www.afa.go.ke

Finger millet (*Eleusine coracana*) is grown widely in Nepal. It is locally known as "Kodo". It is a staple crop grown predominantly in the hilly and mountainous regions. It is valued for its resilience to poor soils and minimal inputs. It is one of the vital parts of traditional diets, used to prepare dishes like Dhido, Roti, and

beverages such as Raksi and Tongba. Renowned for its high nutritional content, especially calcium and iron.It also plays a crucial role in ensuring food security, especially in rural high land regions of Nepal.

Botanical description

Finger millet (*Eleusine coracana*) is a hardy, drought-resistant cereal crop with narrowleaves and belongs to the Poaceae/Graminae family. Its inconspicuous flowers are clustered in finger-like spikes which gives the plant its distinctive name. It can grow up to 170 cm tall and produces small, reddish-brown to dark brown very nutritive grains.

History and Origin

Finger millet is a short-day annual plant which is a highly nutritious grain that has been cultivated for thousands of years in Africa and Asia. Finger millet is said to be originated in the Ethiopian and Ugandan highlands of East Africa, approximately 5,000 years ago. It has been cultivated in these regions later spread to other parts of Africa and Asia, including India and Nepal. It is a resilient crop that can thrive in harsh conditions like drought.

Importance

- **Rich in Nutrient**: It is known as the power house of the essential nutrients like protein, fiber, vitamins, and minerals, making it a healthy addition to human diet.
- **Gluten-Free:** It is naturally gluten-free, making it a suitable option for people with celiac disease or gluten sensitivity.
- **Eco-Friendly:** Finger millet is a drought-resistant crop that requires less water and fewer chemical fertilizers, promoting sustainable agriculture.
- **Cultural Significance:** It has been a staple food in many cultures for centuries, and it continues to be an important part of traditional diets.
- **Food Security:** Its resilience and nutritional value make it a valuable crop for ensuring food security, especially in regions prone to climate change and water scarcity.

Area and Distribution

India is known as the largest producer of finger millet in the world which is followed by Nigeria and Ethiopia, respectively.It is cultivated widely in different Province like Gandaki, Karnali, Lumbini, Sudurpaschim etc. According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23);

Name of the crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Finger Millet	227,934	310,847	1.36

Climate

Millets are grown in tropical as well as sub-tropical up to an altitude of 2,100m. It is a heat loving plant and for its germination the minimum temperature required is 8 to10°C. A mean temperature range of 26-29°C during the growth is best for proper development and good crop yield. It is grown well where rainfall ranges from 500-900mm.

Soil

Finger Millet has wide adaptability to different soil from very poor to very fertile and can tolerate a certain degree of alkalinity. The best soils are alluvial, loamy and sandy soil with good drainage.

Varieties

The different varieties of Finger Millet are, Okhle-1, Dalle-1, Kabre kodo-1, Kabre kodo-2, Sailung kodo-1 and RatoKodo.

Field Preparation

Preparation of field for finger millet cultivation is done by deep ploughing the field immediately after harvesting the previous crop using a mould board plough. As the monsoon begins plough the field two to three times with a local plough and level it. Make the seed bed is free of weeds, smooth, and well-tilled to create the best conditions for millet to germinate and grow.

Manures and Fetilizers

Apply 5 to 10 tonnes of farmyard manure or compost per hectare about one month before sowing. Use balanced NPK fertilizer (50:20:20 kg/ha) for the proper better growth, development and yield of the crop. Apply half of nitrogen as basal dose. Split remaining half into two and apply during the tillering and panicle initiation stage.

Seed Rate and Spacing

The seed rate depends upon the methods of sowing. 12 to 15 kg/ha. seed for broadcasting, 8 to 10 kg of seed per hectare is sufficient for line sowing and 4 kg of seed is enough to raise the nursery for one hectare of land. Before sowing, treat the seeds with Thiram at a rate of 2.5 g per kg of seed. For proper growth and development of crop, plant the seeds by keepig R×R 20-25 cm and P×P 8-10 cm.

Sowing Time and Method of Sowing

Finger millet can be sown using broadcasting, line sowing and transplanting methods which are described below:

- **Broadcasting**: This method involves scattering seeds evenly over the soil surface. It is easier and quicker but requires a **higher seed rate** and may result in uneven plant spacing. Broadcasting is typically done **at the beginning of the monsoon season**.
- Line sowing: In this method, seeds are sown in **lines, about 3-4 cm deep**. It ensures better germination, reduces seed usage, and helps with easier crop management. **Line sowing** should be done at the onset of the **monsoon season** to take advantage of the rain.
- **Transplanting**: This method helps to gain higher yield in areas with adequate moisture. Seeds are sown in **nursery beds** during **May-June**. The seedlings are transplanted into the main field after **3-4 weeks**. Transplanting of seedling also helps in better establishment of the crop.

Irrigation

Finger millet is a drought-tolerant crop. It is commonly grown in rainfed areas of Nepal. It can tolerate the dry conditions but it is sensitive to waterlogging in the field. Proper water management is crucial for this crop. For irrigated fields, irrigation during emergence, tillering, heading, and flowering stages leads to better yield of the crop.

Weed Control

Weeding is essential for finger millet. It helps to remove weeds that compete with the crop for nutrients, water, and sunlight. Hand weeding with a hoe is a common practice, especially in small-scale farming. Three weeding can be sufficient for the management of weeds. First one is done in 20-25 days after sowing and the second around 40-45 days. A third weeding might be necessary in heavily infested areas. Timely and effective weeding ensures healthy plant growth and optimal yield.

Harvesting, Threshing, Yield and Storage

Finger millet is usually ready to harvest around 120-135 days after planting. When ear heads turn brown and the grains feel hard then it is time to harvest. It is harvested before all the leaves turns yellow. Harvesting the ear-head with a sickle is popular in Nepal. The straw is harvested close to the ground with the help of sickle. After harvesting ear-heads are piled up for 3-5 days for curing. The ear-heads are threshed by beating them with sticks or using Dhiki according to the available resources. Then the grains are separated from the chaff by winnowing. The winnowed grains are dried in the direct sunlight until the moisture content of remains below 13%. After drying, the dried grains are stored in a clean, dry, and airtight container. With the improved cultivation practice, grain yield of 20 to 25 quintals and 60 to 80 quintals of fodder per hectare can be obtained.

Insects, Pests and Diseases of Finger Millet

Insects and Pests

Finger millet can be attacked by different pests like stem borers, aphids, hairy

caterpillars, grasshoppers, and ear-head bugs. Among these, stem borers can cause the most damage.To control them, use of Diazinon 5% at a rate of 20 kg per hectare can be effective.

1. Shoot Fly *(Atherigona approximata)*

Shoot fly is a common insect that attacks young millet plants. It is small and looks like a housefly. It lays eggs near the base of millet plants, especially during the early stages of crop growth.

Symptoms of Damage

- The central shoot of the young plant dries up, which is called a "dead heart."
- Affected plants stop growing and remain stunted.
- The crop becomes thin and patchy in the field.

Management Methods

- Sow millet seeds at the right time to avoid peak fly population.
- Remove and destroy affected plants to stop the spread.
- Use light traps to catch adult flies.

2. Stem Borer *(Coniesta ignefusalis)*

Stem borer is a harmful insect that lives inside the stem of millet plants. The adult is a moth, and the larvae (caterpillars) bore into the stem and feed inside.

Symptoms of Damage

- Holes are seen on leaves and stems.
- Central shoot dies and turns brown.
- Plants may break easily due to weakened stems.

Management Methods

- Use clean and healthy seeds.
- Destroy infected plant parts after harvest.
- Grow varieties that are resistant to stem borers.

- Apply neem-based or other eco-friendly insecticides if needed.

3. White Grub (*Holotrichia* spp.)

White grubs are soil-dwelling insects that feed on the roots of millet plants. The adult insect is a beetle, and the young ones (grubs) stay under the soil and eat the roots.

Symptoms of Damage

- Plants become yellow and weak.
- They may wilt or fall over due to poor root support.
- Affected plants may die early in the growing stage.

Management Methods

- Plough the field properly to expose the grubs to sunlight and birds.
- Rotate millet with non-host crops to break the life cycle.
- Use neem cake in the soil to reduce grub population.
- Collect and kill adult beetles during the evening when they come out.

Diseases of Millet

The different diseases of the finger millet are blast, seedling blights, downy mildew and smut.

1. Blast

Blast disease is a fungal disease caused by *Pyricularia oryzae*. It can affect finger millet plants at various stages, from seedlings to mature plants.

Symptoms of Damage

- Grey-green to yellow spots appear on the leaves. Severe infections can cause large, blighted areas on the leaves.
- The main stem becomes infected, leading to the breaking of ear-heads.
- Infected grains become shriveled and lighter in weight.

Management Methods

- Treat seeds with fungicides like Thiram at a rate of 2.5 grams per kilogram of seed.
- Cultivate disease resistant varieties
- Crop rotation with non-host crops to reduce the buildup of the pathogen in the soil.
- Remove and destroy infected plant debris to minimize disease spread.

2. Seedling Blight

Seedling blight is a fungal disease caused by *Cochilobolusnodulus*. It is particularly observed during high rainfall.

Symptoms of Damage

- The fungus can infect seeds before germination or young seedlings, causing them to rot and die.
- The fungus can also infect older plants, leading to leaf spots, stem lesions, and ear-head rot.

Management Methods

- Treat seeds with fungicides like Carbendazim or Thiramat a rate of 2.5 grams per kilogram of seed before sowing.
- Remove and destroy infected plant debris to reduce the source of infection.
- Improve drainage in waterlogged fields to minimize fungal growth.

3. Downy Mildew

Downy mildew is a fungal disease caused by *Scleroporagraminicola*. It can cause significant damage to finger millet crops, especially in areas with high humidity and moderate temperatures.

Symptoms of Damage

- White, cottony fungal growth appears on the underside of leaves.

- In severe cases, the entire plant may become infected, leading to stunted growth and reduced yield.

Management Methods

- Cultivate resistant varieties if available.
- Apply fungicides like Metalaxyl at the rate of 25g/10L of water or Mancozeb at the rate of 2gm/L of water.
- Remove and destroy infected plant debris to reduce the source of infection.
- Rotate finger millet with non-host crops.

4. Cercospora Leaf Spot

Causal Organism: *Cercospora* species.

Symptoms of Damage

- Dark, round or angular spots on leaves with a yellow border around them.
- The spots may merge and leads to larger areas of necrotic tissue on leaves.
- Premature leaf drop can be observed in severe cases.
- Stunted plant growth.

Management Methods

- Choose disease resistant variety for cultivation.
- Properly remove and destroy infected leaves and debris from the field before sowing and after harvest of the crop.
- Apply Mancozeb at the rate 2.5–3.0 grams per liter of water

Marketing

The economics of cultivating finger millet involves the costs of growing the crop, such as purchasing seeds, fertilizers, and irrigation, as well as the labor

required for planting, intercultural activities and harvesting the crop. After harvesting, finger millet is traded and marketed both locally and in national markets also. Farmers often sell their produce at local markets or to middlemen who distribute it to larger markets. Direct access of farmers to the market could be better for farmers to get right price of the cultivated product. In Nepal, finger millet is valued for its nutritional benefits and glutein free properties. It is a popular choice for people with diabetes or those who are health-conscious now a days. As a result, more and more people from rural to urban areas are consuming finger millet and the demand for it is growing day by day. By enhancing the marketing, trade systems, better government policies in agriculture sector can motivate farmers to cultivate and supply as the demand of nation and export to other countries.

Exercises

Choose the correct answer from the given alternatives.

1. Finger millet is locally known as.....

   a. Chino b. Kaguno c. Kodo d. Phapar

2. Finger millet is a crop that thrives in.....

   a. Wet and humid conditions b. Dry and arid conditions

   c. Cold and rainy conditions d. All of these

3. The ideal temperature range for finger millet growth is.....

   a. 0-10°C b. 10-15°C c. 26-29°C d. 15-20°C

4. Finger millet is free of.....

   a. Carbohydrate b. Vitamins

   c. Iron d. Gluten

5. The most damaging pest to finger millet is.....

   a. Aphids b. Grasshoppers

   c. Stem borer d. Ear-head bug

6. A major fungal disease affecting finger millet is.....

   a. Rust b. Blast c. Blight d. Smut

7. Which of the following is a common practice to control weeds in finger millet fields?

   a. Herbicide application b. Mulching

   c. Hand weeding d. Crop rotation

8. The ideal time for harvesting finger millet is when.....

   a. The leaves turn completely yellow

   b. The ear-heads turn brown and the grains are hard

c. The ear-heads are green

d. The plant is flowering

9. One of the major benefits of finger millet is its.....

a. High water requirement c. Low nutritional value

b. Sensitivity to pests and diseases d. Drought tolerance

Write short answer to the following questions.

1. List the five importances of Finger Millet.
2. Discuss the area and distribution of Finger Millet. Describe the ideal climatic and soil conditions for finger millet cultivation.
3. Describe the weeding, irrigation and fertilization in Finger Millet.
4. List different pest and diseases of Finger Millet.

Write long answer to the following questions.

1. Explain the key steps involved in the cultivation of finger millet, from land preparation to harvesting.
2. List the different pests and diseases with their symptoms and management practices in detail.

Project Work

1. List different traditional and modern recipes made from Finger Millet in your locality.
2. Make one best popular recipe from millet in your locality and perform a video/presentation including its procedure and present in classroom.

2.5 Buckwheat

Source:https://thehimalayantimes.com

Buckwheat is a short-day annual plant often referred to as a "pseudo-cereal" crop. It is cultivated across diverse regions, from the Terai plains to the Himalayan foothills of Nepal.It is one of themain food sources for many communities. Buckwheat is renowned for its nutritional value. Flour is used to make a variety of dishes, including the popular Nepali dishes like "Dhido" and "Phulaura".

Botanical Description

Buckwheat is a fast-growing bushy plant belongs to the Polygonaceae family. It has upright growth habit which typically reaches a height of 1-2 feet. The leaves are triangular of heart-shaped. Buckwheat has triangular seeds and produces a flower which is usually white, although can be white or pink.

History and Origin

Buckwheat was originated in the southeastern part of China. After that it gradually spread to other areas in East, Southeast, and South Asia. It has been an important crop in Nepal for centuries. It is believed that buckwheat cultivation in Nepal started during the Vedic period.

Importance

Buckwheat is a highly nutritious crop with many health benefits. Some of the

importances are listed below.

- Buckwheat is a great source of protein, fiber, and essential vitamins (like B vitamins and vitamin E), as well as minerals such as magnesium, phosphorus, and iron.
- It is naturally gluten-free, making it an excellent choice for people with celiac disease or gluten intolerance.
- Due to its low glycemic index and high fiber content can help manage blood sugar levels, which is particularly helpful for people with diabetes.
- The fiber and antioxidants in buckwheat can help lower cholesterol levels and reduce the risk of heart disease.

Area and Distribution

Globally, Russia is the biggest producer of buckwheat, followed by China, Ukraine, and the United States. Buckwheat is grown in most of the districts of Nepal ranging from high hills to terai region**.** According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23)

Name of the crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Buckwheat	11,857	15,083	1.27

Climate and Soil

Buckwheat generally prefers cool and moist climate. Minimum temperature required for germination is 6-8^{o}C. Ideal temperature for good emergence of buckwheat is 16-22^{o}C. Ideal temperature throughout the growth development stage of buckwheat is 17-30^{o}C. High temperature above 30^{o}C can lead to reduced yields due to flower and fruit desiccation (Extreme drying). Adequate moisture is crucial throughout growing season, especially during flowering. Buckwheat grows best in variety of soils such as sandy loam, loam, and silt loam. It can

survive in soils that are low in nutrients and can handle slightly acidic conditions. It prefers soil with a pH between 5.0 to 7.0.

Varieties

Several improved varieties of buckwheat are cultivated for their adaptability and productivity. These include Mithe Phapar-1, known for its better taste and high-quality grains, and two bitter varieties, Tite Phapar-1 and Tite Phapar-2, which are valued for their resilience and nutritional content. Each variety has unique characteristics suited to different growing conditions and farmer preferences.

Land Preparation

One deep plowing followed by 2-3 shallow plowing is good enough to obtain fine tilth. Destroying the clods, levelling the land and burning the crop residues is essential. Buckwheat is tolerant of poor soil conditions and can be grown with minimal tillage. It can be cultivated in marginal lands also.

Manure and Fertilizer

Buckwheat generally requires lower nutrients compared to other crops. The application of 6 tons of well-decomposed farmyard manure (FYM) per hectare is usually sufficient to improve soil fertility for healthy crop growth. General recommendation for chemical fertilizer application is 30:30:20 kg/ha of Nitrogen (N), Phosphorus (P), and Potassium (K). Balanced nutrient management helps to enhance yield of the crop.

Seed Rate and Spacing

The ideal seed rate for buckwheat is between 35 to 50 kg per hectare. While sowing, the seeds should be planted at a depth of 4-5 cm to help them germinate properly. To encourage healthy growth and good plant population, the R×R should be spaced 30 cm apart, and P×P should be 10-15 cm in the row.

Sowing Time and Method

Generally in the high hill regions buckwheat is sown between June and July (Ashad to Shrawan). In mid-hill regions sowing is carried out July to August

(Shrawan to Bhadra). In some lower hills or Terai areas, buckwheat can be grown as a winter crop by sowing it in October to November (Kartik to Mangsir). Buckwheat can be sown in different methods. The most common method is broadcasting, where seeds are scattered evenly over well-prepared land. Line sowing also can be practiced where seeds are placed in rows.

Irrigation

Buckwheat is drought-tolerant crop which can grow under limited moisture conditions. However, supplemental irrigation can be beneficial particularly at critical growth stages such as flowering and grain filling during prolonged dry periods. Providing the right amount of moisture during these times helps the grains develop better and can lead to a higher yield. Buckwheat is sensitive to waterlogging so care should be taken to avoid over irrigation and should maintain proper drainage facility in the field.

Weeding

Weeding is an important task that should be carriedout 3 to 4 weeks after sowing. For small-scale or organic farming, hand weeding is the best option. If there is a larger field, mechanical weeding can save time and labor. Another useful method is mulching, which involves covering the soil with organic materials like straw or leaves. This helps to keep weeds from growing and also helps the soil to stay moist and healthy.

Thinning

Thinning is an important step in growing buckwheat, especially when the plants are highly dense. By removing some of the plants, optimum space is given to the remaining ones. This helps to gain proper light and nutrients which leads plants to grow healthier and stronger.

Harvesting, Yield and Storage

Buckwheat should be harvested when most of the seeds becomes matured, and the plant has turned brown and dry. The seeds should feel firm, and the flowers should be withered. Buckwheat can keep flowering even as the seeds mature so,

it is generally harvested when about 75-80% of the seeds are fully developed. During harvesting the plants are cut at the base using a sickle or similar tool. After cutting, the plants need to be dried in a clean, dry place, away from rain, to reduce moisture and prevent mold.

Once the plants are dried, the next step is threshing, which means separating the seeds from the plant heads. This can be done by rubbing them by hand or using a machine called a thresher. After threshing, the seeds should be cleaned to remove any plant pieces, chaff, or broken grains. Air blowers and fans also can be used for cleaning grains. Finally, store the dried and cleaned seeds in airtight containers in a cool and dry place to keep them safe from moisture and pests.

Insects Pests and Diseases of Buckwheat

Insect Pests

1. Aphids (*Aphis spp*.)

Symptoms of Damage

- Small green or black insects can be seen on the leaves and stems of the plant.
- The leaves or stems may have a sticky substance called honeydew, which is secreted by the aphids.
- The leaves might curl or become distorted in shape.
- The plant may show signs of stunted growth.

Management Methods

- Take neem oil at a dose of 1-2 tablespoons per liter of water, and spray directly onto the affected plants.
- Insects like ladybugs and lacewings love to eat aphids, so attracting these helpful creatures can reduce aphid numbers.
- Too much nitrogen can encourage aphid growth, so it is best to use the right amount of nitrogenous fertilizer.
- Regular monitor the field and remove any visible aphids by hand.

2. Cutworms (Agrotis spp.)

Symptoms of Damage

- Young seedlings are cut off at the base usually at night.
- The affected plants may show signs of wilting or drooping.
- Plants may have irregular or uneven growth.
- The soil around the base of the plant may show signs of disturbance or holes.

Management Methods

- Introduce biological control agents like *Bacillus thuringiensis* (Bt).
- If there are only a few cutworms, manually remove and destroy them to prevent further damage.
- Regularly check the soil around young plants to disturb and expose any cutworms hiding in the soil.

3. Leafhoppers (Empoasca spp)

Symptoms of Damage

- Leafhoppers feed on plant sap, causing the leaves to turn yellow, especially near the veins.
- As they suck sap, leafhoppers can cause the plant to become weak and stunted growth.
- The leaves may curl upwards.
- The feeding marks of the leafhopper can lead to discolored, spotted, or blotchy leaves.

Management Methods

- Take neem oil, mix 1-2 tablespoons per liter of water and spray it directly onto the affected plants.
- Maintain field hygiene before sowing and harvesting of the crop.
- Release and encourage **predatory insects** like **ladybugs** or **lacewings**

that naturally feed on leafhoppers.

- Avoid over-fertilizing with nitrogen.

Diseases of Buckwheat

1. Powdery Mildew

Causal Organism: *Erysiphe cichoracearum*

Symptoms of Damage

- White powdery growth on the leaves, stems, and flowers.
- Leaves may curl and become distorted.
- Reduced photosynthesis and can lead to weak plant growth.
- Premature leaf drop can occur in severe cases.

Management Methods

- Ensure **good air circulation** by properly spacing plants to reduce humidity around the plant.
- **Avoid overhead irrigation** to reduce moisture on the leaves, which promotes fungal growth.
- **Spray Mancozeb** at the rate of **2-3 grams** of per liter of water.

2. Root Rot

Causal Organism:*Fusarium spp., Rhizoctonia spp.*

Symptoms of Damage

- **Wilting of plants** even when soil moisture is adequate.
- **Browning of roots** and sometimes a foul smell coming from the roots.
- Poor **plant vigor**, leading to stunted growth and reduced yield.
- **Yellowing of leaves** due to insufficient water and nutrient uptake.

Management Methods

- Practice crop rotation with non-host crops to break the disease cycle.
- Improve drainage and avoid waterlogging conditoin in the field.

- Treat seeds with Thiram at the rate 2-3gm/kg seed before sowing.

3. Leaf Spot

Causal Organism: *Septoria spp.*and *Alternaria spp.*

Symptoms of Damage

- Brown or black spots appear on the leaves, usually starting small.
- These spots may enlarge, causing the leaves to yellow and die.
- Premature leaf drop can occur, weakening the plant.
- In severe cases, the disease can cause a significant reduction in plant vigor and yield.

Management Methods

- Use disease-free seeds to prevent the introduction of pathogens.
- Remove and destroy infected plant parts to prevent the spread of disease.
- Spray Mancozeb at the rate of 2-3 grams of per liter of water.

Marketing

Buckwheat is an important crop in Nepal. It is grown as both a staple food and a cash crop. It has low production costs because it requires minimal fertilizers and irrigation making it ideal for small-scale farmers also. Buckwheat can thrive in harsh climatic condition and can be grown on marginal lands which makes it more valuable. The demand for buckwheat is increasing both locally and internationally for the production of gluten-free products. This can provide farmers with new market opportunities. Proper transportation, storage, research, subsidies in agriculture can enhance the cultivation and trade of this crop. Cultivation of this crop can be profitable, offers steady income and has potential for export.

Critical Stages of Buckwheat

Proper management during these stages is essential for achieving good yield and

seed quality.

- **Germination and Seedling Stage**: Adequate soil moisture; avoid waterlogging for healthy seed emergence.
- **Flowering Stage**: Critical for yield; ensure enough moisture and protect from insect pests.
- **Grain Filling Stage**: Light irrigation if dry conditions; avoid any stress for good grain development.

2.6 Barley (*Hordeum vulgare)*

Family: Gramineae/Poaceae

Barley is an important cereal crop globally, ranking fourth in terms of area harvested. It is a staple food in many temperate regions, particularly in areas where wheat cultivation is challenging. In Nepal, it is a significant food crop in higher altitudes.

Botanical Description

Barley is an annual, self-pollinating cereal grass. It exhibits a robust root system, hollow stems (culms), and narrow leaves. The inflorescence is a spike, bearing multiple florets that develop into grains.

History and Origin

Barley is one of the oldest cultivated crops, with its origin traced back to the Fertile Crescent in Southwest Asia.

Importance

- **Food Security:** Barley provides a vital source of carbohydrates, protein, and other essential nutrients, particularly in regions where other cereal crops are less suitable.
- **Animal Feed:** Barley grain and straw are widely used as feed for livestock, including cattle, sheep, and poultry.
- **Malting Industry:** Barley is a key ingredient in the production of beer, whiskey, and other alcoholic beverages.
- **Industrial Uses:** Barley is used in the production of various products, including animal feed, malt extract, and dietary fiber.

Area and Distribution

According to FAOSTAT of the United Nations In 2023, Russia is leading followed by Australia, France, and Germany in the production of Barley. In Nepal, barley is cultivated in various regions, particularly in the high hill. According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23);

Name of the crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Barley	17,536	25,912	1.48

Climate and Soil

Barley is well adapted to cool climates, making it suitable for cultivation in temperate regions. The optimal temperature range for its growth is between 15-20°C. While barley can tolerate cold conditions. It is sensitive to high temperatures, particularly during the flowering stage, which can negatively impact yield. Barley can be cultivated on a variety of soil types, but well-drained

loam soils are most preferred for optimal growth. It performs best in soils with a slightly acidic to neutral pH range of 6.0 to 7.5, which supports good nutrient availability and root development.

Varieties

Several varieties of barley are suitable for different agro-climatic conditions. Commonly cultivated varieties include Solu uwa**,** Ketch**,** CI-10448**,** Galt**,** and HBL-56.

Land Preparation

Proper land preparation is essential for growing barley successfully. It helps to give better tilth for the soil which makes seeds to be contact with the soil and to control weeds. Plough the field to a depth of 15-25 cm. After that, the soil is harrowed and leveled to create a smooth, fine seedbed. This approach ensures that the barley seeds germinate evenly and helps the roots grow strong, giving the crop a good start.

Manures and Fertilizers

Balanced nutrient management is important for healthy growth and optimal yield of Barley. The application of 10-15 tons per hectare of well-decomposed FYM/ compost helps to improve soil fertility, structure, and water-holding capacity. In addition to organic inputs, chemical fertilizers should be applied based on moisture availability: under irrigated conditions, a dose of 60:30:10 kg N:P:K per

hectare is recommended, while for rainfed conditions, a reduced rate of 30:20:10 kg N:P:K per hectare is suitable. For irrigated condition, It recommended to apply half of the nitrogen and all of the phosphorus and Potassium at sowing time. The remaining half of the nitrogen should be applied as top dressings. For rainfed condition it is recommended to apply all the nitrogen, phosphorus and Potassium fertilizers 8-10 cm deep in the furrows at sowing time.

Seed Rate and Spacing

For successful barley cultivation, a seed rate of 90-125 kg per hectare is generally recommended to ensure an adequate plant population. When line sowing is practiced, a row spacing of 22-25 cm is typically used to allow proper sunlight penetration and ease of field operations. While plant-to-plant spacing is not strictly fixed due to the common use of broadcasting or drill sowing methods, it usually ranges from 5-7 cm under normal sowing conditions, providing enough space for healthy tillering and growth.

Sowing Time and Method

Sowing time is a crucial factor for successful barley cultivation. The best time to sow barley is between October 15 and November 15. If sowing is delayed the yield may gradually decrease. In irrigated areas seed should be sown in the first or second week of November. In rainfed areas, barley should be sown in the third or fourth week of October. In Nepal, barley is mostly sown by broadcasting and line sowing methods.

Irrigation

Barley is commonly grown under rainfed conditions. The additional irrigation can improve yield in irregular rainfall areas. Irrigating during critical growth stages such as tillering and flowering is beneficial. This supports strong tiller development and improve grain formation and yield.

Weeding

Regular weeding is important in barley cultivation. It helps to prevent weeds from competing with the crop for water, nutrients, and sunlight. The most crucial

time for weeding in barley is 2-4 weeks after sowing. Manual or mechanical weeding is commonly practiced for weed control. Herbicides can also be used for effective weed control. However, herbicide use should be carefully applied according to recommended guidelines to avoid crop injury and environment pollution.

Harvesting, Yield, and Storage

Barley is harvested generally when grains turns in to a golden color**,** leaves and stem dries off, and moisture of grain content reaches 18-20%. Harvesting can be done manually with sickles or using combine harvesters for larger fields. After harvesting, barley grains must be dried properly and stored in a cool, dry, and well-ventilated place to avoid spoilage and pests. Threshing is done by beating on the floor, trampling bullocks or using threshers.With high-yielding varieties and improved methods, barley can produce 30-35 quintals of grain and 40-45 quintals of straw per hectare.

Insects, Pests, and Diseases

Insects Pests

1. Aphids (*Rhopalosiphum padi)*

Symptoms of Damage

- Small green or black insects on the leaves and stems.
- Yellowing of leaves due to sap-sucking.
- Stunted growth and poor plant development.
- Honeydew secretion, leading to the growth of sooty mold on leaves.

Management Methods

- Neem oil (spray at 1-2 tablespoons per liter of water).
- Regularly spray plants with a strong stream of water to flush off.
- Imidacloprid at a dose of 1 ml per liter of water.

2. Stem Borers (*Scirpophaga excerptalis*)

Symptoms of Damage

- Damage to the stems, causing holes and weakening.
- Lodging of barley plants due to weakened stems.
- Yellowing of the plant leaves.
- Drying of plants or parts of plants, especially near the base.

Management Methods

- Use neem oil or garlic spray (crush garlic and mix with water) to deter borers.
- Hand-pick and destroy infested stems, or use trap crops to attract borers away from barley.
- Grow barley varieties that show resistance to stem borers.
- Emamectin Benzoate 5.7% WDG at the rate of 1 g per 2.5 liters of water.

3. Cutworm (*Agrotis ipsilon*)

Symptoms of Damage

- Cutting off seedlings at or near the soil surface.
- Wilting or falling over of young barley plants.
- Presence of holes or irregular feeding marks on leaves.
- Stunted growth of the plant.

Management Methods

- Use diatomaceous earth or neem oil to create a barrier around the base of plants.
- Remove cutworms by hand and destroy them early in the season.
- Plant barley varieties less susceptible to cutworm feeding.
- Use Lambda-cyhalothrin at the rate of 5 ml per liter of water to the soil and plant base.

4. White Grubs (*Holotrichia spp.)*

Symptoms of Damage

- Root is damaged and wilting of the plant.
- Stunted growth of plant.
- Yellowing of leaves.
- Presence of larvae or grub holes around the root zone.

Management Methods

- Apply neem oil at the rate of 5-10 ml per liter of water or Bacillus thuringiensis (Bt) at 1-2 grams per liter of water and spray around the base of the plant.
- Use manual soil tilling to expose and destroy grubs.
- Grow barley varieties that show resistance to root-feeding insects like white grubs.
- Diazinon at the rate of 2 ml per liter of water can be applied to control white grubs.

Diseases

1. Black Rust (*Puccinia graminis)*

Symptoms of Damage

- Black pustules are observed on leaves, stems, and heads.
- Yellowing of leaves (chlorosis).
- Reduced grain quality and yield.
- Premature leaf drop.

Management Methods

- Spray neem oil at the rate of **5-10 ml per liter of water**.
- Remove and destroy infected plant material.
- Plant barley varieties resistant to rust.
- Application of Tebuconazole (1-2 ml per liter of water) is effective.

2. Loose Smut (*Ustilago nuda*)

Symptoms of Damage

- Affected heads are replaced with a mass of black spores.
- Misshapen or empty heads.
- Stunted plant growth due to the smut's effect on development.
- Reduce yield.

Management Methods

- Spray neem oil at the rate of 5-10 ml per liter of water.
- Practice seed treatment with fungicides before planting.
- Use barley varieties that are resistant to loose smut.
- Carbendazim (2 grams per liter of water) is effective for loose smut control.

3. Kernel Bunt *(Tilletia caries)*

Symptoms of Damage

- Discoloration of grains, typically brown or black.
- Grains have a foul odor when infected.
- Reduced grain quality.
- Stunted growth and poor overall plant health.

Management Methods

- Spray Bacillus thuringiensis (Bt): 1-2 grams per liter of water or Neem oil at the rate of 5-10 ml per liter of water.
- Use clean, disease-free seeds for planting.
- Select barley varieties resistant to kernel bunt.
- Spray the solution of Thiram (2-3 grams per liter of water).

4. Powdery Mildew (*Blumeria graminis*)

Symptoms of Damage

- White, powdery growth on the leaves, stems, and spikes.
- Leaf curling and distortion.
- Reduced photosynthesis and stunted growth of the plant.
- Premature leaf drop and stunted growth.

Management Methods

- Spray neem oil at the rate of 5-10 ml per liter of water.
- Maintain good plant spacing to allow air circulation.
- Plant barley varieties resistant to powdery mildew.
- Trifloxystrobin (2-3 ml per liter of water) is effective.

Exercise

Choose the correct answer from the given alternatives.

1. Which of the following is the best sowing time for barley in Nepal?

   a. June to July
   c. March to April
   b. October 15 to November 15
   d. December to January

2. What is the primary purpose of buckwheat cultivation in Nepal?

   a. Animal feed
   c. Food and traditional dishes like "Dhido"
   b. Fodder
   d. Oil production

3. Which of these soil types is ideal for growing paddy (rice)?

   a. Sandy soil
   c. Alkaline soil
   b. Acidic soil
   d. Fertile clayey loam soil

4. What is the most common method of sowing barley in Nepal?

   a. Broadcasting
   b. Line sowing
   c. Drilling
   d. Dibbling

5. Which disease in barley is caused by the fungus *Blumeria graminis*?

   a. Kernel Bunt
   c. Powdery Mildew
   b. Loose Smut
   d. Black Rust

6. What is the ideal temperature range for growing finger millet?

   a. 5-15°C
   c. 26-29°C
   b. 8-15°C
   d. 15-25°C

7. Which of the following varieties of paddy is most suited for rainfed conditions in Nepal?

   a. Hardinath 4
   c. Khumal 4
   b. Chaite 2
   d. Ghaiya 3

8. What is the main cause of yellow rust in wheat?

   a. Bacteria
   c. Virus
   b. Fungus
   d. None of them

9. Which of the following is a seed treatment method for paddy?

   a. Soak in carbendazim
   c. Spraying neem oil
   b. Apply sulfur-based fungicides
   d. Applying Malathion

Write short answer to the following questions.

1. What are the main symptoms and control measures for aphid infestation in barley?
2. Describe the key steps involved in land preparation for growing paddy.
3. Explain why the sowing time for barley is crucial and how it affects the yield.
4.. What are the ideal climatic conditions for cultivating finger millet in Nepal?
5. List and explain the different **methods of sowing** for maize in Nepal.

Write long answer to the following questions.

1. Discuss the **economic importance** of **wheat** cultivation in Nepal.
2. Explain the process of making different nurserey beds for rice seedlings, and compare the wet bed and dry bed methods.
3. Describe the harvesting and threshing methods of barley in Nepal and discuss how they affect the quality of the grains.
4. What are the common pests and diseases that affect buckwheat in Nepal, and what are the integrated pest management strategies for controlling them?

Project Work

1. Talk to local farmers of your community and record the different types of rice they grow. Ask about how long it takes for the rice to grow, how much

they harvest, how it tastes like, and it is resistant to some diseases or not. Learn about the farming methods they use. Share your findings in the class room using your reports, pictures, charts or a short video if it is possible.

2. Finger millet is one of the important crops of Nepal. It is not grown as much as rice or maize. Visit the local farmers of your community and find out what challenges they face in growing, harvesting, processing and marketing of finger millet. Discuss the ways to improve finger millet production and marketing and make a report. After that present your report in your classroom.

Cultivation of Oilseed Crops

Unit 3

3.1 Rapeseed (*Brassica napus*)

Introduction

Rapeseed (*Brassica napus*)**,** belongs to the Brassicaceae family. It is an annual plant with a tall, branching stem, large leaves, and bright yellow flowers that grow in clusters. It is an important oilseed crop grown worldwide. It is primarily used to produce vegetable oil for cooking. The byproduct of rapeseed is used as animal feed. Rape seed is said to be Originated from the Mediterranean region. It has been cultivated for centuries.

Area and Distribution

Rapeseed is widely cultivated in Europe, Canada, China, and India. In Nepal, it is grown in various regions from terai to higher elevations.

Climate and Soil

Rapeseed grows best in cool and moist conditions. This crop thrives well with temperatures ranging from 10°C to 25°C. It can tolerate a wide range of temperatures but it is sensitive to extreme heat especially during the flowering

stage. Frost during the early growth stages can also damage the plants. Adequate rainfall during early stages, is important for healthy development. Rapeseed grows best in well-drained, fertile soils that have a neutral to slightly acidic pH of 6.0 to 7.5. Loamy soil is considered ideal for cultivation of this crop.

Varieties

The popular varieties of rapeseeds are Bikash, Lumle-1, Pragati, Unnati, Preeti, Morang Tori-1 and Nawalpur Local-4.

Field Preparation

Better field preparation is one of the important steps for the successful cultivation of rapeseed. This ensures optimal conditions for seed germination and healthy plant growth. At first deep plowing should be done using a soil-turning plough to a depth of 20 to 25 centimeters. After deep plowing, the field should be cross-harrowed twice to break up soil clumps and create a fine and well-pulverized seedbed. Planking should follow each plowing to level the field. It is essential to remove all weeds, stubbles, and crop residues from the field.

Manures and Fertilizers

Applying 6 to 8 tons of farmyard manure per hectare help to improve soil health. For chemical fertilizers apply 60 kg of nitrogen (N), 40 kg of phosphorus (P_2O_5), and 20 kg of potassium (K_2O) per hectare. It is essential to apply the right amount of nutrients for healthy crop. Nitrogen should be applied in two doses: half during sowing as a basal application, and the remaining half at the first irrigation. If the crop relies on rainwater, only half of the recommended nutrient dose should be used. Rapeseed requires more sulfur, so it is ideal to apply nitrogen through ammonium sulfate and phosphorus through single superphosphate. This ensures that the plants grow strong and produce a high yield.

Seed Rate and Spacing

For rapeseed cultivation, use a seed rate of 8 to 10 kilograms per hectare. Sow the seeds in rows spaced 30 to 45 centimeters apart**,** with plants spaced 5 to 10 centimeters apart within each row. This spacing helps the plants grow well with

enough room for air circulation and sunlight.

Time and Method of Sowing

The optimum planting time for rapeseed is crucial for getting a good yield. Sowing too early or too late can reduce the growth, flowering, and seed size of the crop. Rapeseed is generally sown from mid-October to mid-November (Kartik to Mangsir). There are two methods of sowing: broadcasting and line sowing. In broadcasting seeds are scattered by hand and lightly covered with soil. In line sowing seeds are planted in rows 25-30 cm apart, 1.5-2 cm deep. Line sowing is recommended because it helps with better weed control and crop management.

Irrigation

There is practice of cultivating rapeseed in rainfed condition. To cultivate rapeseed with rainwater, fields should be bunded and leveled to retain moisture, ploughed during the monsoon for better water absorption, and enriched with organic manures to improve soil fertility and water-holding capacity. If there is irrigation facility Irrigation during the pre-bloom and pod filling stages can enhance yield of the crop. It is important to manage proper drainage facility in field to avoid waterlogging condition.

Weeding

Weeds in rapeseed crops can reduce yield by 20-30%. It is important to remove weeds early to avoid competition for water, nutrients, and sunlight. It is crucial to remove weeds at 2-4 weeks after sowing seeds. Hand weeding, using hoe of weeding machine is helpful to control the weeds in the field. Herbicides like Nitrofen (1–1.5 kg a.i. per hectare) can be used as a pre-emergence spray, usually applied before weeds start to emerge. Proper weeding ensures healthy growth and better crop yield.

Thinning

During broadcasting the seeds can be scattered unevenly during line sowing also seeds can be place closely which leads overcrowding of seedlings. Thinning

is necessary to ensure that the plants have enough space to grow properly and receive the right amount of nutrients, water, and light for optimal growth. Thinning should be done 2-3 weeks after sowing.

Harvesting, Threshing, Yield, and Storage

Rapeseed should be harvested when the pods turn yellowish-brown. Harvesting is typically done by hand with sickles. After harvesting, the crop should be stacked on the threshing floor for 5 to 6 days to dry slightly before threshing. Threshing can be done easily with sticks or with the help of bullocks or a thresher. The threshed grain is then separated from the husk by allowing natural air or using blower to clean the seeds from mixture. After threshing, the cleaned seeds must be dried under the sun for about 4 to 5 days until the moisture content drops to 8%. The seeds should be stored in a cool, dry, and well-ventilated place to keep them fresh and safe. With the use of improved varieties and good farming practices, farmers can expect a yield of 14-20 quintals per hectare.

Insects, Pests, and Diseases

Insects and Pests

1. Mustard Sawfly (*Athalia lugens*)

Symptoms of Damage

- Larvae make holes in the leaves and sometimes consumes entire leaf leaving midrib.
- Severe infestations lead to complete defoliation.
- Stunted growth of plant.
- Wilting and premature drying of plants

Management Methods

- Release parasitic wasps at a rate of 1,000-2,000 wasps per hectare, depending on the infestation level.
- Spray neem oil on affected areas in every 7-10 days at the rate of 5-10 ml per liter of water.

- Dusting with 2% Methyl Parathion dust at 20-25 kg per hectare.
- Spray with 0.05% Malathion 50 EC at the rate of (5 ml per liter of water).

2. Mustard Aphid (*Lipaphis erysimi*)

Symptoms of Damage

- Nymphs and adults suck sap from leaves, stems, inflorescence, and pods.
- Affected leaves curl, and severe infestations cause wilting and drying of the plant.
- A black mold grows on honeydew secreted by aphids, affecting plant health.

Management Methods

- Spray neem oil on affected areas in every 7-10 days at the rate of 5-10 ml per liter of water.
- Release 1,000-2,000 lady bird beetle predators per hectare at the first sign of aphid infestation.
- Sowing earlier than usual to avoid aphid attack.
- Spray with 0.05% Malathion 50 EC at the rate of (5 ml per liter of water).

3. Painted Bug of Mustard (*Brachynema praealtum*)

Symptoms of Damage

- Both nymph and adult suck sap from leaves, tender stems, and pods, causing poor growth.
- Leaves become pale yellow, and seed quality and yield of seeds are reduced.
- Presence of black spots or lesions on affected plant parts due to prolonged feeding.
- Deformed or shriveled pods are observed.

Management Methods

- Spray neem oil on affected areas in every 7-10 days at the rate of 5-10 ml per liter of water.
- Collect and destroy the nymphs and adults to reduce the pest population.
- Dusting with 2% Methyl Parathion dust at the rate of 20-25 kg per hectare.
- Spray with 0.05% Malathion 50 EC at the rate of (5 ml per liter of water).

4. Cabbage Butterfly (*Pieris brassicae*)

Symptoms of Damage

- Larvae leave behind irregular holes on the leaves.
- Larvae feed on leaves, branches, and pods, causing significant defoliation.
- Small plants may die, and large plants suffer reduced growth and yield.
- In severe infestations the leaves turn yellow and the plant may show stunted growth.

Management Methods

- Apply Bacillus thuringiensis (Bt) to control early-stage larvae organically (2.5 grams per liter of water)
- Use yellow sticky traps to attract and reduce the adult butterfly population, preventing further laying of eggs.
- Hand-pick and kill caterpillars during early stages.
- Spray with Monocrotophos (Nuvacron) 40 EC (1 liter per hectare in 1000 liters of water).

Diseases

1. Alternaria Blight (*Alternaria brassicae)*

Symptoms of Damage

- Black, concentric (circular) spots on the leaves, stems, and pods.

- Pods turning black and rotting.
- Shriveled, undersized seeds inside affected pods.
- Leaves may drop prematurely due to severe infection.

Management Methods

- Use healthy, disease-free seeds for planting.
- Spray with **Iprodione** or **Mancozeb 75 WP** at the rate of 2 kg in 1000 liters of water per hectare.
- Remove and burn affected plant parts after harvest to prevent the fungus from spreading.
- Crop rotation can reduce disease pressure in subsequent years.

2. Downy Mildew (*Peronospora brassicae)*

Symptoms of Damage

- Yellow, irregular spots appear on the upper surface of leaves.
- White fuzzy growth appears on the underside of leaves opposite to the spots.
- Affected flower clusters (inflorescences) twist and are covered with white powder.
- Poor or no pod development in severely infected areas.

Management Methods

- Use resistant varieties if available.
- Practice good field hygiene by removing and destroying infected plant debris after harvest.
- Treat seeds with Apron 35 SD at a rate of 6 g per kg of seed before planting.
- Spray the crop with Ridomil (0.2%) or Karathane (0.1%) as soon as symptoms appear and repeat every 10 days.

3. White Blister (*Albugo candida)*

Symptoms of Damage

- White, raised blisters on the leaves, stems, petioles (leaf stalks), and flowers.
- Blisters burst, releasing a white powder.
- Malformed and sterile flowers that cannot produce seeds.
- Deformed, stunted pods and poor crop yield in severe cases.

Management Methods

- Treat seeds with Apron 35 SD at the rate of 6 g per kg before sowing.
- Spray the crop with Ridomil (0.2%) as soon as symptoms are observed and repeat at 10-day intervals.
- Keep the field free from weeds to reduce fungal spread.
- Crop rotation helps in reducing the risk of re-infection in future seasons.

4. Fusarium Wilt (*Fusarium oxysporum)*

Symptoms of Damage

- Yellowing of lower leaves, which later turn brown.
- Wilting and stunted growth of infected plants.
- Root rot or blackening of the roots, which can lead to plant death.
- Reduced seed formation and poor plant health.

Management Methods

- Use disease-resistant varieties when available.
- Apply Trichoderma viride as a biological control agent to combat the fungal infection at the rate of 10-20 grams per kg of seed or 2-3 kg per hectare when applied to the soil.
- Rotate crops to prevent the buildup of the fungus in the soil.
- Improve soil drainage and avoid overwatering to prevent the conditions that favor this disease.

Critical Stages of Rapeseed and Mustard

1. Germination

- This is when the seed sprouts and the seedling emerges from the soil.
- Keep the soil moist and warm for good germination. Avoid waterlogging.

2. Rosette Stage

- The plant grows a circle (rosette) of leaves close to the ground before the stem grows tall.
- Keep the soil free of weeds and apply nitrogen fertilizer for strong leaf growth.

3. Bolting

- Bolting means the plant's stem grows rapidly upwards as it prepares to flower.
- Provide enough nutrients and watch for pests or diseases; treat if needed.

4. Flowering

- Yellow flowers appear on the plant.
- Protect from pests like aphids and water regularly without overwatering.

5. Pod Development

- Seed pods start to form and grow.
- Reduce watering and keep an eye on diseases; spray pesticides if necessary.

6. Maturity

- Seeds ripen and dry inside the pods.
- Stop watering to help pods dry, then harvest when pods are brown and dry.

3.2 Mustard

Introduction

Mustard (*Brassica* spp.) belongs to the Brassicaceae family. It is a widely grown oilseed crop in Nepal. It is cultivated in the Terai, inner Terai, and mid-hill regions. The crop is valued for its oil, green leaves and the seed cake which can be served as cattle feed. Historically, mustard has been cultivated for over 5,000 years. It is said to be originated in China. It has long been used by ancient civilizations for food, oil, and medicine.

Area and Distribution

Mustard is widely cultivated in India, China, Nepal, and other parts of Asia. In Nepal, it is predominantly grown in the Terai, inner Terai, and mid-hill regions, as well as in higher elevations. The crop thrives in diverse climatic conditions, making it suitable for a range of regions across the country.

Climate and Soil

The crop requires cool and moist conditions during seed germination and early growth stages for optimal development. It can tolerate a wide range of temperatures but is sensitive to extreme heat and frost, which can damage the plant. Adequate rainfall during germination and early growth is essential to ensure healthy establishment. The crop prefers well-drained, fertile soils with

a neutral to slightly acidic pH for healthy growth. Loamy soils are ideal as they provide good aeration and moisture retention. It is important to avoid waterlogged conditions, as excess water can harm the roots and reduce crop productivity.

Varieties

Some well-known varieties include Pusa Bold, Krishna, Rohini, and Pusa Bahar. The choice of specific varieties may vary depending on the region and local growing conditions.

Field Preparation

Better field preparation is one of the important steps for the successful cultivation of rapeseed. This ensures optimal conditions for seed germination and healthy plant growth. At first deep plowing should be done using a soil-turning plough to a depth of 20 to 25 centimeters. After deep plowing, the field should be cross-harrowed twice to break up soil clumps and create a fine and well-pulverized seedbed. Planking should follow each plowing to level the field. It is essential to remove all weeds, stubbles, and crop residues from the field.

Manures and Fertilizers

Applying 6 to 8 tons of farmyard manure per hectare help to improve soil health. For chemical fertilizers apply 60 kg of nitrogen (N), 40 kg of phosphorus (P_2O_5), and 20 kg of potassium (K_2O) per hectare. It is essential to apply the right amount of nutrients for healthy crop. Nitrogen should be applied in two doses: half during sowing as a basal application, and the remaining half at the first irrigation. If the crop relies on rainwater, only half of the recommended nutrient dose should be used. Rapeseed requires more sulfur, so it is ideal to apply nitrogen through ammonium sulfate and phosphorus through single superphosphate. This ensures that the plants grow strong and produce a high yield.

Seed Rate and Spacing

For rapeseed cultivation, use a seed rate of 8 to 10 kilograms per hectare. Sow the seeds in rows spaced 30 to 45 centimeters apart**,** with plants spaced 5 to 10 centimeters apart within each row. This spacing helps the plants grow well with

enough room for air circulation and sunlight.

Time and Method of Sowing

The optimum planting time for rapeseed is crucial for getting a good yield. Sowing too early or too late can reduce the growth, flowering, and seed size of the crop. Rapeseed is generally sown from mid-October to mid-November (Kartik to Mangsir). There are two methods of sowing: broadcasting and line sowing. In broadcasting seeds are scattered by hand and lightly covered with soil. In line sowing seeds are planted in rows 25-30 cm apart, 1.5-2 cm deep. Line sowing is recommended because it helps with better weed control and crop management.

Irrigation

There is practice of cultivating rapeseed in rainfed condition. To cultivate rapeseed with rainwater, fields should be bunded and leveled to retain moisture, ploughed during the monsoon for better water absorption, and enriched with organic manures to improve soil fertility and water-holding capacity. If there is irrigation facility Irrigation during the pre-bloom and pod filling stages can enhance yield of the crop. It is important to manage proper drainage facility in field to avoid waterlogging condition.

Weeding

Weeds in rapeseed crops can reduce yield by 20-30%. It is important to remove weeds early to avoid competition for water, nutrients, and sunlight. It is crucial to remove weeds at 2-4 weeks after sowing seeds. Hand weeding, using hoe of weeding machine is helpful to control the weeds in the field. Herbicides like Nitrofen (1–1.5 kg a.i. per hectare) can be used as a pre-emergence spray, usually applied before weeds start to emerge. Proper weeding ensures healthy growth and better crop yield.

Thinning

During broadcasting the seeds can be scattered unevenly during line sowing also seeds can be place closely which leads overcrowding of seedlings. Thinning

is necessary to ensure that the plants have enough space to grow properly and receive the right amount of nutrients, water, and light for optimal growth. Thinning should be done 2-3 weeks after sowing.

Harvesting, Threshing, Yield, and Storage

Rapeseed should be harvested when the pods turn yellowish-brown. Harvesting is typically done by hand with sickles. After harvesting, the crop should be stacked on the threshing floor for 5 to 6 days to dry slightly before threshing. Threshing can be done easily with sticks or with the help of bullocks or a thresher. The threshed grain is then separated from the husk by allowing natural air or using blower to clean the seeds from mixture. After threshing, the cleaned seeds must be dried under the sun for about 4 to 5 days until the moisture content drops to 8%. The seeds should be stored in a cool, dry, and well-ventilated place to keep them fresh and safe. With the use of improved varieties and good farming practices, farmers can expect a yield of 20-25 quintals per hectare.

Insects, Pests, and Diseases

Insects and Pests

1. Mustard Sawfly (*Athalia lugens*)

Symptoms of Damage

- Larvae make holes in the leaves and sometimes consumes entire leaf leaving midrib.
- Severe infestations lead to complete defoliation.
- Stunted growth of plant.
- Wilting and premature drying of plants.

Management Methods

- Release parasitic wasps at a rate of 1,000-2,000 wasps per hectare, depending on the infestation level.
- Spray neem oil on affected areas in every 7-10 days at the rate of 5-10 ml per liter of water.

- Dusting with 2% Methyl Parathion dust at 20-25 kg per hectare.
- Spray with 0.05% Malathion 50 EC at the rate of (5 ml per liter of water).

2. Mustard Aphid (*Lipaphis erysimi*)

Symptoms of Damage

- Nymphs and adults suck sap from leaves, stems, inflorescence, and pods.
- Affected leaves curl, and severe infestations cause wilting and drying of the plant.
- A black mold grows on honeydew secreted by aphids, affecting plant health

Management Methods

- Spray neem oil on affected areas in every 7-10 days at the rate of 5-10 ml per liter of water.
- Release 1,000-2,000 lady bird beetle predators per hectare at the first sign of aphid infestation.
- Sowing earlier than usual to avoid aphid attack.
- Spray with 0.05% Malathion 50 EC at the rate of (5 ml per liter of water).

3. Painted Bug of Mustard (Brachynema praealtum)

Symptoms of Damage

- Both nymph and adult suck sap from leaves, tender stems, and pods, causing poor growth.
- Leaves become pale yellow, and seed quality and yield of seeds are reduced.
- Presence of black spots or lesions on affected plant parts due to prolonged feeding.

- Deformed or shriveled pods are observed.

Management Methods

- Spray neem oil on affected areas in every 7-10 days at the rate of 5-10 ml per liter of water.
- Collect and destroy the nymphs and adults to reduce the pest population.
- Dusting with 2% Methyl Parathion dust at the rate of 20-25 kg per hectare.
- Spray with 0.05% Malathion 50 EC at the rate of (5 ml per liter of water).

4. Cabbage Butterfly (*Pieris brassicae*)

Symptoms of Damage

- Larvae leave behind irregular holes on the leaves.
- Larvae feed on leaves, branches, and pods, causing significant defoliation.
- Small plants may die, and large plants suffer reduced growth and yield.
- In severe infestations the leaves turn yellow and the plant may show stunted growth.

Management Methods

- Apply Bacillus thuringiensis (Bt) to control early-stage larvae organically (2.5 grams per liter of water)
- Use yellow sticky traps to attract and reduce the adult butterfly population, preventing further laying of eggs.
- Hand-pick and kill caterpillars during early stages.
- Spray with Monocrotophos (Nuvacron) 40 EC (1 liter per hectare in 1000 liters of water).

Diseases

1. Alternaria Blight (*Alternaria brassicae)*

Symptoms of Damage

- Black, concentric (circular) spots on the leaves, stems, and pods.
- Pods turning black and rotting.
- Shriveled, undersized seeds inside affected pods.
- Leaves may drop prematurely due to severe infection.

Management Methods

- Use healthy, disease-free seeds for planting.
- Spray with Iprodione or Mancozeb 75 WP at the rate of 2 kg in 1000 liters of water per hectare.
- Remove and burn affected plant parts after harvest to prevent the fungus from spreading.
- Crop rotation can reduce disease pressure in subsequent years.

2. Downy Mildew: The Causal Organism of this disease is *Peronospora brassicae* (fungus)

Symptoms of Damage

- Yellow, irregular spots appear on the upper surface of leaves.
- White fuzzy growth appears on the underside of leaves opposite to the spots.
- Affected flower clusters (inflorescences) twist and are covered with white powder.
- Poor or no pod development in severely infected areas.

Management Methods

- Use resistant varieties if available.
- Practice good field hygiene by removing and destroying infected plant debris after harvest.

- Treat seeds with Apron 35 SD at a rate of 6 g per kg of seed before planting.
- Spray the crop with Ridomil (0.2%) or Karathane (0.1%) as soon as symptoms appear and repeat every 10 days.

3. White Blister: The Causal Organism of this disease is *Albugo candida* (fungus)

Symptoms of Damage

- White, raised blisters on the leaves, stems, petioles (leaf stalks), and flowers.
- Blisters burst, releasing a white powder.
- Malformed and sterile flowers that cannot produce seeds.
- Deformed, stunted pods and poor crop yield in severe cases.

Management Methods

- Treat seeds with Apron 35 SD at the rate of 6 g per kg before sowing.
- Spray the crop with Ridomil (0.2%) as soon as symptoms are observed and repeat at 10-day intervals.
- Keep the field free from weeds to reduce fungal spread.
- Crop rotation helps in reducing the risk of re-infection in future seasons.

4. Fusarium Wilt (Less common but significant): The Causal Organism of this disease is *Fusarium oxysporum* (fungus)

Symptoms of Damage

- Yellowing of lower leaves, which later turn brown.
- Wilting and stunted growth of infected plants.
- Root rot or blackening of the roots, which can lead to plant death.
- Reduced seed formation and poor plant health.

Management Methods

- Use disease-resistant varieties when available.

- Apply Trichoderma viride as a biological control agent to combat the fungal infection at the rate of 10-20 grams per kg of seed or 2-3 kg per hectare when applied to the soil.
- Rotate crops to prevent the buildup of the fungus in the soil.
- Improve soil drainage and avoid overwatering to prevent the conditions that favor this disease.

3.3 Sunflower

Sunflower (*Helianthus annuus*), is an annual plant belonging to the Asteraceae family. It is considered a day-neutral plant, meaning its flowering is not significantly influenced by the length of day or night. However, sunlight plays a crucial role in sunflower growth and development. During the early stages of growth, sunflowers exhibit a phenomenon known as heliotropism. This means that young sunflower heads actively track the sun across the sky from east to west throughout the day. This solar tracking maximizes photosynthesis and promotes faster growth. As the sunflower matures and the head becomes heavier, heliotropism gradually diminishes.

Botanical Description

Sunflower (Helianthus annuus) is an annual herb belonging to the Asteraceae family. It has a large, single flower head with bright yellow ray florets and a dark brown or black disc center. The plant has a tall, thick stem with large, rough

leaves.

History and Origin

Sunflowers originated in North America, likely in the southern United States and Mexico. They were domesticated by Native Americans thousands of years ago and used for food, medicine, and dyes.

Area and Distribution

Sunflowers are now grown all over the world, but the major producers include Ukraine, Russia, Argentina, China, and the United States. In Nepal, sunflower is primarily cultivated in the Terai, inner Terai, and mid-hill regions, particularly in districts like Bara, Parsa, Rupandehi, Chitwan, and Kaski.

Climate and Soil

Sunflowers need a cool climate for germination and seedling growth. They can handle light frost when they are young, but only until they develop four to six leaves. Once they grow past this stage, they need warm weather to continue growing, especially during the flowering and seed-filling stages. Sunflowers need lots of sunshine and warm temperatures during flowering to produce good seeds. However, high humidity, cloudy weather, and rainfall during flowering can result in fewer seeds. If the temperature is too high during maturity, the oil content in the seeds decreases. Sunflowers grow best in warm, sunny conditions with moderate rainfall and cannot tolerate frost, so they need a frost-free period to develop properly.

Sunflowers can grow in various types of soil. It can handle moderate pH levels and some salt. They grow best in loamy soils with the ideal soil pH between 6.5 and 8.5. well-drained, and fertile soils in this pH range support proper growth and development of the crop.

Varieties

There are many different varieties of sunflowers available, each with its own unique characteristics. Some popular varieties for oil production include Hybrid 424, Pioneer 64A83, and DK 5148. Some popular varieties for seed production

include Black Oil Sunflower, Gray Stripe Sunflower, and Mammoth Russian Sunflower.

Field Preparation

The field should be deeply plowed to a depth of 20 to 25 centimeters, followed by harrowing and leveling. This prepares a fine, weed-free seedbed that supports proper seed germination and healthy crop growth. The soil should be loose and field should be managed well-drained to allow the sunflower roots to grow deeply and access essential nutrients and avoid water logging condition.

Manures and Fertilizers

Sunflowers are heavy feeders and require sufficient nutrients for healthy growth. They respond well to nitrogen, phosphorus, and potash. The recommended fertilizer dose for sunflower is 60-80 kg of nitrogen (N), 60 kg of phosphorus (P_2O_5), and 40 kg of potash (K_2O) per hectare. Apply two-thirds of the nitrogen, and the entire amount of phosphorus and potash, as a basal dose during land preparation. The remaining nitrogen should be applied as a topdressing during the second irrigation, which usually happens at the flowering stage. Using the right amount of fertilizers helps to improve seed size, oil content, and overall yield of the crop.

Time and Method of Sowing

Sunflower is a day-neutral crop, which means it doesn't rely on specific day lengths to grow or flower. This makes sunflowers adaptable to different regions and planting times, as long as the temperature and moisture are right. In Nepal, the best times to sow sunflowers are during March-April for the spring/summer crop, June-July for the autumn crop, and October-November for the winter crop. Before sowing sunflower seeds, proper seed treatment is essential for healthy growth. Seeds can be treated with Trichoderma (4g per kg) to protect from fungal infections, but avoid fungicides when using Trichoderma. Line sowing method is popular for sowing sunflower.

Seed Rate and Spacing

Spacing of R×R 60 cm apart and P×P 20-30 cm between within each row. The seed rate is around 5 to 6 kg per hectare**,** and the seeds should be sown at a depth of 2.5 to 5 cm. This method ensures proper spacing, good sunlight exposure, and air circulation, which helps improve seedling growth, flowering, and seed development.

Irrigation

Sunflowers are moderately drought-tolerant crop. It can be benefited from irrigation during dry periods. Optimum moisture during germination, flowering, and seed filling stages supports healthy growth of the crop. It is important to manage well drainage facility in the field to prevent waterlogging condion.

Weeding and Earthing up

Weeding and earthing up are important practices for healthy growth of sunflower. It is crucial to keep the field weed-free for up to 60 days after sowing to minimize competition with crop. Weeding removes unwanted plants that compete for water, nutrients, and sunlight with crop. When the sunflower plants reach knee-high stage, earthing up should be done along the rows to protect against lodging. For effective weed control, herbicides like alachlor or pendimethalin (1.5 kg per hectare) can be applied as pre-emergence. Regular weeding and earthing up ensure the best growing conditions for proper growth and development of the crop.

Harvesting, Threshing, Yield, and Storage

Sunflowers are ready for harvest when the back of the head turns yellow and the bracts become dry and brown. The seeds are mature when the moisture content is around 20%. Since not all sunflower heads ripen at the same time. Multiple harvesting is done to prevent seed shattering. After harvesting, the heads should be thoroughly dried in the sun. Once dry, the seeds can be threshed by beating the center of the head with a small stick or using a thresher. Once the seeds are threshed, they should be sun-dried further until the moisture content is below

10%. Proper drying is essential to prevent spoilage. The seeds should be stored in a cool, dry place in airtight containers or bags to maintain their quality and prevent mold growth. With proper care and good growing conditions, yield of the sunflower range from 2000 to 4000 kg per hectare**.**

Insects, Pests, and Diseases

Insects and Pests

1. Sunflower Beetle (*Zygogramma bicolorata*)

Symptoms of Damage

- Holes in the leaves and flower heads.
- Yellowing and wilting of leaves.
- Premature leaf drop.
- Poor growth of the plant due to damage.

Management Methods

- Spray neem oil (5-10 ml per liter of water) to repel beetles.
- Use natural predators like ladybugs that feed on sunflower beetle larvae.
- Handpick the beetles and drop them into soapy water or use sticky traps.
- Apply Lambda-cyhalothrin (20-25 ml per 10 liters of water) to control large infestations.

2. Sunflower Moth (*Homoeosoma elactella*)

Symptoms of Damage

- Small holes in sunflower seeds and heads.
- Webbing or silken threads around the flowers.
- Stunted growth and distorted heads.
- Damaged seeds that appear chewed or hollow.

Management Methods

- Use neem oil (5-10 ml per liter of water) or garlic-based sprays to naturally repel the moths.
- Release Trichogramma wasps to parasitize moth eggs and larvae.
- Remove and destroy affected heads to limit further spread.
- Use Cypermethrin (10-15 ml per 10 liters of water) to control moth larvae effectively.

3. Aphids (*Aphis gossypii*)

Symptoms of Damage

- Curling, yellowing, or wilting leaves.
- Sticky substance (honeydew) on leaves and surrounding areas.
- Stunted growth and deformed flowers.
- Ants attracted to the sticky honeydew produced by aphids.

Management Methods

- Spray a mixture of neem oil (5 ml per liter of water) or a mild dish soap solution to disrupt aphid feeding.
- Encourage natural predators such as ladybugs or lacewings that feed on aphids.
- Use a strong stream of water to wash aphids off the plant leaves.
- Apply Imidacloprid (5-7 ml per 10 liters of water) or Dimethoate (10 ml per 10 liters of water) for severe aphid infestations.

4. Cutworms (*Agrotis ipsilon*)

Symptoms of Damage

- Severed stems near the base of young plants.
- Wilting or drooping plants that may collapse overnight.
- Circular holes around the base of sunflower stems.
- Missing or disappearing plants as cutworms feed on them at night.

Management Methods

- Spread diatomaceous earth (10-20 g per plant) or fine sand around the base of plants to act as a barrier against cutworms.
- Apply nematodes (500,000 per hectare) that specifically target and kill cutworms in the soil.
- Use collars around young sunflower plants to protect them from cutworms or manually remove them from the soil.
- Apply Carbaryl (20-25 g per 10 liters of water) to control severe infestations.

Diseases

1. Seed Rot

Causal Organism: *Fusarium*, *Alternaria*, and *Rhizoctonia*

Symptoms of Damage

- Seeds rot before germination.
- Mould growth on seed surface.
- Poor seedling stand and germination failure.
- Affected seeds appear shriveled or discolored.

Management Methods

- Use neem oil (5-10 ml per liter of water) to soak seeds before sowing to reduce fungal growth.
- Treat seeds with Trichoderma at the rate of 4-5 g per kg of seed to suppress mold growth.
- Ensure proper seed storage in cool, dry conditions to prevent fungal growth.
- Treat seeds with Apron at 6 g/kg of seed before sowing to protect from seed rot.

2. Charcoal Rot

Causal Organism: *Macrophomina phaseoli* (fungus)

Symptoms of Damage

- Early plant maturity.
- Black, ashy color on stems when plants dry.
- Undersized flower heads.
- Plants appear weak and stunted.

Management Methods

- Use neem oil or garlic sprays at the rate of 5-10 ml of neem oil per liter of water on affected plants to slow the spread.
- Apply Trichoderma to soil to suppress fungal growth.
- Remove and burn infected plants immediately.
- Use Mancozeb (2.5 kg per hectare) as a preventive spray, especially during humid conditions.

3. Alternaria Blight

Causal Organism: *Alternaria helianthi* (fungus)

Symptoms of Damage

- Dark brown to black round spots on leaves.
- Concentric rings around spots.
- A narrow chlorotic zone around the spots.
- Drooping and drying of leaves.

Management Methods

- Spray neem oil (5 ml per liter of water) as a preventive measure against fungal infections.
- Apply Trichoderma to help control fungal growth in the soil.
- Remove and destroy affected leaves to reduce fungal spread.

- Spray Mancozeb 75 WP (2.5 kg per hectare in 1000 liters of water) starting when disease symptoms appear. Repeat every week for a total of 4 sprays.

4. Sclerotinia Wilt and Rot

Causal Organism: *Sclerotinia sclerotiorum* (fungus)

Symptoms of Damage

- Wilt symptoms like Sclerotium wilt but with black, large, and irregular sclerotia on affected stems and heads.
- Soft rotting of stems and flower heads.
- Shredding of the stem and head.
- Affected plants may appear to collapse.

Management Methods

- Apply neem oil or garlic oil to prevent fungal infection.
- Use Trichoderma to control fungal growth in the soil.
- Collect and burn all affected plants and the surrounding 15 cm of soil.
- Treat seeds with Apron at 6 g/kg of seed before sowing, and apply Mancozeb (2.5 kg per hectare) if the disease appears during the growing season.

Critical stages in Sunflower

- Germination :Keep the soil moist but not too wet, and make sure the seeds are planted at the right depth.
- Seedling Growth: Protect seedlings from pests and weeds, and make sure there is enough moisture and avoid water logging condition.
- Vegetative Growth: Provide plenty of water and nutrients, and make sure the plant doesn't fall over by checking for pests.
- Flowering: Provide optimum irrigation, and watch for insects that might damage the flowers.

- Seed Filling: Avoid the stress from drought or pests.
- Maturation: Harvest sunflowers at the right time to prevent seed loss by shattering and ensure the seeds are dry to avoid mold.

3.4 Linseed/Flaxseed

Introduction

Linseed *(Linum usitatissimum L.)*, belongs to the family Linaceae. It is an important oilseed crop that is cultivated worldwide for its versatile uses. These seeds are rich in oil and used for its nutritional benefits and industrial applications. It is used as food for nutrition and also used in industries such as textiles, paints, and cosmetics.

Botanical Description

Linseed is an annual herbaceous plant grows between 30 to 120 cm in height. It has a shallow root system with a slender taproot and small lateral roots. The plant has narrow, lanceolate leaves that are alternate and sessile. Linseed flowers are typically white or blue in colour with five petals, sepals, and stamens. The flowers open in the morning and close in the afternoon. The plant is self-pollinated, and the ovary develops into a capsule containing 2 seeds per cell.

History and Origin

Linseed has been cultivated from ancient time. It is said to be originated from

Mediterranean region. It was one of the earliest plants used by ancient civilizations for its seeds, oil, and fibers. Linseed played a significant role in early societies, providing a valuable source of food, oil, and fabric. The oil extracted from its seeds was used for cooking and medicinal purposes, while its fibers were woven into fabrics and ropes. Over the centuries, linseed spread across the world and continues to be cultivated today for its versatile uses in both food and industry.

Area and Distribution

Linseed (*Linum usitatissimum*) is grown worldwide, particularly in temperate and tropical regions. Major producers include India**,** Canada**,** China, and Russia. In Nepal, linseed is cultivated mainly in the hills and mid-hills districts like Kaski, Syangja, and Gulmi. This crop is grown for its oil-rich seeds and fiber, and is increasingly popular in Nepal for its nutritional value.

Climate and Soil

Linseed thrives well in cool climates with temperatures between 21°C and 26°C**.** It is sensitive to high temperatures above 32°C and frost during flowering. This can reduce yield and oil quality. This crop can be grown in low rainfall areas, with annual precipitation between 45 to 75 cm. It can also be grown under irrigation in dry climates. It requires a long day photoperiod for optimal growth and development. Linseed can be grown in a variety of soils. It can perform best in clay loam soil which have good water retention capacity. Soil rich in humus can supply essential nutrients for healthy growth of the crop. Linseed can be cultivated in soils with a pH range of 6.5 to 8.0. Proper moisture and good drainage are important for optimal growth and better yield of the crop.

Varieties

Commonly grown linseed varieties include Gaurav, Garima, Nagarkot, Pusa-2, and Sheetal. Selection of variety may depend on local growing conditions and farmer preferences.

Field Preparation

Field must be well-prepared to ensure good germination and better yield of the

crop. 3 to 4 plowings is done to a depth of about 25 centimeters using plough. It is followed by 2 to 3 harrowings to create a fine seedbed with a smooth even surface is essential. The field should also be free from weeds and clods to prevent competition for nutrients and for better germination of seeds.

Manures and Fertilizers

Apply 6 to 8 tons of farmyard manure (FYM) per hectare to enrich the soil with organic matter. For chemical fertilizers, use a basal dose of 50 kg nitrogen (N), 40 kg phosphorus (P_2O_5), and 40 kg potassium (K_2O) per hectare. Apply half of the nitrogen with the full phosphorus and potassium at field preparation, and the remaining nitrogen at the 4 to 6 leaf stage. In unirrigated areas, apply all fertilizers during sowing time following the deep placement method.

Time and Methods of Sowing

The time of sowing plays a crucial role in the successful cultivation of linseed. In Nepal, linseed is generally sown from the first week of October to the first week of November. This period ensures optimal growth. Delayed sowing can negatively impact plant development and reduce yield. The ideal sowing time may vary depends on the region where it is cultivated. Early sowing is preferred in warmer areas and slightly delayed in cooler regions. Linseed can be sown by using both broadcasting and line sowing methods. The line sowing method is recommended for better yield.

Seed Rate and Spacing

The recommended seed rate for linseed is 20 to 25 kg per hectare. In line sowing method, the seeds should be spaced about 20-25 cm apart within rows, with rows 30-35 cm apart. This ensures good sunlight exposure, air circulation, and better development of the plants. Seeds should be sown at a depth of 2-3 cm.

Irrigation

Linseed is commonly grown under rainfed conditions. This crop also responds well to irrigation during critical stages. Generally, two irrigations are sufficient for better yield of this crop. The first irrigation should be applied 30-40 days

after sowing, and the second irrigation should be given just before flowering. The crop may not need additional irrigation if there is winter rainfall.

Weeding and Thinning

Linseed is a poor competitor with weeds due to its small size and limited leaf area. Weeds reduce yield, oil content, and seed quality of the crop. To control weeds, two weedings are generally carriedout. The first weeding should be done at 3 weeks and the second at 6 weeks after sowing. Thinning should also be done during the first weeding to maintain optimum plant to plant distance. For chemical control, Pendimethalin (Stomp 30 EC) at 1.0 kg a.i. per hectare pre-emergence for broadleaf weed control, or Isoproturon (1 kg per hectare) can be applied to manage early weed growth.

Harvesting, Threshing, Storage and Yield

Harvesting of Linseed can be done by hand-pulling or using sickles. The crop typically takes 130-150 days to mature, and it's ready for harvest when the stems turn yellow and the capsules and leaves begin to dry. The lower leaves of the plant will wither away at this stage. Linseed should be harvested when about 75% of the capsules turn yellowish brown in colour.

The harvested plants should be bundled and left to dry for 4 to 5 days on a threshing floor. The seeds can be extracted by beating the plants with sticks or by trampling them under the feet of bullocks or by using threshers. After threshing, seeds should be dried to a moisture content of 8-10% to prevent spoilage. The dried seeds should be stored in airtight containers and kept in cool and dry place to maintain seed quality. The expected yield of linseed ranges from 14 to 20 quintals per hectare.

Insect Pests and Diseases

Insects and Pests

1. Linseed Midge (*Contarinia linicola*)

Symptoms of Damage

- Destruction of flower buds.

- Formation of galls (swollen growths) on buds.
- Damaged buds fail to open.
- Reduced seed production due to damaged flowers.

Management Methods

- Use neem oil (5-10 ml per liter of water) to repel the pest naturally.
- Introduce natural predators like parasitic wasps that target midge larvae.
- Remove and destroy affected buds to limit pest spread.
- Dust with 2% Methyl parathion (25-30 kg per hectare) or spray Oxydemeton methyl (Metasystox) 25 EC or Dimethoate (Rogor) 30 EC at the rate of 1 liter in 1000 liters of water per hectare.

2. Leaf Miner (*Liriomyza spp.*)

Symptoms of Damage

- Leaves develop small, winding mines or tunnels.
- Reduced photosynthesis due to leaf damage.
- Affected leaves turn yellow and dry out.
- Stunted growth in severe infestations.

Management Methods

- Spray a mixture of neem oil (5-10 ml per liter of water) for natural control.
- Release Trichogramma wasps that parasitize the leaf miner larvae.
- Remove and destroy damaged leaves.
- Spray Oxydemeton methyl (Metasystox) 25 EC or Dimethoate (Rogor) 30 EC at the rate of 1 liter in 1000 liters of water per hectare.

3. **Caterpillars (Includes Semi-Looper:** *Autographa gamma*, **Lucerne Caterpillar:** *Spodoptera litura* **and Gram Caterpillar:** *Helicoverpa armigera***).**

Symptoms of Damage

- Larvae feed on the foliage, leaving large holes in the leaves.
- Defoliation reduces plant growth and health.
- Presence of caterpillars feeding on plants, especially in March-April.
- Damage to young plants can stunt their growth.

Management Methods

- Use neem oil (5-10 ml per liter of water) to discourage caterpillars.
- Introduce natural predators like parasitic wasps or predatory beetles.
- Handpick and remove caterpillars from the plants.
- Spray Dichlorophos (Nuvan) 70 EC (700 ml in 1000 liters of water per hectare).

4. **Greasy Cutworm (*Agrotis ipsilon*)**

Symptoms of Damage

- Light yellowish-grey larvae feed at night.
- Plants are cut near the soil surface, causing them to fall over.
- Presence of holes or cracks in the soil where the larvae hide during the day.
- Active mostly from November to March.

Management Methods

- Apply diatomaceous earth around the base of plants to act as a natural barrier.
- Use nematodes (biological control agents) that target and kill cutworms.
- Remove and destroy larvae by hand if detected.
- Apply 2% Methyl parathion dust (20-25 kg per hectare) mixed into the soil to control larvae.

Diseases

1. Rust

Causal Organism: *Melampsora lini* (fungus)

Symptoms of Damage

- Pink-colored spots appear on the leaves, stems, and capsules.
- Reddish-brown to black pustules form on the leaves later in the season.
- Infected leaves turn yellow and die prematurely.
- Reduced seed production due to infected capsules.

Management Methods

- Grow resistant varieties.
- Use Trichoderma to prevent fungal spread.
- Remove and destroy diseased plant parts and weeds.
- Spray Mancozeb 75 WP at 2 kg in 1000 liters of water per hectare

2. Wilt

Causal Organism: *Fusarium oxysporum f. sp. lini* **(fungus)**

Symptoms of Damage

- Wilting and yellowing of leaves, especially in seedling stage.
- Infected seedlings may die before producing a second leaf.
- Dark green or brownish spots appear on older leaves.
- Plants may collapse and die due to vascular system blockage.

Management Methods

- Grow resistant varieties.
- Apply Trichoderma to the soil to fight the fungus.
- Avoid planting linseed in the same field for 2-3 years; follow good crop rotation.
- There are no specific chemicals, but crop rotation remains a key control method.

3. Powdery Mildew

Causal Organism: *Oidium lini* **(fungus)**

Symptoms of Damage

- A greyish-white powder appears on the youngest growing tips.
- In severe cases, it affects branches, leaves, and flowers.
- The plants may lose their leaves (defoliation), leading to shriveled grains.
- Heavy losses due to reduced seed production.

Management Methods

- Collect and burn infected plants after harvest.
- Use Trichoderma to suppress fungal growth.
- Manually remove infected plant parts and dispose of them properly.
- Spray wettable sulfur like Sulfex or Elosal at 3 kg per hectare in 1000 liters of water.

4. Leaf Spot

Causal Organism: *Alternaria lini* **(fungus)**

Symptoms of Damage

- The buds fail to open and develop small dark black spots near the calyx.
- Spots spread to the pedicel (stem of the flower).
- Affected flowers shrink, rot, and eventually die.
- The disease primarily affects the floral parts.

Management Methods

- Use resistant/tolerant varieties..
- Apply Trichoderma to the affected plants.
- Remove and destroy infected buds and flowers.
- Treat seeds with Thiram or Bavistin at 2.5 g per kg of seed before sowing.

Critical stages of Linseed:

- **Germination:** Ensure adequate moisture for proper seed sprouting and avoid waterlogging.
- **Seedling Growth:** Protect young plants from pests and ensure proper irrigation for healthy growth.
- **Vegetative Growth:** Control weeds and provide adequate nutrients, especially nitrogen, for strong plant development.
- **Flowering:** Maintain proper moisture and avoid excessive heat to ensure good flower formation.
- **Seed Filling:** Avoid drought stress and ensure consistent water supply for seed development.
- **Maturation:** Harvest at the right time to prevent seed shattering, and dry seeds properly before storage.

3.5 Groundnut

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Groundnut, also known as peanut. It is scientifically called *Arachis hypogaea* and belongs to the Fabaceae/Leguminous family. It is one of the most important oilseed crops. Groundnut is rich in oil (about 45%) and protein (26%) which makes it a highly nutritious food. It is easy to digest and a great source of vitamin B. It also contains important minerals like phosphorus, calcium, and

iron. Groundnut kernels are often consumed roasted, fried, or salted. The oilcake is valuable for animal feed and organic manure. Additionally, groundnut can be used as a rotation crop that helps to improve soil fertility by fixing nitrogen in the soil.

Botanical Description

Groundnut is an annual herb from the leguminous family. Generally groundnut are of two types one spread on the ground (prostrate) and another stand upright (erect). The leaflets are arranged on each side of the stem. The flowers are small, yellowish in colour. After the flowers are pollinated, the pods start to develop underground. These pods contain the seeds which are eaten as peanuts.

History and Origin

Groundnut is said to be originated in South America, specifically in regions of Brazil and Peru. It has been cultivated from centuries and spread to different parts of the world. The plant was introduced to Africa and then to Asia by European traders. Due to its valuable oil and source of protein it quickly became one of the important crops in the world.

Area and Distribution

Groundnut is widely grown in tropical and subtropical regions in the different part of the world. Major producers of groundnut crop includes India, China, Nigeria, USA, and Argentina. In Nepal, it is cultivated in Terai, inner Terai, and mid-hill regions. It is commonly cultivated in districts such as Chitwan, Bara, Parsa, and Rupandehi.

Climate and Soil

Groundnut grows best in a warm and humid climate. The ideal temperature for its growth is between 27°C and 30°C. For good germination, the soil temperature should be 18°C or higher. It thrives in areas with well-distributed rainfall of at least 50 cm during the growing season, along with plenty of sunshine. Lower temperatures can hinder its growth of the plant. This crop needs, it needs about a month of warm, dry weather during ripening period. Groundnut can be cultivated

successfully in well-drained sandy or sandy loam soil. This type of soil allow the pegs (the underground stems) to easily penetrate and develop the pod. This also makes easy for harvesting the pods. The soil with a pH between 6.0 and 6.5 known to be best for groundnut crop cultivation.

Varieties

Several groundnut varieties have been released by NARC. The different varieteis are Baidehi, Rajarshi, Jayanti, Jyoti, Janak, and B4. Farmers can choose varieties based on local conditions and preferences to achieve the best yields.

Field Preparation

Proper field preparation is important for healthy growth and a good harvest of the Groundnut crop. This crop has a deep root system but deep ploughing should be avoided. Deep ploughing can cause the pods to develop in deeper layers of the soil. Deeper pod formation results in difficulty to harvest the pods. One 10-15 cm deep ploughing followed by two harrowings, is enough to create a better surface for planting. During field preparation good drainage facility is to be managed to prevent waterlogging.

Manures and Fertilizers

Groundnut gets most of its nitrogen through nitrogen fixation. Applying 20 kg of nitrogen per hectare in poor soils as a starter dose helps early growth of the crop. Apply FYM/Compost 10-15 tons per hectare during field preparation. For phosphorus and potassium, apply 50-40 kg of phosphorus and 20 kg of potassium per hectare. Use superphosphate for phosphorus. Fertilizers should be placed 4-5 cm below and beside the seed at sowing. Add gypsum (125 kg per hectare) for calcium, and for sandy soil. If there is zinc deficiency, apply zinc sulfate at the rate of 25-30 kg per hectare.

Time and Method of Sowing Seed

In Nepal, groundnut should be sown during the last week of June to first week of July for rainfed crops. Early sowing can leads to better yield of the crop. If there is irrigation facility, seed is sown around 15 to 20th June with a pre-sowing

irrigation. Groundnut seeds can be sown in different ways. One common method is behind the plough method. In this method the seeds are dropped in furrows made by the plough. Another method is using a dibbler. Dibbler is a tool that makes small holes in the soil for each seed and the seed is dropped in that hole. Large scale farmers often use a seed drill. Seed drill is a machine that sows seeds in rows uniformly and quickly.

Seed Rate and Spacing

The seed rate and spacing of groundnut depend on the type of plant. For erect/ bunch type, the row-to-row distance should be 30-40 cm and seed rate should be about 60-70 kg of seed per hectare**.** For spreading type the row-to-row distance should be 45-60 cm and the recommended seed rate is 80-100 kg per hectare. In terms of plant-to-plant spacing, keep 15 cm between plants for bunch types and 20 cm for spreading types. This spacing ensures proper growth, good air circulation, and makes it easier to manage the plants. Proper spacing is key to achieving healthy plants and better yields.

Irrigation

Groundnut is a rainy season crop. This crop usually irrigated in dry conidition if needed. Groundnuts are sensitive to water stress, especially during flowering and pod development, so providing optimum moisture during these periods is important.

Weeding and Earthing up

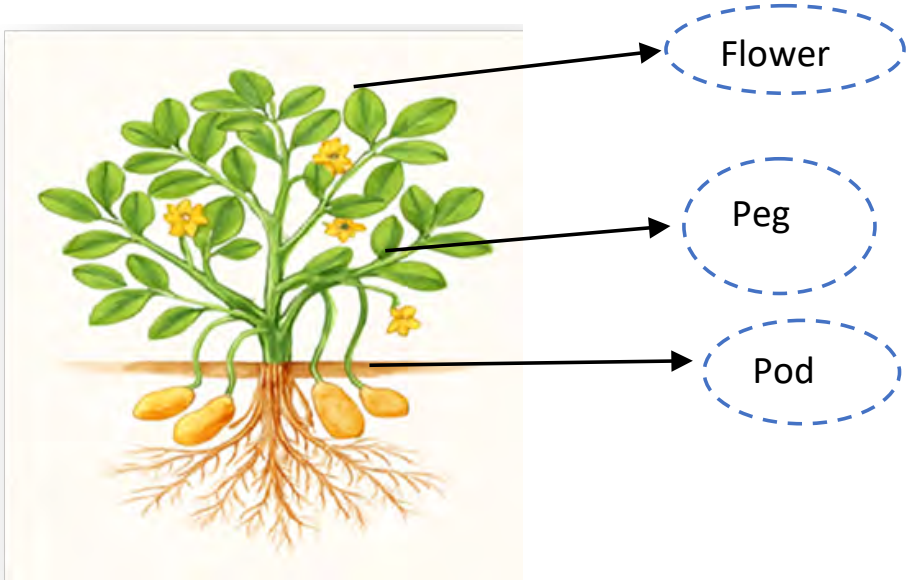
Weeding is an important task for groundnut growth, and it is commonly done by hoeing. Hoeing helps loosen the soil and removes weeds that compete with the groundnut plants for water, nutrients, and sunlight. The first hoeing is done three weeks after sowing, and the second hoeing is done three weeks later of first hoeing. Weeding can also be done using pre-emmergence herbicide at the rate of 1.0 kg of Pendimethalin (Stomp 30 EC) in 800-1000 liters of water. to make the process faster and more efficient. At the same time as weeding, earthing up is also done. During earthing up the soil is mounded around the base of the plant. This

helps the pegs (underground stems) penetrate the soil easily and provides more space for formation of pods. Earthing up also improves soil moisture retention and promotes healthy plant growth.

How does pod formation occurs in groundnut?

- Flowering: The process begins with the flowering stage, where small, yellow flowers bloom on the groundnut plant. These flowers are self-pollinating or can be pollinated by insects.
- Pollination: After the flowers are pollinated, the flower begins to fade, and the plant starts the next step.
- Peg Formation: The plant then produces pegs, which are long, slender stems that grow downward from the base of the pollinated flowers.
- Peg Penetration: These pegs penetrate the soil and start developing into pods.
- Pod Maturation: As the pods mature underground, they change color from green to a yellow-brown shade, signaling they are ready for harvest.

Harvesting, Threshing, Storage and Yield



Harvesting groundnuts at the right time is important for better yield and quality. Groundnuts typically take 2 to 4 months to reach full maturity. There are different indicators to know the harvesting time. The vines turn yellow, the leaves start shedding, and the pods are difficult to split with fingers. Plants can be harvested by pulling them from the soil or by digging with the help of spade or groundnut digger. After harvesting, the groundnut plants should be left in small heaps for about 2 to 3 days in a shed which is called curing. This process allows the plants to dry out slowly and ease to detach the pods from the plant. After the initial curing, the plants should be dried in the sunlight for 2 to 3 more days. Once the plants are completely dry, the pods are detached either by hand or using a groundnut strippers. When the dried seed reach a moisture content of about 8-10% before storing. It is important to store the pods in ventilated containers or sacks and store in a cool and dry place**.** Airtight containers should be avoided because they can trap moisture and spoil the seed. The expected yield of buch type groundnut is 15-20 quintals/ha and spreading type is 20-25 quintals/ha.

Insects, Pests, and Diseases

Insects and Pests

1. Groundnut Aphid (*Aphis craccivora*):

Symptoms of Damage

- Leaves curl and the plant growth becomes stunted due to sap-sucking.
- Flowers and pods are affected.
- Aphids are found in colonies on the underside of leaves and top shoots.

Management Methods

- Encourage natural predators like ladybugs to control aphid populations.
- Use Neem oil or Azadirachtin (from Neem) at a rate of 5 ml per liter of water for spraying.
- Spray water on affected plants to wash off aphids.
- Spray Monocrotophos (Nuvacron 36 SL) at 1 ml per liter of water.

2. Groundnut Leaf Miner (*Aproaerema modicella*)

Symptoms of Damage

- Blister-like mines appear on leaves from larvae feeding.
- Leaves become webbed and deformed.
- The plants fail to grow properly.

Management Methods

- Release natural predators such as parasitoid wasps that target leaf miners.
- Use Trichoderma at 4 g per kg of seed for prevention or Bacillus thuringiensis (Bt) at 5-10 ml per liter of water to control larvae.
- Handpick affected leaves and destroy them.
- Spray Monocrotophos (Nuvacron 36 SL) at 1 ml per liter of water.

3. Termites (*Isoptera* species)

Symptoms of Damage

- Termites feed on the roots, causing wilting and poor plant growth.
- The attack weakens the pods, making them more likely to shatter during harvest.
- Hollowing of the soil around the plant roots.
- Presence of mud tubes on the plant stems or around the root zone.

Management Methods

- Use nematodes (like Steinernema species) to attack termites in the soil.
- Apply Bacillus thuringiensis (Bt) at 10 ml per liter of water to target larvae in the soil.
- Use soil barriers to prevent termites from reaching the plants.
- Mix 5% Malathion dust at 25 kg per hectare in the soil during the last harrowing.

4. White Grub (*Phyllophaga* species)

Symptoms of Damage

- Grubs feed on roots, leaving only the tap root behind.
- Yellowing of leaves.
- Plants turn pale, droop, and wither, eventually dying of plant.
- Easy uprooting of affected plants.

Management Methods

- Encourage natural predators like birds and ground beetles.
- Use Bacillus thuringiensis (Bt) at 10 ml per liter of water to target larvae in the soil.
- Flood the field to drown grubs.
- Apply Phorate (Thimet) 10% granules at 15 kg per hectare before sowing.

Diseases

1. Rust (*Melampsora lini*)

Symptoms of Damage

- Orange or reddish-brown pustules appear on the upper surface of the leaves.
- The leaves become yellow and fall off prematurely.
- Black pustules may form on the lower side of the leaves during the later stages.
- The pods also develop rust-like spots, affecting their quality.

Management Methods

- **Organic Method:** Rotate crops with non-leguminous plants like cereals to break the disease cycle.
- **Biological Pesticides:** Use Trichoderma or Bacillus thuringiensis for soil treatment to reduce fungal growth.

- **Physical Method:** Remove and burn infected plant parts to prevent further spread.
- **Chemical Method:** Spray Mancozeb 75 WP at 2 kg in 1000 liters of water per hectare or use Sulfur dust at 20 kg per hectare to control rust.

2. Wilt (*Fusarium oxysporum*)

Symptoms of Damage

- Yellowing of the leaves, starting from the lower leaves and spreading upward.
- Stunted growth and wilting of the plants, particularly during hot weather.
- The plants may collapse suddenly due to root damage.
- Brown lesions appear in the vascular tissues of the plant.

Management Methods

- **Organic Method:** Use compost and organic matter to improve soil health and increase plant resistance.
- **Biological Pesticides:** Apply Trichoderma (4g per kg of seed) to the soil before planting to protect against fungal attacks.
- **Physical Method:** Practice crop rotation with non-legumes like cereals to reduce disease buildup.
- **Chemical Method:** Use Carbendazim (Bavistin) at 1.5-2 g per liter of water to prevent and control wilt.

3. Powdery Mildew (Oidium lini)

Symptoms of Damage

- A white, powdery fungal growth appears on the upper side of the leaves.
- Leaves become curled and distorted, with a dry, whitish appearance.
- In severe cases, the fungus affects the flowers and pods, reducing yield.

- Defoliation can occur, weakening the plant.

Management Methods

- **Organic Method:** Use Neem oil or Garlic extract as a natural fungicide to control the spread of powdery mildew.
- **Biological Pesticides:** Spray Trichoderma or Bacillus subtilis to fight the fungal infection.
- **Physical Method:** Remove and destroy infected leaves to reduce the spread of the disease.
- **Chemical Method:** Use Wettable Sulfur (Sulfex or Thiovit) at 3 kg per hectare in 1000 liters of water for effective control.

4. Leaf Spot (*Alternaria helianthi*)

Symptoms of Damage

- Dark, round spots appear on the leaves with a yellow halo around them.
- The spots grow larger, causing leaf damage and premature defoliation.
- Affected plants show reduced photosynthesis, leading to weaker growth.
- In severe cases, the flower buds can also be affected, reducing pod formation.

Management Methods

- **Organic Method:** Use compost and organic fertilizers to improve plant resistance to fungal infections.
- **Biological Pesticides:** Apply Trichoderma to prevent fungal spread and treat the soil.
- **Physical Method:** Remove and burn infected plant parts and practice crop rotation to prevent disease buildup.
- **Chemical Method:** Spray Zineb at 2.5 kg per 1000 liters of water per hectare for effective control of leaf spot disease.

Marketing

In Nepal, oilseed crops like groundnut, mustard, linseed and rapeseed are important for both local consumption and trade. These crops are primarily grown in the Terai and hilly regions. Farmers are investing in seeds, fertilizers, and labor for cultivation. After harvesting, oilseeds are sold in local markets or processed in oil mills to produce vegetable oils and cakes. There are challenges like market price fluctuations, infestation of disease and pests. Despite of these, oilseed farming offers good opportunities for farmers, especially through cooperatives that help them get better prices. There is high demand for these oilseeds in foreign markets also. It can be better opportunity for farmers to increase yield and export the related products. The government support through subsidies and improved infrastructure, eleminating middlemen can boost production and marketing of oilseed crops.

Critical Stages of Groundnut

- Germination: Ensure the soil has sufficient moisture.
- Flowering: Maintain consistent moisture and protect the plants from pests to ensure proper pollination and flower development.
- Pod Development: Prevent water stress and control weeds to support healthy pod formation and seed development.
- Maturation: Monitor the crop for proper timing of harvest to avoid seed loss from shattering.

Exercise

Choose the correct answer from the given alternatives.

1. Which of the following crops belongs to the Brassicaceae family?
   a. Sunflower
   b. Groundnut
   c. Rapeseed
   d. Lentil

2. Which crop is known for its heliotropic behavior in the early stages of growth?
   a. Rapeseed
   b. Sunflower
   c. Linseed
   d. Mustard

3. Which crop is a significant source of omega-3 fatty acids?
   a. Rapeseed
   b. Linseed
   c. Groundnut
   d. Sunflower

4. Which crop is primarily cultivated for its fiber and oil?
   a. Rapeseed
   b. Mustard
   c. Linseed
   d. Groundnut

5. Which of the following crops is a legume?
   a. Sunflower
   b. Linseed
   c. Groundnut
   d. Rapeseed

6. Which crop is known for its ability to fix atmospheric nitrogen?
   a. Sunflower
   b. Linseed
   c. Groundnut
   d. Rapeseed

7. Which crop is sensitive to waterlogging?
   a. Sunflower
   b. Groundnut
   c. Linseed
   d. Mustard

8. Which of the following is a major pest of rapeseed and mustard?

   a. Aphids b. Cutworms

   c. Whiteflies d. Bollworms

9. Which of the following diseases affects a wide range of crops, including rapeseed, mustard, and sunflower?

   a. Rust b. Powdery Mildew

   c. Bacterial Blight d. Downy Mildew

Write short answer to the following questions.

1. Describe the ideal soil and climatic conditions required for growing rapeseed.
2. Explain the recommended seed rate, spacing, and method of sowing for sunflower cultivation.
3. List and describe three major insect pests of mustard and their management practices.
4. Discuss the importance of weeding and thinning in linseed cultivation.
5. Explain the effect of insect pests on sunflower production and the integrated pest management strategies used.
6. Discuss the importance of balanced fertilization in rapeseed, mustard, and sunflower cultivation, considering the role of different nutrients.

Write long answer to the following questions.

1. Describe the steps involved in field preparation and manure/fertilizer application for rapeseed cultivation, explaining their importance.
2. Explain the symptoms of damage and management methods of powdery mildew and leaf spot in groundnut.

Project Work

1. Prepare a Detailed plan of groundnut cultivation in your area and present the plan in your class room.

2. Find out if there is a rapeseed/mustard oil extraction mill in your area. Visit the mill to observe how the oil is extracted from the seeds. Take notes on each step of the process. Create a flowchart on chart paper to show the steps of oil extraction. If possible, take photos or videos to capture the process. Afterward, present your findings to the class using the flowchart, photos, and videos to explain how oil is extracted from rapeseed and mustard seeds.

Summer and Winter Grain Legume Production

Unit 4

4.1 Lentil

Lentil (*Lens culinaris*) belong to the Fabaceae/ Leguminosae family. It is also known as "musuro" in Nepali. It is a nutritious crop grown in cool seasons. It is rich in protein, fiber, iron, zinc, and folate which makes them valuable for health. It is commonly eaten as "dal" in Nepal. It is one of the popular source of protein for vegetarians and body builders. Lentils are easy to cook and are often splitted,peeled or used as a whole for preparing different dishes. The dry leaves and husks are used as livestock feed.

Botanical Description

Lentil is annual, herbaceous, short day plant. It have compound leaves. Lentil plants produce small, colorful flowers that are usually purple or white, and they grow in clusters. These flowers later turn into pods that contain the lentil seeds. It generally grow to a height of about 30 to 50 cm.

Origin

Lentil is known as one of the oldest crops. It has a history of over 10,000 years. It is said to be originated from the Middle East, in areas like modern-day Turkey and Syria. After that lentil spread to other parts of the world through trade and

migration. In ancient time lentil was an important food for civilizations like the Egyptians, Greeks, and Romans. Now a days, they are one of the popular crops of Nepal and India.

Area and Distribution

Globally, India is the largest producer of lentils, followed by countries like Canada**,** Turkey, and Australia. These countries play a major role in supplying lentils to the world market.Lentils are mainly grown in the Terai region and the inner Terai, but they are also cultivated in the mid-hills. The major growing areas are: Terai Region: This is the primary lentil-producing region. Inner Terai: Chitwan, Dang, bardiya, Banke and Kailali, also produce significant amounts of lentils. Mid-hills: Although less than in the Terai, lentils are cultivated in the mid-hills, particularly in areas like the districts of Kaski, Tanahu, and Makwanpur. According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23);

Name of the crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Lentil	173,011	200,787	1.16

Climate and Soil

Lentil is planted as a winter crop. It can tolerate frost and grown at high hills regions also. Lentil need cold temperatures during early growth and warmer temperatures at maturity stage. The ideal temperature for lentil cultivation is range of 18°C to 30°C. It can also tolerate drought condition. Lentil require moderate rainfall (400-600 mm) for cultivation. Lentil grow best in well-drained loamy or sandy loam soils. It can tolerate slightly alkaline soil but with a pH between 6.5 and 7.5 suits best for cultivation. Lentil is nitrogen-fixing plants, and can be grown in soil with less nitrogen.

Varieties

There are different varieties of Lentil chosen based on its ability to grow well in different climates and soil conditions in Nepal such as: Simal, Shikhar, Shital,

Sagun, Shisir, Shraddha Kalo Musuro, Khajura Musuro-1, Khajura Musuro-2, Khajura Musuro-3, Khajura Musuro-4.

Field Preparation

Field must be well-prepared to ensure good germination and better yield of the Lentil crop. 3 to 4 plowings is done to a depth of about 20-25 centimeters using plough. It is followed by 2 to 3 harrowings to create a fine seedbed with a smooth even surface is essential. The field should also be free from weeds and clods to prevent competition for nutrients and for better germination of seeds.

Manures and Fertilizers

Lentil is a nitrogen-fixing crop. It requires less nitrogen compared to other crops. In general, lentils grow well with minimal fertilizer application. Application of well-decomposed Farmyard Manure (FYM) at the rate of 4-6 tons per hectare helps to improve soil structure and fertility. A balanced fertilizer with a ratio of 20:20:20 $N:P_2O_5:K_2O$ kg/ha. can also be applied for proper growth and development of the crop for better yield. The application of nitrogen is usually split into two doses:

- **First application:** Half of the nitrogen is applied as a basal dose
- **Second application:** The remaining half of the nitrogen is applied 3-4 weeks after sowing in early vegetative stage of crop.

Seed Rate and Spacing

The seed rate is usually of lentil is 25 to 35 kg per hectare for optimum plant population in the field. While planting, the spacing between rows should be about 30 to 45 cm. This row to row spacing allows the plants to have enough space for proper growth. Within each row, the plants should be spaced 5 to 10 cm apart to ensure enough room for their roots for better absorptio of nutrients and water.

Time and Methods of Sowing

Lentil can be sown during November to December for better yield. It is planted by both broadcasting and line sowing methods. The line sowing method is known

to be best for sowing Lentil. This method ensures better spacing, allowing each plant to get enough sunlight, water, and nutrients absorption. It also makes it easier to carryout intercultural operations. While sowing, seeds should be planted at a depth of 2-4 cm. This depth allows the seeds to germinate properly and promotes healthy root growth.

Seed Treatment

To protect lentil seeds from fungal disease, lentil seeds are treated with fungicide. Dissolve 2-3 grams of Bavistin or Carbendazim per kilogram of seed in 1-2 liters of water to make a solution. Soak the seeds for 10-15 minutes to ensure they are fully coated with the fungicide. After soaking, spread the seeds out in a shaded area to dry completely. After drying of seeds Rhizobium treatment is done to help improve the ability to fix nitrogen in the soil. The procedure of Rhizobium treatment is listed below:

- Prepare a 10% sugar solution by boiling water with sugar and then cool it to room temperature.
- Mix the specific strain of Rhizobium (at the rate of 2-3gm per kg of seed) into the cooled sugar solution and let it sit for one day to culture.
- Dip the dried lentil seeds into the Rhizobium culture for about one hour.
- After soaking, dry the seeds under the shade.
- Now the dried seeds are ready for sowing.

Irrigation

Lentil crop can be grown in areas where there is less rainfall. It can tolerate drought to some extent. To get better yield one or two irrigations are helpful if there is no optimum winter rainfall. The first irrigation should be given about 45 days after planting, and if needed, a second irrigation can be applied during the pod filling stage. It is very sensitive to waterlogging condition so proper irrigation and drainage facility should be maintained.

Weeding

Weeding is important in lentil cultivation to prevent competition for nutrients, water, and sunlight. Manual weeding is the most common method, done by hand using tools like hoes, usually 2-3 weeks after sowing, with a second weeding around 6-8 weeks. Timely weeding, especially early in the growth stage, helps ensure healthy plant development and better yields by reducing weed competition. Pre-planting herbicide Fluchloralin (Basalin) at the rate of 0.75 kg a.i./800-100 liters of water also can be used to control weeds.

Harvesting, Threshing, Storage and Yield

Lentil crop becomes ready to be harvest when pods are dried and the plants turn into yellowish colour. It is usually harvested around 90 to 120 days after sowing. Delayed in harvesting could lead to loss of seeds by shattering. To avoid shattering of seeds it is best to harvest plants with dew in the morning. After harvesting, the threshinf of lentil is done by beating the plants with sticks or by trampling the plants by animals or by using threshing machine. After threshing, the seeds should be cleaned and then dried in the sun until the moisture content is reduced to about 12%. This helps prevent spoilage during storage. For storage, lentil seeds should be kept in cool, dry, and airtight containers to keep them safe from pests and moisture. The expected yield of lentil ranges from 700 to 1,200 kg per hectare**.**

Insects Pests

1. Lentil Pod Borer (*Maruca vitrata*)

Symptoms of Damage

- Damage to flowers and young pods as larvae feed on them.
- Boring holes in developing pods, causing damage to seeds.
- Drying of affected pods, which may lead to seed loss.
- Discoloration of flowers and pods due to feeding damage.

Management Methods

- Spray neem oil (5 ml per liter of water) to repel the pests and reduce damage.

- Release Trichogramma (200,000 per hectare) or Telenomus (150,000 per hectare), which are natural predators that parasitize the pod borer eggs.
- Regularly inspect plants and manually remove affected pods to reduce pest population.
- Apply Lambda-cyhalothrin (1.5 ml in 1 liter of water) during flowering and pod formation to control the larvae effectively.

2. Aphids (*Aphis craccivora*)

Symptoms of Damage

- Yellowing and curling of leaves due to sap feeding.
- Stunted plant growth as aphids weaken the plants.
- Sticky honeydew excreted by aphids, attracting mold and ants.
- Transmitting viral diseases, which further harm the plants.

Management Methods

- Use neem oil (5 ml per liter of water) to spray the plants, which effectively repels aphids.
- Release ladybugs (1,000 per hectare) or lacewing larvae (500 per hectare) that feed on aphids and help control their population.
- Prune affected leaves and plants to reduce aphid numbers.
- Apply Dimethoate (1.5 ml per liter of water) or Imidacloprid (1 ml per liter of water) when aphid infestations are severe.

3. Hairy Caterpillar (*Spodoptera species*)

Symptoms of Damage

- Chewing holes in leaves, leading to reduced photosynthesis.
- Defoliation (loss of leaves) as caterpillars feed on plant tissues.
- Visible caterpillars on the plant leaves and stems.
- Stunted growth due to excessive damage to the foliage of plants.

Management Methods

- Use Bacillus thuringiensis (Bt) (1-2 kg per hectare), a biological pesticide, which is safe and effective against caterpillars.
- Encourage the presence of predators like birds and parasitic wasps to naturally reduce caterpillar populations.
- Hand-pick caterpillars from the plants or use netting to trap them.
- Apply Cypermethrin (1.5 ml per liter of water) to control caterpillar infestations effectively.

Diseases

1. Fusarium Wilt

Causal Organism: *Fusarium oxysporum*

Symptoms of Damage

- Yellowing of leaves and overall plant stunting.
- Drying of plants, especially in the later stages of growth.
- Underdeveloped roots, which appear light brown.
- Shriveled and dead plants in severe cases.

Management Methods

- Rotate crops every three years to help reduce the fungal buildup in the soil.
- Use healthy, disease-free seeds to prevent initial infection.
- Remove and destroy infected plants to reduce disease spread.
- Use resistant varieties like to prevent the disease.
- Treat seeds with Carbendazim (2.5 g per kg) to control the disease.

2. Rust

Causal Organism: *Uromyces fabae*

Symptoms of Damage

- Pink to brown pustules appear on leaves and stems.

- Black pustules are visible on stems and leaves in severe cases.
- Drying of affected plants.
- Reduced plant growth and leaf damage due to pustules.

Management Methods

- After harvesting, burn plant debris to reduce fungal spores in the soil.
- Grow resistant lentil varieties to prevent infection.
- Regularly inspect plants and remove any affected leaves or stems.
- Spray Mancozeb 75 WP (0.2%) at 15-day intervals to control rust.

3. Powdery Mildew

Causal Organism: *Erysiphe polygoni*

Symptoms of Damage

- Small whitish patches on the lower surface of leaves.
- White powdery mass covering leaves, stems, and pods.
- Spread of patches across the plant as the disease progresses.
- Reduced plant growth and poor yield due to leaf damage.

Management Methods

- Collect and burn affected plant debris to reduce fungal spores.
- Use natural predators like ladybugs to reduce fungal spore spread.
- Prune infected leaves and stems regularly to control the disease spread.
- Spray with Sulfex or Elosal (0.3% wettable sulfur) as soon as the disease is observed. Apply a second spray 15 days later for better control.

Critical Stages of Lentil

- **Germination:** Keep the soil moist, but not too wet, to help the seeds sprout properly.
- **Flowering:** Protect the flowers from pests and make sure the plants don’t get too much or too little water.

- **Pod Formation:** Keep the field free of weeds and pests, and ensure the plants get enough water during dry periods.
- **Seed Filling:** Provide enough nutrients, especially phosphorus and potassium, and avoid water stress to help the seeds formation.
- **Maturity:** Harvest the lentils on time when the pods turn brown to prevent seed loss or damage from rain.

4.2 Chickpea

Introduction

Chickpea (*Cicer arietinum*) is an important legume from the Fabaceae family. It is rich in protein, fiber, and other essential minerals. It contains 21.1% protein, 61.5% carbohydrates, and is high in calcium, iron, and niacin. Chickpea seeds are eaten as boiled, fried, or as split pulses (dal). It is also used in making chickpea flour (besan) which is widely used for making sweets and snacks. It is also one of the best protein source choice for body builders and vegeterians. Apart from being a human food source, chickpeas are also valuable as animal feed. The husks, dal, and straw are used to feed cattle, and the fresh leaves are eaten as a vegetable. Chickpeas are known for their medicinal benefits, especially for blood purification.

Botanical Description

Chickpea is an annual herbaceous plant. It has compound leaves which contains 5 to 11 smaller leaflets on each leaf. The flowers of the chickpea plant are usually white, pink, or purple, and they bloom in clusters. The fruit of the chickpea is called pod which contains 1 to 2 seeds inside.

History and Origin

Chickpea is said to be originated originated in the Near East, specifically in the region that is now southeastern Turkey and northern Syria, around 8000-7500 BCE. This crop is also known as one of the oldest crops cultivated by humans. Slowly chickpea became an important food source due to their high protein, fiber and versatile use. Over time, the cultivation of chickpeas spread to other regions, including Asia, Europe, and eventually to different parts of the world. Now a days, it is deeply integrated into the food culture and cuisine of Nepal.

Area and Distribution

Chickpeas are grown most of the part of the world. They are mainly grown in countries in Asia, Africa, and the America. The largest producers of chickpeas are India, Australia, and Pakistan. In Nepal, this crop is grown in Terai and hilly regions of the country. According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23);

Name of the crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Chickpea	10,408	11,980	1.15

Climate and Soil

Chickpea is a winter season crop. Being winter season crop it cannot tolerate severe cold or frost. If frost occurs during flowering hinders in the formation of the seeds. Chickpeas grow best in areas with moderate rainfall, around 60 to 90 centimeters per year. The well-drained loamy soil is best for chickpea cultivation. The soil pH between 6.0 and 7.5, which is slightly acidic to neutral is known to be best for chickpea.

Varieties

There are different varieties of chickpea chosen based on its ability to grow well in different climates and soil conditions in Nepal such as: Dhanush, Radha, Sita, Kosheli, Kalika, Tara and Abarodhi.

Field Preparation

Field must be well-prepared to ensure good germination and better yield of the chickpea. 3 to 4 plowings is done to a depth of about 25 centimeters using plough. It is followed by 2 to 3 harrowings to create a fine seedbed with a smooth even surface is essential. The field should also be free from weeds and clods to prevent competition for nutrients and for better germination of seeds. There should be managed well drainage facility.

Manures and Fertilizers

Chickpea is a nitrogen-fixing crop. It requires less nitrogen compared to other crops. In general, lentils grow well with minimal fertilizer application. Application of well-decomposed Farmyard Manure (FYM) at the rate of 4-6 tons per hectare helps to improve soil structure and fertility. A balanced fertilizer with a ratio of 20-30:40-60:20-30 $N:P_2O_5:K_2O$ kg/ha. can also be applied for proper growth and development of the crop for better yield. The application of nitrogen is usually split into two doses.

- **First application:** Half of the nitrogen is applied as a basal dose
- **Second application:** The remaining half of the nitrogen is applied 3-4 weeks after sowing in early vegetative stage of crop.

Seedrate and Spacing

For successful cultivation of chickpea, It is important to maintain the right amount of seed rate and spacing. The recommended seed rate for chickpea is 80-100 kg per hectare. The recommended spacing is rows to row should be set about 30-45 cm apart and the plants to plant should be 5-10 cm apart. This spacing allows crop to receive adequate sunlight, water, and nutrients.

Time and Methods of Sowing

Chickpea can be sown during October and November for better yield. It is planted by both broadcasting and line sowing methods. The line sowing method is known to be best for sowing chickpea. This method ensures better spacing, allowing each plant to get enough sunlight, water, and nutrients absorption. It also makes it easier to carryout intercultural operations. While sowing, seeds should be planted at a depth of 4-5 cm. This depth allows the seeds to germinate properly and promotes healthy root growth.

Seed Treatment

To protect chickpea seeds from fungal disease, chickpea seeds are treated with fungicide. Dissolve 2-3 grams of Bavistin or Carbendazim per kilogram of seed in 1-2 liters of water to make a solution. Soak the seeds for 10-15 minutes to ensure they are fully coated with the fungicide. After soaking, spread the seeds out in a shaded area to dry completely. After drying of seeds Rhizobium treatment is done to help improve the ability to fix nitrogen in the soil. The procedure of Rhizobium treatment is listed below:

- Prepare a 10% sugar solution by boiling water with sugar and then cool it to room temperature.
- Mix the specific strain of Rhizobium (at the rate of 2-3gm per kg of seed) into the cooled sugar solution and let it sit for one day to culture.
- Dip the dried lentil seeds into the Rhizobium culture for about one hour.
- After soaking, dry the seeds under the shade.
- Now the dried seeds are ready for sowing.

Irrigation

Chickpea crop can be grown in areas where there is less rainfall. It can tolerate drought to some extent. To get better yield one or two irrigations are helpful if there is no optimum winter rainfall. The first irrigation should be given about 4 weeks after sowing, and if needed, a second irrigation can be applied during

the pod filling stage. The irrigation should be avoided during flowering state in chickpea. It is very sensitive to waterlogging condition so proper irrigation and drainage facility should be maintained.

Weeding

Weeding is important in chickpea cultivation to prevent competition for nutrients, water, and sunlight. Manual weeding is the most common method, done by hand using tools like hoes, usually 25-30 days after sowing, with a second weeding around 60 days after sowing. Timely weeding, especially early in the growth stage, helps ensure healthy plant development and better yields by reducing weed competition. Pre-planting herbicide Fluchloralin (Basalin) at the rate of 0.75 kg a.i./800-100 liters of water also can be used to control weeds.

Harvesting, Threshing, Storage and Yield

Chickpea is ready for harvest when the plants leaves turn in to reddish-brown colour, and the pods will dry and becomes brown. This crop matures around 90 to 110 days after sowing. It is important to harvest at the right time because delaying harvest can lead to seed loss by shattering. Crop is usually harvested by using hand manually in small scale farming or using a harvesting machine in large scale farming. After harvesting, threshing can be done manually by beating the pods with stick or using a mechanical thresher. Once chickpeas are threshed, they should be sun dried for 3-4 days to reduce the moisture up to 8-10%. The dried seeds should be stored in a airtight containers and placed in cool, dry place to prevent spoilage or fungal growth. The yield of chickpea depends on several factors like soil fertility, water availability, and pest management. The expected yield of chick pea is around 1000 kg to 2,000 kg per hectare**.**

Insects and Pests

1. Cutworm (*Agrotis spp.*)

Symptoms of Damage

- Plants cut off at ground level.
- Wilting of young plants due to damaged stems.

- Visible presence of cutworm larvae in the soil.
- Irregular plant stands where some plants are missing entirely.

Management Methods

- Use neem oil (Azadirachta indica) as a natural repellent. Apply 5 ml per liter of water as a spray to deter larvae.
- Introduce Trichogramma (a parasitic wasp) to control moth eggs and larvae. Recommended release rate: 100,000 parasitic wasps per hectare.
- Remove clods or soil debris in the field to reduce hiding places for larvae. You can also hand-pick the larvae if infestation is low.
- Apply Lindane 6% granules at 20-25 kg per hectare mixed in the soil to kill the larvae before they can damage the plants.

2. Gram Pod Borer (*Helicoverpa armigera*)

Symptoms of Damage

- Defoliation of leaves and flowers.
- Holes on the pods where caterpillars feed.
- Presence of caterpillars inside the pods with their anterior part inside, and the posterior part sticking out.
- Seed damage, where developing seeds are eaten, reducing yield.

Management Methods

- Use neem oil to disrupt the lifecycle of the pest. Apply 5 ml of neem oil per liter of water as a foliar spray.
- Use Bacillus thuringiensis (Bt), a biological pesticide that targets the caterpillar larvae. Apply 2 kg per hectare in water.
- Remove and destroy infected pods to reduce the pest population.
- Spray Monocrotophos (Nuvacron) 36 EC at 1 ml per liter of water during pod formation. Apply 600-800 liters of solution per hectare.

3. Aphids (*Aphis craccivora*)

Symptoms of Damage

- Curling or yellowing of leaves.
- Stunted plant growth.
- Black sooty mold on leaves due to aphid excrement.
- Presence of aphids on the underside of leaves or tender stems.

Management Methods

- Spray a mixture of garlic extract (5-10 cloves crushed in 1 liter of water) to repel aphids naturally.
- Release ladybird beetles which feed on aphids. Recommended release: 20,000 larvae per hectare.
- Spray plants with a strong jet of water to physically remove aphids from the plant.
- Spray Imidacloprid (20% SL) at a rate of 1 ml per liter of water. Apply 500-600 liters per hectare.

4. Whiteflies (*Bemisia tabaci*)

Symptoms of Damage

- Yellowing of leaves.
- Presence of small whiteflies on the undersides of leaves.
- Leaves may become sticky due to honeydew excretion.
- Stunted growth due to reduced photosynthesis.

Management Methods

- Use neem oil or insecticidal soap to control whiteflies naturally. Apply 5 ml of neem oil per liter of water.
- Introduce Encarsia formosa, a parasitic wasp that targets whitefly larvae. Release 30,000 wasps per hectare.
- Install yellow sticky traps to catch adult whiteflies.

- Use Thiamethoxam at the rate of 0.25 g per liter of water. Apply 400-500 liters of the solution per hectare.

Diseases

1. Wilt (Fusarium Wilt)

Causal Organism: The main cause of wilt is the fungus *Fusarium oxysporum* (sometimes other fungi are involved as well).

Symptoms of Damage

- Yellowing of the leaves, starting from the lower ones.
- Leaves dry out and the plant wilts.
- The plant turns yellowish and eventually dies.
- The roots turn black and decompose.

Management Methods

- Apply neem cake to the soil to help control fungal growth and improve soil health.
- Use Trichoderma viride, a fungus that helps control Fusarium. Apply 5 kg per hectare in the soil before sowing.
- Rotate chickpea with non-legume crops for at least 3-4 years to break the disease cycle.
- Treat seeds with Benlate T or a mixture of Benlate and Thiram (1:1) at a rate of 2.5 g per kg of seed to prevent infection.

2. Sclerotinia Blight

Causal Organism: This disease is caused by the fungus *Sclerotinia sclerotiorum*.

Symptoms of Damage

- Yellowing of the leaves, especially near the ground.
- Affected plants turn brown and dry out.
- Brown spots may appear on the stems, which eventually girdle them.

- White cottony fungal growth and black sclerotia (hard fungal bodies) on the stem.

Management Methods

- Apply composted neem cake around the base of the plants to reduce fungal growth.
- Use Trichoderma spp., which naturally controls Sclerotinia. Apply 5 kg per hectare.
- Remove and destroy infected plant material to reduce fungal spread.
- Spray Carbendazim or Thiophanate methyl at a rate of 1 g per liter of water to control the disease.

3. Grey Mold (Botrytis Blight)

Causal Organism: *Botrytis cinerea* causes grey mold disease.

Symptoms of Damage

- Grey, fuzzy mold growth on leaves, stems, and pods.
- Affected leaves become water-soaked and turn brown.
- The fungus causes soft rot on the pods and seeds.
- Premature drying of the plant and reduced seed quality.

Management Methods

- Use garlic extract (10-15 cloves crushed in 1 liter of water) as a natural fungicide. Spray on plants to prevent fungal growth.
- Apply Bacillus subtilis, a biological agent that helps control Botrytis. Use 2-3 kg per hectare.
- Ensure proper spacing of plants for good air circulation to reduce humidity around the plants, which can promote mold growth.
- Spray Chlorothalonil at the rate of 0.5 kg per hectare to control the disease.

4. Rust

Causal Organism: The fungus *Uromyces ciceris-arietini* causes rust disease.

Symptoms of Damage

- Yellow or orange pustules appear on the underside of leaves.
- Leaves become spotted, dry out, and fall off.
- Reduced plant growth and stunted development.
- Premature leaf drop and weakened plants.

Management Methods

- Use neem oil (5 ml per liter of water) as a foliar spray to reduce fungal infection.
- Apply Trichoderma harzianum to protect plants from rust. Use 5 kg per hectare.
- Remove and destroy infected plant material and practice crop rotation to break the disease cycle.
- Spray Propiconazole at the rate of 1 ml per liter of water to control rust infection.

Critical Stages of Chickpea

- **Germination:** Ensure the soil is well-drained and the temperature is right for seeds to sprout.
- **Seedling Establishment:** Keep the young plants protected from strong winds and extreme temperatures.
- **Flowering:** Avoid over-irrigation during flowering to prevent fungal diseases.
- **Pod Formation:** Control pests, especially aphids, that can damage the pods at this stage.
- **Maturation:** Harvest chickpeas at the right time when the pods are dry to avoid loss of seeds.

4.3 Cowpea

Cowpea is scientifically known as *Vigna unguiculata*. It belongs to the Fabaceae family. It is a highly versatile plant grown for its edible seeds, young pods, and as feed for livestock. It is commonly called as "Bodi" in Nepali. Cowpea is often called "vegetable meat" because it is packed with protein and other essential nutrients. This makes it an important food source for both humans and animals. The seeds of cowpea are rich in proteins (about 23.4%), fats (1.8%), and carbohydrates (60.3%), making it a great source of energy and nutrition. It is also rich in calcium and iron which is better for bone health and aliminating anemia.

Botanical Description

Cowpea is an annual herbaceous plant. It grows with twining or trailing vines. Cowpea has compound leaves which is made up of three leaflets. The flowers can be white, purple, or pink, in colour. The fruit of the cowpea is called pod that contains several seeds.

History and Origin

Cowpea is believed to have originated in Africa. It has been cultivated from thousands of years by ancient civilizations like Greeks, Romans, and Spaniards in Mediterranean region. Over time, cowpea spread to many parts of the world

due to its usefulness as a nutritious food and hardy crop. Today it is integrated part of Nepali cuisine also.

Area and Distribution

Cowpea is grown in many countries in the world. The largest producers of cowpea are Nigeria, India, and Niger. Cowpea is also grown in many other African, Asian, and American countries. In Nepal, cowpea is cultivated in in the terai and hilly areas. It is widely grown in the lowland terai regions.

Climate and Soil

Cowpea thrives well in hot and humid climate. It can also handle some extent of drought. Temperature between 12°C and 15°C is ideal for germination of seed. Cow pea can grow best in temperatures between 27°C and 35°C. This crop can be grown in variety of soil but it grows best in well-drained loamy soil. Slightly acidic to neutral pH between 6.0 to 7.5 is ideal for cowpea cultivation.

Varieties

There are different varieties of Cowpea chosen based on its ability to grow well in different climates and soil conditions in Nepal such as: Aakash, Prakash, Surya, Malepatan-1 and Gajale Bodi.

Field Preparation

Field must be well-prepared to ensure good germination and better yield of the crop. 3 to 4 plowings is done to a depth of about 25 centimeters using plough. It is followed by 2 to 3 harrowings to create a fine seedbed with a smooth even surface is essential. The field should also be free from weeds and clods to prevent competition for nutrients and for better germination of seeds. Proper drainage facility should be managed to eleminate waterlogging condition in the field.

Manures and Fertilizers

Cowpea is a nitrogen-fixing crop. It requires less nitrogen compared to other crops. In general, lentils grow well with minimal fertilizer application. Application of well-decomposed Farmyard Manure (FYM) at the rate of 4-6 tons per hectare

helps to improve soil structure and fertility. A balanced fertilizer with a ratio of 20-30:40-60:20-30 N:P_2O_5:K_2O kg/ha can also be applied for proper growth and development of the crop for better yield. The application of nitrogen is usually split into two doses:

- **First application**: Half of the nitrogen is applied as a basal dose
- **Second application**: The remaining half of the nitrogen is applied 3-4 weeks after sowing in early vegetative stage of crop.

Seed Rate and Spacing

The recommended seed rate is 20-30 kg per hectare for cow pea cultivation**.** During sowing seeds the R×R spacing should be 45-60 cm, and the P×P spacing within each row should be 10-15 cm. This spacing helps to receive sufficient sunlight, water, and nutrients for proper growth and development of plants.

Sowing Time and Methods

Cowpea can be sown during March-April in terai region and April-May for better yield. It is planted by both broadcasting and line sowing methods. The line sowing method is known to be best for sowing cowpea. This method ensures better spacing, allowing each plant to get enough sunlight, water, and nutrients absorption. It also makes it easier to carryout intercultural operations. While sowing, seeds should be planted at a depth of 2-3 cm. This depth allows the seeds to germinate properly and promotes healthy root growth.

Seed Treatment

To protect cowpea seeds from fungal disease, cowpea seeds are treated with fungicide. Dissolve 2-3 grams of Bavistin or Carbendazim per kilogram of seed in 1-2 liters of water to make a solution. Soak the seeds for 10-15 minutes to ensure they are fully coated with the fungicide. After soaking, spread the seeds out in a shaded area to dry completely. After drying of seeds Rhizobium treatment is done to help improve the ability to fix nitrogen in the soil. The procedure of Rhizobium treatment is listed below:

- Prepare a 10% sugar solution by boiling water with sugar and then cool it to room temperature.
- Mix the specific strain of Rhizobium (at the rate of 2-3gm per kg of seed) into the cooled sugar solution and let it sit for one day to culture.
- Dip the dried lentil seeds into the Rhizobium culture for about one hour.
- After soaking, dry the seeds under the shade.
- Now the dried seeds are ready for sowing.

Irrigation

Cowpea is grown during the rainy season so, less irrigation can be sufficient. During dry periods five to six irrigations may be needed. The most critical stage for irrigation in cowpea is during flowering and pod formation. The optimum moisture during this period is nessary for better yield of this crop.

Weeding

Weeding is important in cowpea cultivation to prevent competition for nutrients, water, and sunlight. Manual weeding is the most common method, done by hand using tools like hoes, usually 20-25 days after sowing, with a second weeding around 40-45 days after sowing. Timely weeding, especially early in the growth stage, helps ensure healthy plant development and better yields by reducing weed competition. Pre-planting herbicide Fluchloralin (Basalin) at the rate of 0.75 kg a.i./800-100 liters of water also can be used to control weeds.

Harvesting, Threshing, Storage and Yield

Cowpea can be harvested for green pods (used as vegetables) at 45 to 90 days after sowing. The green pods shold be harvested when they are tender and less fiber content. It is harvested at 40-45 days after sowing for fodder. For grain the crop should be harvested at 90 to 125 days after sowing when the pods are fully matured. In this period the pods turn yellowish brown and the seeds inside become hard. Generally, hand-picking method is carriedout for harvesting green pods for vegetables and cutting mature plants with sickle for grains. After

harvesting, the grains are separated from pods by beating with sticks. The threshed grains should be sun-dried for 4-7 days until moisture reaches about 8-10% before storage. The expectec yield of cowpea is 1200-1500 kilograms per hectare.

Insects and Pests

1. Hairy Caterpillar (*Spodoptera litura*)

Symptoms of Damage

- The caterpillar feeds on the leaves, eating away all the green matter, leaving the leaves damaged or eaten up.
- The damage is most severe during the seedling stage.
- It can cause such severe damage that re-sowing may be necessary in some cases.
- The eggs are laid in large clusters, and the young larvae tend to congregate in one area.

Management Methods

- Hand-pick and destroy the eggs and young larvae.
- Spray with Bacillus thuringiensis (Bt) at the rate of 1-2 kg/ha for controlling young larvae.
- Use light traps to capture adult moths and reduce egg-laying.
- Spray with Lambda-cyhalothrin 5 EC at a dose of 1ml per liter of water for controlling full-grown caterpillars.

2. Leaf Hoppers, Jassids, and Aphids (*Empoasca spp.*, *Amrasca biguttula*, *Aphis craccivora*)

Symptoms of Damage

- These insects suck the sap from the leaves, causing the leaves to turn brown, crumple, and look sick, especially in young plants.
- The damage may result in stunted growth and reduced yield.

- A yellowing of the leaves (chlorosis) can also be noticed.
- These pests especially jassids and aphids may also transmit plant viruses.

Management Methods

- Use neem oil (5 ml per liter of water) to spray the plants, which helps in repelling aphids and leafhoppers.
- Spray with Nicotiana tabacum extract (tobacco extract) at a rate of 2-3 liters per hectare.
- Remove affected leaves and destroy them to reduce the pest population.
- Spray with Monocrotophos 36 EC at 1.5 liters in 1000 liters of water per hectare for effective control.

4. Red Palm Weevil (*Rhynchophorus ferrugineus*)

Symptoms of Damage

- The larvae of this pest burrow into the stems and roots of cowpea plants, causing weakening and death of the plant.
- You can often see holes in the stems and sawdust-like excretions near the entrance points.
- The plant may fall over due to internal damage.
- Affected plants may show yellowing and wilting.

Management Methods

- Apply garlic or neem oil extract (10 ml per liter of water) to the base of the plant for repelling the weevil.
- Use Bacillus thuringiensis (Bt) at a rate of 1-2 kg/ha to control larvae.
- Cut and remove the affected stems and dispose of them properly.
- Use Lambda-cyhalothrin 5 EC at a dose of 1ml per liter of water to spray affected areas.

Diseases

1. Bacterial Blight of Cowpea

Causal Organism: *Xanthomonas vignicola*

Symptoms of Damage

- Red and shriveled cotyledons.
- Necrotic (dark) spots on the margins of the primary leaves.
- The disease affects the stem and spreads to other parts of the plant.
- Cankers form on the stem, and affected plants may break due to wind.

Management Methods

- Use crop rotation with non-leguminous plants to reduce bacteria buildup.
- Bacillus subtilis (a biological control agent) can help suppress bacterial growth.
- Remove and destroy affected plants to limit the spread of infection.
- Spray with 0.2% Blitox (Copper-based fungicide) to control severe infection.

2. Cowpea Mosaic

The causal organism of this disease is virus. Aphids easily transmit this disease from one plant to the other.

Symptoms of Damage

- Pale yellow leaves with a mosaic pattern and vein banding.
- The leaves become smaller and twisted.
- Pods are also affected, becoming reduced in size and twisted.

Management Methods

- Use neem oil (5 ml per liter of water) to repel aphids and other pests.
- Release ladybugs (natural aphid predators) to reduce aphid populations.

- Remove and destroy infected plants to prevent virus spread.
- Spray with 0.1% Oxydemeton methyl (Metasystox) to control aphids and prevent further virus transmission.

3. Powdery Mildew

Causal Organism: *Erysiphe polygoni* (fungus)

Symptoms of Damage

- White, powdery growth appears first on leaves.
- This powder spreads to stems, branches, and pods.
- Affected leaves become twisted and smaller in size.

Management Methods

- Use neem oil (5 ml per liter of water) as a foliar spray to prevent fungal growth.
- Trichoderma harzianum (fungal antagonist) can be used to control mildew.
- Remove and burn infected plant material after harvest to reduce fungal spores.
- Spray with wettable sulfur (e.g., Sulfex, Elosal) at 2-3 kg per hectare in 800-1000 liters of water.

4. Rust

Causal Organism: *Uromyces appendiculatus* (fungus)

Symptoms of Damage

- Small white pustules appear on the lower surface of the leaves.
- These pustules contain uredia (fungal spores) which turn brown and then black by the end of the season.
- Affects leaves, pods, and sometimes new shoots.

Management Methods

- **Organic method:** Remove and destroy infected leaves to prevent

spores from spreading.

- **Biological pesticide:** Use Trichoderma spp. (fungus) to naturally control rust infection.
- **Physical method:** Prune affected parts and ensure good airflow around the plants.
- **Chemical method:** Spray with Mancozeb 75 WP at the rate of 2 kg per hectare in 1000 liters of water for effective rust control.

Critical Stages of Cowpea

- **Germination:** Ensure proper soil moisture to help seeds sprout effectively.
- **Seedling Stage:** Protect seedlings from pests and provide enough sunlight for healthy growth.
- **Vegetative Growth:** Weed regularly and ensure the plant gets enough water and nutrients.
- **Flowering:** Avoid excessive water stress and protect from strong winds to prevent flower drop.
- **Pod Formation:** Keep an eye on pests and diseases that may affect pod development.
- **Maturation:** Harvest the pods when they are fully mature to prevent seed loss or damage.

4.4 Pigeonpea

Pigeon pea (*Cajanus cajan*) is an important pulse crop in Nepal. It is especially grown in the Terai and Mid-Hills regions. It belongs to the Fabaceae family. It can fix atmospheric nitrogen in the soil. Pigeonpea is drought tolerance and has multipurpose uses. Seeds of pigeonpea contains 20-25% protein, 60% carbohydrates, and 1.5% fat, along with essential vitamins, minerals, and amino acids. In Nepal, it is typically grown as an annual crop and is used as dal (pulses). It also can be used as windbreak which helps to reduces lodging of the main

crops and soil erosion. Additionally, this crop supports in fodder for livestock and firewood from its dry stems.

Source: https://worldcrops.org

Botanical Description

Pigeon pea is a perennial plant. It is a woody shrub that can grow between 1 to 3 meters tall and has compound leaves with 3 leaflets. It produces yellow or purple flowers and forms pods that contain seeds.

Area and Distribution

Pigeonpea is cultivated in different countries in the world. Among others, India is the largest producer of pigeon pea, followed by Nigeria, Myanmar, and Tanzania. In Nepal it is mostly grown in terai and mid-hill regions. According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23);

Name of the crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Pigeonpea	11,745	12,710	1.08

Climatic and Soil

Pigeonpea grows best in a warm and humid climate. For germination, pigeon pea seeds need a soil temperature between 25°C to 30°C. After germination, the

ideal temperature range for proper growth and development is 30°C to 35°C. This crop requires an annual rainfall of 600-900 mm for optimal growth. Pigeonpea is highly sensitive to frost, especially during flowering stage. Cloudy weather and heavy rainfall during flowering also can reduce yield. This crop can be grown in variety of soil ranging form sandy loam to clay loam but it grows best in well-drained loamy soil. Slightly acidic to neutral pH between 6.0 to 7.5 is ideal for pigeonpea cultivation.

Varieties

There are different varieties of pigeonpea chosen based on its ability to grow well in different climates and soil conditions in Nepal such as: Rampur-1, Bageshwori and Khajura Rahar-1.

Land Preparation

Field must be well-prepared to ensure good germination and better yield of the crop. Pigeonpea is deep rooted crop so, deep ploughing is necessary for proper growth and development of the crop. 3 to 4 plowings is done to a depth of about 25-30 centimeters using plough. It is followed by 2 to 3 harrowings to create a fine seedbed with a smooth even surface is essential. The field should also be free from weeds and clods to prevent competition for nutrients and for better germination of seeds.

Manures and Fertilizers

Pigeonpea is a nitrogen-fixing crop. It requires less nitrogen compared to other crops. In general, lentils grow well with minimal fertilizer application. Application of well-decomposed Farmyard Manure (FYM) at the rate of 4-6 tons per hectare helps to improve soil structure and fertility. A balanced fertilizer with a ratio of 20-30:40-60:20-30 N:P_2O_5:K_2O kg/ha. can also be applied for proper growth and development of the crop for better yield. The application of nitrogen is usually split into two doses:

- **First application**: Half of the nitrogen is applied as a basal dose
- **Second application**: The remaining half of the nitrogen is applied 3-4

weeks after sowing in early vegetative stage of crop.

Sowing Time and Methods

Pigeon pea can be sown from late May to early June just before the monsoon. Pre-sowing irrigaion ensure moisture for the seeds to germinate. Pigeon pea can be sown using several methods, including broadcasting**,** dibbling**,** behind the plough, and with a seed drill. Among them, the behind the plough method involves planting seeds in furrows which helps to create proper depth for sowing seed. Seed drill is a modern and efficient method where a machine sows the seeds in straight rows at the right depth and spacing.

Seed Rate and Spacing

For successful cultivation of pigeonpea, It is important to maintain the right amount of seed rate and spacing. The recommended seed rate for pigeonpea is 12-15 kg per hectare. The recommended spacing is rows to row should be set about 60-75 cm apart and the plants to plant should be 15-20 cm apart. This spacing allows crop to receive adequate sunlight, water, and nutrients.

Seed Treatment

To protect pigeonpea seeds from fungal disease, pigeonpea seeds are treated with fungicide. Dissolve 2-3 grams of Bavistin or Carbendazim per kilogram of seed in 1-2 liters of water to make a solution. Soak the seeds for 10-15 minutes to ensure they are fully coated with the fungicide. After soaking, spread the seeds out in a shaded area to dry completely. After drying of seeds Rhizobium treatment is done to help improve the ability to fix nitrogen in the soil. The procedure of Rhizobium treatment is listed below:

- Prepare a 10% sugar solution by boiling water with sugar and then cool it to room temperature.
- Mix the specific strain of Rhizobium (at the rate of 2-3gm per kg of seed) into the cooled sugar solution and let it sit for one day to culture.
- Dip the dried lentil seeds into the Rhizobium culture for about one hour.

- After soaking, dry the seeds under the shade.
- Now the dried seeds are ready for sowing.

Irrigation

Pigeonpea can tolerate drought to some extent. To get better yield one or two irrigations are helpful if there is no optimum winter rainfall. The first irrigation after pre-sowing irrigation should be given about 3-4 weeks after sowing, and if needed, a second irrigation can be applied during the pod filling stage. The irrigation should be avoided during flowering state in pigeonpea. It is very sensitive to waterlogging condition so proper irrigation and drainage facility should be maintained.

Weed Management

Weeding is important in pigeonpea cultivation to prevent competition for nutrients, water, and sunlight. Manual weeding is the most common method, done by hand using tools like hoes, weeding machine usually 25-30 days after sowing, with a second weeding around 45-60 days after sowing. Timely weeding, especially early in the growth stage, helps ensure healthy plant development and better yields by reducing weed competition. Pre-planting herbicide Fluchloralin (Basalin) at the rate of 0.75 kg a.i./800-100 liters of water also can be used to control weeds.

Harvesting, Threshing, Storage and Yield

The best time to harvest pigeon pea is when seeds are fully matured and about 70% of the pods turns brown in colour. Durign harvesting of pigeonpea plants are usually cut with a sickle or harvester near the ground level. After harvesting, the plants should be left in the sun to dry for 4-5 days. Once dried, threshing is done by beating the pods with sticks or using a threshing machine to separate the seeds from the pods. After threshing, the seeds should be cleaned and sun-dried until the moisture content is reduced to about 10-11%. After drying of seeds it is stored in air tight containers and stored in cool and dry place. The expected yield of pigeonpea is around 20-25 quintals per hectare.

Insects and Pests

1. Pod Borer (*Helicoverpa armigera*)

Symptoms of Damage

- The larvae feed on tender leaves and twigs, but during pod formation, they puncture pods and feed on developing grains.
- The caterpillars are green with dark brown and grey lines along their sides.
- Damaged pods may contain holes and show signs of feeding.
- The crop may show reduced pod formation and lower seed yield.

Management Methods

- Hand-pick and destroy the caterpillars in the early stages by shaking the plants.
- Use Bacillus thuringiensis (Bt) for controlling the larvae (1-2 kg per hectare).
- Remove and destroy affected pods and plant parts.
- Spray with 1.5 liters of Monocrotophos 36 EC in 1000 liters of water per hectare.

2. Tur Pod Fly (*Melanagromyza obtusa*)

Symptoms of Damage

- Eggs are laid in tender pods, and as the larvae feed, the grains become damaged.
- Affected grains show stripes on their surface.
- The pods may become twisted or deformed.
- In severe cases, 80% of pods and 60% of grains may be damaged.

Management Methods

- Use neem oil (5 ml per liter of water) to repel the pest.
- Release Trichogramma spp. (parasitoid wasps) to control the fly.

- Remove and destroy infested pods.
- Spray with 1.5 liters of Monocrotophos 36 EC in 1000 liters of water per hectare.

3. Plume Moth (*Pterophoridae* family)

Symptoms of Damage

- The larvae damage seeds and cause flowers, buds, and pods to drop.
- The caterpillars are greenish-brown with short hairs and spines.
- They also feed on developing grains inside the pods.
- Pods may appear damaged, and flowers may fall prematurely.

Management Methods

- Use neem oil (5 ml per liter of water) for controlling larvae.
- Apply Bacillus thuringiensis (Bt) to control larvae (1-2 kg per hectare).
- Remove affected plant parts and destroy them.
- Spray Lambda-cyhalothrin 5 EC at 0.5-1 ml per liter of water, using 800-1000 liters per hectare

4. Hairy Caterpillar (*Spodoptera spp.*)

Symptoms of Damage

- Three species of hairy caterpillars feed on the green tissue of the leaves, leaving them damaged.
- The caterpillars are typically red and have hairy bodies.
- They may damage the crop at the seedling stage, eating away the green parts.
- The caterpillars often lay eggs in large clusters.

Management Methods

- Collect and destroy the eggs and young larvae by shaking the plants.
- Use Nematodes (biological agents) to attack caterpillars.

- Remove and destroy affected leaves.
- Dust with 2% Methyl Parathion at 25-30 kg per hectare .

Diseases

1. Wilt Disease

Causal Organism: *Fusarium oxysporum* f. sp. *udum* (fungus)

Symptoms of Damage

- The leaves turn yellow and fall off.
- The plant dries out completely, even though there is plenty of moisture in the soil.
- The disease can be mistaken for a moisture shortage.
- The roots show black streaks when the outer bark is removed.

Management Methods

- Practice crop rotation and remove plant residues after harvesting.
- Use Trichoderma harzianum to suppress the growth of the fungus.
- Remove infected plants and avoid planting pigeon pea in the same field for several years.
- Plant resistant varieties.

2. Stem Rot

Causal Organism: *Phytophthora dreschsleri* var. *cajani* (fungus)

Symptoms of Damage

- Brown to dark brown lesions form on the stem near the soil surface.
- The lesions girdle the stem, causing the plant to dry out.
- The plant can’t be easily pulled out; it breaks at the affected stem.
- Healthy roots differentiate it from wilt disease.

Management Methods

- Improve soil drainage to avoid waterlogging.

- Use Trichoderma spp. for controlling fungal growth in the soil.
- Avoid stem injuries and remove affected plants immediately.
- Apply Mancozeb 75 WP at 2.5 kg per hectare to control the spread of the fungus.

3. Cankers

Causal Organism: ***Diplodia cajani, Colletotrichum cajani, Macrophoma cajanicola*** **(fungi)**

Symptoms of Damage

- Cankers (raised, dark spots) appear on the stems and twigs.
- Affected parts of the plant may break off at these cankers.
- This leads to reduced plant strength and damage.

Management Methods

- Crop rotation is effective to prevent reoccurrence in the same field.
- Use Trichoderma for controlling fungal growth in the soil.
- Prune and destroy infected parts of the plant.
- Spray the crop with Mancozeb 75 WP at 2.5 kg per hectare for severe cases.

4. Sterility Mosaic

Causal Organism: Sterility Mosaic Virus

Symptoms of Damage

- Plants turn light green and appear stunted.
- Leaves become smaller than normal.
- No flowers or fruits are produced, leading to total yield loss.
- Sometimes only a few branches are affected, causing partial yield loss.

Management Methods

- Remove infected plants as soon as they are noticed in the field.

- Use predatory mites or other natural enemies to control the Eriophyid mites that spread the virus.
- Prune and destroy infected branches.
- Spray with 0.1% Oxydemeton methyl (Metasystox) to control the mites. It may require 3-4 sprays.

4.5 Soyabean

Introduction

Soybean (*Glycine max*) belongs to the *Fabaceae* family. It is a highly valuable crop known for its nutritional benefits and varied usefullness. It contains around 20% oil and 40% high-quality protein. Soybean protein is rich in lysine, an essential amino acid. It also provides vitamins like thiamine, riboflavin, vitamin C, and vitamin A. Soybeans are used in many foods such as bread, chapati, milk, and sweets. Mixing soybean flour with wheat flour makes chapatis more nutritious. Soybean oil is used to make vanaspati ghee and other industrial products. Additionally, soybeans help to improve soil fertility by fixing nitrogen and provide nutritious feed for livestock.

Botanical Description

Soybean is an annual herbaceous plant. This plant consists of compound leaves, with three smaller leaflets. Soybean flowers are small and can be white, purple, or pink in color. These flowers bloom in clusters along the plant. The fruit of the soybean plant is called pod which contains 2 to 4 seeds.

History and Origin

Soybean is believed to have originated in East Asia, especially in China, where it

has been grown for thousands of years. Over time, it spread to other parts of the world. Now a days, it is one of the important crop globally. In recent scenario, soybean plays a key role in agriculture, food production, and various industries.

Area and Distribution

Soybean is grown in different parts of the world. The largest producers of soybeans are countries like the United States, Brazil, and Argentina, which account for a significant portion of global production. In Nepal, soybean is cultivated in the Terai and some parts of the Hill areas. According to the stastistical data of Ministry of Agriculture and Livestock Development (MOALD) 2079/80 (2022/23);

Name of the crop	Area in Hectare	Production in Metric Tonnes	Yield in Metric Tonnes/Hectare
Soyabean	26,842	36,672	1.37

Climate and Soil

Soyabean thrives well in hot and humid climate. Temperature between 15°C to 20°C is ideal for germination of seed. It can grow best in temperatures between 25°C to 30°C. This crop can be grown in variety of soil but it grows best in well-drained loamy soil. Slightly acidic to neutral pH between 6.0 to 7.5 is ideal for soyabean cultivation.

Varieties

There are different varieties of soyabean chosen based on its ability to grow well in different climates and soil conditions in Nepal such as: Hadi, Ransam, Seti, Kab, Lumle Bhatmas-1,Tarkari Bhatmas-1, Puja, Khajura Bhatmas-1.

Manure and Fertilizers

Soyabean is a nitrogen-fixing crop. It requires less nitrogen compared to other crops. Application of well-decomposed Farmyard Manure (FYM) at the rate of 4-6 tons per hectare helps to improve soil structure and fertility. A balanced fertilizer with a ratio of 20-30:70-80:30-40 $N:P_2O_5:K_2O$ kg/ha. can also be applied for proper growth and development of the crop for better yield. The

application of nitrogen is usually split into two doses:

- **First application**: Half of the nitrogen is applied as a basal dose
- **Second application**: The remaining half of the nitrogen is applied during flowering of the crop.

Time of Sowing and Methods of Sowing

Soyabean can be sown during late May to mid June for better yield. It is planted by both broadcasting, behind the plough, line sowing, using seed drill methods. The line sowing and seed drill methods are known to be best for sowing soyabean. These methods ensures better spacing, allowing each plant to get enough sunlight, water, and nutrients absorption. It also makes it easier to carryout intercultural operations. While sowing, seeds should be planted at a depth of 3-4 cm. This depth allows the seeds to germinate properly and promotes healthy root growth.

Seed Rate and Spacing

For successful cultivation of soyabean, it is important to maintain the right amount of seed rate and spacing. The recommended seed rate for soyabean is 70-80 kg per hectare. The recommended spacing is rows to row should be set about 45-60 cm apart and the plants to plant should be 4-5 cm apart. This spacing allows crop to receive adequate sunlight, water, and nutrients.

Seed Treatment

To protect soyabean seeds from fungal disease, soyabean seeds are treated with fungicide. Dissolve 2-3 grams of Bavistin or Carbendazim per kilogram of seed in 1-2 liters of water to make a solution. Soak the seeds for 10-15 minutes to ensure they are fully coated with the fungicide. After soaking, spread the seeds out in a shaded area to dry completely. After drying of seeds Rhizobium treatment is done to help improve the ability to fix nitrogen in the soil. The procedure of Rhizobium treatment is listed below:

- Prepare a 10% sugar solution by boiling water with sugar and then cool

it to room temperature.

- Mix the specific strain of Rhizobium (at the rate of 2-3gm per kg of seed) into the cooled sugar solution and let it sit for one day to culture.
- Dip the dried lentil seeds into the Rhizobium culture for about one hour.
- After soaking, dry the seeds under the shade.
- Now the dried seeds are ready for sowing.

Irrigation

To get better yield one or two irrigations are helpful if there is no optimum rainfall. The first irrigation after pre-sowing irrigation should be given about 10-21 days after sowing, and if needed, a second irrigation can be applied during the pod filling stage. It is very sensitive to waterlogging condition so proper irrigation and drainage facility should be maintained.

Weeding

Weeding is important in soyabean cultivation to prevent competition for nutrients, water, and sunlight. Manual weeding is the most common method, done by hand using tools like hoes. Weeding is also done my using weeding machine. First weeding is usually done at 3-4 weeks after sowing, second weeding around 6-8 weeks after sowing and third weeding is done around 10-12 weeks after sowing. Timely weeding, especially early in the growth stage, helps ensure healthy plant development and better yields by reducing weed competition. Pre-planting herbicide Fluchloralin (Basalin) at the rate of 0.75 kg a.i./800-100 liters of water also can be used to control weeds.

Harvesting, Threshing, Storage and Yield

The best time to harvest soyabean is when seeds are fully matured and leaves of the plant turns to yellow colour and starts defoliation. Late harvesting can result in loss of seeds due to shattering. Durign harvesting of soyabean plants are usually cut with a sickle or harvesting machine near the ground level. After harvesting, threshing is done by beating the pods with sticks or using a threshing

machine to separate the seeds from the pods. After threshing, the seeds should be cleaned and sun-dried until the moisture content is reduced to about 12-13%. After drying of seeds it is stored in air tight containers and stored in cool and dry place. The expected yield of pigeonpea is around 30-35 quintals per hectare.

Insects and Pests

1. Stem Fly (*Melanagromyza sojae)*

Symptoms of Damage

- White spots on leaves caused by adult feeding.
- Eggs laid on soft leaf tissues; larvae feed on the leaves and move towards the stem.
- Infested plants show drooping and partly dried leaves.
- Tunnels inside the stem where larvae have fed.

Management Methods

- Use neem oil or neem-based products (like Azadirachtin) at a dose of 3 ml/liter of water.
- Apply 1 million Trichogramma parasitic wasps per hectare during the flowering stage to control fly populations.
- Use yellow sticky traps to reduce adult population levels in the early stages of infestation.

2. Girdle Beetle (*Acanthocinus aedilis)*

Symptoms of Damage

- Adult beetles create parallel girdles on the stem, typically around the petiole or main stem.
- Leaves show signs of drying around the edges, eventually curling and dying.
- Severe infestation causes significant leaf and pod loss.

Management Methods

- Use neem oil at a concentration of 5 ml/liter of water to spray directly on infested plants. Repeat every 7-10 days.
- Release Trichogramma species to parasitize the eggs laid by the beetles, at a rate of 1 million per hectare.
- Remove and destroy infested stems manually to reduce beetle population.
- Spray Dimethoate (Rogor) 30 EC at the rate of 1 liter in 1000 liters of water per hectare.

3. Whitefly (*Bemisia tabaci)*

Symptoms of Damage

- Small, yellow-bodied insects with white wings and a waxy powder.
- Transmit yellow mosaic virus that causes reduced pod formation and poor yield.
- Leaves may show yellowing and curling, leading to stunted growth.

Management Methods

- Use a mixture of neem oil and soap solution (2% neem oil, 2% soap) to spray on plants, which repels whiteflies.
- Release Encarsia formosa, a parasitic wasp, at 1 million per hectare to parasitize whitefly nymphs.
- Use yellow sticky traps to capture adult whiteflies, reducing the population.
- Apply Malathion (0.1%) at the rate of 1 liter per 1000 liters of water.

Diseases

1. Seed and Seedling Rot

Causal Organism: **Fungi**: *Aspergillus flavus*, *F. semitectum*, *Macrophomina phaseoli*, and others.

Symptoms of Damage

- Seed rotting before germination, leading to poor emergence.
- Seedlings rotting before or after emerging from the soil.
- Seeds may appear soft, dark-colored, or moldy.
- Foul odor from seeds.

Management Methods

- Compost rich in beneficial microorganisms can help improve soil health and prevent the spread of fungi.
- Use Trichoderma spp. (a beneficial fungus) as a soil drench at a rate of 1 kg per hectare to control soil-borne fungal diseases.
- Good seedbed preparation and proper irrigation help prevent soil-borne pathogens by reducing moisture around seeds.
- Treat seeds with Thiram at the rate of 4.5 g per kg of seed before sowing. Thiram helps protect seeds from rotting fungi.

2. Frog Eye Leaf Spot

Causal Organism: ***Cercospora sojina***

Symptoms of Damage

- Grey to light tan spots on leaves with reddish-brown margins.
- Yellow halos around the spots.
- Small circular leisons expands and mearges eachother and patches on leaves are observed.
- Heavily infected leaves may fall prematurely, reducing plant photosynthesis.

Management Methods

- Neem oil can be sprayed at a 5% concentration to reduce fungal growth.
- Use Bacillus subtilis (a natural bacterium) at 1 kg per hectare to reduce fungal growth on the leaves.

- Remove infected leaves manually to reduce disease spread.
- Use fungicides like Mancozeb 75 WP at 2.5 kg per hectare in 1000 liters of water to control the spread of the fungus.

3. Pod Blight (Anthracnose)

Causal Organism: *Colletotrichum truncatum*

Symptoms of Damage

- Yellowish-green pods that eventually dry out and shrivel.
- Moldy, shriveled seeds inside the diseased pods.
- Severe cases can lead to poor seed formation.

Management Methods

- Use compost teas containing beneficial microbes to treat soil and reduce fungal growth.
- Apply Trichoderma harzianum (a beneficial fungus) at 1-2 kg per hectare to reduce fungal infections in pods.
- Remove and destroy infected pods to limit disease spread.
- Spray Zineb at 2.5 kg per hectare in 1000 liters of water during the flowering to pod-filling stages.

4. Rust

Causal Organism: *Puccinia pisi*

Symptoms of Damage

- Brownish pustules on the leaf surface.
- Leaves may turn brown and become covered with loose brown powder from the rust.
- In severe cases, the plant may defoliate prematurely.

Management Methods

- Use neem oil at 5 ml/liter of water to reduce fungal infections on leaves.

- Apply Bacillus subtilis at 1 kg per hectare to reduce rust formation by promoting plant health.
- Prune infected branches to reduce spreading of rust.
- Spray Mancozeb 75 WP at the rate of 2.5 kg per hectare in 1000 liters of water.

Marketing of Summer and Winter Legumes

In Nepal, summer and winter legumes like lentil**,** cowpea**,** pigeonpea, soyabean and chickpea are important for both local consumption and trade**.** These crops are primarily grown in the Terai and hilly regions**.** Farmers are investing in seeds**,** fertilizers**,** and labor for cultivation**.** After harvesting, seeds are sold in local markets or processed in to dal and soyabean is taken to oil mills to produce vegetable oils and cakes**.** There are challenges like market price fluctuations**,** infestation of disease and pests**.** Despite of these, legumes crop cultivation offers good opportunities for farmers, especially through cooperatives that help them get better prices. There is high demand for these crops in foreign markets also. It can be better opportunity for farmers to increase yield and export the related products. The government support through subsidies and improved infrastructure, eleminating middlemen can boost production and marketing of oilseed crops.

Exercises

Choose the correct answer from the given alternatives.

1. Which of the following crops belongs to the Fabaceae (Leguminosae) family?

   a. Sunflower
   c. Lentil
   b. Linseed
   d. Rapeseed

2. Which crop is known for its ability to fix atmospheric nitrogen?

   a. Lentil
   c. Linseed
   b. Sunflower
   d. Mustard

3. Which crop is a good source of protein and is widely used in soups and stews?

   a. Lentil
   c. Linseed
   b. Sunflower
   d. Mustard

4. Which crop is known as "garbanzo bean"?

   a. Lentil
   c. Cowpea
   b. Chickpea
   d. Pigeon pea

5. Which crop has climbing vine and is often used as a vegetable (young pods)?

   a. Lentil
   c. Cowpea
   b. Chickpea
   d. Pigeon pea

6. Which crop is an important source of oil and is used for making tofu and tempeh?

   a. Lentil
   b. Cowpea
   c. Chickpea
   d. Soybean

7. Which crop is sensitive to waterlogging?

   a. Lentil
   b. Chickpea
   c. Cowpea
   d. All of them

8. Which of the following is a major pest of legumes like chickpea and lentil?

   a. Aphids
   b. Cutworms
   c. Whiteflies
   d. Bollworms

9. Which of the following diseases commonly affects legumes?

   a. Rust
   b. Powdery Mildew
   c. Bacterial Blight
   d. All of the above

Write short answer to the following questions.

1. List three important uses of lentils and explain their importance in human nutrition.
2. List any two varieties of following.

   a. Lentil b. Soyabean c. Chickpea

   d. Cowpea e. Pigeon Pea

3. Explain the importance of rhizobium inoculation in soyabean before cultivation.
4. List Biological and physical methods that can be employed to manage pests and diseases in pulse crops.

Write long answer to the following questions.

1. Explain in detail the climatic and soil requirements, sowing time, sowing methods, irrigation practices and harvesting of lentil.
2. Describe any two major diseases and insect pests of pulse crops (symptoms of damage and management methods.

Project Work

1. Prepare a comparative table for each of the following topics for all 5 legume crops. Include the given headings.
    a. Botanical Name and Family
    b. Suitable Climate and Soil
    c. Major Growing Areas in Nepal
    d. Seed Rate, Spacing, and Sowing Time
    e. Field Preparation and Fertilizer Application
    f. Major Insects and Pests with Management Methods
    g. Diseases and their Management
    h. Harvesting Time, Yield, and Storage
    i. Varieties Grown in Nepal
    j. Market Value and Scope in Nepal

(To collect these information, you can refer to books, articles, government reports, local farmers, and ask teachers)

❖ SRI (System of Rice Intensification)

The System of Rice Intensification, known as SRI, is a climate-smart, agroecological methodology for increasing the productivity of rice and, more recently, other crops by changing the management of plants, soil, water, and nutrients. The System of Rice Intensification (SRI) is an innovative method of rice cultivation that originated in Madagascar in the 1980s. SRI was developed by a French Jesuit priest, Fr. Henri de Laulanié, who observed and experimented with different rice cultivation practices in the highlands of Madagascar.

SRI Principles

SRI methodology is based on four main principles that interact with each other:

- Early, quick and healthy plant establishment

- Reduced plant density
- Improved soil conditions through enrichment with organic matter
- Reduced and controlled water application

Recommended SRI Management Practices for Irrigated Conditions

- Seedlings should be transplanted when they are very young at the 2-leaf stage.
- Seedlings should be transplanted carefully and quickly to prevent damage of roots and minimize transplanting shock.
- Seedlings should be Planted singly, placing one plant per hill instead.
- Seedling should be planted in the spacing of 25x25 cm to encourage better root and canopy growth.