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The Training Manual for Agriculture Community Resource Person (CRP)



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Food and Agriculture
Organization of the
United Nations

Department of Agriculture,
Ministry of Agriculture and Livestock

TRAINING MANUAL FOR AGRICULTURE COMMUNITY RESOURCE PERSON (CRP)



**Department of Agriculture
Ministry of Agriculture and Livestock**

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Foreword

Agriculture in Bhutan is increasingly challenged by climate change, land degradation, declining soil fertility, and the emergence of new pests and diseases. These challenges call for practical, innovative, and sustainable farming approaches that improve productivity while safeguarding the natural resources. Climate-Resilient Practices provide an effective means to enhance agricultural productivity, strengthen farmers' resilience, and ensure the long-term sustainability of our farming systems.

The successful adoption of climate-resilient technologies depends largely on an effective agricultural extension system. Extension personnel play a vital role in translating research into practical solutions for farmers. Community-based learning is an important extension approach that has demonstrated considerable effectiveness in facilitating technology adoption, strengthening local capacity, and promoting peer-to-peer knowledge and experience sharing. In this approach, Community Resource Persons (CRPs), as trusted members of their communities, serve as important catalysts by demonstrating improved agricultural practices, providing technical guidance, and promoting wider adoption among fellow farmers.

Recognising the important role of CRPs, the Department of Agriculture has developed this Community Resource Person (CRP) Training Manual under the GEF-8 Food Systems Project. The manual is designed as a practical training and reference guide for Community Resource Persons, extension personnel, and farmers. It provides clear, step-by-step guidance on climate-resilient agricultural technologies and agricultural practices that can be readily applied in the field. By equipping CRPs with the necessary knowledge and skills, this manual aims to strengthen farmer-to-farmer extension and enhance the dissemination of sustainable agricultural technologies across the country.

This manual reflects the collective efforts of technical experts, extension professionals, and development partners who have combined scientific knowledge with practical field experience to produce a user-friendly resource. I am confident that it will strengthen the capacity of Community Resource Persons and extension workers to promote sustainable farming practices, improve soil health, enhance resilience to climate change, and contribute to increased agricultural productivity and rural livelihoods.

I extend my sincere appreciation to the Food and Agriculture Organisation of the United Nations (FAO), all technical experts, and everyone who contributed to the development of this manual. I encourage all users to make full use of this resource in supporting farming communities and advancing the country's vision of a resilient, productive, and sustainable agriculture sector.



(Yonten Gyamtsho)

Director

Department of Agriculture

AI Use Declaration

Artificial Intelligence (AI) tools were used in the preparation of this manual to assist with language editing and the generation of selected images and graphic elements. All technical content has been reviewed, verified, and approved by the Department of Agriculture and subject matter experts. The Department of Agriculture assumes full responsibility for the content of this publication.

Acronyms and abbreviations

AI	Artificial Intelligence
ARDC	Agriculture Research and Development Centre
ARID	Agriculture Research and Innovation Division
ASSR	Agricultural Service & Sales Representative
AWD	Alternate Wetting and Drying
BFDA	Bhutan Food and Drug Authority
CRP	Community Resource Person
CSA	Climate-Smart Agriculture
C-SUCSeS	Consortium for Scaling-up Climate-Smart Agriculture in South Asia
DoA	Department of Agriculture
DoPH	Department of Public Health
EM	Effective Microorganisms
FAO	Food and Agriculture Organization of the United Nations
FSAPP	Food Security and Agriculture Productivity Programme*
FSIP	Food Systems Integrated Programme/Project*
FYM	Farmyard Manure
GEF-8	Global Environment Facility – Eighth Replenishment*
GDP	Gross Domestic Product
IPM	Integrated Pest Management
IoT	Internet of Things
MoAL	Ministry of Agriculture and Livestock
NCOA	National Centre for Organic Agriculture
NPPC	National Plant Protection Centre
PPE	Personal Protective Equipment
RAMCO	Regional Agriculture Marketing Cooperatives
SLM	Sustainable Land Management
SMS	Short Message Service
USDA	United States Department of Agriculture
WP	Wettable Powder

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Introduction

Agriculture remains the backbone of the country's economy, sustaining nearly half the population (41.7%) and contributing 14.15% to national GDP in 2024. Beyond its economic role, agriculture is central to rural development, cultural identity, environmental stewardship, and community well-being.

Most farmers cultivate fragmented plots of less than three acres, constrained by difficult biophysical conditions and limited access to modern tools, climate-smart practices, digital advisory services, small-scale mechanisation, and improved post-harvest technologies, all essential for building resilient, sustainable, and inclusive agrifood systems.

These structural challenges are compounded by low investment, climate vulnerability, labour shortages, and rising human-wildlife conflict. Gaps in extension services have further slowed technological adoption, leaving farming systems dominated by traditional practices. The result is low productivity, reduced incomes, and inefficient use of resources.

Meanwhile, population growth and an expanding non-farming population are driving up food demand, which the country increasingly meets through imports of cheaper produce from neighbouring countries. This growing reliance on imports weakens the competitiveness of local production and undermines smallholder livelihoods.

However, the sector is gradually transforming, with increasing emphasis on climate-resilient technologies, sustainable intensification, and modern production systems. Realising this shift depends on stronger agricultural extension services that can deliver technologies and knowledge to farmers. Yet, limited human resources continue to constrain these services, leaving critical gaps in farmer support.

Community Resource Persons (CRPs) offer a practical way to close this gap. Positioned at the grassroots level, CRPs can extend the reach of technology dissemination and advisory support to farmers who would otherwise remain underserved.

Therefore, this training manual is intended to equip Agriculture CRPs with the knowledge and skills needed to support agricultural production and management. In strengthening CRPs, the

manual aims to build resilient, efficient, and sustainable agricultural systems, reducing carbon emissions, raising productivity, and securing rural livelihoods, while safeguarding happiness, harmony, and national well-being.

Objectives

- To improve understanding of modern and sustainable agricultural production practices.
- To strengthen skills in farm management, planning, and resource utilization.
- To build capacity in the dissemination of agricultural technologies and innovations.
- To enhance the ability of agriculture CRPs to provide advisory and support services to farmers.
- To promote efficient, climate-resilient, and sustainable farming systems.

Training Approach

Selected Community Resource Persons (CRPs) will undergo a structured training program comprising four courses. Participants must attend and complete all four to qualify as trained Agriculture CRPs.

The courses are scheduled to align with the cropping seasons, allowing participants to apply the knowledge and skills gained directly to real-time farming contexts. Upon successful completion of the full program, CRPs will be awarded a completion certificate and assigned to their respective Dzongkhags to deliver services under the supervision of the Gewog Extension Officer and Dzongkhag Agriculture Officer.

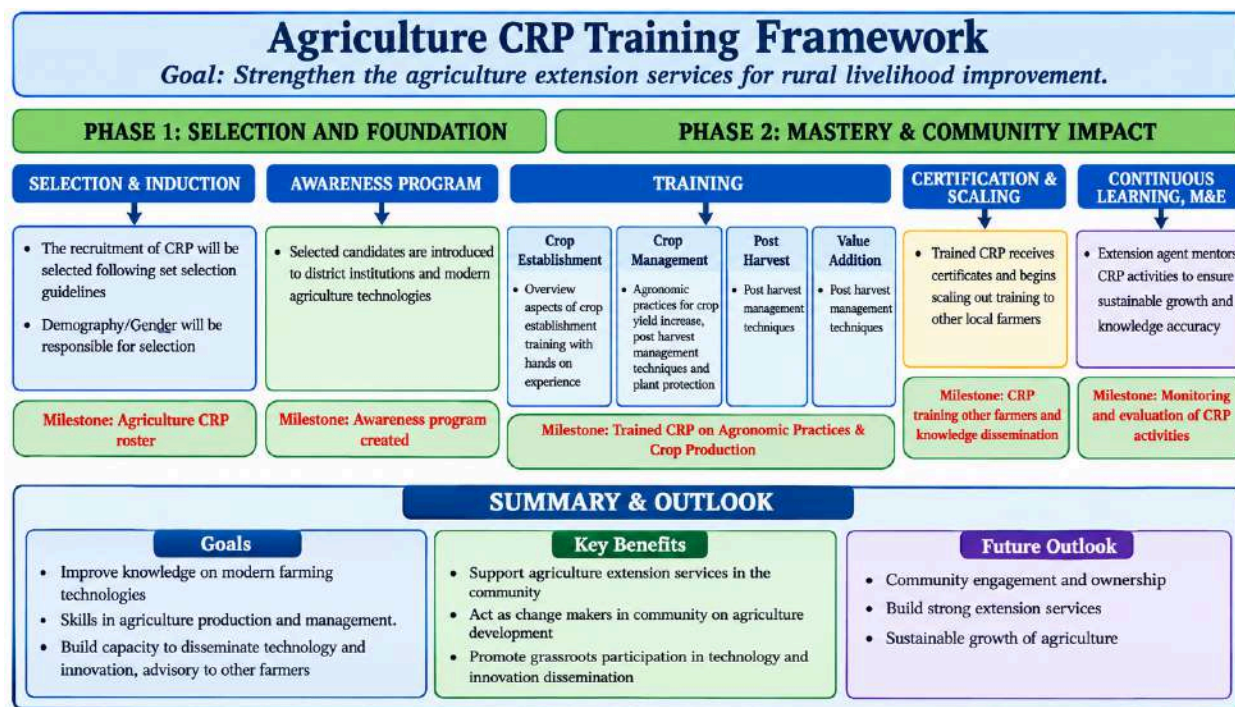


Figure 1: Agriculture CRP training framework



Figure 2: Agriculture CRP training roadmap

Training Structure

Course 1: Introduction to Program Profiles and Awareness Program on Modern Farming Technologies

This course will be conducted before the start of cultivation. It will introduce participants to the overall program, its objectives, and key agricultural concepts.

Course 2: Crop Establishment & Management Practices

This course will take place at the onset of the cropping season. It will focus on essential practices related to land preparation, planting, and crop establishment. Upon completion, CRPs will be assigned practical tasks to apply the knowledge and skills learned on their own farms.

Course 3: Soil Fertility and Plant Health Management

Delivered during the crop growth stage, this course will emphasise crop management practices, including irrigation, nutrient management, and other field management strategies. Participants will also share their experiences and report on the outcomes of the assignments undertaken after Course 2.

Course 4: Post Harvest and Farm Business Management

This final course will be conducted during the harvest period. It will provide hands-on training in harvesting techniques, post-harvest handling, storage, and management practices. Participants will gain practical, real-time experience by observing and applying appropriate methods during the harvest season.

Training Curriculum

Course Title	Session Topic	Schedule /Month	Duration	Methodology	Assessments tools
<u>Course One:</u> Introduction to Program Profiles and Awareness Program on Modern Farming Technologies	• Introduction to program Profiles • Awareness on modern Farming Technologies • Food Diversity for sustainable food systems	October	3 days	Lecture, group discussion, field visits	Q&A, Participation
<u>Course Two:</u> Crop Establishment and Management Practices	• Orchard establishment and management techniques • Vegetable production and protected vegetable production techniques • Field crop production and management techniques • Mushroom production and management technique	January	8 days	Lecture, group discussion, practical demonstration	Q&A session, Active participation
<u>Course Three:</u> Soil Fertility and Plant Health Management	• Integrated Soil Fertility, Soil erosion, and plant Nutrition Management • Plant Protection • Crop water management systems • Fruit thinning techniques	May	7 days	Lecture, group discussion, hands on practice	Q&A; participation
<u>Course Four:</u> Post Harvest and Farm Business management	• Post Harvest handling and value addition techniques • Seed production and management techniques • Farm business management	September	4 days	Lecture, group discussion, practical session	Q&A session and Active participation

COURSE ONE: INTRODUCTION TO PROGRAM PROFILES , AWARENESS ON MODERN FARMING TECHNOLOGIES

This course orients participants to agricultural institutions, programs and their role in supporting agricultural development and extension services. It also introduces climate-smart farming technologies and their applications in improving productivity and promoting sustainable agriculture.

The course also highlights the importance of food diversity, encouraging the use of local and seasonal crops to enhance nutrition and strengthen sustainable food systems.

Objectives

- Provide participants with an orientation on the roles and responsibilities of key agricultural institutions in supporting agricultural development and service delivery.
- Introduce participants to modern agricultural technologies and innovations available in the country to enhance agricultural productivity and sustainability.
- Promote awareness of food diversity and its importance in improving nutrition, dietary quality, and household food security.

Teaching Approaches

The following teaching approaches will be applied to effectively deliver the course:

- Learner-centred and participatory.
- Interactive lectures with visuals.
- Group discussions, case studies, and role-play exercises.
- Field visits for hands-on exposure to modern farming systems.

Expected outcome

After completing this training, participants will:

- Enhanced understanding of the roles of key agricultural institutions and available support services.
- Improved awareness of modern farming technologies and sustainable agricultural practices.

- Increased knowledge of food diversity and nutrition-sensitive agriculture.
- Strengthened capacity to promote sustainable and climate-smart farming practices within communities.

Course Details

The detailed content of the course is described in the following sections.

Session One: Introduction to Program Profiles

Time:	3 hrs	Delivery Methods:	Theory 100%
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This session provides participants with an overview of different agricultural institutions and their significance in supporting agricultural development. It introduces the objectives, scope, and key components of agricultural programs, vis-à-vis their role in strengthening extension services and improving farmers' livelihoods. The session will also create awareness of ongoing project activities and their contributions to sustainable agriculture.

Additionally, through interactive discussion and visual presentations, participants will reflect on how community-level actors and extension workers can contribute to the successful implementation of these programs.

Session Content:	• Overview of Programs • Institutional Setup and Functions • GEF-8 (FSIP) Project & Scope • Regional Agriculture Marketing Cooperatives (RAMCO)
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Section Two: Awareness of Climate-Smart Farming Technologies

Time:	5 hrs	Delivery Methods:	Theory: 40% Practical: 60%
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This session familiarizes participants with modern farming technologies and innovations available in the country to enhance agricultural productivity, efficiency, and sustainability. It covers technologies in horticulture, cereals, and other crops, as well as farm management tools, advanced irrigation techniques, and digital solutions, with an emphasis on practical applications to improve farmers' livelihoods.

Session Content:	• Horticulture technologies (fruits & vegetables) • Field crops technologies (cereals), • Farming systems technologies (cropping systems, electric fencing, water management) • Post-harvest technologies
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Note: For details on CSA technologies, refer to the book on CSA technologies and practices in Bhutan, published by SARRC Agriculture Centre.

Link: <https://c-suces.sac.org.bd/the-book-on-csa-technologies-and-practices-in-bhutan/>

Session Three: Food Diversity for Sustainable Food Systems

Time:	2 hrs.	Delivery Methods:	Theory: 80% Practical: 20%
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This session introduces the concepts of food diversity and local farming systems, and explains how they are interconnected in building sustainable, resilient, and nutritionally healthy food systems that support improved nutrition and community well-being. It highlights the importance of diverse diets and indigenous crops in improving nutritional outcomes, strengthening local economies, and conserving agricultural biodiversity. The session also examines how traditional and diversified farming systems contribute to climate resilience and long-term food security.

Session Content:	• Food Diversity Concepts • Local/Traditional Crops • Diversified Farming Systems • Sustainable Crop Intensification • Impact of Monoculture & Climate Change
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INFORMATION

A. What is Food Diversity?

Food Diversity refers to the variety of plants, animals, fungi, and microorganisms used directly or indirectly for food, encompassing genetic diversity within species, diversity among species, and diversity of ecosystems that together sustain productive, resilient, and nutritious food systems.

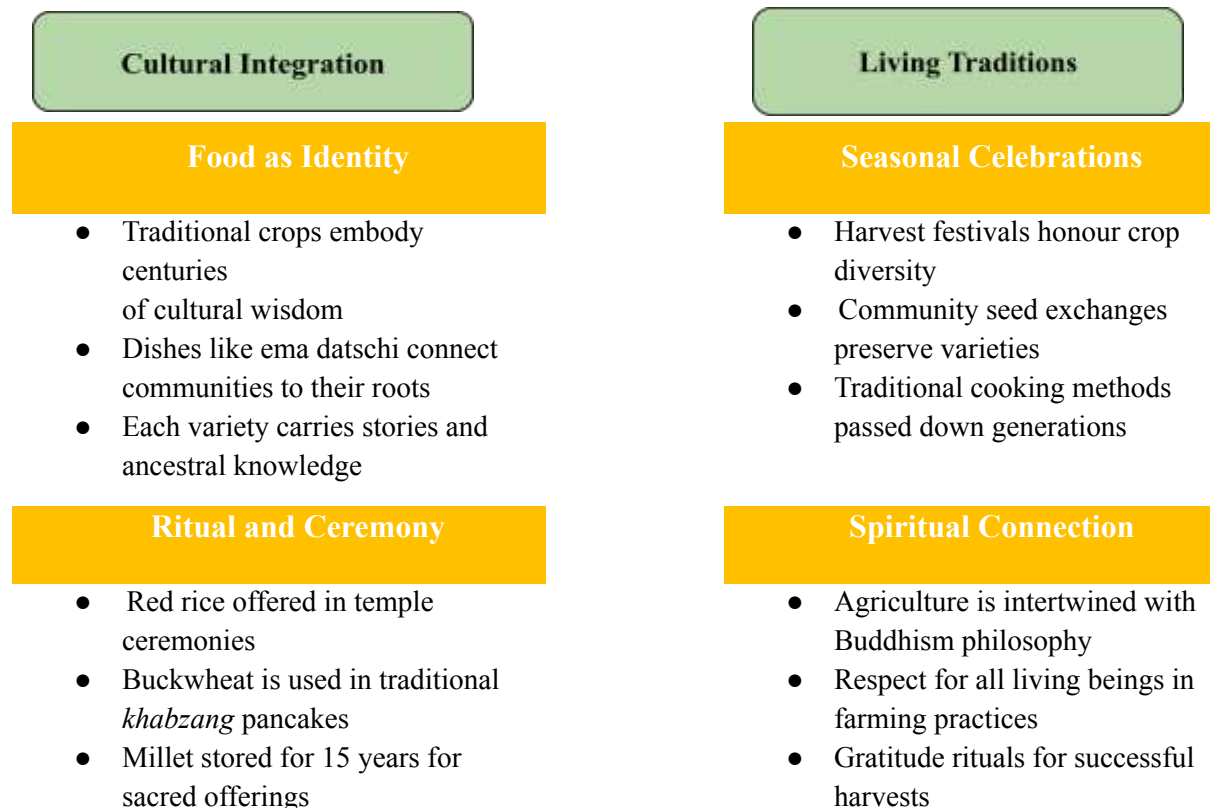
1.1. Three Pillars of Resilient Food Systems

Genetic Diversity	Species Diversity	Ecosystem Diversity
Variety within species, e.g., 100+ traditional rice varieties in Bhutan; resilience against pests and climate stress	Multiple plant, animal, and microbial species for food; nutritional balance; reduces single-crop dependency	Variety of habitats and agroecological zones for food production. Wetland paddies to dryland highlands supporting unique crop systems

B. What are Traditional/Local Crops?

Traditional or local crops are crop varieties that have been grown in a region for generations and are naturally resilient to the local climate, soil, and farming practices. They often have cultural significance and help preserve agricultural biodiversity.

2.1. Cultural and Religious Significance -traditional crops as living heritage



2.1.. Sustainable Crop Intensification – Growing more on less land through smart innovation

Key strategies for Bhutan's limited arable land

- Maximise Vertical Space - High-density planting systems increase yields per acre
- Extend Growing Seasons – Protected cultivation enables year-round production
- Optimise Resource Use -Precision irrigation and nutrient management
- Integrate Multiple Crops -Intercropping and agroforestry systems

2.2. Risks of monoculture and Soil degradation -The hidden costs of single crop farming in Bhutan's mountains.

Monoculture Vulnerabilities	Soil Degradation Impacts
Pests and Disease Outbreaks • 1996 Rice Blast Epidemic, 80-90% crop loss in high-altitude regions • 2007 Maize Blight - 50% harvest destruction across central districts Uniform crops = uniform vulnerability	Erosion & nutrient Depletion • 3-21 tons of topsoil lost per hectare annually • Steep slopes amplify erosion during monsoons • Continuous cultivation exhausts soil fertility

C. Climate Change Vulnerabilities

3.1. What is climate change, and why is it important for agriculture?

Erratic Weather Patterns	Glacier Retreat & Water Scarcity	Farming System Changes
• Flash floods destroyed over 800 acres of farmland in 2010 • Hailstorms and intense rainfall now occur annually • Unpredictable seasons disrupt traditional planting cycles	• Glaciers retreating at accelerated rates due to warming • Reduced snowmelt threatens irrigation systems • Water shortages during critical growing periods	• Potato cultivation is declining in high-altitude regions • Traditional wheat and barley zones shifting upward • Farmers abandoning ancestral crop varieties

3.2. How to adapt to Climate Change?

Core Strategy: Climate-smart agriculture

Goal: Sustainably increase productivity, enhance resilience (adaptation), and reduce greenhouse gas emissions (mitigation) where possible.

3.3. Core CSA Technologies

Category	Technology	Key Benefit
Water-Smart	Drip irrigation, rainwater harvesting, AWD (rice)	Saves water, fights drought
Soil-Smart	Conservation tillage, Biochar, Bokashi, mulching	Prevents erosion, retains moisture
Crop-Smart	Resilient seeds, agroforestry, intercropping	Withstands heat/flood/pests
Livestock-Smart	Improved shelter, rotational grazing, silage banks	Reduces heat stress, secures feed
Info-Smart	Weather index insurance, SMS agro advisories	Enables early action

Session Four: Health and Nutrition

Time:	2 hrs	Delivery Methods:	Theory 100%
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Good health is strongly linked to proper nutrition, as the body needs essential nutrients to grow, function, and resist disease. A household may have enough food but still experience poor health if the diet is not balanced and lacks key nutrients.

Malnutrition occurs when the body does not receive adequate nutrients or cannot properly absorb them. It can result from poor diets, inadequate hygiene, illness, and improper childcare practices. Malnutrition weakens the immune system, slows growth, reduces energy levels, and increases susceptibility to diseases, ultimately leading to poor health outcomes.

This session helps farmers understand how local food production, balanced diets, hygiene, and proper care can improve family health and nutrition.

Session Content	● Understanding Malnutrition ● Healthy Food Healthy Family ● Local Farming for Better Nutrition ● Dietary Diversity and Balanced Meals ● Food Safety, Hygiene and Sanitation
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INFORMATION

1. Malnutrition

Malnutrition occurs when the body does not receive the right balance of nutrients

1.1. Types of Malnutrition

- Undernutrition:** Stunting, wasting, and underweight.
- Micronutrient Deficiencies:** Lack of vitamins and minerals such as iron, iodine, Vitamin A, and Vitamin D.
- Overnutrition :** Overweight and obesity caused by excessive intake of unhealthy foods and lack of physical activity.

1.2. Effects of Malnutrition

- Poor growth and development in children.
- Weak immunity and frequent illness.
- Low energy and productivity.
- Increased risk of diabetes, heart disease, high blood pressure, and other non-communicable diseases.

2. Healthy Food for a Healthy Family

Food can be classified in different ways. It may be grouped by the nutrients it provides, such as carbohydrates, proteins, fats, vitamins, and minerals; by its function in the body, such as energy-giving, body-building, or protective foods; or by commercial categories, including cereals, roots and tubers, nuts and seeds, fruits, and vegetables. The five basic food groups that combine both nutrient content and their importance for health are as follows:

FOOD GROUP	WHAT THEY DO	EXAMPLES
1. Grains and Cereals <i>(Energy-giving foods)</i> 	• Give the body energy to work, walk, and do daily activities. • Without enough, you may feel tired, weak, and cannot function well.	 Examples: Rice, maize, potatoes, sweet potatoes, buckwheat, wheat, barley, millet
2. Meat, Fish, Eggs and Lentils <i>(Body-building foods)</i> 	• Build and repair body tissues. • Help you grow, stay strong, and recover from illness.	 Examples: Meat, fish, eggs, lentils, beans, peas, soybeans
3. Fats <i>(Store energy)</i> 	• Store energy for later use. • Help the body absorb vitamins and keep you warm.	 Examples: Cooking oil, butter, pork fat, groundnuts
4. Fruits and Vegetables <i>(Protective foods)</i> 	• Protect the body from illness. • Help you heal faster, and reduce tiredness and fatigue.	 Examples: Green leafy vegetables, pumpkin, carrots, tomatoes, citrus fruits, bananas, papaya. Food Group: Vitamins and Minerals
5. Milk and Dairy Products <i>(Strong bones and joints)</i> 	• Keep bones and joints strong. • Important for growth, pregnancy, and breastfeeding.	 Examples: Milk, cheese, curd (datshi), yogurt Food Group: Calcium and Protein

3. Benefits of Backyard/ Kitchen Gardening

A backyard garden is often referred to as a “natural doctor” for the household because it provides a continuous supply of fresh, nutritious, and safe food that supports good health and prevents malnutrition.

Kitchen or backyard gardening is a traditional and common practice in Bhutan, especially in rural households. It supplements staple foods like rice, maize, and wheat by providing fresh vegetables, fruits, and sometimes animal products.

Beyond food, kitchen gardens also serve as:

- Social spaces for family interaction and community bonding
- Small economic zones for selling surplus produce
- Areas for growing medicinal plants and keeping small livestock

Many households rely on them to improve diet quality and nutrition, especially where market foods are limited or expensive.

Environmental Benefits	Health Benefits	Economic & Social Benefits
Reduces need for food transport (lower fuel use and air pollution) Encourages natural farming (less chemical fertilizer and pollution) Improves soil health and protects water sources Supports cleaner , more sustainable local ecosystems	Provides fresh, diverse, and nutritious foods Helps prevent micronutrient deficiencies and diseases Improves diet variety (vegetables, fruits, eggs, meat) Home-grown foods often have fewer chemicals Supports child growth, maternal health, and elderly nutrition	Reduces household spending on food Generates income from selling surplus produce Improves food security and self-reliance Strengthens social ties through shared gardening and market activities Encourages community cooperation and knowledge sharing

Why Grow Nutritious Foods?

Many Bhutanese diets rely heavily on staples, which can lead to poor nutrition.

Key insight (NHS 2023): 37% consume vegetables daily | 25% consume fruits daily

How to choose what to grow?

Consider:	<i>Nutrition needs</i>	Include all food groups
	<i>Preferences</i>	Grow foods families eat
	<i>Climate suitability</i>	Match crops to local conditions
	<i>Seasonality</i>	Plan crops for year-round supply
	<i>Wild foods</i>	Use forest foods to supplement diet

4. Dietary Diversity and Balanced Meals

Food diversity based on the Food Pyramid

Dietary diversity means eating different foods from different food groups every day.

The Food Guide Pyramid is a simple diagram that shows how to eat a balanced diet. It is divided into six food groups, with those at the bottom to be eaten in larger amounts and those at the top in smaller amounts.

- **Bottom (staple foods like rice, maize, and potatoes):** These provide energy for daily activities and should form the largest part of the diet.
- **Middle levels (vegetables, fruits, dairy, poultry, and meat):** These help the body grow, stay strong, and fight disease. They should be eaten regularly in moderate amounts.
- **Top (oils, fats, and sweets):** These provide energy but should be used sparingly, as too much can lead to weight gain and health problems.

Eating a variety of foods from all groups helps maintain good health and a balanced diet.



Figure 3: Food Guide Pyramid. Adopted from FAO-TA, FSAAP, DoA & DoPH (2029)

5. Healthy Plate Model (Food Diversity)

The healthy plate model is a simple guide for preparing balanced meals using everyday foods. It divides a plate into three main parts, with fats, oils, and sweets used only in small amounts.

1. Half the plate: Energy-giving foods	• Rice, maize, buckwheat, noodles, potatoes • Provide energy for daily activities • Form the main part of the meal
2. One-third of the plate: Protective foods	• Vegetables and fruits such as spinach, pumpkin, turnip leaves, guava, banana • Protect the body, improve eyesight and blood, and prevent illness • Use a variety of colors and seasonal/local
3. Small portion: Body-building food	• Eggs, meat, milk, cheese, lentils, beans, dried fish • Support growth, muscle
4. Fats, oils, and sweets	• Use sparingly in cooking • Not a main part of the plate

My Healthy Plate

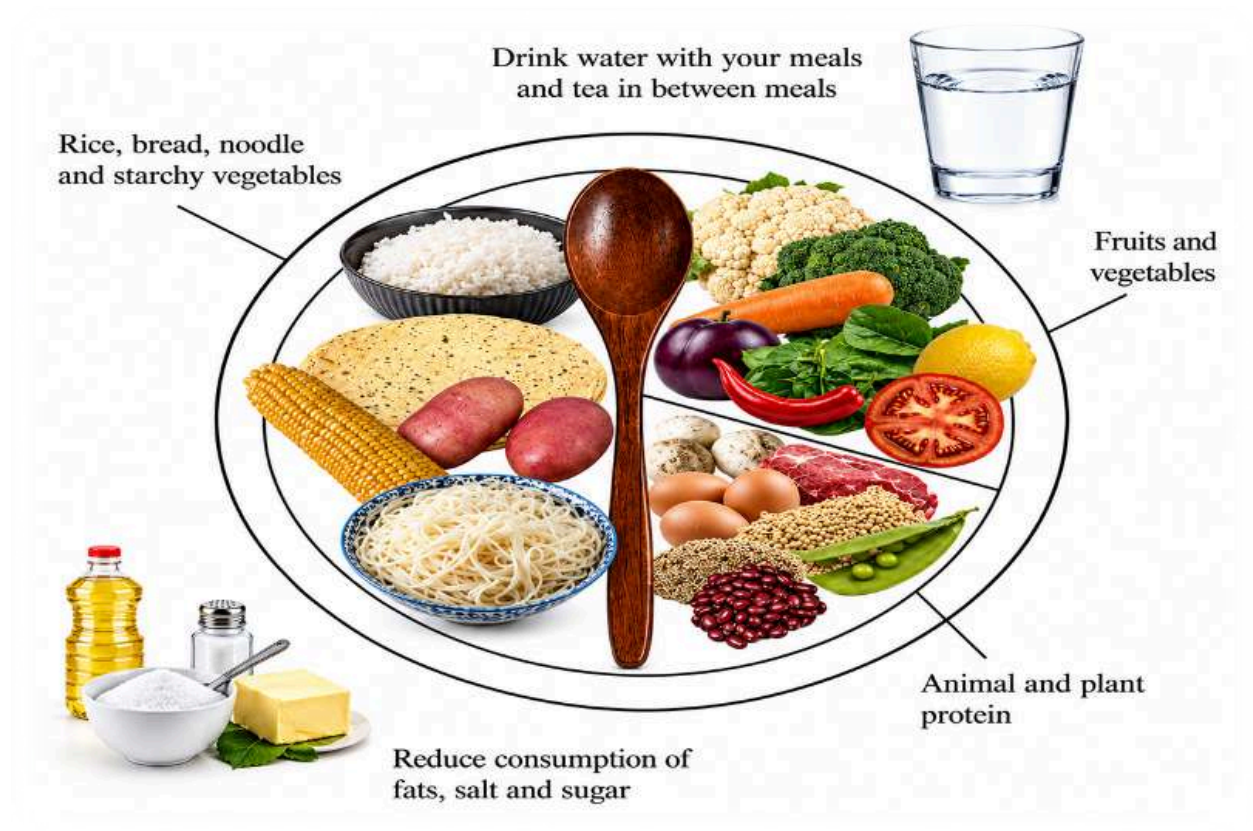


Figure 4: Healthy Plate adopted from FAO-TA, FSAPP, DoA & DoPH (2019)

6. Food Safety, Hygiene and Sanitation

When and How Food Becomes Contaminated ?

Food can become contaminated at any stage, from farm to table, including growing, processing, transport, storage, cooking, and serving.

Contamination occurs when harmful germs (bacteria, viruses, parasites) or chemicals enter food. These are invisible, so food may look and smell normal but still cause illness.

Common sources of contamination include:

- Dirty water used for washing or cooking
- Unwashed hands, dirty utensils, or surfaces
- Leaving food uncovered or unrefrigerated for too long

- Flies, pests, and animals
- Polluted soil or air during production or drying

What Are Foodborne Illnesses?

Foodborne illnesses are diseases caused by eating contaminated food containing germs or harmful chemicals.

Common symptoms:

- Stomach pain
- Vomiting
- Diarrhoea

They can sometimes lead to long-term health problems. Chemicals such as pesticides, fertilisers, cleaning agents, and veterinary drugs can also cause illness if misused.

How to Prevent Foodborne Illness (Five Keys to Safer Food)

Keep Clean

- Wash hands before and after handling food and after toilet use
 - Clean utensils, surfaces, and equipment
 - Protect food from insects and animals
- Why:** Germs spread easily through hands and surfaces.

Separate Raw and Cooked Food

- Keep raw meat separate from other foods
 - Store in covered containers
- Why:** Raw foods can spread germs to ready-to-eat food.

Cook Thoroughly

- Cook food well, especially meat
 - Reheat leftovers properly
- Why:** Heat kills harmful germs.

Store Food Safely

- Do not leave cooked food at room temperature for more than 2 hours
 - Refrigerate perishable foods or cook only what is needed
- Why:** Germs multiply quickly at room temperature.

Use Clean Water

- Use safe or boiled water
 - Wash fruits and vegetables well
- Why:** Water is a common source of invisible germs.

COURSE TWO:

CROP ESTABLISHMENT AND MANAGEMENT PRACTICES

This course provides a comprehensive introduction to the agronomic practices of horticulture, field crops, and vegetable production. It integrates theoretical knowledge with hands-on training in crop establishment and management. Key areas include orchard establishment and management, covering layout, planting, propagation, and high-density systems, alongside vegetable nursery raising and protected cultivation. The course also addresses the production of major field crops such as maize, quinoa, and buckwheat, emphasising improved agronomic practices and quality seed selection.

A specialised module on commercial mushroom production is included, focusing on shiitake and oyster cultivation using log, straw, and sawdust-based systems, as well as modern, climate-resilient technologies such as IoT-enabled climate control.

Overall, the course equips participants with practical knowledge and hands on skills on crop establishment and management practices.

Objective

The main objectives of this course are:

- Develop practical skills in orchard establishment and management, including planting systems and cultural practices.
- Strengthen knowledge and techniques in plant propagation and nursery management.
- Enhance vegetable production skills, including protected cultivation and staggered cropping systems.
- Build agronomic competencies in major field crops such as maize, quinoa, and buckwheat.
- Train participants in commercial mushroom production (shiitake and oyster) using various substrate systems.

Teaching approaches

To impart the required knowledge and skills to the participants, resource persons will apply the following teaching approaches:

- Provide the theoretical concepts using relevant presentation slides and visual aids
- Initiate question-and-answer sessions and group discussions to understand the field issues and provide field-based technical information
- Provide adequate hands-on practice training on the intended farming practices

Expected outcome

At the end of this course, the participants are expected to;

- Understand and apply crop establishment and management practices in their farms and those of their neighbours.
- Able to implement and transfer the knowledge and skills gained in their farms and to the community.

Course Details

The detailed content of the course is described in the following sections.

Session One: Orchard establishment and Management techniques

Time:	5 hrs.	Delivery Methods:	Theory: 30% Practical: 70%
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This session provides participants with both theoretical understanding and practical skills in orchard establishment and management, emphasising the importance of proper orchard development and effective management practices. It is organised into four sequential sections to ensure a structured and comprehensive learning experience.

Session Content:	1. Orchard establishment techniques ● Orchard layout systems, site selection and feasibility study ● Pit digging and planting method 2. Orchard management techniques ● Basin making, mulching, manuring and irrigation methods ● Training & pruning of fruit trees 3. Plant propagation and nursery management 4. Protected cultivation of fruits
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Materials Required

Essential Field Tools	Propagation & Grafting Materials	Binding & Support Materials
Pruning saw	Grafting Tape	Jute Rope (Sutali)
Secateur	Parafilm	
Grafting & Budding Knife	Grafting Wax	
Measuring Tape	Aluminium Tags	
Wooden Pegs		

INFORMATION

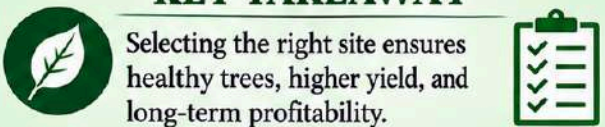
1. Fruit Orchard Establishment

Fruit orchard establishment refers to the systematic process of planning, designing, and planting fruit trees in a defined area using appropriate techniques. It includes site selection, land preparation, layout design, selection of suitable fruit species and varieties, pit preparation, planting, and initial care to ensure healthy growth and long-term productivity.

Importance of Fruit Orchard Establishment

- Ensures healthy tree growth and long-term productivity
- Improves fruit yield and quality
- Optimises use of land, water, and inputs
- Facilitates efficient orchard management
- Enhances resilience to climatic conditions
- Increases profitability and sustainability

1.1. Site Selection Criteria

1. CLIMATE SUITABILITY  Temperature, rainfall, and frost conditions must match the crop requirements.	6. ACCESSIBILITY  Easy access to roads and markets for transport and management.
2. SOIL QUALITY  Deep, fertile, well-drained soil with good structure and appropriate pH.	7. DRAINAGE  Proper natural drainage to prevent water stagnation.
3. WATER AVAILABILITY  Reliable source of irrigation with good-quality water.	8. WIND PROTECTION  Shelter from strong winds to reduce damage and moisture loss.
4. TOPOGRAPHY  Gentle slope preferred for drainage; avoid waterlogged or steep areas.	10. PEST AND DISEASE HISTORY  Avoid areas prone to major pests and diseases.
9. PROXIMITY TO LABOR AND INPUTS  Availability of workforce and farm inputs nearby.	KEY TAKEAWAY  Selecting the right site ensures healthy trees, higher yield, and long-term profitability.

1.2. Recommended Elevation

Type	Commodity	Elevation (m)
Temperate	Almond	1300-2000
	Apple	2000-2800
	Apricot	1200-2500
	Cherry	1600-2600
	Peach	1200-2500
	Pear	1600-2500
	Persimmon	1500-2200
	Plum	1600-2500
	Walnut	1600-2500
	Grapes	500-2500
	Kiwi	1600-2300
Subtropical	Litchi	<1200
	Citrus	900-1400
	Mango	<1200
	Passion fruit	300-1600
	Pineapple	<1500
	Watermelon	<1500
	Banana	<1500
	Dragon fruit	300-1500
	Lime	500-1500
	Avocado	300-1600

1.3. Orchard Layout

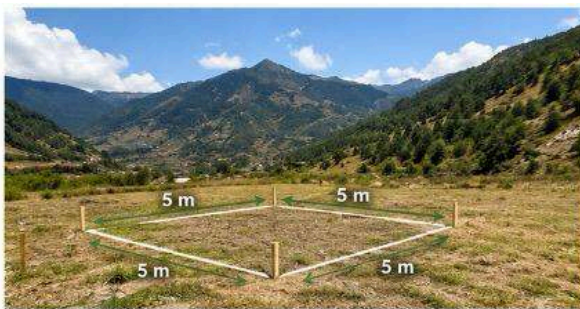
Why is orchard layout important?

- Improves plant growth and development
- Facilitates easy cultural operations (such as pruning, spraying, irrigation, and harvesting)
- Ensures efficient use of land and resources
- Enhances overall operational efficiency in orchard management



Figure 5: Well-designed orchards enhance both agricultural productivity and landscape structure (Source: ARDC-Wengkhar).

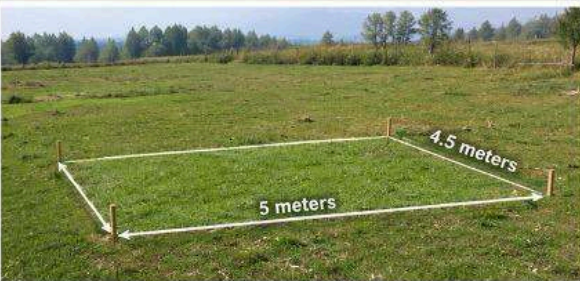
1.4. Common Orchard Layout Systems



Square system



Triangular system



Rectangular system



Contour system

1.5. Spacing Requirements for Common Fruit Trees

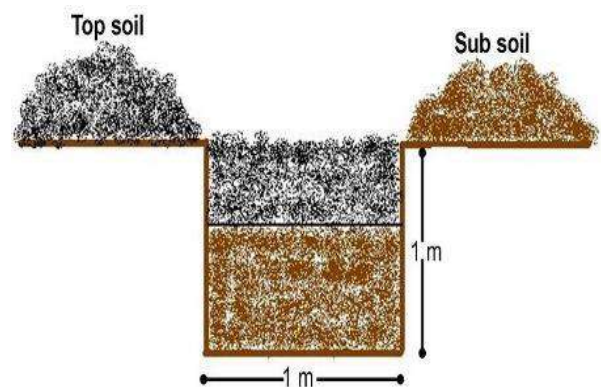
Commodity	Local name	Spacing (m)	Remarks
Pear	<i>Lee</i>	5mX5m	<i>row to row and plant to plant</i>
Peach	<i>Kham</i>	5mX5m	
Plum	<i>Chhu-li</i>	5mX5m	
Apricot	<i>Ngari kham</i>	5mX5m	
Apple	<i>Apple</i>	5mX5m	
Kiwi	<i>Zhimpeykotong</i>	6mX6m	
Citrus	<i>Tselu</i>	5mX5m	
Mango	<i>Amchhukuli</i>	7mX7m	
Litchi	<i>Li-chi</i>	7mX7m	
Walnut	<i>Tago</i>	7mX7m	
Passion fruit	<i>Jaga chhup</i>	3mX6m	
Dragon fruit	<i>Gewaringa</i>	3mX3m	

**** Overall, the aforementioned spacing is followed in all the regions of the country; however, the spacing may vary depending upon the variety

1.6. Pit Preparation

Pit size: 1 m width × 1 m depth

Time: 1–2 months before planting

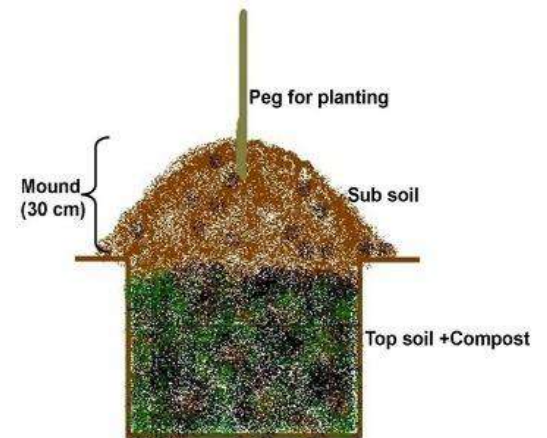


Method:

- Dig pits of the specified size well in advance of planting.
- Separate the topsoil and subsoil while digging.

1.7. Refilling the pit and mound preparation

- ❖ Fill the pit with topsoil, FYM and leaf mould
- ❖ Use subsoil for mound preparation
- ❖ Mound to be prepared 2 weeks before planting time.



Planting Techniques

- Graft union to be maintained at least 15cm above the mound
- Planting season for subtropical fruit crops- May-June
- Planting season for temperate fruit crops- February-March
- Irrigate after planting
- Use a peg as a stake to support the plant from the wind



Figure 6: Planting a grafted citrus plant with the graft union kept above ground level
(Source: ARDC-Wengkhur)

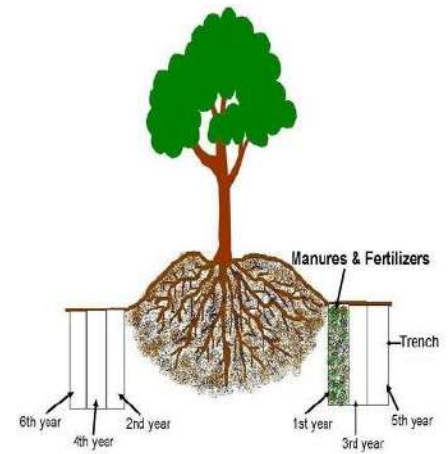
2. Orchard Management

Orchard management refers to the planned care and maintenance of fruit trees grown in an orchard to ensure healthy growth, high yield, and good fruit quality.

Key components of Orchard Management	Importance of Orchard Management
1. Soil & Nutrient Management	1. Increases Yield and Productivity
2. Irrigation Management	2. Enhance Fruit Quality
3. Pruning & Training	3. Improve Tree Health and Longevity
4. Weed Management	4. Optimize Resource utilization
5. Pest & Disease Control	5. Control Pests and Diseases
6. Flowering & Fruit Management	6. Ensures Sustainable Production

2.1. Basin making, Trenching & Manuring -Tips

- Size of the basin should be equal to the size of the plant canopy
- Prepare the trench just below the tree canopy (drip line area), where active feeder roots are concentrated.
- Recommended trench size: 60 cm width × 45 cm depth.
- Mix well-decomposed Farmyard Manure (FYM) with the required chemical fertilisers before application.
- Apply the FYM + fertilizer mixture evenly in the trench and cover it with soil.
- Do not apply FYM or fertilisers at the collar region (base of the plant stem), as it may cause rotting and disease infection.



2.2. Mulching

The practice of covering the soil surface around plants or trees with a protective layer of material to conserve moisture, improve soil health, and reduce weed growth.

It helps in:

- ❖ Conservation of moisture
- ❖ Reduce weed pressure
- ❖ Improves soil health



2.3. Irrigation for Fruit Trees

Water requirement varies according to the growth stage. Critical stages of fruit trees for irrigation are:

1. Flowering stage:

Keep soil slightly moist. Avoid water stress and excess irrigation to ensure good flowering and fruit set.

2. Marble stage (fruit set stage):

Provide regular irrigation. Maintain uniform soil moisture to prevent fruit drop and support early fruit growth.

Ensure adequate and continuous irrigation. Water stress at this stage reduces fruit size and quality.

2.4. Training and Pruning

Training

- Shape young trees for a strong framework and proper canopy structure.
- Maintain good spacing between branches for sunlight penetration and air movement.
- Develop a tree structure that can support a heavy fruit load without breakage.

- Common systems: central leader, open centre, modified leader (as per crop).

Types of Training



Open Centre



Modified Leader



Trellis



Ring Pole Support



Kniffin System



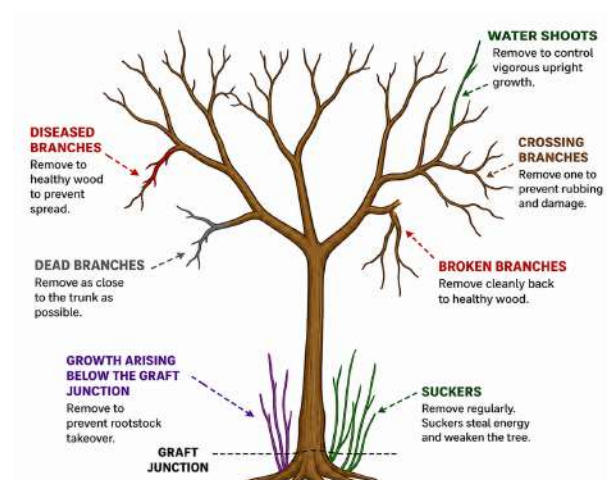
Pergola

Pruning

Removal of dead, diseased, weak, overcrowded branches (crisscrossed), watershoots & suckers.

Why Pruning

- Improve light entry and air circulation inside the canopy.
- Encourage growth of healthy new shoots and better fruiting wood.



- Control tree height for easy management and harvesting.

Key Timing

- Do major pruning during the dormant season (January-February).
- Light pruning can be done to maintain shape during growth.

Tips: Training builds the tree structure, and pruning maintains and improves it

3. Plant Propagation Techniques and Nursery Management

Plant propagation is the process of producing new plants from existing plants. It can be done through Seeds, Cuttings, Grafting / Budding, & Other plant parts, such as roots, stems, or leaves.

There are two main types of plant propagation:

- **Sexual Propagation** (through seeds)
- **Asexual Propagation** (through vegetative plant parts)

The union of rootstock and scion wood is commonly used in grafting techniques.

Asexual Propagation	
Advantages	Disadvantages
• Genetic consistency, true to type • Short juvenile phase • Mass multiplication in short period of time	• Required skills and different techniques • Expensive and proper structure required

Sexual Propagation	
Advantages	Disadvantages
• Simple and easy • Seeds can be stored for longer duration • Seedling plants are long lived, productive and tolerant to biotic and abiotic stresses.	• Not true to type • Long Juvenile phase • Inferior quality fruits

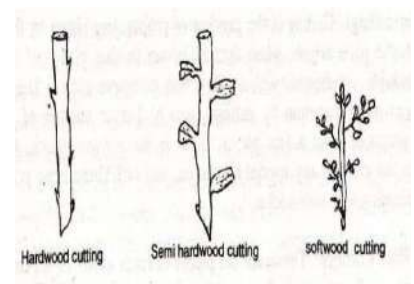
3.1. Asexual Propagation Methods

A. Cuttings

Involves cuttings of plant parts like the stem, leaf and root

Stem cutting

- Hardwood cutting: Grape, fig, apple, rose, hibiscus, Bougainvillea



- Semi-hardwood cutting: citrus, guava, geranium
- Softwood cutting: Azalia

B. Grafting

- Require two plant parts, scion and rootstock
- They are encouraged to unite and grow as one plant
- Possible only in a dicot plant having a cambium layer



I. Rootstock

The lower part of the plant that develops into the root system.

Characteristics

- It should be a high-quality rootstock.
- Must be compatible with the scion variety.
- Produces a strong and healthy root system.
- Well adapted to the local climatic conditions.

II. Scion

The upper part of the plant (usually a shoot or bud) that is grafted onto the rootstock and develops into the stem, branches, leaves, flowers, and fruits.

Characteristics

- Should be taken from a healthy, disease-free plant.
- Must be compatible with the rootstock.
- Should have desirable traits (e.g., high yield, good fruit quality, disease resistance).
- Should be mature but not too old (proper physiological age).

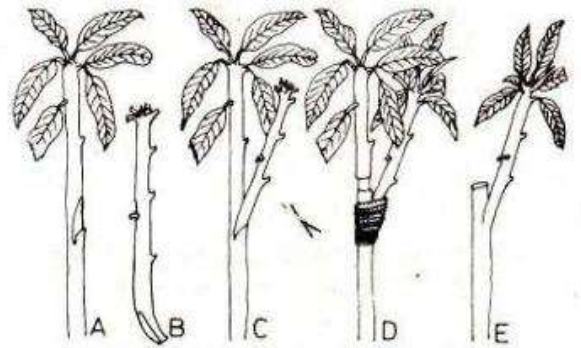
Types of Grafting

A. Side Veneer Grafting

A widely used grafting method for commercial mass multiplication, especially in fruit crops.

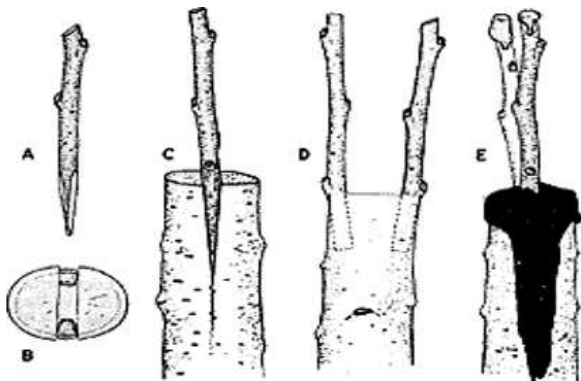
Key Points

- Suitable for large-scale nursery production.
- Rootstock should be healthy and more than 1 year old.
- A slanting cut is made on the side of the rootstock, and a matching cut is prepared on the scion.
- The scion is inserted into the cut and firmly tied to ensure proper contact.
- Promotes a high success rate and uniform plant growth.



B. Softwood Grafting

A common grafting technique is used when the plant tissues are young, actively growing, and soft.



C. Top Working

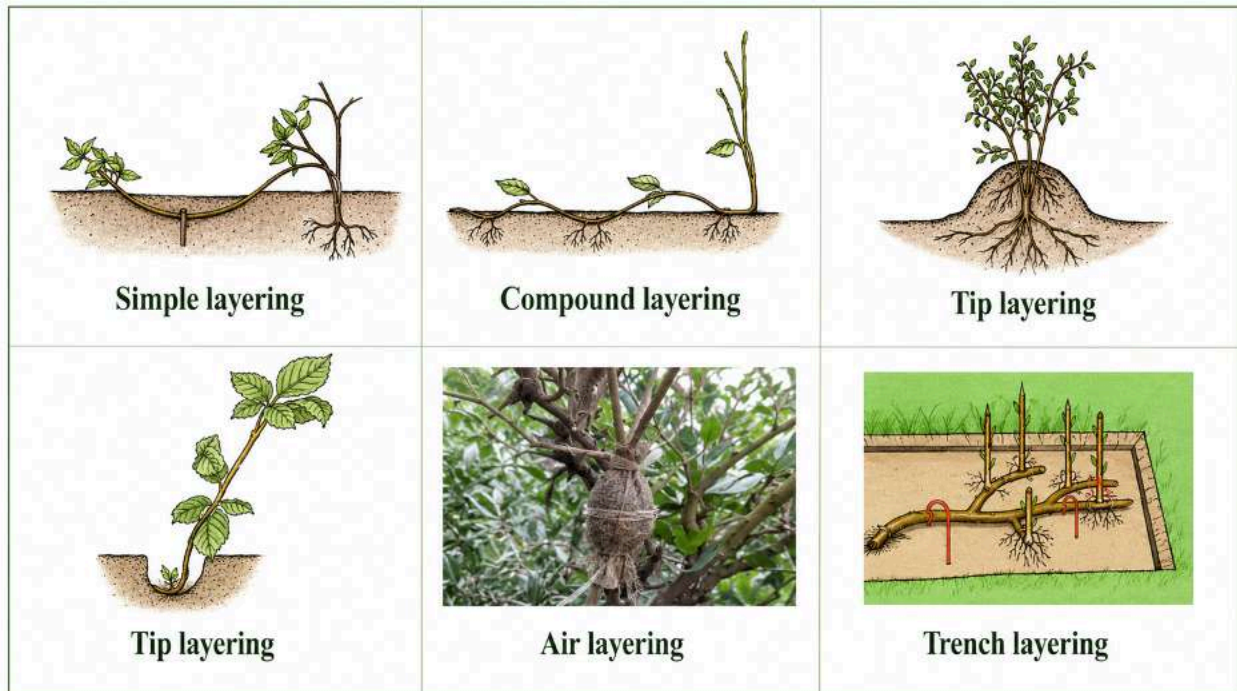
- Used for rejuvenation of old orchards
- Helps rework unproductive or inferior trees into high-yielding ones

D. Layering

- Develop roots on a stem while it is still attached to the mother tree.
- The rooted stem is then detached and planted in polypots
- Easy methods and the success rate are high

Types of layering:

- Tip layering (blackberries),
- Simple layering,
- Trench layering (apple)
- Mound layering (apple, litchi, guava)
- Air layering (pomegranate, litchi)



3.2. Plant Propagation Structures

1. Green house:

The most common structure used in Bhutan for cultivating high value vegetables and fruits all round the year. The size dependent on the need of plant with 5x10m or 5x20m



2. Net house:

Popular in sub-tropical regions for providing shade and ideal conditions for nursery and plant development.



3. Poly carbonate green house:

Usually use for those plants which require high temperature for optimum growth such as Mango and citrus



4. Protected Cultivation of Fruits

Method of planting fruit crops under protected conditions (greenhouse and net house)

Why?

- Enhance productivity
- Control pests, diseases and bird attack
- Easy intercultural operation
- Protection against wind and other hazards

How?

- High density planting
- High value crops (strawberry, Irwin mango, orange varieties)
- Total cost of protected citriculture (5X20m)- Nu. 0.4 million
- Expected break-even point- 10th year.



Figure 7: Citrus cultivation under protected structures (Source: ARDC-Wengkhar)

Session Two: Vegetable Production And Protected Vegetable Production Techniques

Time:	4 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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This session is designed to equip participants with the knowledge and practical skills required for vegetable production. It combines theoretical learning with hands-on training in nursery raising techniques, crop management, staggered production, and protected cultivation methods.

Session Content:	1. Vegetable production in open-field condition 2. Basic management practices 3. Protected Vegetable production techniques
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Materials Required

Planting Materials	Nursery & Growing Supplies	Nutrients	Crop Management Materials	Tools & Infrastructure
● Seeds ● Seedlings	● Poly pots ● Plug trays ● Tunnel plastics	● Manures ● Fertilisers	● Mulching materials ● Irrigation materials (pipes and drip system) ● Staking materials (poles, jute ropes)	● Secateurs ● Greenhouse set

INFORMATION

1. Vegetable production in an open field

Vegetable production depends on altitude, climate, and season. Farmers should focus on producing the right crop at the right time to achieve better yield and quality.

Important Criteria to Consider

- Select crops suitable for the local climate (low, mid, high altitude)
- Improve soil fertility using compost and manure
- Ensure proper drainage to avoid waterlogging
- Follow crop rotation to reduce pests and diseases
- Practice timely planting and harvesting

1.1. Crop Rotation Guidelines

- ★ Avoid growing the same crop or crop family repeatedly in the same field. This causes low yield, pests, diseases, and poor soil health.
- ★ Practice crop rotation every 3–5 years for better productivity and quality.

High-Risk Crops (Must Rotate)	Moderate-Risk Crops	Low-Risk Crops
• Tomato, chilli, eggplant, potato • Cucumber, watermelon, melon, bitter gourd • Beans, pea, okra, groundnut • Garlic, ginger, taro	• Cabbage, cauliflower, broccoli • Radish, carrot, turnip • Onion, pumpkin, spinach	• Soybean, mustard, beans, grain crops

1.2. Climatic Conditions for Different Vegetables

Crop Name	Climate Remarks
Kale, Cabbage, Cauliflower, Broccoli, Pea, Asparagus, Coriander, Leek, Mustard	Mild winter, semi-dry, warm summer
Watermelon	Desert climate, hot, short rainy season, low humidity
Radish, Turnip, Carrot, Onion, Spinach, Garlic	Hot dry summer, cool short rainy season, severe winter
Cucumber, Melon (Cantaloupe)	Warm temperature, low humidity, high rainfall
Eggplant, Ginger, Bitter gourd, Okra	High humidity, hot temperature
Chinese cabbage, Bunching onion, Soybean, Azuki bean	Cool summer, severe dry winter, summer rainfall
Maize, Bean, Pumpkin, Zucchini, Cassava, Sweet potato, Tomatillo	Hot temperature, high humidity
Potato, Tomato, Chili, Groundnut (Peanut), Tree tomato	Low humidity, strong sunlight, highland conditions

2. Basic Management Practices

- ❖ Use fresh and good-quality seeds for better germination and healthy crop growth.
- ❖ Seed germination depends on three key factors: Moisture (water), Temperature & Air (oxygen)
- ❖ Temperature is the most critical factor; each crop requires a specific temperature for proper germination.
- ❖ The time required for germination varies depending on crop type and temperature conditions.
- ❖ Before sowing, farmers should know:
 - ★ Suitable germination temperature
 - ★ Proper sowing method (direct or nursery)
 - ★ Required nursery period before transplanting

2.1. Sowing Method, Temperature & Nursery Requirements

Direct Sowing Crops		Transplanting Crops (Nursery Required)		
Crops	Optimum Temperature (°C)	Crops	Optimum Temperature (°C)	Nursery Period (Months)
Radish / Turnip	15–27°C	Cabbage / Chinese cabbage	15–20°C	1.5
Carrot	15–23°C	Broccoli / Cauliflower	15–25°C	1.5
Okra	25–30°C	Bulb onion	17–25°C	2.5–3
Kidney beans	18–30°C	Pumpkin	25–30°C	1
Pea	15–25°C	Watermelon	25–30°C	1.5
Other beans	22–30°C	Tomato	23–30°C	1.5
Sweet corn	22–30°C	Chili / Capsicum	23–30°C	1.5–2
Spinach	15–23°C	Brinjal (Eggplant)	20–30°C	1.5–2

2.2. Soil Improvement

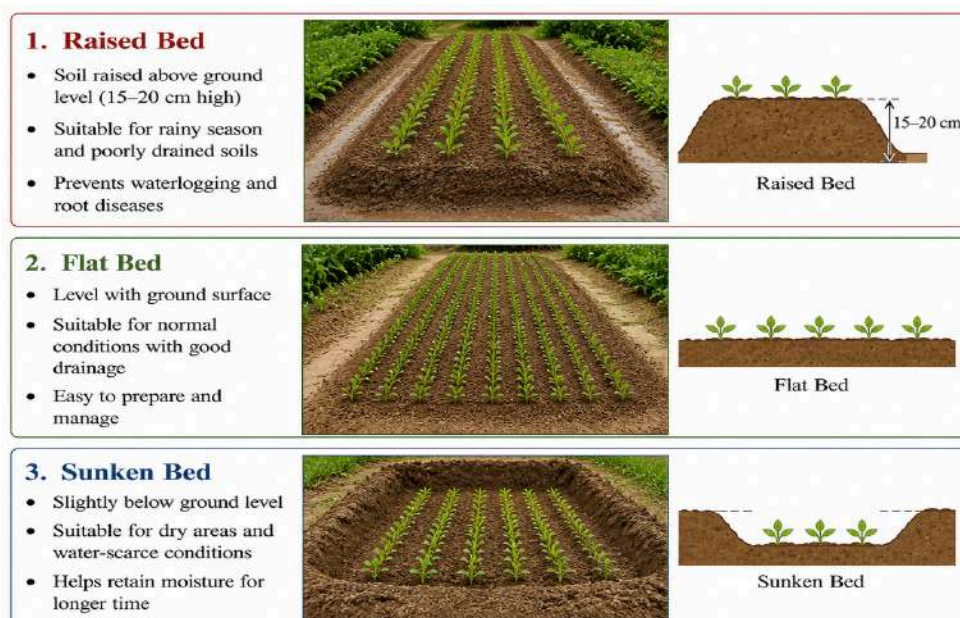


2.3. Nursery Management

Importance of Nursery Management

- Provides strong and disease-free seedlings
- Improves the survival rate after transplanting
- Ensures uniform crop growth and higher productivity

2.4. Types of Nursery Beds



2.5. Nursery Bed Preparation



2.6. Nursery After Care

1. POTTING OF SEEDLINGS	2. NURSERY CARE AND MANAGEMENT	3. TRANSPLANTING TO MAIN FIELD
1 Transplant seedlings at 2–3 leaf stage	1 Irrigate daily (if no rainfall)	1 Select healthy seedlings (5–6 leaves)
2 Use soil + compost mixture	2 Monitor regularly for pests and diseases	2 Transplant during late afternoon or cloudy/rainy days
3 Keep under temporary shade for 4–5 days	3 Ensure adequate sunlight after germination	3 Avoid deep planting
4 Water regularly and ensure proper drainage	4 Seedlings are ready for transplanting in about 1 month	4 Irrigate immediately after transplanting
		5 Apply mulch (straw, grass, sawdust)
		6 Provide staking for tall crops (tomato, brinjal, cucumber)

2.7. In-Field Management

1. STAKING

- Use bamboo stakes for support
- Height: Tomato, brinjal: 1–2 m
Beans, cucumber, gourds: 2–2.5 m
- Fix stakes 20 cm deep
- Tie plants in figure-8 method
- Use A-shaped support for climbers
- ✓ Improves sunlight, ventilation, and yield

Tomato / Brinjal 1–2 m
Beans / Cucumber / Gourds 2–2.5 m
20 cm depth

Figure-8 tying A-shaped support

2. THINNING

- Remove excess seedlings to maintain spacing
- Do 2–3 times gradually
- Early stage spacing: 3–4 cm
- Final spacing depends on crop
- ✓ Prevents overcrowding and improves growth

Before thinning
After 1st thinning (3–4 cm apart)
After 2nd / 3rd thinning (final spacing)

3. IRRIGATION

- Irrigate based on crop, soil, and weather
- Avoid overwatering (causes root disease)
- Summer: morning / evening watering
- Winter: less frequent (7–10 days)
- Check moisture using stick test (15–30 cm depth)
- ✓ Mulching reduces irrigation need

Summer (Morning) Summer (Evening)
Winter (7–10 days interval)
Stick test (15–30 cm depth)
Dry stick (Irrigate) Wet stick (No need)
Mulching with straw

4. FERTILIZATION

- Basal dose: Apply compost + NPK before planting
- Top dressing: Apply during growth stages
- Do not apply fertilizer directly on leaves
- Irrigate after fertilizer application

Basal dose (before planting)
Compost + NPK Fertilizer
Top dressing (during growth)
Do not apply directly on leaves
Irrigate after fertilization

5. MULCHING, WEEDING & EARTH-UP

Mulching

- Straw, husk, sawdust
- Retains moisture, reduces weeds

Straw Husk Sawdust

Weeding

- Remove regularly with roots

Earth-up

- Improves root growth (potato, onion, etc.)

6. PINCHING & BRANCH CONTROL

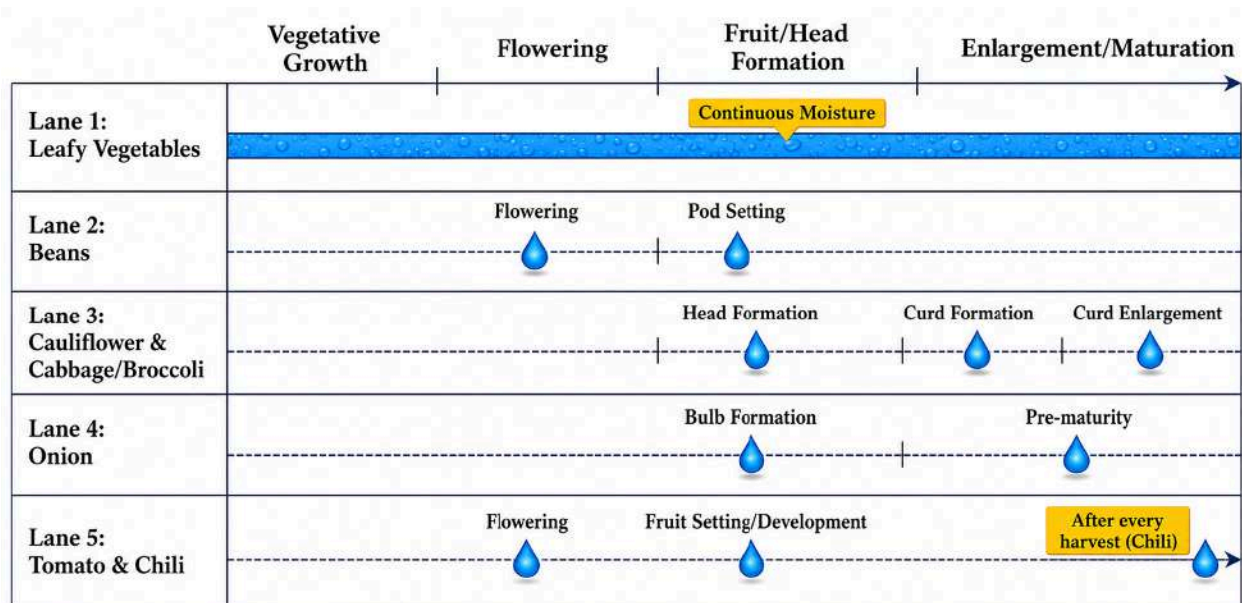
- Remove unwanted branches early
- Tomato: keep 1–2 main stems
- Brinjal / Chilli: remove lower branches
- Cucurbits: pinch main stem, allow side branches
- ✓ Improves fruit size, yield, and plant health

Tomato: Remove side shoots (1–2 main stems)
Brinjal / Chilli: Remove lower branches
Cucurbits (Cucumber, Gourd, etc.): Pinch main stem (at 6–7 leaves), Allow side branches, Good vine growth & more fruits

2.8. Staking requirements for the vegetables

Crop	Stake materials	Stake height (m)	Support method	Benefits
Tomato	Bamboo/Jute ropes	1-2	Staking/trellising	Improves sunlight, ventilation, and yield
Brinjal	Bamboo/Jute ropes	1-2	Staking	
Beans	Bamboo/Jute ropes	2-2.5	Use support for the climber	
Cucumbers	Bamboo/Jute ropes	2-2.5	Use support for the climber	
Guards	Bamboo/Jute ropes	2-2.5	Use support for the climber	

2.9. Critical stages of irrigation requirements in vegetable crops



2.10. Staggered vegetable production

Vegetable growing technique that consists of planting vegetable crops in a phased manner every 1–2-week interval

Benefits

- Provides continuous vegetable supply/income
- Reduces risk of crop failure to pests/weather
- Space management

Staggered production techniques

- Succession planting: replanting a new crop after harvest of the previous crop
- Spacing the sowing: Sowing seeds of the same crops in batches at 2–3-week intervals
- Selection of crop and variety

3. Protected Vegetables Production

Growing vegetables under protected structures such as plastic tunnels, greenhouses, or polyhouses to control the environment. There are two common sizes of greenhouses in the farmer's field, and the cost estimates for the installation of greenhouses are as shown in the table below.

Particulars	5m X 10m Greenhouse	5m X 20m Greenhouse
Greenhouse (GH) cost	Nu.65,000	Nu.85,000
Installation cost	Nu.3500	Nu.7000
Field preparation cost	Nu.1400	Nu.2800
Total	Nu. 69,900	Nu.94,000



Advantages

- Protects crops from rain, wind, frost, and pests
- Enables off-season production
- Improves yield and quality
- Efficient use of water and fertilizers

Types of Structures

Low tunnel: Small plastic cover over beds

Plastic tunnel: Medium-sized, low-cost structure

Greenhouse / Polyhouse: Large structure with full protection

Crop Management Practices to Be Followed Inside a Protected Structure

- ❖ Timely pruning
- ❖ Trellising/staking
- ❖ Humidity management
- ❖ Pest and disease monitoring
- ❖ Irrigation

Session Three: Field Crop Production and Management Techniques

Time:	3 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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In this session, participants will gain comprehensive knowledge and practical skills in the production and management of major field crops, particularly maize, quinoa, and buckwheat, under diverse agro-ecological conditions. The module integrates crop physiology, sound agronomic practices, and quality seed selection to enhance productivity and promote sustainable farming systems.

Session Content:	1. Introduction to Field Crops 2. Field Crop Production Practices 3. Field Crop Management Practices
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Materials Required

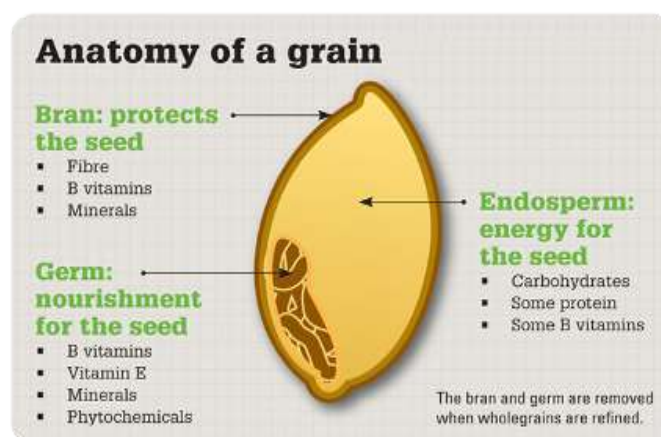
Planting rope, measuring tape, fresh seed, spade & hoe

INFORMATION

1. Introduction to Field Crops

1.1. Cereals Grains

Any grain or edible seed of the grass family (Gramineae). Most cereal grains are plant seeds and contain three distinct anatomical portions: Hull or husk, Bran layer, Endosperm & Embryo or germ.



1.2. Key Features of Cereals

A. *Nutritional Value*

Rich in carbohydrates, vitamins, minerals, fats, oils, and moderate proteins.

B. *Adaptability*

Adaptable to different climates and soil (pedoclimate).

C. *Dietary Importance*

Forms a significant part of the human diet globally, more than any other crop.

D. *Production, Storage and Transport*

Cheap to produce, easily stored and transported, and do not deteriorate readily if kept dry.

1.3. Major Cereals in Bhutan (Dru-Na-Gu)



1.4. Significance of Dru-Na-Gu

- Staple food source and animal feed
- Plays crucial role in culture and tradition
- Diversity reduces risk associated with crop failures
- Generate income for farmers
- Few are naturally gluten-free and rich in antioxidants, providing better health.

2. Cropping system & Cropping Pattern

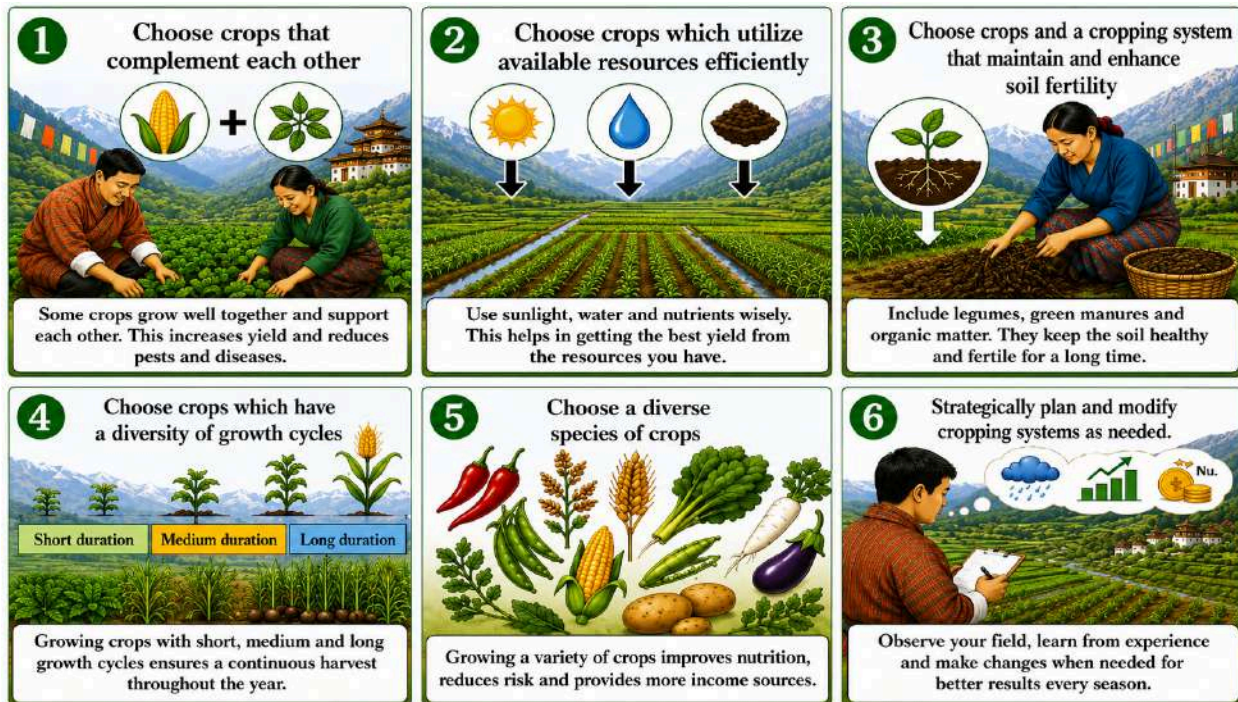
Cropping System

Crop sequence and the management techniques

Cropping Pattern

Yearly sequences and spatial arrangement in a given area used on a particular field over a period of years

1.5. Basic Principles of Cropping System



1.6. Types of Cropping system

Cropping System	Description
Sole Cropping	Growing a single crop in a pure stand at normal density during one farming year.
Monocropping	Growing only one crop on the same piece of land, year after year.
Multiple Cropping	Growing two or more crops on the same piece of land within a single season.
Crop Rotation	Growing different crops in planned succession on the same piece of land.

Cropping System	Description
Mixed Cropping	Growing more than two crops together without a distinct row arrangement.
Intercropping	Growing more than two crops together with a distinct row arrangement.
Relay Cropping	Planting a succeeding crop once the first crop has reached physiological maturity.
Strip Cropping	Growing more than two crops in separate strips, in single or multiple rows.

1.7. Importance of Cropping System

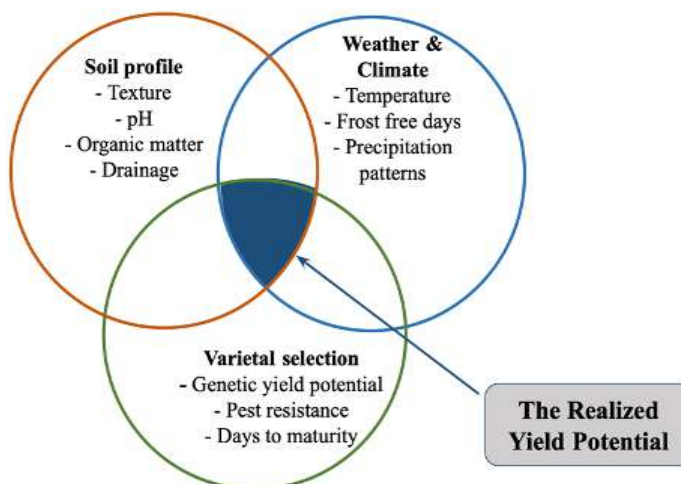
Cropping System	Monocropping	Intercropping	Crop Rotation
Resource Utilization	 High specific demand	 Complementary niche use	 Sequenced nutrient cycling
Pest Vulnerability	 High/compounding	 Disrupted pest cycles	 Pathogen starvation
Soil Health Impact	 Rapid depletion	 Synergistic retention	 Restorative over time
Economic risk	 High volatility	 Hedged output	 Diversified longterm

1.8. Existing Cropping Systems

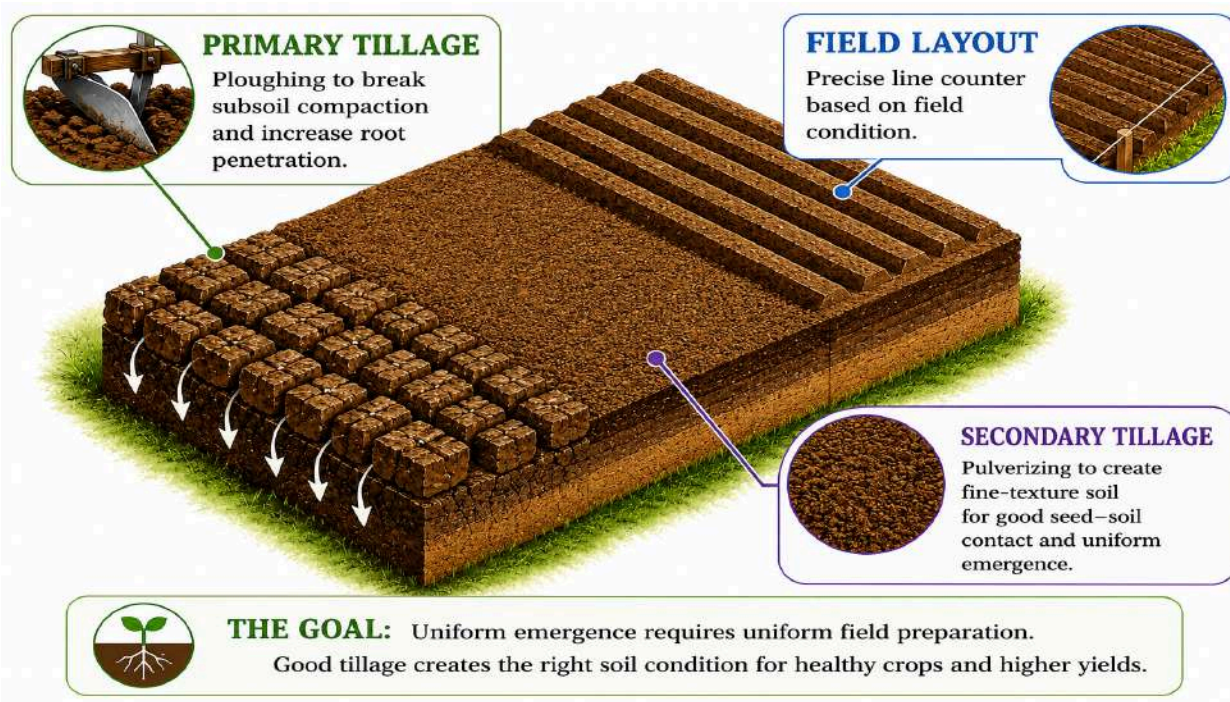
Cropping system	Existing practice	Agro-ecological zones
Crop rotation	Maize-soybean	Mid altitudes
	Maize-Legumes	Low and mid altitudes
	Maize-Mustard	Low and mid altitudes
	Maize-Upland rice	Low altitudes
	Maize-Buckwheat	Dry and humid subtropical
	Rice-Rice	Small scale in mid altitudes
	Rice-Wheat	In mid and low altitudes

Cropping system	Existing practice	Agro-ecological zones
	Rice-Mustard	Mid altitudes
	Rice-Maize	Humid and wet subtropical zones
	Rice-Potato	Warm temperate in irrigated wetland
	Rice-Vegetables	Warm temperate in irrigated wetland
	Rice-Onion	Warm temperate in irrigated wetland
	Rice-Early Chilly	Low altitude
Intercropping/Mixed cropping	Maize + Potato	Mid altitudes
	Maize + Soybean	Mid and low altitudes
	Maize + Millet	Humid and wet subtropical
	Maize-Barley + Mustard	Mid altitudes
	Maize + Ginger	Dry and humid subtropical
	Maize + Vegetable	Low and mid altitudes
	Maize + Tuber crop	Humid and wet subtropical
Relay cropping	Maize-Beans	Low and mid altitudes
Strip cropping	Chilli-Beans/Maize	Dry and humid subtropical

1.9. Optimal Crop Establishment



1.10. Land Preparation and Field Layout

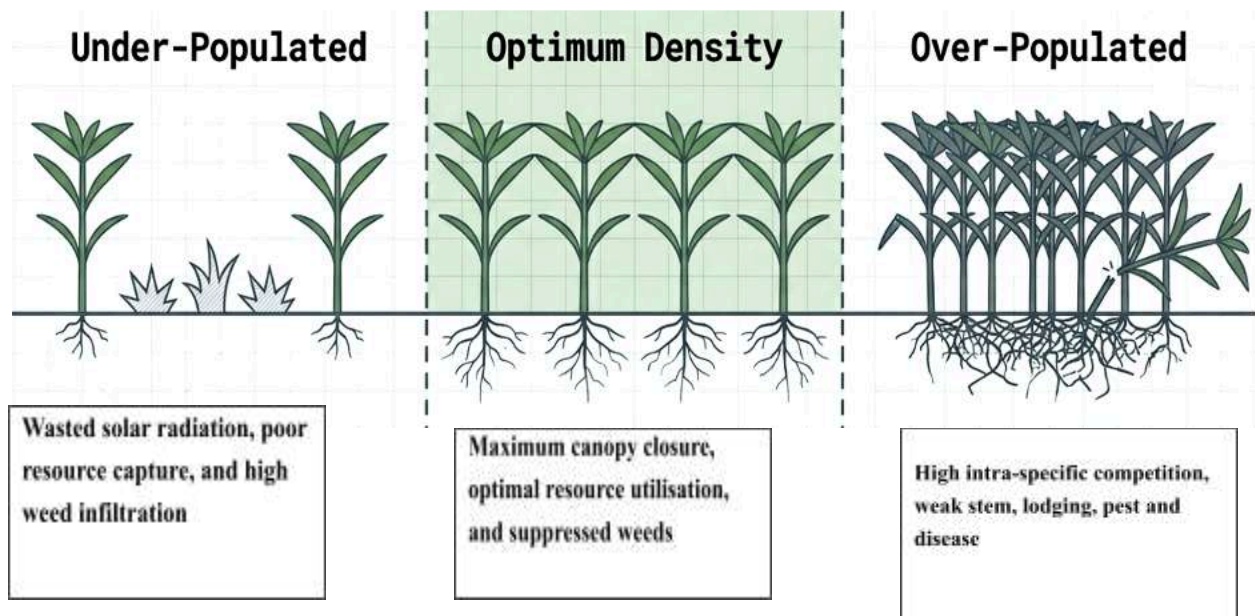


2. Field Crop Production Practices

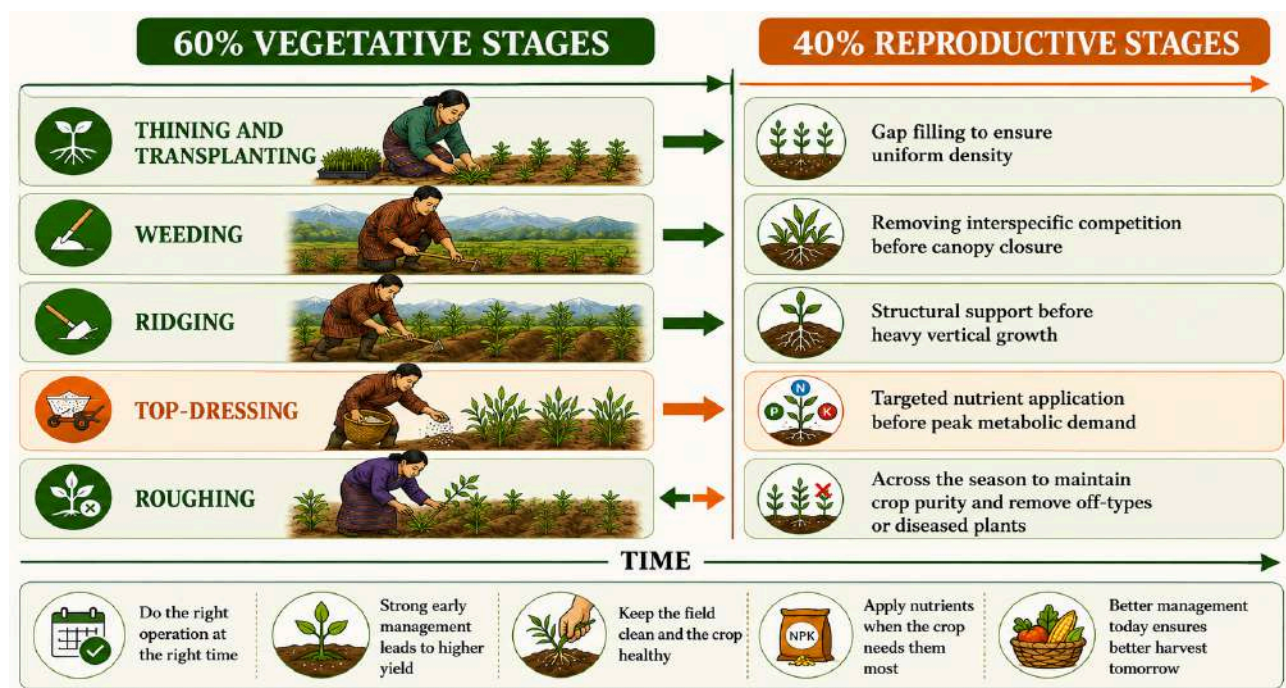
2.1. Different Methods of Seed Sowing



2.2. Optimising the Plant Density

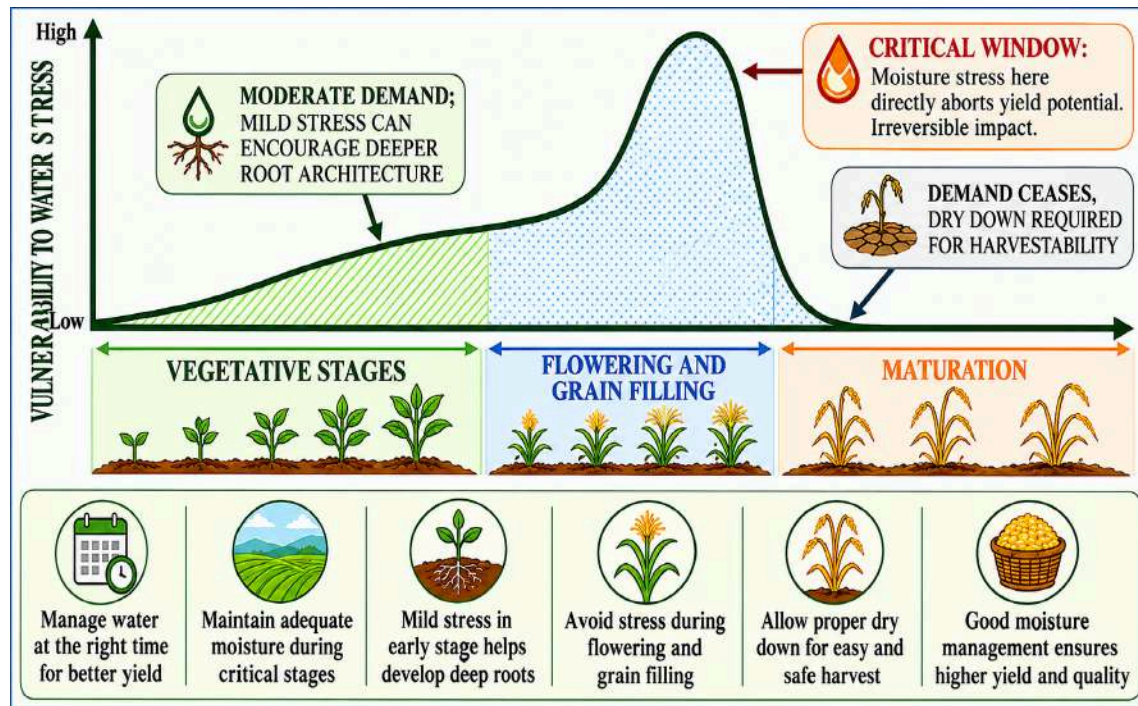


2.3. Intercultural Operation



3. Field Crop Management Practices

3.1. Crop Water Requirement



3.2. Nutrient Management

1 BALANCED FERTILIZATION



- Use the right balance of Nitrogen (N), Phosphorus (P) and Potassium (K).
- Avoid overuse of one nutrient.
- Follow recommended doses for each crop.

Balanced nutrition improves yield and soil health.

2 USE OF ORGANIC MANURE



- Apply Farmyard Manure (FYM), compost or green manure.
- Improves soil structure and water retention.
- Enhances long-term soil fertility.

Apply before land preparation.

3 SOIL TESTING



- Test soil every 2–3 years.
- Helps identify nutrient deficiencies.
- Guides correct fertilizer use.

Saves cost and prevents over-fertilization.

4 RIGHT TIME OF APPLICATION

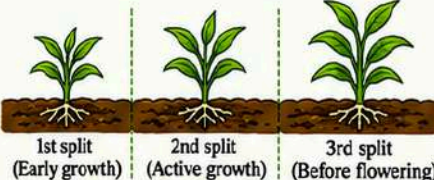


BASAL APPLICATION
Before or at sowing (mainly P & K)

TOP-DRESSING
During crop growth (mainly N)

Apply nutrients when crops need them most.

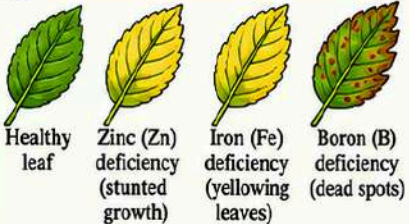
5 SPLIT APPLICATION OF FERTILIZERS



- Apply nitrogen in 2–3 splits.
- Reduces nutrient loss and improves efficiency.

Especially important for maize, rice and wheat.

6 MICRONUTRIENT MANAGEMENT



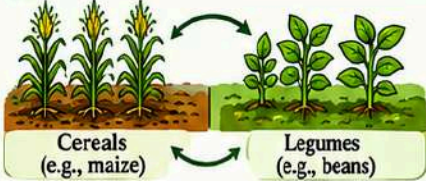
- Watch for deficiency symptoms.
- Apply micronutrients when needed.

7 INTEGRATED NUTRIENT MANAGEMENT (INM)



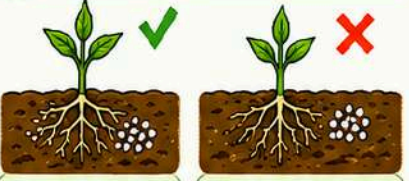
- Combine chemical fertilizers, organic manure and biofertilizers.
- Maintains soil fertility and sustainability.

8 CROP ROTATION



- Rotate cereals with legumes.
- Legumes fix nitrogen and improve soil fertility.

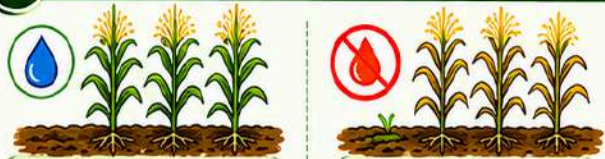
9 PROPER PLACEMENT OF FERTILIZER



Place fertilizer near the root zone.

Avoid direct contact with seeds.

10 WATER AND NUTRIENT MANAGEMENT



Adequate moisture helps nutrient absorption.

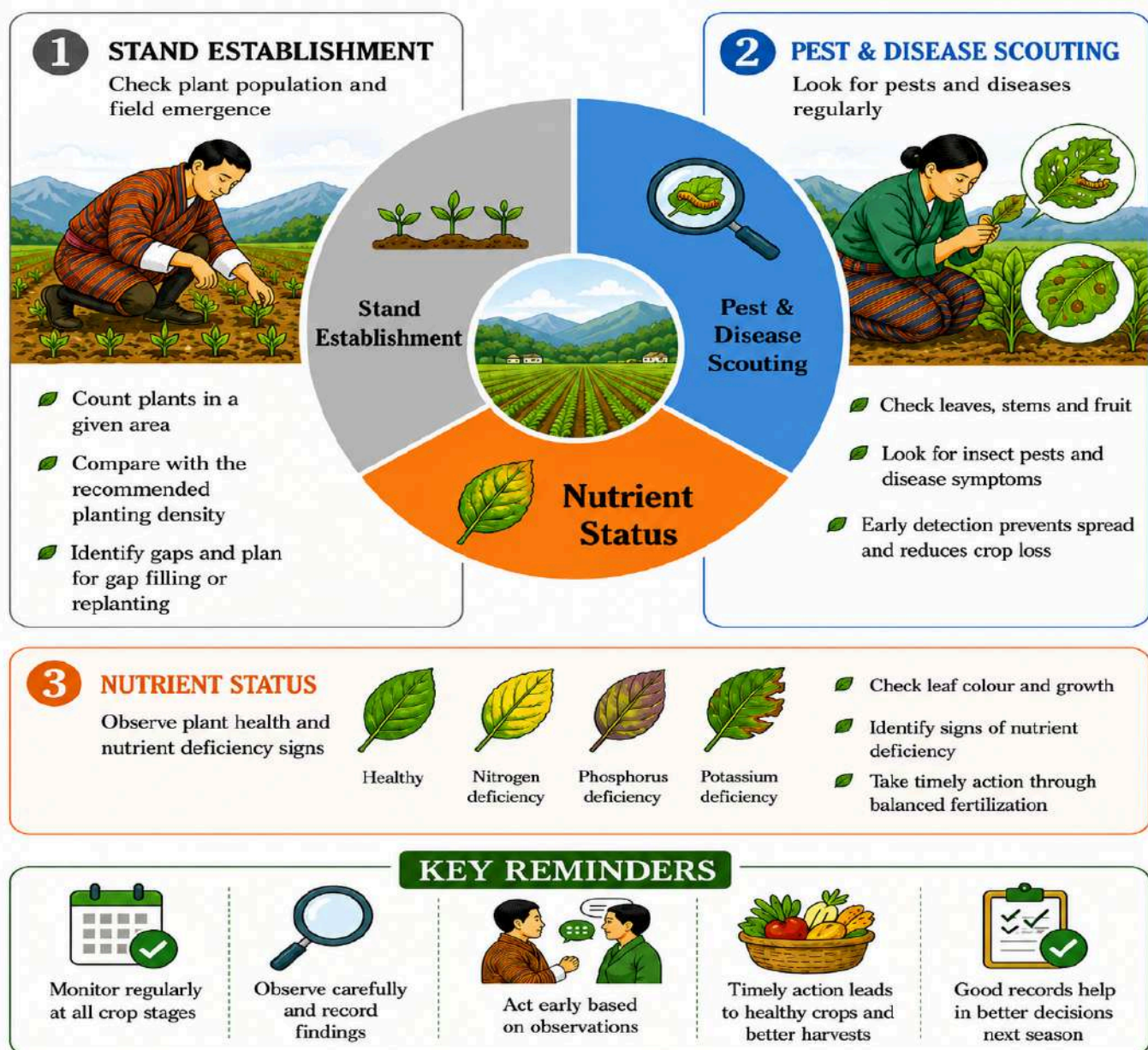
Avoid waterlogging and drought stress.



- Check soil
- Use organic + chemical fertilizers
- Apply at correct stages
- Observe crop response

3.3. Field Monitoring and Inspection

Regular field monitoring helps farmers detect problems at an early stage and take timely corrective action to maintain healthy crops and achieve better yields. The following are the key aspects that need to be monitored:



Session Four: Mushroom Production and Management Techniques

Time:	4 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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This session aims to equip participants with advanced technical and managerial competencies in commercial mushroom production, focusing on shiitake and oyster cultivation using log-, straw-, and sawdust-based systems. It introduces market-oriented, climate-resilient production practices alongside innovative technologies such as Internet of Things (IoT)-enabled climate control systems for efficient, year-round production. Participants will gain practical skills in substrate preparation, pest and disease management, and post-harvest handling to enhance productivity and product quality. By promoting high-value mushroom enterprises, this training supports income diversification, rural employment generation, and youth engagement in agribusiness.

Session Content:	1. Introduction to Mushroom Biology 2. Shiitake Mushroom Production Techniques 3. Oyster Mushroom Production Techniques 4. Sawdust-based Mushroom Production Techniques
-------------------------	---

Materials Required

Shiitake spawn, Oyster mushroom spawn, wax, logs, rosin, rubber band, plastic bags, metallic drum, plastic sheet, rice bran

INFORMATION

Why Grow Mushrooms?

Mushrooms are nutritious, easy to grow, and can provide both food and income. They are rich in protein, vitamins, minerals, and fibre, while being low in fat. Mushrooms grow on agricultural wastes such as straw, sawdust, and wood logs, require little land and low investment, and produce a harvest within a short time.

1. Mushroom Biology

1.1. Types of Mushrooms

There are three types of mushrooms. Only one type can be grown by farmers.

Type	Where it grows	Can you grow it?
Saprophytic	On dead straw, sawdust, or wood	Yes — this is what you will grow
Mycorrhizal	On roots of living trees in forests	No
Parasitic	On living trees, can cause disease	No

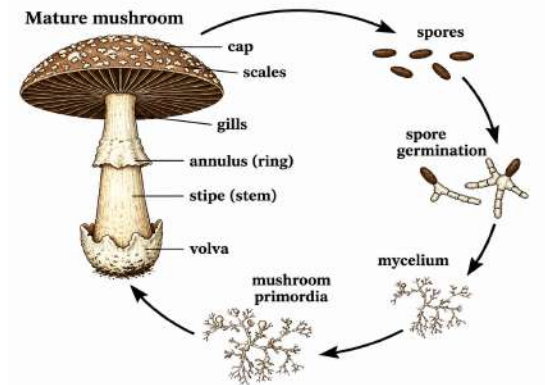
Examples you can grow: Oyster, Shiitake, Button mushrooms.

1.2. Parts of a Mushroom

- **Mycelium** – white thread-like growth. This is like the roots. If it's thick and white, it's healthy.
- **Cap** – the top part of the mushroom.
- **Gills** – thin lines under the cap.
- **Stem** – holds up the cap.

1.3. How Mushrooms Grow

1. A spore (like a seed) lands on straw, sawdust, or wood.
2. It grows into white mycelium.
3. The mycelium spreads through the material.
4. When conditions are right, mushrooms appear.
5. You harvest the mushrooms.
6. New spores are released, and the cycle starts again.



To grow well, mushrooms need three things:

- Moisture
- Fresh air
- The right temperature

Common mistakes to avoid:

- Using old or dirty straw/sawdust without preparing it properly
- Growing in a space with poor airflow or too much sun
- Picking mushrooms too late, after the cap opens
- Not cleaning the growing area between batches

2. Cultivation Methods of Different Mushrooms

A. Shiitake Mushroom

Shiitake (*Lentinula edodes*) is one of the world's most popular edible mushrooms. It grows naturally on hardwood and can be cultivated on logs or supplemented with sawdust.

1. Growing Conditions

Factor	Requirement
Temperature	18–25°C (spawn run); 12–20°C (fruiting)
Humidity	85–95%
Light	Indirect light (500–1,000 lux)
Ventilation	Good fresh air exchange
pH	5.5–6.5

2. Infrastructure and equipment requirements

a. Mushroom Shed

A well-designed mushroom shed is essential for successful shiitake cultivation. It should provide a clean, controlled environment with separate incubation and fruiting rooms to ensure optimal conditions for mycelial growth and mushroom production. The shed can be built from locally available materials or modern insulated panels.

Size and structural type depend entirely upon log volume and geographic location.

Large Corrugated Shed



Mud & Bamboo Structure



Slatted Bamboo & Timber Shed



Insulation
between roof
and ceiling



Active
ventilation
required



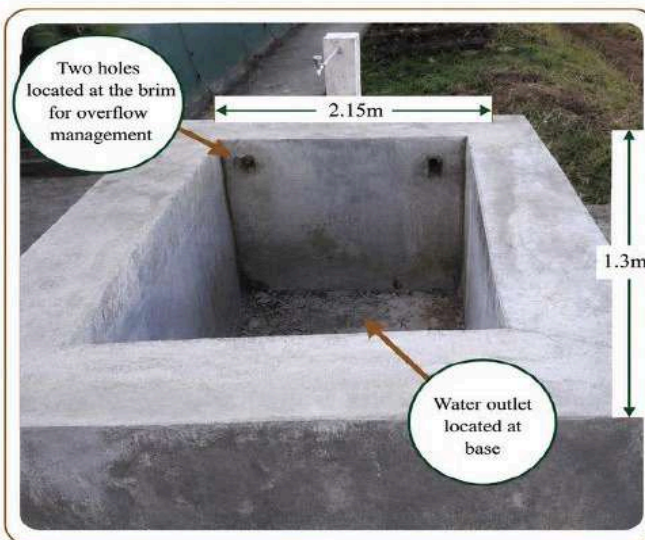
Proper
drainage
facility



Secure roofing
and structured
flooring

b. Soaking Tank

A soaking tank is essential for hydrating substrate blocks or logs before fruiting and for rehydrating them between successive flushes. The recommended design and construction specifications of the soaking tank are provided below.



Placement: Construct immediately adjacent to the cropping shed for efficient transfer.

c. Raw material requirement



3. Procedure of shiitake mushroom production

A. Log collection and cleaning



Target Species: *Oak*

Sharchop:

Bainangshing, Beytsegnangshing,
Thongpashing, Tshaeshing

Dzongkha:

Shishi, Ghum, Bijshing, Soekay

Log Dimensions:

Diameter:
6–20cm

Strict Length:
1m

B. Drilling



Chemistry Formula:

Mixture: 4kg Wax + 1kg Rosin
= Yields 200 Logs

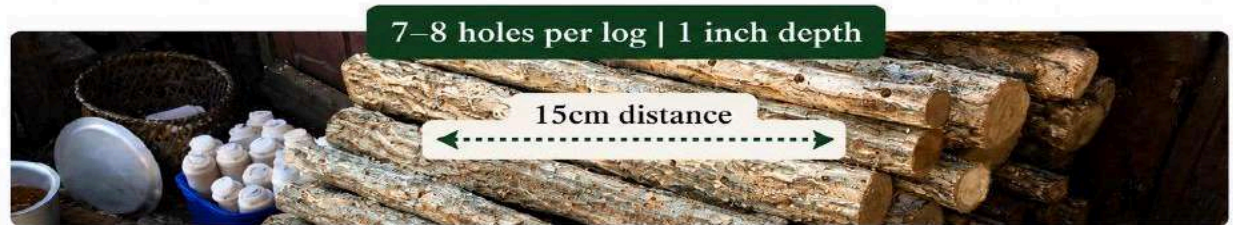


Required Temp: 110°C – 120°C



Apply thoroughly. Avoid half-fill waxing
to ensure a complete environmental seal.

C. Waxing



7-8 holes per log | 1 inch depth

15cm distance



Injecting spawn



Spawning tool application

Process Rules:

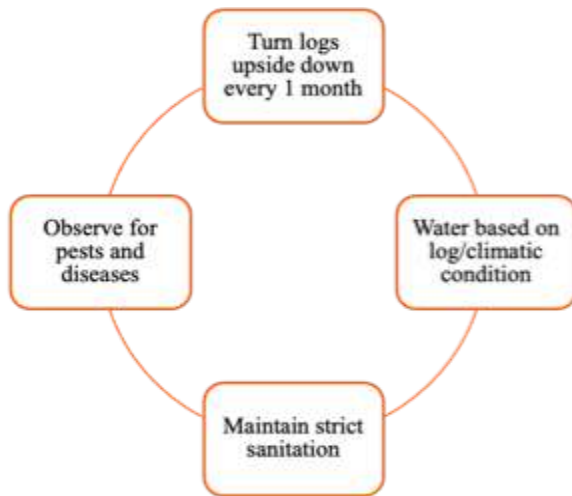
- Inject spawn tightly into the bored holes.

 **Strictly avoid** half-filled holes or over-spawning to prevent early contamination.

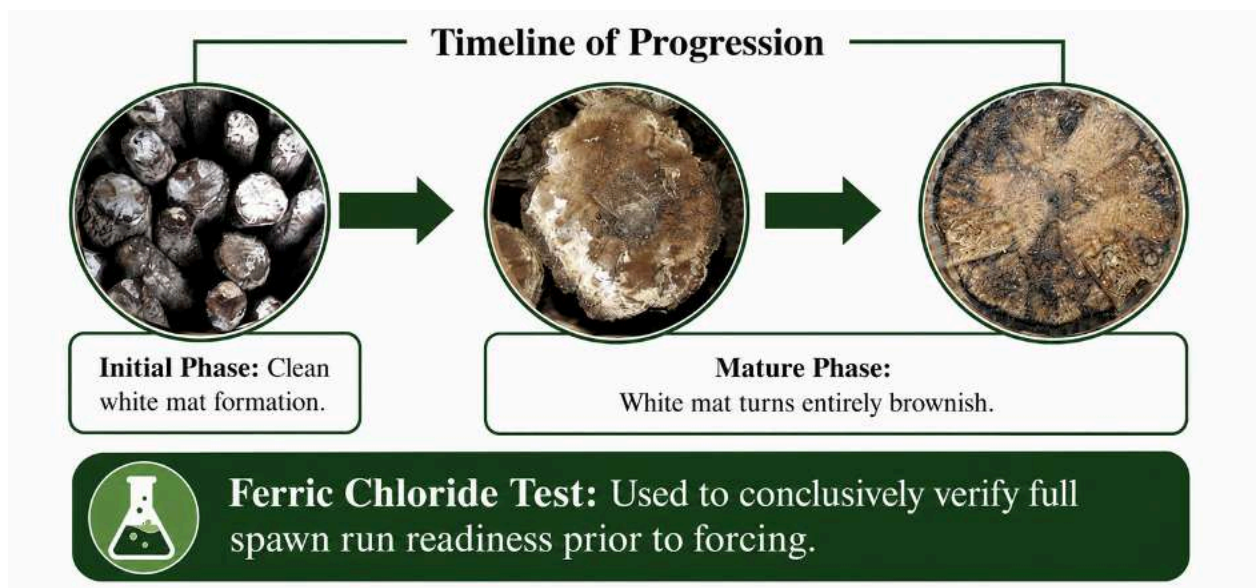
D. Incubation



Management in incubation



Inspection of mycelium run



4. Signs of high moisture content

Alert Matrix		
		
Symptom 1: Spawn prematurely coming out of the billet.	Symptom 2: Severe bark damage and rot compromises moisture retention.	Symptom 3: Unwanted living shoot development draining energy from the billet.

5. Soaking of log

Before Forcing: Dry Log Stacking 		After Forcing: Submerged Logs 
Duration: 24 Hours Mechanism: Fully immerse the billet under water to give a sudden thermal and hydration shock to the fungus, activating the fruiting cycle.		

6. Stacking



Square Shape Stacking

Dense, stable grid for airflow.



V-Shape Stacking

Tent-like arrangement for drainage.



Harvest Validation

Proper stacking ensures optimal airflow, humidity control, and physical space for fruiting bodies to emerge unhindered.

7. Resting



B. Oyster Mushroom Production

Oyster mushroom (*Pleurotus* spp.) is one of the easiest and most profitable mushrooms to cultivate because it grows quickly on agricultural wastes such as paddy straw, wheat straw, maize stalks, sugarcane bagasse, and sawdust.

1. Growing Conditions

Factor	Requirement
Temperature	20–28°C (spawn run); 18–25°C (fruiting)
Humidity	85–95%
Light	Indirect light (avoid direct sunlight)
Ventilation	Good fresh air exchange
pH	5.5–6.5

2. Materials required

- 1) Quality oyster mushroom spawn
- 2) Clean, dry paddy or wheat straw
- 3) Polythene bags (40–60 cm long)
- 4) Clean water
- 5) A clean growing room with good ventilation

3. Cultivation Procedure

PHASE 1: RAW MATERIAL PREPARATION

1



Chop straw
at 4–7 cm

2



Fill in
the jute sack

3



Soak for
15 minutes

4



Drawn out the
excess water

PHASE 2: STERILIZATION AND COOLING

5



Entangle 3 woods to
prevent direct contact
of sack with water

6



Steam for minimum
1 hr 30 min after
bulging plastic sheet

7



Spread on clean
sheet for cooling

8



Inoculation in
layer wise

PHASE 3: SPAWNING, INCUBATION AND FRUITING

9



Layer by layer
spawning

10



Incubating for
1 month

11



Fruit body formation
after colonization

12



Matured
fruit body

KEY POINTS

- ✓ Maintain cleanliness at every step.
- ✓ Sterilization is critical to eliminate contaminants.
- ✓ Handle gently to avoid contamination.
- ✓ Ensure proper moisture: not too wet, not too dry.
- ✓ Incubate in a dark, cool and well-ventilated place.
- ✓ Patience during incubation ensures good yield.

4. Common Disease in Cultivated Mushroom



Green Mold



Hypoxylon sp.



Schizopora sp.



The Golden Rule of Prevention: Mushroom production requires a properly constructed shed, rigorous sanitation, and the maintenance of optimum humidity and temperature throughout the entire incubation period.

COURSE THREE: SOIL FERTILITY AND PLANT HEALTH MANAGEMENT

This course is intended to provide essential knowledge and practical skills in sustainable crop production, covering integrated soil fertility and nutrient management (conventional and organic), integrated pest management, efficient water and irrigation management, and fruit thinning and bagging techniques. It introduces sustainable land management practices, pest and disease control using integrated approaches, and efficient use of water resources, while also emphasising methods to improve fruit quality and yield through proper thinning and bagging practices.

Objectives

The objectives of this course are:

- To develop an understanding of integrated soil fertility and plant nutrient management (conventional and organic)
- To build skills in applying integrated pest management (IPM) for sustainable crop protection
- To promote efficient water use and appropriate irrigation practices
- To enhance knowledge of fruit thinning and bagging techniques for better yield and quality
- To encourage the adoption of environmentally friendly and sustainable farming practices
- To improve overall crop productivity and long-term soil health

Teaching Approach

To impart the intended knowledge and skills to the participants, resource persons are required to apply the following teaching approaches:

- Provide theoretical concepts using relevant presentation slides and visual aids.
- Discussion to understand and capture field issues.
- Demonstrate the plant protection, soil fertility and plant nutrient management practices.
- Provide adequate hands-on practice/training.

Expected Outcome

At the end of the course, the participants are expected to:

- Understand and apply integrated soil and crop health management practices.
- Gain hands-on experience on integrated soil and crop health management practices, including fruit thinning techniques and efficient water/irrigation management technologies.
- Identify soil and crop health problems, apply suitable management strategies and disseminate knowledge and skills learned through the training to other farmers in their community.

Course details

The detailed content of the module is described in the following sessions below.

Session One: Soil Fertility Management

Time:	4 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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This session is divided into four sub-sessions: Integrated Soil Fertility Management (ISFM), Conventional Soil Fertility Management Practices, Organic Soil Fertility Management Practices, and Sustainable Land Management (SLM). The session aims to equip participants with the knowledge and skills needed to manage soil fertility and enhance agricultural productivity effectively.

Session Content:	1. Principles of Integrated Soil Fertility and Plant Nutrient Management 2. Soil Fertility Management in Conventional Practices 3. Soil Fertility Management in Organic Practices 4. Sustainable Land Management (SLM) Practices
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Materials Required

Hedge planting materials, stones, saws, knives, wooden logs, bamboo, cow dung, cow urine, leaves and twigs, earthworms, shovel, spade, mulching plastic sheets, Effective Micro-organisms (EM) solution & biochar.

INFORMATION

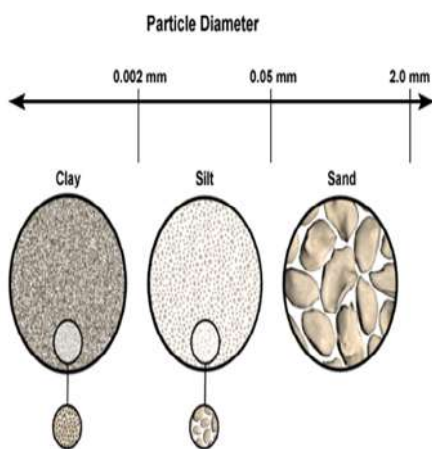
1. Understanding Soil and Soil Fertility

Soil is the foundation of crop production. It supports plant growth by supplying nutrients, water, and air, and by providing a habitat for the organisms that maintain its fertility. Soil fertility depends on nutrient content, structure, biological activity, moisture, and how the soil is managed over time.

1.1. Components of Soil

Agricultural soil typically contains 45% mineral matter, 5% organic matter, 25% water, and 25% air, though proportions vary with soil type, management, and conditions.

Mineral matter consists of sand, silt, and clay, which determine soil texture. Loam is the most suitable soil for growing most crops.



Organic matter comes from compost, farmyard manure, and plant residues. It improves soil fertility, structure, and water-holding capacity, and supports beneficial soil organisms.

Soil water dissolves and carries nutrients to plant roots, supports photosynthesis, and helps plants remain healthy and upright.

Soil air supplies oxygen to plant roots and soil organisms. Poor aeration can lead to waterlogging, poor root growth, and disease.

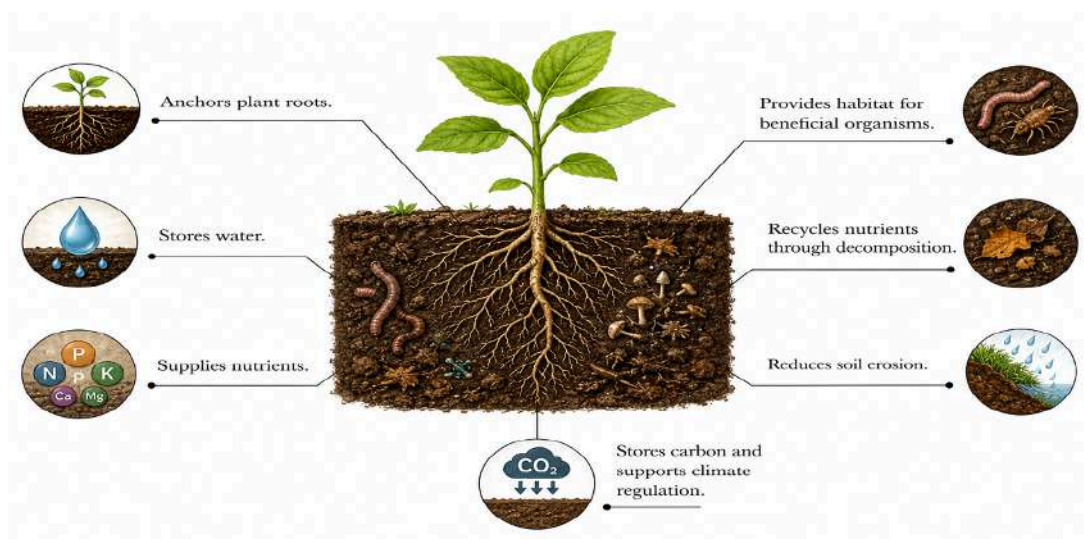
Soil organisms, such as earthworms, bacteria, fungi, and insects, break down organic matter, recycle nutrients, and improve soil structure. Earthworms also increase soil aeration and drainage.

1.2. Soil Fertility vs. Soil Health

Soil Fertility	The ability of soil to supply essential nutrients in adequate, balanced, and available forms throughout the season to support optimal plant growth and yield.
Soil Health	The capacity of soil, as a living ecosystem, to support plants, animals, and humans through balanced physical, chemical, and biological functions.

****A soil may be fertile because fertilisers are applied, but if it has little organic matter, poor structure, or few living organisms, it is not considered healthy. Sustainable farming requires both fertile and healthy soil.*

1.3. Functions of Soil in Crop Production



1.4. Soil Properties Affecting Fertility

Property	Examples	Importance
Physical	Texture, structure, porosity	Influences root growth, water movement, and aeration.
Chemical	Soil pH, nutrient content	Determines nutrient availability to crops. Most crops grow well at pH 6.0–7.0.
Biological	Organic matter, earthworms, beneficial microorganisms	Improves nutrient cycling, soil structure, and disease suppression.

1.5. Essential Plant Nutrients

Plants require essential nutrients for growth, development, and yield formation. These nutrients are classified into macronutrients (primary), secondary nutrients, and micronutrients.

1.5.1. Macronutrients

Nutrient	Main Function	Deficiency Symptoms
Nitrogen (N)	Promotes green leafy growth and protein formation.	Older leaves turn yellow; plants become stunted.
Phosphorus (P)	Promotes root growth, flowering, and seed development.	Poor root growth; leaves become dark green or purplish; delayed maturity.
Potassium (K)	Improves disease resistance, water use, and crop quality.	Yellow or brown leaf edges; weak stems; poor drought tolerance.

1.5.2. Secondary Nutrients

Required in moderate amounts:

- Calcium (Ca) – strengthens cell walls and root growth
- Magnesium (Mg) – essential component of chlorophyll and photosynthesis
- Sulphur (S) – involved in protein formation and enzyme activity

1.5.3. Micronutrients

Required in small quantities but essential: Zinc (Zn), Iron (Fe), Manganese (Mn), Copper (Cu), Boron (B), Molybdenum (Mo), Chlorine (Cl). The following image shows the deficiency symptoms of essential nutrients in maize.

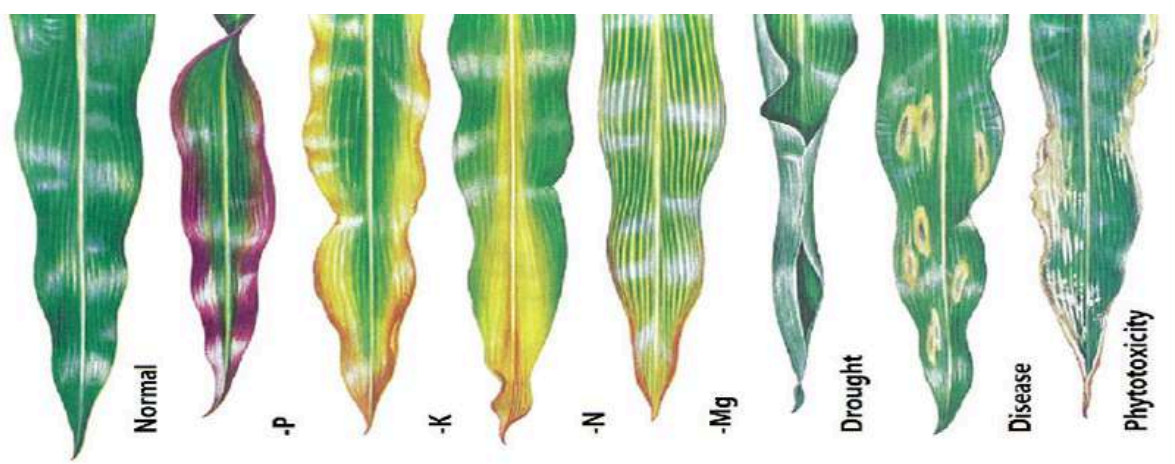


Figure 8: Visual Identification Guide for Maize Leaf Deficiency and Stress Symptoms (Source: International Plant Nutrition Institute)

2. Integrated Soil Fertility Management (ISFM)

Integrated Soil Fertility and Plant Nutrient Management combines organic, mineral, and biological inputs with improved practices to sustain soil fertility, enhance nutrient efficiency, and increase crop productivity.

2.1. Four Pillars of ISFM

1 Use organic sources of nutrients • Farmyard manure (FYM) • Compost • Green manure • Crop residues	 Farmyard manure (FYM)	 Compost	 Green manure	 Crop residues
2 Apply chemical fertilizers wisely • Use recommended fertilizer rates. • Apply fertilizers based on soil test results whenever possible. • Split nitrogen fertilizer into two or more applications.				
3 Improve crop and soil management • Use improved crop varieties. • Practice crop rotation. • Maintain proper plant spacing. • Control weeds, pests, and diseases.				
4 Protect and conserve the soil • Reduce soil erosion. • Maintain ground cover. • Minimize nutrient losses. • Improve water management.				

2.2. Benefits of ISFM

- Improve soil fertility and soil health.
- Increase crop yields and quality.
- Reduce fertilizer losses.
- Improve water-holding capacity.
- Increase beneficial soil organisms.
- Reduce production costs over time.
- Protect the environment.

3. Soil Testing and Diagnosis

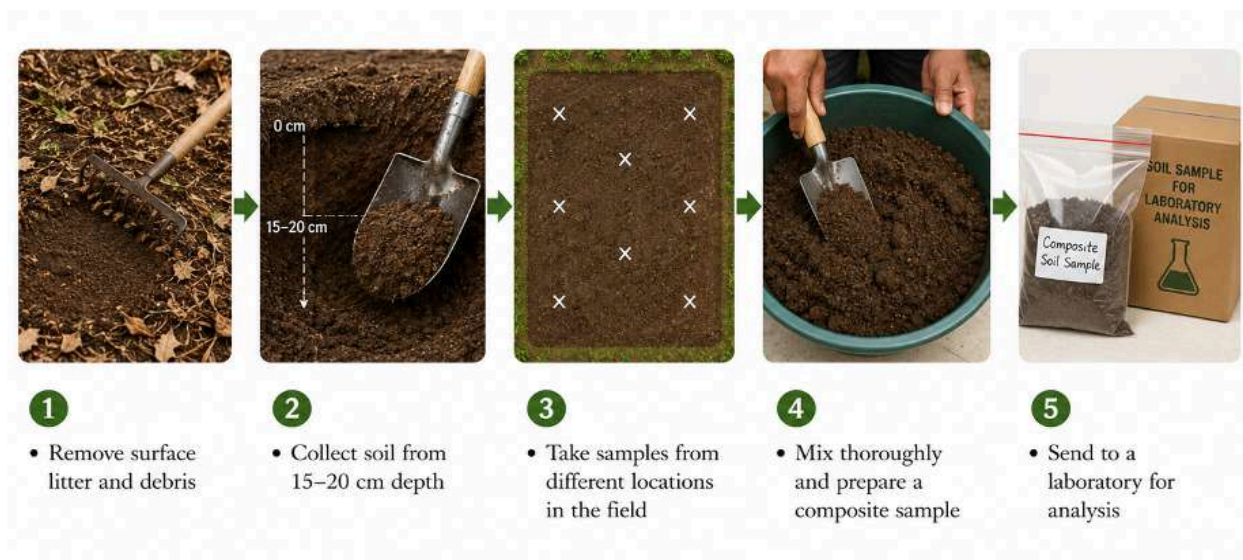
Soil testing helps farmers determine nutrient levels and fertilizer requirements. Soil testing services are available at the National Soil Services Centre (NSSC), Thimphu, while NPK analysis is also conducted by the Agriculture Research and Development Centres (ARDCs).

3.1. Why Test Soil?

- To identify nutrient deficiencies
- To avoid unnecessary fertiliser use
- To improve crop productivity and soil health

***Soil testing involves collecting soil samples from the field and analysing them in a laboratory.

3.2. Soil Sampling Procedure



4. Principles of Nutrient Management

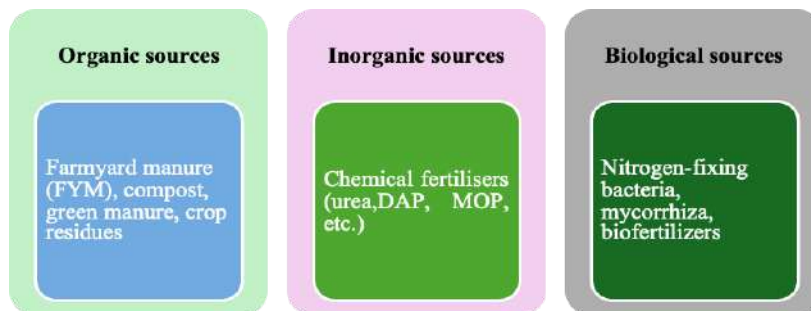
Nutrient management involves supplying plants with balanced and timely nutrients to achieve sustainable yields while maintaining soil health.

Key principles include:

- Balanced application of nutrients based on soil test results
- Integration of organic and inorganic nutrient sources
- Application of nutrients according to crop growth stages
- Minimising nutrient losses through proper management practices

4.1. Sources of Plant Nutrients

Plant nutrients come from both natural and external sources:



4.2. Methods of Fertiliser Application

Broadcasting	Spreading evenly across the soil surface; suited to basal dressing before sowing.
Band placement	Placing fertilizer near the root zone; improves uptake efficiency for phosphorus in particular, since P does not move far in soil.
Fertigation	Applying dissolved fertilizer through irrigation water.
Foliar application	Spraying nutrients (often micronutrients) directly onto leaves for fast correction of deficiency.

4.3. Timing of Application

Term	Meaning	Best suited fertilizers
Basal dressing	Applied at or before sowing/planting.	Slow-release types: SSP, MoP, Suphala.
Top-dressing	Applied to a standing crop during the season.	Fast-dissolving types: Urea.
Split application	Applied in two or more doses at different growth stages to reduce losses from leaching or volatilisation.	Especially Urea, particularly on light soils or in high-rainfall areas.

4.4. Crop-Specific Nutrient Management

Different crops require varying nutrients: rice needs high nitrogen, maize needs balanced NPK, and vegetables need higher inputs. Proper timing improves root, leaves, and yield formation. For details on crop-specific nutrient requirements, refer to the fertiliser recommendation guide for important crops published by NSSC.

5. Conventional Soil Fertility Management

Conventional soil fertility management relies mainly on chemical fertilisers. However, fertilizer application is often based on experience rather than soil testing, causing nutrient imbalances. Continuous use without adequate organic inputs has reduced soil organic matter, structure, water retention, and biological activity. High rainfall and steep terrain increase nutrient losses, highlighting the need for integrated, balanced, site-specific nutrient management.

5.1. Commonly Available Chemical Fertilisers in Bhutan

Fertilizer	Nutrient supplied	Nutrient content
Urea	Nitrogen (N)	46% N
Single Super Phosphate (SSP)	Phosphorus (P ₂ O ₅)	16% P ₂ O ₅
Triple Super Phosphate (TSP)	Phosphorus (P ₂ O ₅)	45-48% P ₂ O ₅
Muriate of Potash (MoP)	Potassium (K ₂ O)	60% K ₂ O
Suphala (compound fertilizer)	N, P ₂ O ₅ , K ₂ O together	15:15:15
CAN (Calcium Ammonium Nitrate)	Nitrogen (N)	26% N

Urea, SSP/TSP, and MoP each supply one major plant nutrient. By using the right combination of these fertilisers, farmers can provide crops with the exact nutrients they need. This method is usually more flexible and economical than using only a compound fertilizer such as Suphala.

In Bhutan, chemical fertilisers are supplied through a government-managed distribution system. The Government centrally procures fertilisers and distributes them to farmers through authorised Agricultural Service & Sales Representatives (ASSR). The fertiliser distribution process is shown in the figure below.



*** Contact your Agriculture Service and Sales Representative (ASSR) for chemical fertiliser requirements.

6. Organic Soil Fertility Management

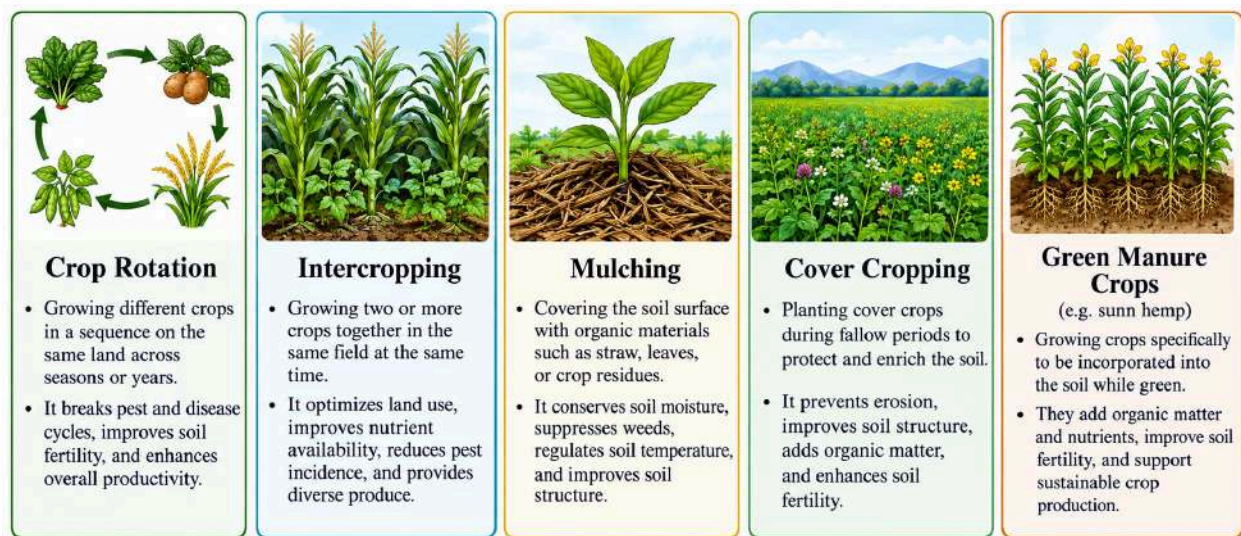
Organic soil fertility management means keeping the soil healthy by using natural materials instead of chemical fertilisers. Healthy soil produces healthy crops, improves water retention, supports beneficial soil organisms, and maintains productivity for many years.

Organic soil fertility can be improved through:

- Cultural practices
- Organic fertilizers
- Biofertilizers

6.1. Cultural Method

Cultural methods improve soil fertility through good farming practices. The common practices are as given below:



Benefits

- ★ Improves soil fertility
- ★ Conserves moisture
- ★ Reduces soil erosion
- ★ Increases soil organic matter
- ★ Reduces weed growth

6.2 Organic Fertilizers

A. Compost

Compost is made by allowing organic materials to decompose naturally. It supplies nutrients, improves soil structure, and increases soil organic matter.

Compost preparation

<i>Materials required</i>	5. Green biomass – 1,000 kg (nitrogenous)
	6. Dry Biomass – 1,000 kg (carbonaceous)
	7. Cow dung – 25 kg
	8. Water - 100 L

Steps for preparation of Heap Compost

★ Step 1: Demarcate an area of 2 m wide × 3 m long. Depending on material availability, the length of the heap can be extended.
★ Step 2: Place a layer of stones or wooden logs within the demarcated area as the basal layer to provide aeration.
★ Step 3: Prepare a dung slurry by mixing 25 kg of dung in 100 L of water. Spread a layer of dry biomass uniformly up to a height of 30 cm and moisten it with the dung slurry.
★ Step 4: Spread green biomass on top of the dry biomass layer and moisten it with the dung slurry.
★ Step 5: Continue laying alternate layers of dry and green biomass until the heap reaches a height of 1-1.5 m.
★ Step 6: Once the desired height is reached, cover the heap with soil or straw.
★ Step 7: To minimise nutrient loss through volatilisation, prepare the heap in a shaded area. Depending on the temperature, the compost will be ready in 2–3 months.

<i>Good compost should be</i>	<u>Benefits</u>
• Dark brown or black • Soft and crumbly • Earthy smell • No visible undecomposed materials	• Improves soil fertility • Increases water-holding capacity • Supplies nutrients slowly • Encourages beneficial microorganisms



Figure 9: Preparation of heap



Figure 10: Covering the heap



Figure 11: Mature Compost

B. Vermicompost

Vermicompost is compost produced using earthworms. The worms convert organic materials into nutrient-rich castings.

Vermicompost preparation

<i>Materials required</i>	1. Cattle dung, green and dry leaves (1 MT) 2. Earthworms (1 kg) 3. Wooden/concrete bed (2 m x 1 m x 0.4 M (LBH)) 4. Shovel and spade 5. Jute sack/banana leaves
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Steps

★ Step 1. Prepare the cattle dung Keep fresh cattle dung for 7–10 days to cool and partially decompose before use.
★ Step 2. Prepare the compost bed Make a bed measuring 2 m × 1 m × 0.4 m (L × W × H) using alternate layers of cattle dung and crop residues such as straw, dry leaves, and grasses.
★ Step 3. Cool and moisten the bed Leave the bed for 4–5 days to cool, then sprinkle water to keep it moist (not waterlogged).
★ Step 4. Add the earthworms Release about 1 kg of earthworms evenly over the prepared bed.

★ Step 5. Cover the bed Cover the bed with banana leaves or a jute sack and leave it undisturbed for 2–3 days.
★ Step 6. Maintain the bed Keep the bed moist by sprinkling water regularly and protect it from direct sunlight and heavy rain.
★ Step 7. Harvest the vermicompost After 7–10 days, collect the top layer of vermicompost. Loosen the next layer, cover the bed again, and continue the process.
★ Step 8. Complete the composting Continue harvesting every 7–10 days. The vermicompost will be ready in about 40 days.
★ Step 9. Reuse the earthworms Leave the bottom layer containing earthworms and add fresh cattle dung and crop residues to start a new composting cycle.
★ Step 10. Sieve and store Sieve the harvested vermicompost to remove worms and undecomposed materials. Return the worms to the bed and store the compost in clean bags in a cool, dry place.



Figure 12: Step-by-Step Process for making a Vermicompost (Source: NCOA-Yusipang)

Benefits

- Rich in plant nutrients
- Improves soil structure
- Promotes root growth
- Enhances soil biological activity

C. Jeevamrut (*Rangzhin Luechu*)

Jeevamrut is a fermented liquid biofertilizer prepared from locally available materials. It increases beneficial microorganisms in the soil and improves nutrient availability.

Preparation of Jeevamrut

<i>Materials required</i>	1. Jaggery/brown sugar (6 kg) 2. Butter Milk (20 liters) 3. Cow urine (10 liters) 4. Gram flour/Besan (2 kg) 5. Soil (2 handfuls) 6. Tank (2 Nos.)
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Preparation in 1000 litres production tank

★ Step 1. Mix the ingredients Add all the required ingredients into a fermentation tank and mix them thoroughly.
★ Step 2. Ferment the mixture Allow the mixture to ferment for 5 days, stirring it 2–3 times daily to ensure proper fermentation.
★ Step 3. Filter the solution After 5 days, filter the fermented mixture to remove solid particles and obtain a clear liquid.
★ Step 4. Dilute before use Mix the filtered Jeevamrut with an equal amount of water (1:1 ratio) before applying it to crops.

Tip: *Use the diluted Jeevamrut as a soil drench or through irrigation to improve soil microbial activity and plant growth.*

*** For detailed preparation, refer to the brochure available from the National Centre for Organic Agriculture (NCOA). <https://ncoa.gov.bt/download/3059/?tmstv=1781161344>

D. Bokashi

Bokashi is a fermented organic fertilizer prepared using beneficial microorganisms under airtight (anaerobic) conditions. Rice bran, wheat bran, or buckwheat bran are suitable materials in Bhutan.

Bokashi Preparation

Materials Required

70L or 80L bucket: 1 pc, 2m×2m plastic sheet: 1 sheet,
Used newspapers: 3-4 pcs , Jute rope: 4-5m , Rice bran:
50kg Water: 10L , Sugar: 500g , Natural salt: 50g , Phoo
(Yeast): 1 small spoon , Plain yogurt: 1 large spoon ,Waste
fruit: 100g

Procedure

★ Step 1. Prepare the fermentation solution

Dissolve sugar, salt, yeast (Phoo), plain yogurt, and waste fruits in 10 litres of water and stir well.

★ Step 2. Mix with rice bran

Gradually add the fermentation solution to 50 kg of rice bran and mix thoroughly until evenly moist. Avoid forming lumps.

★ Step 3. Pack the mixture

Fill the mixture tightly into an airtight bucket, press out as much air as possible, and cover the surface with newspaper.

★ Step 4. Seal the bucket

Cover the bucket with a plastic sheet, tie it tightly with jute rope, and place a weight on top to keep it airtight.

★ Step 5. Ferment and check

Store the bucket in a cool, shaded place for fermentation. A pleasant sweet and sour smell (similar to "Ara") indicates successful fermentation, while a foul or rotten smell indicates unsuccessful fermentation.

Benefits

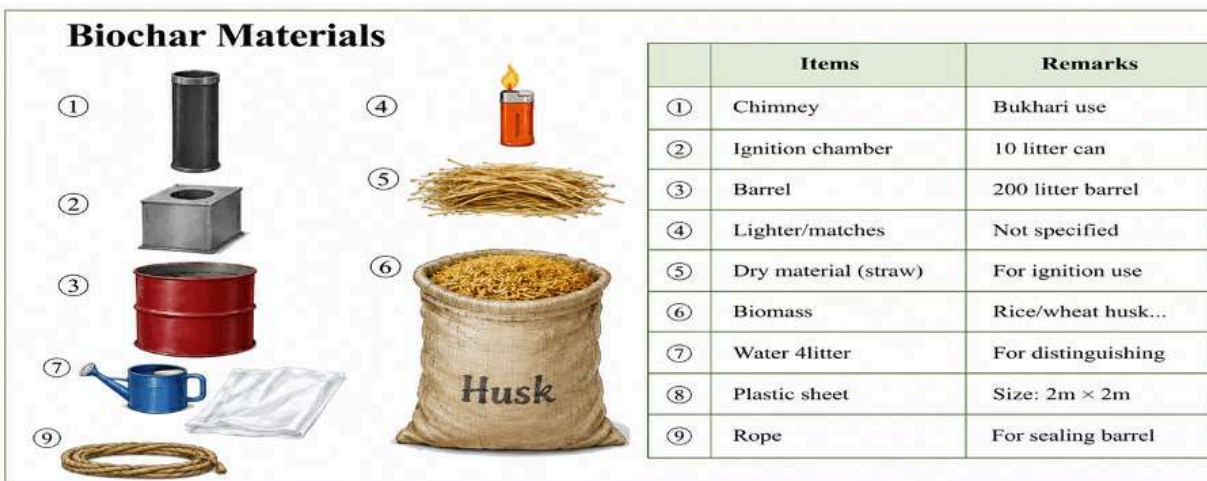
- Supplies nutrients quickly
- Improves soil microbial activity
- Improves soil organic matter
- Easy to prepare using local materials

***Video on Bokashi is available at <https://www.youtube.com/watch?v=sIQtSm17VmQ>

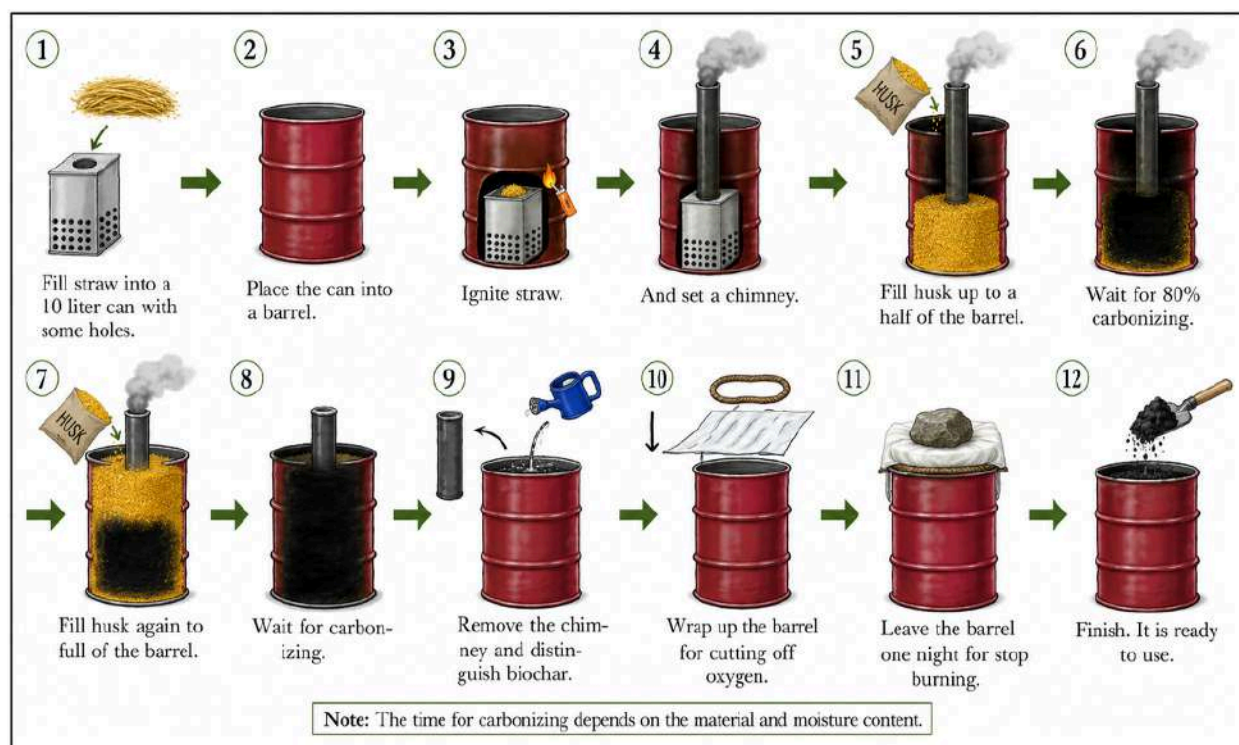
E. Rice Husk Biochar

Biochar is produced by heating rice husk under limited oxygen. It is added to the soil to improve fertility and soil health.

Rice Husk Biochar Preparation



Procedure



***Video on Biochar is available at <https://www.youtube.com/watch?v=V66OpfCholw>

Benefits

- Improves soil structure
- Increases water-holding capacity
- Reduces nutrient losses
- Improves fertilizer efficiency
- Stores carbon in the soil for a long time

7. Sustainable Land Management (SLM) Practices

Sustainable land management (SLM) involves the use of land resources, including soils, water, vegetation and biodiversity, in a way that maintains or enhances productivity while conserving the natural resource base. The different methods of SLM and its benefits are as follows:



Session Two: Plant Protection

Time:	4 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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Plant protection involves preventing and managing pests, diseases, and weeds to protect crop yield, quality, and the environment. This section covers the essential principles and practices for effective, safe, and sustainable plant protection.

Session Content	● Basics of Plant Protection ● Pest Monitoring & Pest Surveillance ● Integrated Pest Management (IPM) ● Spray Calibration & Application ● Safe Use of Pesticides ● Pesticide Safety (PPE) Equipment and Pest Monitoring Kits
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Materials Required

Topic	Essential Equipment and Materials
Safe handling of plant protection chemicals	PPE, first-aid kit, measuring and mixing tools, sprayers, calibration sheet, clean water, soap, and waste bags.
Pest monitoring and sample collection	Pest identification guide, hand lens, sample bags and labels, record book, measuring tools, monitoring traps, and collection tools.

INFORMATION

1. What is Plant Protection?

Plant protection means protecting crops from pests, diseases, weeds, and wild animals so that crops grow healthy and give good yield. It is not only about killing pests, but about:

- Keeping crops healthy
- Reducing crop loss
- Protecting beneficial insects
- Using pesticides only when necessary

Why Plant Protection is Important ?

- ★ Reduces crop loss in the field and storage
- ★ Improves yield and quality
- ★ Ensures farmer income and food security
- ★ Protects human health and environment
- ★ Promotes sustainable farming

1.1. Types of Pests and Problems Caused

A. Insect Pests

Type	Examples	Mode of Damage	Problems Caused
Chewing insects	Caterpillars, beetles	Eat leaves, stems, seedlings	Defoliation, reduced photosynthesis, stunted growth, yield loss
Sucking insects	Aphids, whiteflies, leafhoppers, mites, scale insect, trips	Extract plant sap	Yellowing, curling, weakening, virus transmission
Boring insects	Stem borers, fruit borers, trunk borer	Tunnel inside stems/fruits/grains	Dead hearts, fruit damage, broken stems, direct yield loss
Leaf miners	Leaf miner flies	Feed inside leaf tissues	Reduced leaf function, visible tunnels, reduced vigor



Figure 13: Leaf miner in beans, borer in mango, and fall armyworm in maize showing typical feeding damage symptoms on crops. (Image source: NPPC and ARDC Bajo)

B. Plant Diseases

Type	Examples	Causal Agent / Mode	Problems Caused
Fungal diseases	Blight, powdery mildew, downy mildew, brown spot, clubroot	Fungi infect plant tissues	Spots, rotting, wilting, plant death, yield loss
Bacterial diseases	Wilt, soft rot	Bacteria enter through wounds/stomata	Sudden wilting, decay, collapse of plant
Viral diseases	Mosaic, leaf curl	Virus transmitted by vectors	Stunting, leaf distortion, poor yield
Nematode diseases	Root-knot nematodes	Attack root system	Root galls, poor nutrient uptake, stunting



Figure 14: Powdery mildew on citrus leaves showing white fungal growth (left) and rice blast on rice plants showing characteristic leaf lesions (right) (Image source: NPPC).

D. Weeds

Type	Examples	Mode of Competition	Problems Caused
Grassy weeds	Wild grasses	Compete for nutrients, water, light	Reduced crop yield, poor growth
Broadleaf weeds	Amaranthus, weeds in vegetables	Compete and interfere with crops	Yield loss, contamination of produce
Sedges	Cyperus species	Rapid spread in moist fields	Strong competition, difficult control

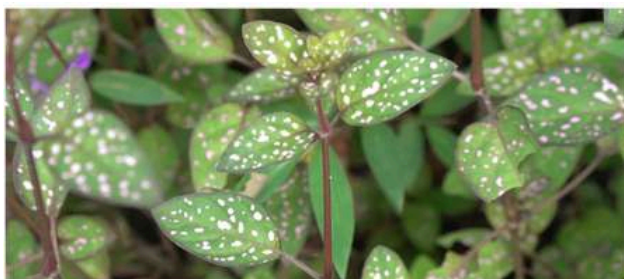


Figure 15: Polka dot plant (Hypoestes phyllostachya) and Parthenium (Parthenium hysterophorus), (Image source: NPPC)

E. Vertebrate Pests

Type	Examples	Mode of Damage	Problems Caused
Rodents	Rats, mice	Feed on grains, stems, storage produce	Field and storage losses, seed damage
Birds	Sparrows	Feed on seeds, grains, fruits	Yield loss, crop destruction at maturity
Wild animals	Boar, deer, monkeys, elephants, Procupine	Feeding and trampling	Severe crop loss, field destruction

2. Pest Monitoring and Surveillance (Core IPM Skill)

2.1. Pest Monitoring (Field Level)

Pest monitoring is the regular inspection of crop fields to detect pests early and inform decision-making.



Figure 16: The officials monitoring pests in the field.

Why is it important?

- Prevents unnecessary pesticide use
- Detects pests before severe damage
- Supports timely control actions

Pest Surveillance (System Level)

Pest surveillance is the organised collection of pest information from multiple fields to:

- Track pest spread
- Detect outbreaks early
- Support regional decision-making

When to Monitor?

At least once per week during cropping season & more frequently during:

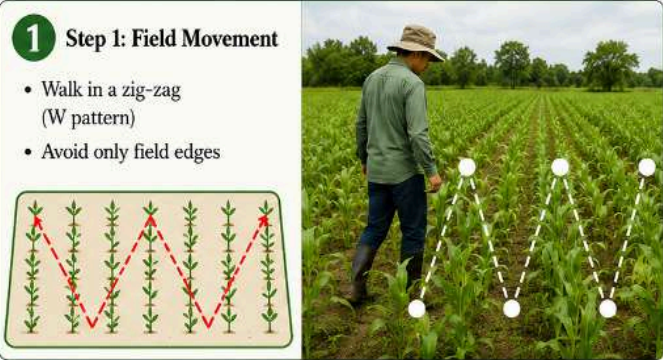
- ★ flowering and fruiting stages
- ★ warm and humid conditions
- ★ outbreak periods

2.2. Field Pest Monitoring: A Step-by-Step Guide

Regular field monitoring is the foundation of effective pest management. By systematically scouting crops, carefully inspecting plant parts, and accurately recording observations, farmers can detect problems early and take timely action to protect crop health and yield.

1 Step 1: Field Movement

- Walk in a zig-zag (W pattern)
- Avoid only field edges



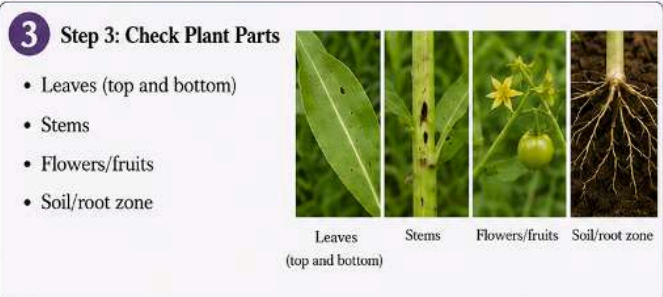
2 Step 2: Plant Sampling

- Inspect 10–20 plants randomly



3 Step 3: Check Plant Parts

- Leaves (top and bottom)
- Stems
- Flowers/fruits
- Soil/root zone



4 Step 4: Record Observations

- Pest type (insect/disease/weed)
- Damage symptoms
- Pest level (low / medium / high)

LOW

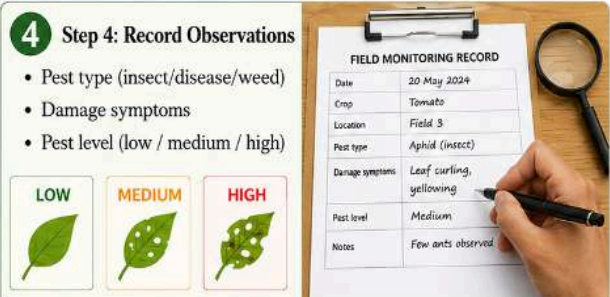


MEDIUM



HIGH





What's Next?



Continue Monitoring
if pest level is low and stable.

→



Apply IPM Actions
if pest population is increasing.

→



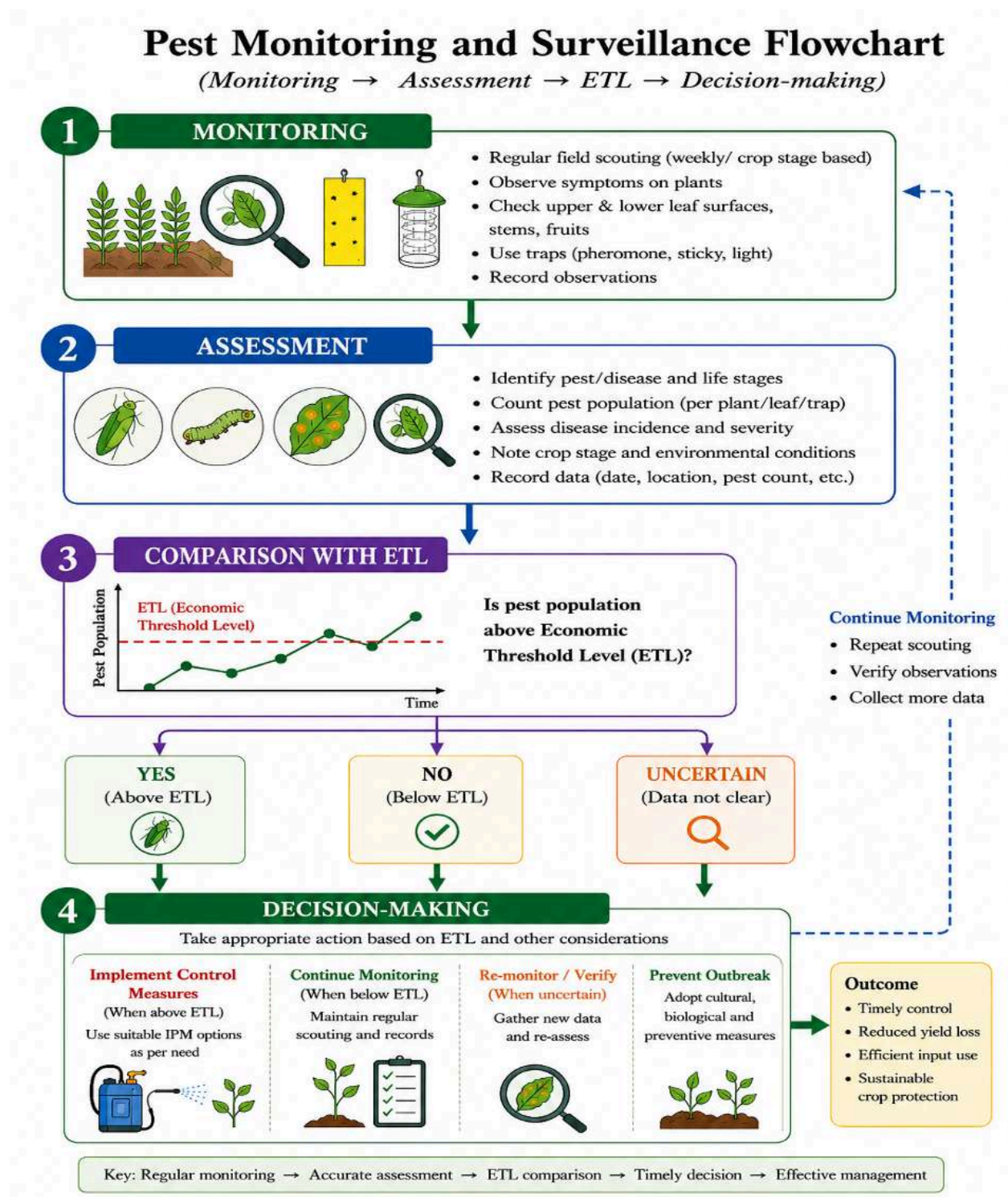
Consider Chemical Control
only when pest level exceeds economic threshold and IPM options are not effective.

→



Regular monitoring helps make better decisions and protects crops and the environment.

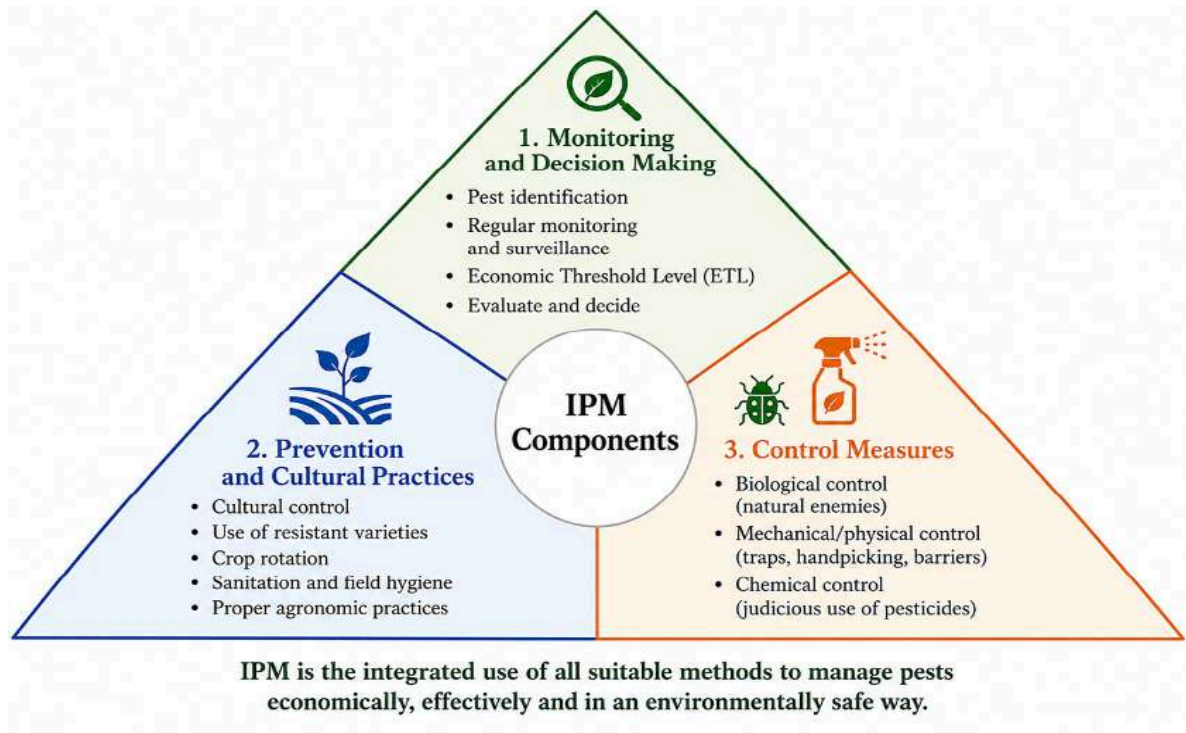
2.3. Pest Monitoring and Surveillance Flowchart



3. Pest Management

The NPPC and ARDCs emphasise the adoption of Integrated Pest Management (IPM) practices for crop protection. IPM combines multiple pest control strategies and promotes the judicious use of pesticides only when necessary.

3.1. Three Pillars of IPM System



3.2. Types of Integrated Pest Management:

A. Cultural Control

These practices are the first line of defence in pest management because they reduce pest establishment and buildup before any chemical or direct control measures are needed.

Cultural control methods prevent pest build-up by using better farming practices.

1. Crop Rotation	2. Clean Field Practices	3. Resistant Varieties	4. Proper Spacing and Planting Time
			
• Rotate crops with different families. • Breaks pest and disease life cycles. • Improves soil health and reduces pest problems.	• Remove crop residues, weeds, and volunteer plants. • Destroy infested plant parts. • Keep field clean to reduce pest shelter and breeding sites.	• Use pest and disease resistant varieties. • Reduces pest damage and yield loss. • Less need for pesticides.	• Maintain proper spacing between plants. • Plant at the right time for the season. • Reduces pest attack and improves plant growth.

B. Mechanical Control

It refers to the direct physical removal, killing, or exclusion of pests using tools, devices, or manual labour.

1. Hand Picking Pests	2. Traps (Light, Sticky, Pheromone)	3. Fencing and Netting	4. Removing Infected Parts
			
• Physically remove pests from plants. • Best for large, visible pests like caterpillars and beetles. • Safe, simple and eco-friendly.	• Light traps attract and trap night-flying insects. • Sticky traps catch insects that land on sticky surfaces. • Pheromone traps attract and trap specific pests. • Helps in monitoring and reducing pest population.	• Fences keep out animals and large pests. • Netting prevents insects, birds and other pests from reaching crops. • Protects crops, especially in nurseries and small vegetable plots.	• Remove and destroy infected leaves, stems, fruits or plants. • Prevents spread of pests and diseases. • Improves plant health and reduces damage.

C. Biological Control

It is the use of natural enemies such as predators, parasitoids, and pathogens to reduce pest populations. In Bhutan, it is a relatively new field, and institutions such as the National Plant Protection Centre (NPPC) and ARDCs are actively working on its development and promotion.



Figure 17: Syrphid fly larva feeding on aphids, a natural biological control agent in crop ecosystems (Image source: NPPC)

D. Botanical Pesticides

Botanical pesticides are pest control products derived from plants and plant extracts that contain natural chemicals toxic, repellent, or disruptive to insects, diseases, or other pests. They are widely used in IPM as a safer alternative to synthetic chemical pesticides. Refer to the Organic Pest Management Section.

E. Chemical Control

It refers to the use of synthetic or natural chemical pesticides to kill, repel, or inhibit pests such as insects, diseases, weeds, and other harmful organisms. In IPM, chemical control is used only as a last resort.

Key Principles of Responsible use of Plant Protection

Chemicals

- ★ Used only when necessary
- ★ Must follow label instructions
- ★ Must follow correct dose and timing
- ★ Overuse should be avoided



Figure 18: Types of Chemical Pesticides Used for Plant Protection (left to right: insecticide, weedicide, fungicide) (Image source: ARDC Bajo)

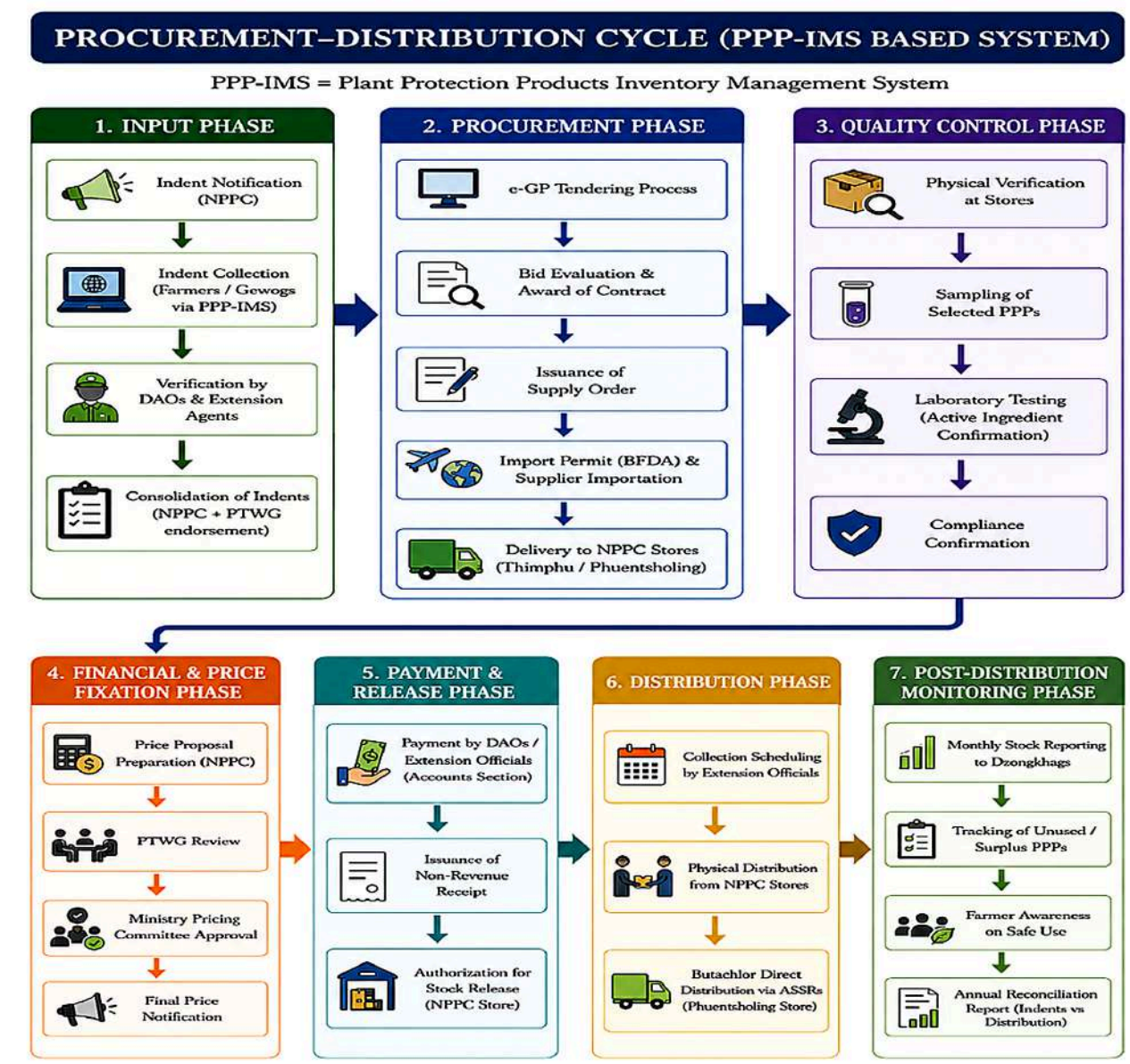
Pesticide Stewardship and Regulatory Control in Bhutan

Pesticides should be used only when necessary and strictly according to label recommendations and field requirements. Unnecessary or excessive application must be avoided to reduce residues, delay resistance development, and prevent accumulation of obsolete stocks. In Bhutan, where pesticide disposal and incineration facilities are not available, careful planning, correct dosing, and Integrated Pest Management (IPM) are essential to minimise excess pesticide use and environmental contamination. For further guidance, refer to the *Safe and Efficient Use of Pesticides Section*

The National Plant Protection Centre (NPPC) is the sole national nodal agency responsible for the procurement and distribution of pesticides in Bhutan, in coordination with Dzongkhags. Only pesticides approved by the Department of Agriculture and endorsed by the Pesticide Technical Working Group (PTWG) are procured and supplied through NPPC.

3.3. Procurement and distribution of Plant Protection Chemicals

The procurement and distribution of plant protection (PP) products are centrally coordinated by the National Plant Protection Centre (NPPC). The overall procurement and distribution process is illustrated in the following diagram.



4. Chemical Spray Considerations

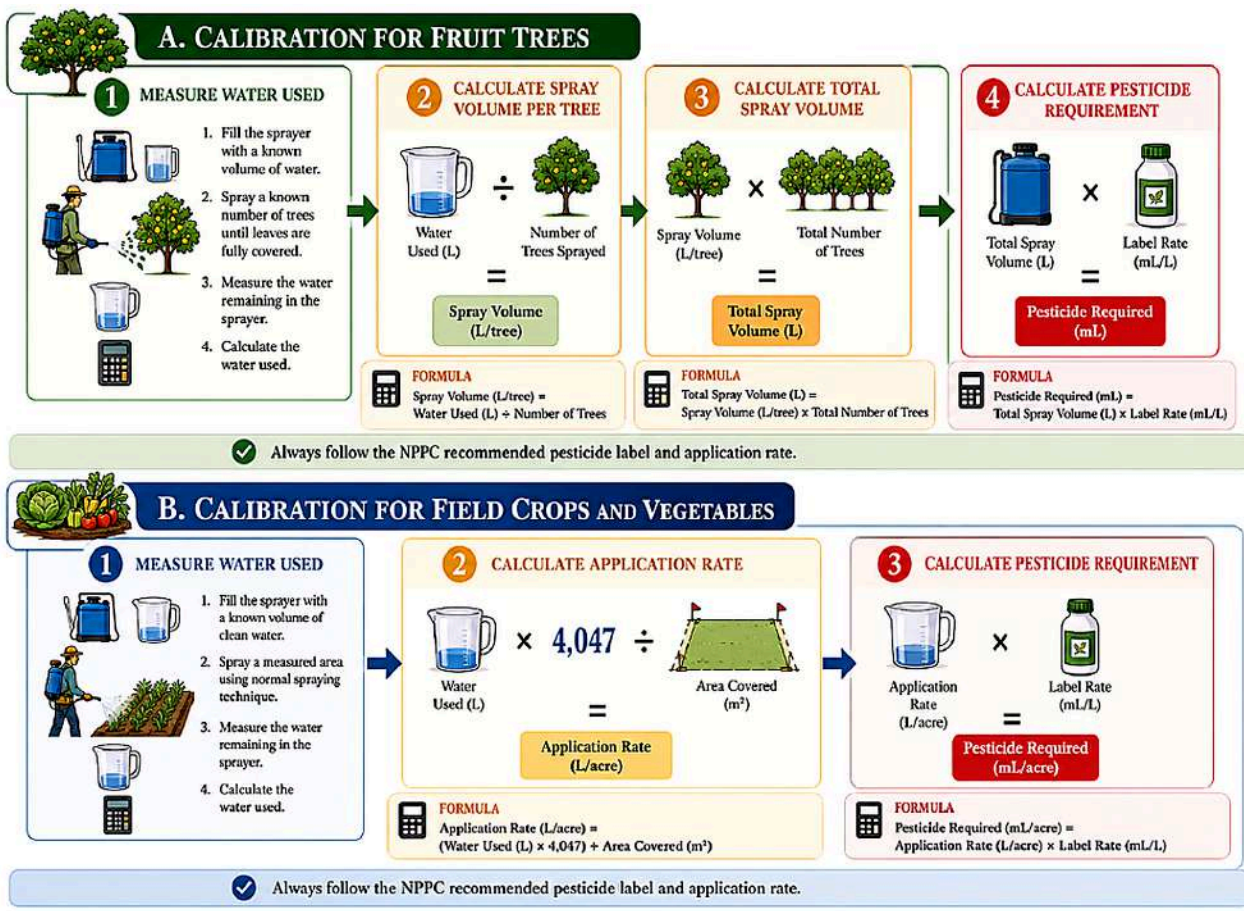


5. Calibration and Application

Calibration is the process of checking and adjusting a sprayer to ensure the correct amount of pesticide is applied to the target crop.

Importance

- ★ Ensures the correct pesticide dose is applied.
- ★ Improves pest control effectiveness.
- ★ Reduces pesticide wastage and costs.
- ★ Prevents crop damage and environmental contamination.
- ★ Enhances operator safety.



5.1 Approved Pesticides and Recommended Application Rates

Category	Product Name	Target Pest/Disease	Application Rate per Acre	Dose per Liter
Insecticide	Chlorpyrifos 20% EC	Soil insects, caterpillars, termites, borers	200–400 L/acre	4 ml/L
Insecticide	Cypermethrin 10% EC	Aphids, caterpillars, beetles, leaf feeders	200–400 L/acre	1 ml/L
Insecticide	Malathion 50% EC	Aphids, fruit flies, sucking insects	200–400 L/acre	2 ml/L
Insecticide	Chlorantraniliprole 18.5% SC	Caterpillars, borers, fall armyworm	60 ml/acre	0.3 ml/L
Insecticide	Emamectin Benzoate 5% SG	Caterpillars, fruit borers, leaf folders	80–100 g/acre	0.2 g/L
Fungicide	Captan 50% WP	Fruit rots, leaf spots, damping-off	200–400 L/acre	2 g/L
Fungicide	Carbendazim 50% WP	Anthrachnose, powdery mildew, leaf spots	200–400 L/acre	1 g/L
Fungicide	Copper Oxychloride 50% WP	Blights, cankers, bacterial leaf spots	200–400 L/acre	1 g/L
Fungicide	Hexaconazole 5% EC	Powdery mildew, rusts, leaf spots	200–400 L/acre	1 ml/L
Fungicide	Mancozeb 75% WP	Early blight, late blight, downy mildew	200–400 L/acre	2 g/L
Fungicide	Sulphur 80% WP	Powdery mildew, mites	200–400 L/acre	2 g/L
Fungicide	Tricyclazole 75% WP	Rice blast	200–400 L/acre	2 g/L
Fungicide	Propiconazole 25% EC	Rusts, leaf spots, powdery mildew	200–400 L/acre	1 ml/L
Fungicide	Copper Sulphate 50% WP	Fungal and bacterial diseases	200–400 L/acre	1 g/L
Fungicide	Potassium Phosphite	Phytophthora, downy mildew, root rot	200–400 L/acre	2 g/L
Herbicide	Metribuzin 70% WP	Broadleaf weeds and grasses	200–400 L/acre	1 g/L
Herbicide	Ethoxysulfuron (Sunrice) 15% WDG	Sedges and broadleaf weeds in rice	40 g/acre	1 g/5 L
Herbicide	Butachlor 5% G	Annual grasses and broadleaf weeds in rice	10–12 kg/acre	N/A
Bio-pesticide	Azadirachtin 10,000 ppm (Neem Oil)	Aphids, whiteflies, caterpillars, sucking pests	200 L/acre	5 ml/L
Horticultural Oil	Horticultural Mineral Oil / Tree Spray Oil	Scale insects, mites, aphids, mealybugs	N/A	30 ml/L

Adjuvant	Sticker / Activator / Spreader	Improves spray coverage, adhesion, and effectiveness	N/A	1 ml/L
Pheromone Lure	Rice Ear-Cutting Caterpillar (<i>Mythimna separata</i>) Lure	Rice ear-cutting caterpillar	5 number per acre	N/A
Pheromone Lure	Chili Pod Borer (<i>Helicoverpa armigera</i>) Lure	Chili pod borer	5 number per acre	N/A
Pheromone Lure	Fall Armyworm (<i>Spodoptera frugiperda</i>) Lure	Fall armyworm	5 number per acre	N/A
Pheromone Lure	Mango Fruit Fly (<i>Bactrocera dorsalis</i>) Lure	Mango fruit fly	5 number per acre	N/A
Pheromone Lure	Red Palm Weevil (<i>Rhynchophorus ferrugineus</i>) Lure	Red palm weevil	5 number per acre	N/A
Attractant	Protein Hydrolysate	Fruit flies and other bait-responsive insects	N/A	N/A
Trap	Coco Trap	Coconut rhinoceros beetle	5 number per acre	N/A
Trap	McPhail Trap	Fruit flies	5 number per acre	N/A
Trap	Funnel Trap	Moth and beetle pests	5 number per acre	N/A
Trap	Steiner Trap	Fruit flies	5 number per acre	N/A
Trap	Sticky Trap	Whiteflies, aphids, leaf miners, thrips	5 number per acre	N/A
Post- Harvest Protection and Storage Product	Super Grain Bag	Storage pests (grain protection)	N/A	N/A

5.2. Pre-Harvest Interval (PHI)

The Pre-Harvest Interval (PHI) is the minimum number of days between the last pesticide application and crop harvest, allowing residues to break down to safe levels. It is important because it ensures food safety, protects human health from harmful residues, and helps farmers comply with Maximum Residue Limits (MRLs) and market regulations.

5.2.1. General Safe Pre-Harvest Intervals (PHI)

Pesticide Type	Pesticide (Active + Formulation)	PHI (days)
Insecticide	Chlorpyrifos 20% EC	21
Insecticide	Cypermethrin 10% EC	7
Insecticide	Malathion 50% EC	7
Insecticide	Chlorantraniliprole 18.5% SC	7
Insecticide	Emamectin Benzoate 5% SG	7
Fungicide	Captan 50% WP	7
Fungicide	Carbendazim 50% WP	14
Fungicide	Copper Oxychloride 50% WP	10
Fungicide	Hexaconazole 5% EC	21
Fungicide	Mancozeb 75% WP	10
Fungicide	Sulphur 80% WP	3
Fungicide	Tricyclazole 75% WP	28
Fungicide	Propiconazole 25% EC	30
Fungicide	Copper Sulphate 50% WP	7
Fungicide	Potassium Phosphite	0
Herbicide	Metribuzin 70% WP	60
Herbicide	Ethoxysulfuron 15% WDG	30
Herbicide	Butachlor 5% G	90
Biopesticide	Neem Oil	1

Note: These are conservative safety estimates. Always check the product label for the exact PHI specific to your crop and country before applying or harvesting.

6. Safe Handling and Use of Pesticides

Safe handling and use of pesticides protect human health, ensure correct pest control, and prevent environmental and food contamination. It reduces poisoning risks, crop damage, and pest resistance while supporting safe, efficient, and sustainable farming. For visual guidance, refer to the video: <https://www.youtube.com/watch?v=eeUKilwO5Gc>.

COMPONENTS OF SAFE USE OF PESTICIDES

1 Pesticide selection and label reading

- Choosing the correct pesticide for the target pest and crop.
- Read and follow all label instructions, dosage, and safety warnings.



2 Personal protective equipment (PPE)

Use protective clothing, gloves, masks, goggles, and boots to reduce exposure during handling and spraying.



3 Safe mixing and preparation

Prepare pesticide solutions in a well-ventilated area using correct measuring tools, and avoid direct contact or contamination.



Work in a well-ventilated area.



4 Safe application practices

Apply pesticides at the correct time, weather conditions, and dosage while minimizing drift and exposure to non-target areas.



Right time



Right weather



Right dose



Avoid drift

5 Calibration of spraying equipment

Ensure sprayers deliver the correct and uniform amount of pesticide for effective and safe application.



Calibrate regularly for accuracy and uniform coverage.

6 Storage and transportation safety

Keep pesticides in original containers, securely stored away from food, children, and animals, and transport safely.



7 Disposal and environmental protection

Dispose of empty containers properly and avoid contamination of soil, water, and ecosystems.



Do not contaminate water sources, soil or ecosystems.

8 Personal hygiene and post-application care

Wash hands and body after spraying, clean equipment, and observe re-entry and pre-harvest intervals.



Bathe and change clothes after spraying



Observe re-entry interval (REI)



Observe pre-harvest interval (PHI)



SAFE USE PROTECTS YOU, YOUR FAMILY, OUR COMMUNITY AND OUR ENVIRONMENT.

7. Organic Methods of Plant Protection

Organic methods of plant protection are eco-friendly, non-synthetic strategies to manage pests and diseases, focusing on prevention through biodiversity, healthy soil, and natural, biological, or physical controls.

Core Principles

- Preventive Action & Ecosystem Management
- Diversity and Crop Rotation
- Soil Health Optimisation
- Biological Control (Natural Enemies)
- Cultural Practices

7.1. Different Organic Methods

Cultural Methods	Physical Methods	Biopesticides	Biological (Predators)
Healthy crops through better management practices  Crop rotation  Use of resistant varieties  Proper planting time and spacing  Field sanitation (removal of infected plants)  Balanced fertilization	Use of physical means to prevent and control pests  Use of nets and screens  Sticky traps  Light traps  Mulching  Hand picking of pests	Pesticides derived from natural materials (microbial/plant origin)  <i>Bacillus thuringiensis</i> (Bt) • Effective against caterpillars • Safe for humans, animals and beneficial insects  <i>Beauveria bassiana</i> • Fungal pathogen of insects • Controls a wide range of pests  <i>Trichoderma</i> spp. • Controls soil borne diseases • Promotes plant growth  Neem based products • Derived from neem seeds/leaves • Repels and controls many pests  Eco-friendly Safe Sustainable	Use of natural enemies to control pests  Ladybird beetle Feeds on aphids, mealybugs, mites  Lacewing Feeds on aphids, thrips, mealybugs and eggs  Praying mantis Feeds on caterpillars, flies and other insects  Parasitic wasps Parasitize eggs and larvae of many pests  Conserve Protect Enhance

8. Locally Prepared Biopesticides

Locally prepared biopesticides are natural pest-control products made from locally available plant materials, animal products, or beneficial microorganisms. Farmers prepare these biopesticides using ingredients such as neem leaves, garlic, chili, tobacco, cow urine, or compost extracts to manage insect pests and plant diseases.

Category	Biopesticides	Uses
Botanical Extracts (Plant-Based Sprays)	• Neem/Melia leaf & kernel seed extract • Garlic–chilli–ginger extract • Chilli extract (hot pepper spray) • Garlic brew / garlic spray • Ginger rhizome extract	<i>Mainly used to repel insects, control sucking pests, and reduce feeding damage</i>
Fermented Plant Preparations	• Herbal tea • Horsetail tea	<i>Help in disease control (especially fungal) and improving plant strength</i>
Nutrient-Based Liquid Preparations	• Compost tea • Liquid manure (bio-digester solution)	<i>Improve plant health, immunity, and resistance to pests and diseases</i>
Household / Simple Chemical Solutions	• Soap solution	<i>Used to repel pests, control moisture, and reduce insect damage</i>
Protective / Topical Applications	• Stem paste	<i>Applied directly to plants for disease prevention and wound protection</i>
Mineral / Physical Materials	• Ash • Lime	<i>Used to repel pests, control moisture, and reduce insect damage</i>

8.1. Preparation Methods

A. Garlic-Ginger-Chilli Extract

MATERIALS		METHOD		
	50 g Garlic	1 Ground all three ingredients separately into a fine paste and soak in water for 20 mins.   Soak for 20 mins	2 Filter the mixture and add 30 ml of dish washing liquid and 5 ml of vegetable oil.  	3 Dosage: 10 % (1 liter of Extract with 9 liters of water for a sprayer tank).  
	50 g Ginger			
	50 g Chilli			
	30 ml Dish washing liquid			
	5 ml Vegetable oil			



B. Neem Extract

MATERIALS REQUIRED	STEPS				
1 kg of fresh Neem/melia leaves 	1 Select good quality fresh Neem/melia leaf 	2 Pound the leaf gently 	3 The pounded leaf are gathered in a muslin cloth 	4 Tie it loosely 	5 Soak it into water for 15 min and then squeeze it 
5 liters of water 					
Muslin (Cotton) cloth 					
Containers 					

C. Compost Tea



D. Jholmol 3 (Rangzhin Bupmen)

Jholmol-3 is a powerful, homemade, nature-based liquid bio-pesticide used to control insects, pests, and diseases in crops. It is made by fermenting locally available botanical plants, animal urine, water, and beneficial microorganisms.

Ingredients Needed

1. Botanical plants: 10 kg of strong-scented or bitter local plants (e.g., neem, stinging nettle, wormwood, or tobacco).
 2. Animal urine: 16 to 20 liters.
 3. Water: 16 to 20 liters.
 4. Microorganisms: 1 liter of Effective Microorganisms (EM).
 5. Container: A 50 liter, airtight plastic drum or bucket.
-

Preparation

★ Step 1: Prepare the Materials

Chop the botanical plants into small pieces. Place the chopped plants, animal urine, water, and microorganisms into a 50-liter drum, then mix thoroughly.

★ Step 2: Ferment the Mixture

Close the drum securely and allow the mixture to ferment for 21–30 days at a temperature of 15–30°C. Stir the contents with a clean bamboo stick every 3–4 days to ensure uniform fermentation.

★ Step 3: Filter and Collect Jholmol-3

When fermentation is complete, the mixture will have a strong rotten odor and a greenish layer on the surface. Filter it through a cotton cloth or fine sieve to separate the liquid. The filtered liquid is Jholmol-3, ready for use.

*** Brochures available at <https://ncoa.gov.bt/download/3055/?tmstv=1781255821>

Session Three: Crop Water Management Systems

Time:	3 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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Irrigation plays a vital role in enhancing agricultural productivity. With increasing water scarcity due to climate change, irrigation technologies have evolved to promote more efficient and sustainable water use. The effective adoption of these technologies is transforming agricultural systems and improving crop performance.

This session will equip participants with knowledge and practical skills on efficient water management technologies. It will also cover different types of irrigation systems and their installation methods, enabling better water use and improved farm productivity.

Session Content:	1. Importance of irrigation management in agriculture 2. Types of irrigation and installation methods 3. Water Harvesting Techniques
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INFORMATION

1. Importance of Irrigation Management in Agriculture

Irrigation management is the proper planning and use of water to meet crop needs at the right time and in the right amount. Good irrigation practices are essential for improving productivity, especially under changing climate conditions. The importance of irrigation are as given below:



PRACTICAL GUIDANCE FOR FARMERS

1

Irrigate crops based on growth stage
(critical stages need more water)



More water is needed during germination, flowering and fruiting stages.

2

Avoid both overwatering and under-watering




Both can harm crops and reduce yield. Give the right amount of water.

3

Use simple methods to check soil moisture (hand test)





Too Wet
(Water dripping)

Wait to irrigate



Good
(Moist soil, forms a ball)

Right time to irrigate



Too Dry
(Soil is loose, crumbles)

Irrigate

4

Prefer irrigation during early morning or evening





Early Morning





Evening

Reduces water loss through evaporation and helps plants absorb water better.

2. Types of Irrigation

Irrigation systems generally fall into a few main categories;

1. **Sprinkler irrigation:** Water is sprayed through the air, mimicking natural rainfall.
2. **Drip irrigation:** Water is delivered directly to the root zone, which is highly efficient.
3. **Surface irrigation:** Water moves across the land by gravity (eg., furrow or flood irrigation, common in wetland irrigation in Bhutan).

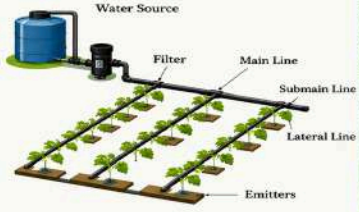
1. DRIP IRRIGATION

Drip irrigation delivers water slowly and directly to the root zone of plants through a network of pipes, tubes and emitters.



FEATURES

- Water is applied drop by drop at the root zone.
- Minimizes water wastage.
- Reduces weed growth.
- Suitable for row crops, fruits, vegetables and orchards.



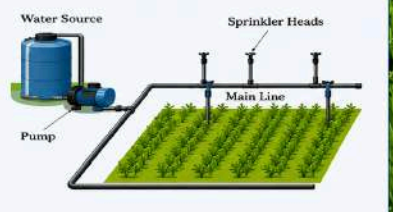
2. SPRINKLER IRRIGATION

Sprinkler irrigation applies water in the form of sprinkles similar to rainfall through a system of pipes and sprinkler heads.



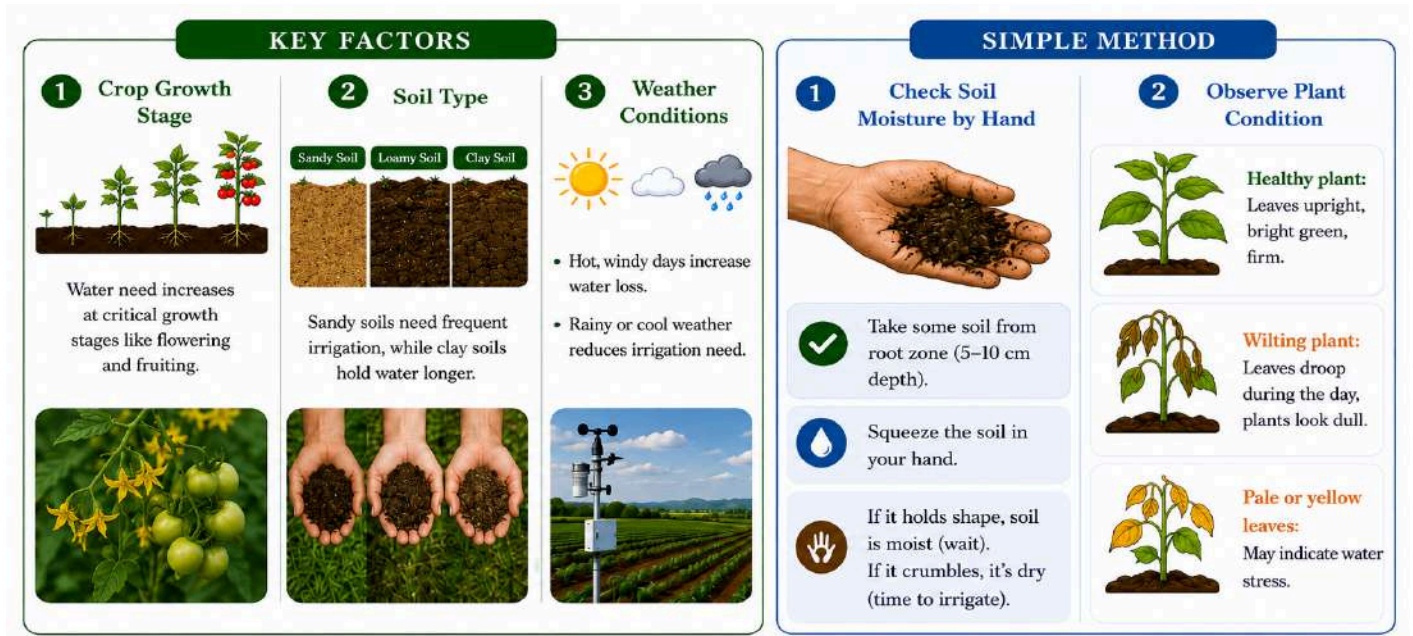
FEATURES

- Water is sprayed over the entire field like rainfall.
- Suitable for a wide range of soils and topography.
- Useful for field crops, lawns, pastures and orchards.
- Helps in cooling the field and maintaining humidity.



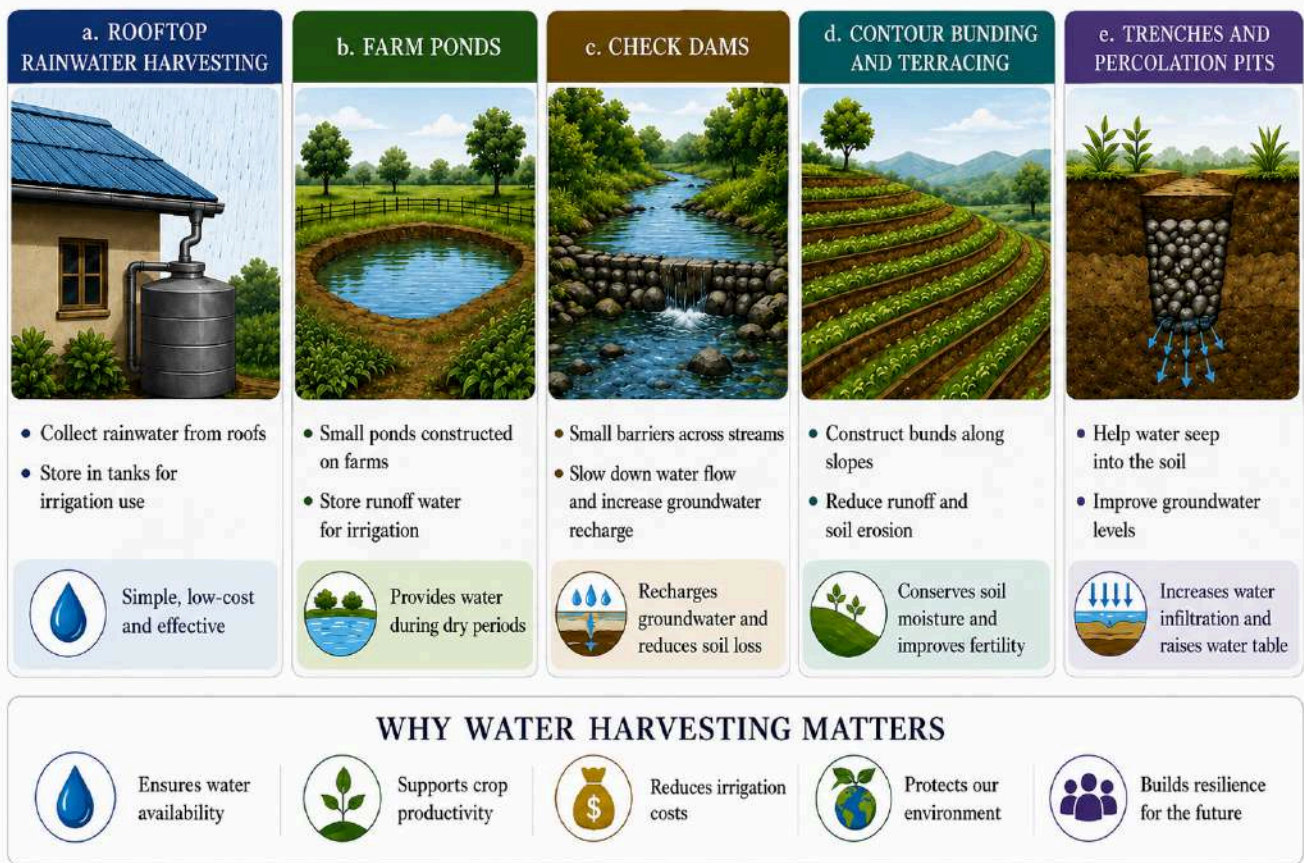
3. Irrigation Scheduling

Irrigation scheduling is the process of deciding when to irrigate, how much water to apply, and how often to irrigate a crop based on the crop's water needs, growth stage, soil moisture, weather, and available water. Consider the following factors and methods for irrigation scheduling.



5. Water Harvesting Techniques

Water harvesting involves collecting and storing rainwater for later use, especially during dry periods. It ensures water availability, supports crop productivity and reduces irrigation costs while building resilience for the future; it also protects our environment.



Session Four: Fruit Thinning Techniques

Time:	4 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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This session will provide participants with both theoretical and practical sessions on fruit thinning and bagging techniques. In the first session, participants will learn about fruit thinning, including its importance in improving fruit quality and yield. The session will cover key aspects such as criteria for fruit selection during thinning and the appropriate timing for the operation. The second session will focus on fruit bagging techniques. Participants will be introduced to the importance of fruit bagging in enhancing fruit quality and protection, along with the appropriate timing and materials required for bagging.

Session Content:	1. Fruit Thinning 2. Fruit Bagging
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Materials Required

Fruit thinning	Fruit bagging
Harvester	Newspaper, Stapler and pin, paper bags, insect proof net, poly bags, biodegradable bags

INFORMATION

1. Fruit Thinning

Fruit thinning is the practice of removing excess fruit from a tree or plant to improve the size, quality, colour, and overall health of the remaining fruit. Thinning helps plants use nutrients and energy more efficiently and prevents overbearing.

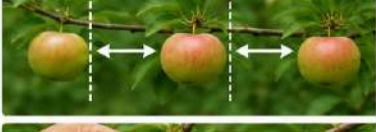
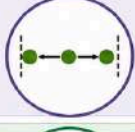
Importance and Benefits of Fruit Thinning

- Improves fruit size, colour, and sweetness
- Reduces competition among fruits for nutrients
- Prevents branch bending and breakage
- Reduces pest and disease incidence
- Promotes uniform fruit development
- Improves market value and farmer income
- Supports better flowering and fruiting in the next season

Best time for thinning

- After natural drop
- Fruits at marble size

2. Methods of Fruit Thinning

	1 Inspect the tree and fruit load	
	2 Remove damaged, diseased, and malformed fruits	
	3 Retain healthy and well-spaced fruits	
	4 Maintain proper spacing between fruits	
	5 Avoid damaging branches and leaves	

3. Fruit Thinning

Removing excess fruits or flowers to improve the size, quality and productivity. The different methods of fruit thinning are given below.

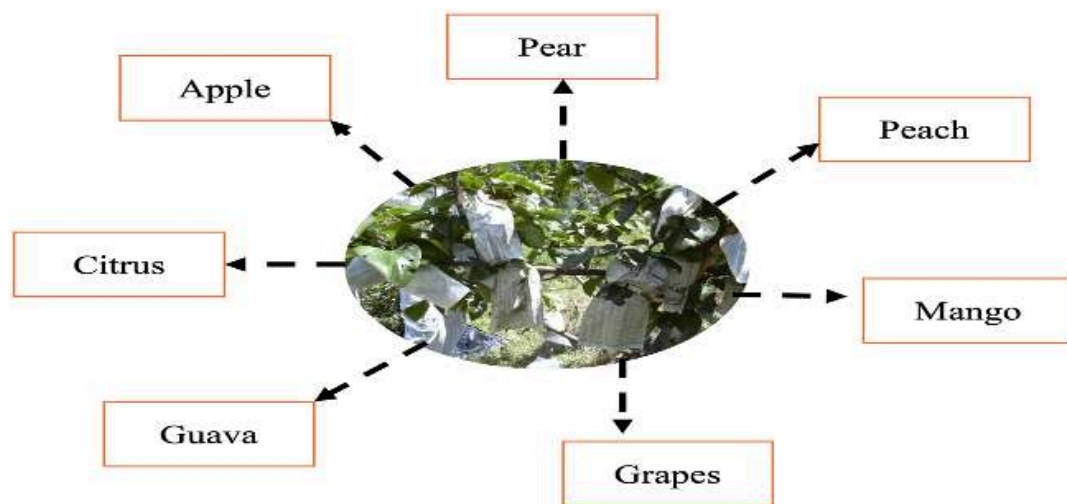
a. HAND THINNING	b. MECHANICAL THINNING	c. CHEMICAL THINNING
Removal of excess fruits manually by hand. 	Use of tools or shaking methods to remove excess flowers or fruits. 	Use of approved chemicals to reduce fruit load. 
ADVANTAGES • Accurate and selective • Suitable for high-value fruits	ADVANTAGES • Speeds up the thinning process • Useful for large orchards • Saves time and labor	ADVANTAGES • Helps in effective thinning, especially in large orchards • Use only approved and recommended chemicals • Should only be applied under technical guidance.
SUITABLE CROPS  Apple Peach Pear Persimmon		

4. Fruit Bagging

Fruit bagging is the practice of covering developing fruits with protective bags to protect them from insects, diseases, birds, sunburn, and physical damage.

Benefits of Fruit Bagging	1. Cleaner and more attractive fruits 2. Reduced insect and bird damage 3. Lower pesticide requirement 4. Improved fruit colour and quality 5. Increased market value
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Most suitable fruits for bagging



5. Steps in Fruit Bagging

1		 Select healthy fruits
2		 Remove damaged or infected fruits
3		 Place bag carefully over fruit
4		 Tie or staple bag securely
5		 Ensure proper ventilation and drainage
  Careful bagging protects fruits, improves quality and increases market value.		

IMPORTANT PRECAUTIONS



Avoid trapping moisture inside bags
Moisture can cause fungal growth and fruit rot.



Use clean and undamaged bags
Good quality bags protect fruits effectively.



Inspect bags regularly
Check for tears, holes or pest entry and replace if needed.



Remove bags before harvest if necessary
Helps improve color, flavor and reduces moisture build-up.



Best Time for Bagging

- After fruit thinning
- When fruits are young and healthy- golf ball size

👉 Bagging too early or too late may reduce effectiveness

COURSE FOUR: POST-HARVEST AND FARM BUSINESS MANAGEMENT

This course is to strengthen the technical, managerial, and entrepreneurial capacities of farmers by integrating post-harvest management, seed production, and farm business skills. It focuses on reducing post-harvest losses, maintaining product quality, promoting value addition, and strengthening market linkages to improve farm profitability and sustainability. The course also supports the development of competitive, market-oriented farm enterprises that contribute to increased household income, employment generation, and resilient rural livelihoods. It consists of three integrated components: Post-Harvest Handling and Value Addition, Seed Production and Management Techniques, and Farm Business Management.

Objectives

- Enhance knowledge and practical skills in post-harvest handling and management
- Reduce post-harvest losses and maintain the quality and safety of agricultural produce
- Promote value addition techniques to increase product value and farm income
- Develop farmers' skills in quality seed production and management practices
- Strengthen farm business and entrepreneurial capacities for market-oriented farming
- Improve farmers' understanding of marketing, record keeping, and business planning
- Support the development of sustainable and competitive farm enterprises

Teaching approach

The training adopts a combination of theoretical instruction and practical sessions, with greater emphasis on hands-on learning to strengthen skills and real-world application.

- 1. Theoretical Sessions:** Participants are introduced to key concepts, principles, and tools in post-harvest handling, value addition, and farm business management, aligned with the module framework.
- 2. Practical Sessions:** Participants engage in hands-on activities including product grading, value addition, record keeping, and development of simple farm business plans.

Expected outcome

By the end of the training, participants are expected to:

- Apply improved post-harvest and business management practices to enhance productivity, reduce losses, and increase farm income
- Develop and implement simple farm business plans and maintain basic farm records
- Disseminate acquired knowledge and skills to other farmers and community members
- Transition from subsistence farming to market-oriented and commercially viable agriculture
- Produce and maintain quality seeds

Course details

The course content is as described in the following session:

Session One: Post-harvest Handling and Value Addition Techniques

Time:	5 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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This session focuses on enhancing farmers' capacity to minimise post-harvest losses and maximise the economic value of cereals and horticultural crops through improved handling, processing, and value addition practices. It introduces the critical stages of post-harvest management (harvesting, cleaning, grading, storage, and processing) with an emphasis on quality preservation, food safety, and market standards. Building on this foundation, the session promotes the transformation of primary produce into diversified, high-value products using simple, cost-effective, and locally adaptable technologies. Through intensive hands-on training, participants will develop practical skills in processing cereals and horticultural crops into marketable products.

Session Content:	1. Postharvest Handling and Management of cereal crops 2. Value addition and product development from cereals (maize, quinoa and buckwheat) 3. Post-harvest handling and management of fruits and vegetables 4. Value addition and product development from fruits and vegetables
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Materials Required

Processing and Preparation Equipment	Measuring and Mixing Tools	Cutting and Handling Tools	Storage and Packaging Materials	Harvesting and Collection Materials
• Baking oven • Dough kneader • Deep fryer • Dryer • Heavy-duty grinding machine • Box mill • Vegetable slicer • Cookies shaper • Sealing machine	• Digital weighing balance • Bowl • Bucket	• Chopping board • Knife • Harvesting knife • Harvesting clipper/secateur • Harvesting bag • Harvesting ladder	• Storage bag • Food packaging container/pouch • Cookies packaging container and pouch • Pickling bottle • Corrugated cardboard box • Plastic crate	• Harvesting clipper • Harvesting bag • Harvesting ladder • Plastic crate

INFORMATION

1. Post-Harvest Management

Post-Harvest Management (PHM) can be defined as the methods and techniques used to increase shelf life and retain produce. PHM comprises various technologies and practices from the field till consumption, like drying, cleaning, sorting, processing, storing and packaging.

1.1. Common Causes of Post-Harvest Losses in Cereal Crops



1.2. Importance of Proper Post-Harvest Management and Handling

A. To Maintain Quality

Proper post-harvest handling helps preserve the freshness, appearance, taste, texture, and nutritional value of agricultural produce. Careful handling also reduces physical damage, bruising, and contamination.

B. To Extend Shelf Life

Appropriate drying, cooling, storage, and packaging practices slow spoilage and deterioration, allowing produce to remain fresh and safe for longer.

C. To Prevent Post-Harvest Losses

Good post-harvest management reduces losses caused by pests, diseases, moisture, poor handling, and improper storage, helping farmers save both produce and income.

D. To Ensure Availability

Proper storage and preservation techniques help maintain a continuous supply of food and agricultural products even during off-seasons or periods of low production.

E. To Improve Market Value

Clean, properly graded, well-packaged, and high-quality produce attracts better prices in the market and increases consumer preference and market competitiveness.

2. General Post-Harvest Management Steps in Cereals



2.1. Post-Harvest Handling of Paddy

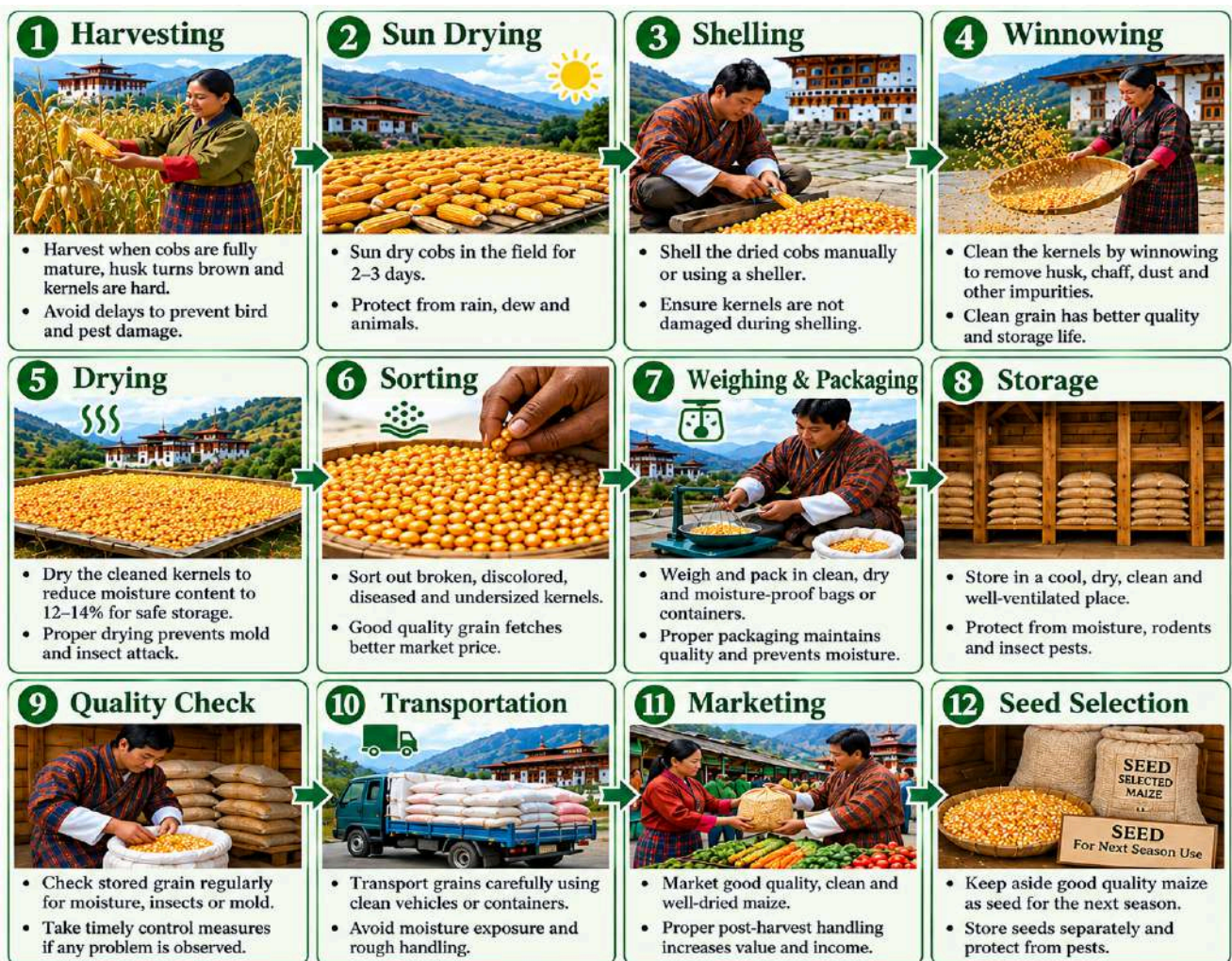
- ❖ A paddy crop is considered mature when most of the grains have turned golden yellow and reached full maturity.
- ❖ At harvest, the grain moisture content is usually around 20–25%.
- ❖ Proper harvesting time is critical, as it directly affects grain quality, milling recovery, and field losses.
- ❖ Harvesting too early, when grains are immature, results in poor grain filling and increases grain breakage during milling.
- ❖ Delayed harvesting exposes grains to shattering, pest and bird damage, lodging, and cracking during threshing, which ultimately reduces grain quality and milling yield.



2.2. Post-Harvest Management in Maize

Physical Maturity Indicators

- ❖ Leaves begin to turn yellow as the crop reaches maturity
- ❖ Leaf tips start drying from the lower portion upward
- ❖ Husk changes from green to straw or light brown colour
- ❖ Silk dries and turns golden brown
- ❖ Some cobs begin to droop downward, indicating maturity and readiness for harvest



2.3. Post-harvest management in Quinoa

Physical Maturity Indicators

Quinoa is ready for harvest when the following maturity indicators are observed:

- ❖ Leaves begin to senesce, dry up, and naturally drop from the plant
- ❖ Panicles change colour to yellow, red, or brown depending on the variety
- ❖ Grain moisture content decreases to approximately 15–20%
- ❖ Seeds become hard and cannot be easily dented with a fingernail
- ❖ Plants appear dry and mature, indicating readiness for harvesting



2.4. Post-harvest management of Buckwheat

Maturity Indicators

- ❖ About 70–75% of the seeds turn brown or black, indicating physiological maturity
- ❖ Plant foliage changes from green to brown, and most leaves dry and drop naturally
- ❖ Stems turn reddish-brown and become dry as the crop reaches full maturity. Pods or seed heads become dry and firm, indicating readiness for harvest



2.5. Common post-harvest diseases and pests in Cereals

Common Post-Harvest Diseases in Cereals

Mold and fungal growth



- Mold and fungal growth caused by high moisture during storage.

Grain discoloration and rotting



- Grain discoloration and rotting due to poor drying and ventilation.

Aflatoxin contamination



- Aflatoxin contamination caused by storage fungi such as *Aspergillus* spp.

Heating and spoilage of grains



- Heating and spoilage of grains due to excess moisture and microbial activity.

Common Storage Insect Pests

Rice weevil



- Adults are small, brownish beetles with a snout. Larvae develop inside the grain.

Grain moth



- Moths lay eggs on grains. Larvae feed on grains, causing webbing and damage.

Lesser grain borer



- Larvae bore into grains and feed inside, reducing grain quality and weight.

Red flour beetle



- Adults feed on broken grains and flour. Larvae grow in stored grain products.

Maize weevil



- Adults are grayish weevils that bore into grains. Larvae feed inside kernels, causing holes and loss.

2.6. Good Management Practices for Cereal crops

1 Proper Harvesting

- Harvest crops at the correct maturity stage.
- Avoid harvesting during rainy or humid conditions.
- Minimize grain damage during harvesting and threshing.

2 Proper Drying

- Dry grains immediately after harvest.
- Reduce grain moisture content to safe storage levels (generally 12–14%).
- Use clean drying surfaces and avoid direct contact with soil.

3 Cleaning and Sorting

- Remove broken, damaged, diseased, and insect-infested grains.
- Clean grains thoroughly to remove chaff, dust, and debris.

4 Safe Storage Practices

- Store grains in clean, dry, and well-ventilated structures.
- Use moisture-proof and airtight containers or bags when possible.
- Keep storage areas free from old grains and residues.

5 Insect and Rodent Control

- Regularly inspect stored grains for insect infestation.
- Use traps, botanical protectants, or approved storage pesticides when necessary.
- Protect stores from rodents by sealing holes and maintaining sanitation.

6 Hygiene and Sanitation

- Clean storage rooms, bags, and equipment before storage.
- Avoid mixing new grains with old stored grains.
- Maintain proper storage hygiene to reduce pest buildup.

7 Regular Monitoring

- Check stored grains periodically for moisture, insects, molds, and spoilage.
- Take immediate control measures if infestation or diseases symptoms are observed.

Remember

Good post-harvest management preserves quality, reduces losses, and ensures food security and better livelihoods.

3. Value addition and Product development of cereal crops

3.1. What is value addition?

The process of improving the quality, usability, nutritional value, shelf life, and market value of cereal crops through processing, packaging, and product development. It involves transforming raw cereals into more useful, attractive, and marketable products that provide higher economic returns to farmers and processors.

3.2. Importance of Value Addition

- ❖ Enhances the value of raw agricultural products through processing and value addition
- ❖ Improves product quality, usability, safety, and shelf life
- ❖ Increases economic returns and creates additional nutritional benefits
- ❖ Enhances marketability and consumer acceptance of agricultural products
- ❖ Reduces post-harvest losses and promotes efficient utilisation of farm produce

3.3. Technique of value addition

- Cleaning, grading and packaging
- Milling (Flour production)
- Fermentation
- Baking
- Extrusion
- Puffing and baking

Different cereal crops such as rice, maize, wheat, barley, buckwheat and millet can be processed into value-added products such as flour, noodles, bread, biscuits, porridge, snacks and beverages. These can be produced at both household and commercial scales, creating income opportunities, reducing post-harvest losses and increasing the value of locally produced cereals.

4. Post-Harvest Management of Fruits

4.1. Common Causes of Post-Harvest Losses in Fruits

- Mechanical injuries during harvesting, handling, packing, and transportation
- Physiological deterioration caused by moisture loss, respiration, and ageing
- Pathological decay due to fungal, bacterial, and other microbial infections
- Improper temperature and humidity management during storage and transport
- Harvesting fruits at an incorrect stage of maturity
- Inadequate packaging and poor storage practices
- Damage caused by insects, rodents, birds, and other pests

4.2. Types of Post-Harvest Losses

- **Quantitative Losses:** Reduction in the quantity, weight, or volume of produce during handling, storage, and transportation
- **Qualitative Losses:** Deterioration in quality attributes such as taste, colour, aroma, texture, and nutritional value
- **Economic Losses:** Reduction in market value due to poor quality, spoilage, physical damage, or lower consumer acceptance

4.3. Common Maturity Indices of Fruits

01		COLOUR	 Colour changes as fruit ripens.	Development of characteristic skin or flesh colour indicating maturity.	
02		SIZE AND SHAPE		Attainment of the typical size and shape specific to the fruit variety.	
03		DAYS AFTER FLOWERING		Number of days from flowering to harvest maturity.	
04		FIRMNESS	 Too firm Right firmness	Appropriate texture and softness indicating readiness for harvest.	
05		SUGAR AND ACID CONTENT		Balanced sweetness and acidity reflecting proper fruit maturity and quality.	

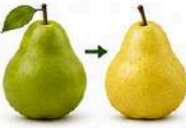
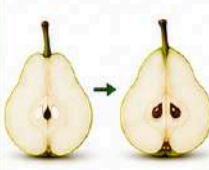
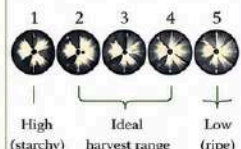
4.4. Types of Maturity

01 PHYSIOLOGICAL MATURITY Crops fully matured The stage when the crop has completed its natural growth and development. It has reached its maximum dry matter and changes are mostly related to senescence (aging). KEY INDICATORS - Seeds fully developed - Maximum dry matter content - Ceases further vegetative growth - Natural changes begin (aging) EXAMPLE Crop has full biological potential but may not be suitable for immediate marketing or consumption.	02 COMMERCIAL MATURITY Ideal for marketing The stage when the crop has attained desirable quality attributes such as size, color, texture and shelf life, making it suitable for sale, transport and storage. KEY INDICATORS - Attractive color and appearance - Optimum firmness and texture - Good flavor and taste potential - Suitable for transport and sale EXAMPLE Crop is at the right stage for marketing and has good shelf life.	03 HORTICULTURAL MATURITY Best for consumption The stage when the crop has optimum eating quality—flavor, aroma, texture and nutritional value—providing the best experience for consumers. KEY INDICATORS - Excellent flavor, aroma and taste - Preferred texture (softness/juiciness) - Maximum nutritional quality - Ready to eat / best eating quality EXAMPLE Crop is at the best stage for consumption and provides highest eating quality.
KEY DIFFERENCE Physiological maturity is about biological completion. Commercial maturity is about market readiness. Horticultural maturity is about consumer satisfaction.		

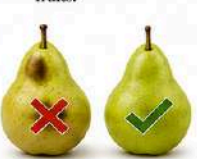
5. Maturity Index, Harvesting Techniques, and Storage of Different Fruits

1. Pear

MATURITY INDEX OF PEAR

1. COLOUR	2. SIZE & SHAPE	3. FIRMNESS	4. SEED COLOUR	5. STARCH INDEX	6. DAYS AFTER FULL BLOOM
 Skin changes from dark green to light green or yellowish green. Background color turns from dark to light. 	 Fruit attains typical size and shape of the variety. Shoulders become rounded. 	 Flesh remains firm but yields slightly to gentle pressure at the neck. 	 Seeds change from white to brown. 	 Starch decreases as pear ripens. Ideal at index 2–4 for most varieties. 	 Varies by variety (usually 120–160 days after full bloom). 

HARVESTING TECHNIQUES

1 Correct Time Harvest pears at physiological maturity (not fully ripe). 	2 Gentle Picking Lift the fruit upward and twist gently. 	3 Leave the Stem Keep the stem intact to reduce bruising and decay. 	4 Handle with Care Avoid drops, pressure and overfilling of picking containers. 	5 Field Heat Removal Move pears to a shaded, cool place immediately. 	6 Sorting Remove damaged, bruised or misshapen fruits. 
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STORAGE OF PEAR

1. OPTIMAL STORAGE CONDITIONS	2. STORAGE LIFE (Under optimal conditions)	3. STORAGE PRACTICES								
 Temperature –1 to 0 °C (30 to 32 °F)  Relative Humidity 90–95%  Ventilation Good air circulation required  Keep away from ethylene producing	<table><tr><th>Variety Type</th><th>Storage Life</th></tr><tr><td>Summer varieties</td><td>2 – 4 weeks</td></tr><tr><td>Autumn varieties</td><td>2 – 4 months</td></tr><tr><td>Winter varieties</td><td>4 – 7 months</td></tr></table> 	Variety Type	Storage Life	Summer varieties	2 – 4 weeks	Autumn varieties	2 – 4 months	Winter varieties	4 – 7 months	✓ Do not wash before storage. ✓ Store immediately after pre-cooling. ✓ Use liners or pads in boxes to prevent bruising. ✓ Inspect regularly and remove any rotting or damaged fruit. ✓ Pears continue to ripen after harvest. Allow ripening at 15–20 °C before consumption.
Variety Type	Storage Life									
Summer varieties	2 – 4 weeks									
Autumn varieties	2 – 4 months									
Winter varieties	4 – 7 months									



3. Mango

MATURITY INDEX OF MANGO

Harvest mangoes at the right maturity for best quality, flavor, shelf life and market value.



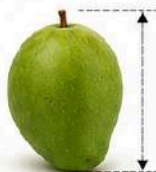
1 COLOUR

Skin color changes from deep green to light green or greenish-yellow. Yellow or golden hue appears in the cheek region (variety dependent).



2 SIZE & SHAPE

Fruit attains full size and shape of the variety. Shoulders become full and plump.



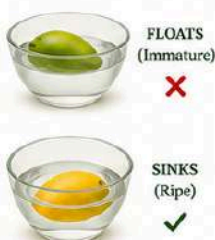
3 FIRMNESS

Flesh is firm but yields slightly to gentle pressure. Overly hard = immature. Too soft = overripe.



4 SPECIFIC GRAVITY (WATER DISPLACEMENT)

Ripe mango sinks in water. Immature mango floats.



5 TOTAL SOLUBLE SOLIDS (°BRIX)

Ideal range 12–20 °Brix (variety dependent) for best taste.



6 DAYS AFTER FLOWERING

Varies by variety (usually 90–150 days after full bloom).



HARVESTING TECHNIQUES

1 Correct Time

Harvest at physiological to mature-green stage (fully developed but not fully ripe).



2 Gentle Harvesting

Use clippers or fruit pickers with polythene bag. Cut the fruit stalk leaving a small stalk (0.5–1 cm).



3 Handle with Care

Avoid dropping, knocks and pressure. Do not twist or pull the fruit.



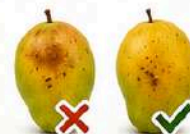
4 Field Heat Removal

Immediately move mangoes to shade or cool place.



5 Sorting & Grading

Sort out damaged, diseased, sap burnt or misshapen fruits. Grade by size and quality.



6 Cleaning

Remove latex stain by wiping with dry cloth. Do not wash with water.



STORAGE OF MANGO

1. OPTIMAL STORAGE CONDITIONS

- Temperature 12–13 °C (54–55 °F)
- Relative Humidity 85–90%
- Ventilation Good air circulation required
- Keep away from ethylene producing fruits and direct sunlight

2. STORAGE LIFE (Under optimal conditions)

Variety Type	Storage Life
Short duration varieties (Alphonso, Dashehari, Langda)	2 – 3 weeks
Medium duration varieties (Kesar, Himsagar, Chausa)	3 – 4 weeks
Late duration varieties (Totapuri, Amrapali)	4 – 6 weeks



3. STORAGE PRACTICES

- ✓ Pre-cool fruits to remove field heat.
- ✓ Store in clean, ventilated cartons or crates.
- ✓ Use paper / newspaper / tissue between layers.
- ✓ Do not store below 10 °C; chilling injury may occur (black spots, poor ripening).
- ✓ Store separately from ethylene producing fruits.
- ✓ Allow fruits to ripen at room temperature (20–25 °C).



4. Mandarin and Oranges

MATURITY INDEX OF ORANGES

Harvest oranges at the right maturity for best quality, juice, flavour and shelf life.

 1 COLOUR Rind changes from dark green to yellowish green to orange, depending on the variety. Uniform and bright colour indicates maturity. 	 2 SIZE & SHAPE Fruit attains full size and characteristic shape of the variety. Shoulders become rounded and the navel (if present) develops well. 	 3 FIRMNESS Rind becomes thinner and slightly soft to firm. Overly hard = immature, very soft = overripe. 	 4 JUICE CONTENT Mature oranges are juicy with high juice yield. 	 5 SUGAR ACID RATIO (TSS/ACID) Ideal TSS/Acid ratio range: 12–18 : 1 (variety dependent) for good taste. Check using refractometer (TSS °Brix).  10–12° Brix (standard range)	 6 DAYS AFTER FLOWERING Varies by variety (usually 210–270 days after full bloom). 
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HARVESTING TECHNIQUES

1 Correct Maturity Harvest at proper maturity when fruit is well coloured and juice content is high. 	2 Use Clippers Use secateurs or clippers to cut the fruit stalk leaving a short stem (1–2 cm). 	3 Handle with Care Avoid pulling or twisting. Handle gently to prevent bruising. 	4 Field Heat Removal Move fruits to shade immediately after harvest to remove field heat. 	5 Sorting Sort out damaged, diseased, sunburned or misshapen fruits. Grade by size. 	6 Packing Pack in clean, padded field crates or cartons to avoid mechanical injury. 
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 Harvest in the cool hours of the day (early morning or late afternoon) for best quality and longer shelf life.

STORAGE OF ORANGES

1. OPTIMAL STORAGE CONDITIONS  Temperature 4 – 8 °C (39 – 46 °F)  Relative Humidity 85 – 90%  Ventilation Good air circulation required  Keep away from ethylene producing fruits and gases.	2. STORAGE LIFE (Under optimal conditions) <table border="1"> <thead> <tr> <th>Variety Type</th> <th>Storage Life</th> </tr> </thead> <tbody> <tr> <td>Early varieties</td> <td>3 – 4 weeks</td> </tr> <tr> <td>Mid season varieties</td> <td>4 – 8 weeks</td> </tr> <tr> <td>Late / Valencia's</td> <td>2 – 3 months</td> </tr> <tr> <td>Navel oranges</td> <td>2 – 4 months</td> </tr> <tr> <td>Blood oranges</td> <td>2 – 3 weeks</td> </tr> </tbody> </table>   Oranges are chilling sensitive below 4 °C. Avoid storing below 2 °C (may cause pitting, rind breakdown, off-flavour).	Variety Type	Storage Life	Early varieties	3 – 4 weeks	Mid season varieties	4 – 8 weeks	Late / Valencia's	2 – 3 months	Navel oranges	2 – 4 months	Blood oranges	2 – 3 weeks	3. STORAGE PRACTICES ✓ Pre-cool fruits as soon as possible after harvest. ✓ Store in clean, ventilated cartons or plastic crates. ✓ Do not wash before storage. ✓ Store separately from ethylene producing fruits (banana, apple, papaya). ✓ Inspect regularly and remove rotten or damaged fruits. ✓ Maintain proper temperature and humidity for better shelf life. ✓ Allow fruits to reach room temperature before consumption for better flavour. 
Variety Type	Storage Life													
Early varieties	3 – 4 weeks													
Mid season varieties	4 – 8 weeks													
Late / Valencia's	2 – 3 months													
Navel oranges	2 – 4 months													
Blood oranges	2 – 3 weeks													

QUICK TIPS

 Harvest slightly immature – oranges will ripen well after harvest.

 Handle gently at all stages to avoid bruising and rind damage.

 Keep in shade in the field and during transport.

 Maintain cold chain for better quality, juice and shelf life.

 Use clean containers and follow good hygiene.

5. Avocado



MATURITY INDEX OF AVOCADO

Harvest avocados at the right maturity for best quality, flavour and shelf life.



1 COLOUR Skin colour changes from bright green to dark green. Some varieties turn purple black when mature. Colour alone is not a reliable indicator of maturity.	2 SIZE & SHAPE Fruit attains full size and shape of the variety. Shoulders become rounded and the navel (if present) develops well.	3 FIRMNESS Flesh yields to gentle pressure. Overly hard = immature, very soft = mushy = overripe.	4 STEM END COLOUR The small area under the stem (pedicel area) changes from green to yellowish green or slightly brown.	5 DRY MATTER (% CONTENT) Ideal range: 20 – 25% dry matter (variety dependent) for best flavour and texture. 20 – 25%	6 DAYS AFTER FLOWERING Varies by variety (usually 160 – 270 days after full bloom).
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HARVESTING TECHNIQUES

1 Correct Maturity Harvest at physiological maturity. Fruit should yield slightly to gentle pressure.	2 Cutting/Picking Use clippers or sharp secateurs to cut the fruit stalk. Leave a short stalk (1–2 cm).	3 Handle with Care Avoid dropping, pressure and bruising.	4 Field Heat Removal Remove field heat by keeping fruits in shade and cool place as soon as possible.	5 Sorting Remove damaged, diseased, misshapen or sunburned fruits. Grade by size.	6 Packing Pack in clean, padded crates or cartons to prevent bruising.
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Harvest in the cool hours of the day (early morning or late afternoon) for best quality and longer shelf life.

STORAGE OF AVOCADO

1. OPTIMAL STORAGE CONDITIONS



Temperature
4 – 7 °C (39 – 45 °F)
for mature-green fruit



Relative Humidity
85 – 95%



Ventilation
Good air circulation
required



Keep away from
ethylene producing
fruits and direct
sunlight

2. STORAGE LIFE (Under optimal conditions)

Maturity Stage	Storage Life
Pre-climacteric (very firm)	Up to 4 – 6 weeks
Mature-green	2 – 4 weeks
Breaking stage	1 – 2 weeks
Ripe	3 – 5 days





Avocados are chilling sensitive.
Do not store below 4 °C (39 °F) as it may cause
chilling injury (pitting, dark spots).

3. STORAGE PRACTICES

- ✓ Store mature-green fruit at 4 – 7 °C.
- ✓ Allow fruit to ripen at room temperature (18 – 25 °C).
- ✓ Do not wash before storage.
- ✓ Store separately from ethylene producing fruits (banana, apple, etc.).
- ✓ Inspect regularly and remove damaged or diseased fruits.
- ✓ Once ripe, keep in cool place (not refrigerator) and consume soon.



6. Post-Harvest Management of Vegetables

6.1. Causes of Post-Harvest Losses in Vegetables

1. Improper Harvesting Stage

Harvesting too early or too late reduces quality and shelf life.

2. Poor Harvesting Practices

Rough handling, wrong harvesting time, and unsuitable containers cause damage.

3. Inadequate Packaging

Weak or overfilled containers lead to bruising and spoilage.

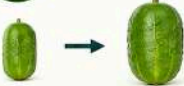
4. Improper Handling and Sorting

Lack of grading and rough handling increases losses.

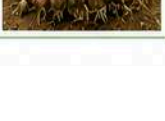
5. Poor Transportation

Overloading, rough loading/unloading, and unfavourable

6.2. Common Maturity Indicators in Vegetables

1 SIZE  - Vegetable reaches the proper harvest size. - Not too small or too big.	2 COLOR  - Change to normal mature color. - Shiny and bright color.	3 SHAPE  - Fully developed shape. - Typical shape of the variety.	4 FIRMNESS  - Neither too soft nor too hard. - Firm and fresh feeling.	5 CROP AGE  - Ready after a certain number of days of planting or flowering. - Follow days recommended for each crop.
6 TASTE AND SMELL  - Better flavor and aroma at maturity. - Good taste when eaten.	7 SEED MATURITY  - Seeds become fully developed. - Hard and firm seeds (within the fruit).	8 EASY PICKING  - Mature vegetables can be harvested easily from the plant. - Detaches with little effort.	9 SURFACE APPEARANCE  - Smooth, glossy and fresh appearance. - Natural shine develops.	10 LEAF / HUSK CHANGE  - Leaves or husk change color / dry up. - Signs of maturity.

6.3. Maturity Index, harvesting Techniques and Storage guide for common vegetables

Vegetable	Maturity Index – When to Harvest	How to Harvest	Storage – How to Keep
Chilli 	- Fruits are full size - Shiny and deep green or red 	 Pick by hand carefully with stalk.	Keep in cool, dry and ventilated place. 
Beans 	Pods are young, tender and crisp 	 Pick by hand regularly.	Store in cool place. Do not keep in sun. 
Peas 	Pods are filled but still tender and green 	 Pick pods carefully by hand.	Keep in cool place. 
Cabbage 	Head is firm, hard and compact 	 Cut the head with sharp knife.	Store in cool, humid place. 
Broccoli 	Head is tight, compact and green 	 Cut the main head with knife leaving some stem.	Keep in cool place. 
Cauliflower 	Curd is full, compact and white 	 Cut the curd with some leaves attached.	Store in cool, humid place. 
Tomato 	Fruits are mature, change color (green to red) and firm 	 Pick gently by hand.	Keep in cool, ventilated place. 
Carrot 	Roots reach good size and color 	 Pull gently or loosen soil first.	Store in cool, moist place. 
Cucumber 	Fruits are green, tender and proper size 	 Cut or pick carefully.	Keep in cool place. Avoid bruising. 
Potato 	- Vines and leaves become dry - Skin is firm 	 Dig carefully from soil. Avoid injury.	Store in cool, dark and dry place. 
Sag (Leafy Greens) 	Leaves are tender, fresh and green 	 Cut leaves carefully or uproot.	Keep in cool, moist place. Use soon. 
Onion 	- Tops fall and neck is dry - Outer skin dry 	 Pull bulbs and dry/cure well.	Store in dry, well ventilated place. 

6.4. Sorting and Grading of Vegetables

1. SORTING – Remove unwanted produce

Sorting means separating vegetables to remove damaged, diseased, over mature or foreign materials.

GOOD – KEEP

NOT GOOD – REMOVE

HOW TO SORT

Handle gently to avoid injury

Work in shade or cool place

Use clean tables/baskets

Remove damaged, rotten and diseased vegetables

Keep sorted vegetables in clean containers

BENEFITS OF SORTING

- Removes damaged and rotten produce
- Reduces loss and increases shelf life
- Improves appearance and market value

2. GRADING – Classify by quality and size

Grading means grouping vegetables into different grades of uniform size, shape, color and quality.

	Grade A (Large)	Grade B (Medium)	Grade C (Small)	Reject
TOMATO				
CABBAGE				
CARROT				
CUCUMBER				

COMMON GRADE CATEGORIES

- **Grade A / Premium** – Best quality, good size, good color, free from defects
- **Grade B / Standard** – Medium quality, slight defects allowed
- **Grade C / Low** – Smaller size, more defects, used for local market/processing
- **Reject** – Damaged, diseased, over mature, not suitable for sale

BENEFITS OF GRADING

- Ensures uniform quality
- Increases consumer satisfaction
- Gets better price in the market
- Easier packing, transport and storage
- Helps in export and market standards

GOOD PRACTICES

Harvest at right maturity

Handle gently

Keep vegetables clean and dry

Use clean containers

Do not throw or drop

Store in cool, shaded place

REMEMBER

Good sorting and grading makes your vegetables more attractive and profitable.

7. Value addition and Product development of fruits and vegetables

Value addition and product development refer to the process of transforming raw agricultural products into products with higher economic value, longer shelf life, improved quality, and better market appeal, reducing post-harvest losses, improving food security, and increasing income for farmers, cooperatives, and agro-processing enterprises.

7.1. Techniques of value addition of fruits and vegetables

Technique	What It Does
Drying/Dehydration	Removes moisture (naturally via sun/air, or artificially via controlled heat, humidity, airflow)
Juice Extraction	Extracts, treats, and packages juice for consumption/storage
Jam/Jelly Making	Cooks fruit with sugar (+ pectin/acid) into a thick, sweet spread
Frying	Cooks in hot oil (180–190°C) to preserve and add flavor
Pickling	Preserves via lactic acid fermentation in brine, or marination in vinegar
Fermentation	Microbes (yeast/bacteria) break down sugars anaerobically — <i>alcoholic</i> or <i>lactic acid</i> types
Candy Making	Glazes/coats fruit, vegetables, or nuts in sugar
Powder Production	Grinds dried produce into fine powder (e.g., ginger, turmeric, chili powder) — improves storage & transport



Figure 19: Different methods of drying vegetables.

Session Two: Seed Production Process and Management Techniques

Time:	3 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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This session introduces the key concepts of quality seeds, their importance, and practical methods for selecting and producing them. It covers vegetable and field crop seed production techniques, including variety selection, plant identification, and harvesting.

Session Content:	1. Introduction and importance of quality seed production 2. Selection of quality seed
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Materials Required

Planting rope, measuring tape, fresh seed, spade, hoe, plastic tarpaulin sheet, packaging plastic/containers, labelling materials

INFORMATION

1. What is a Seed?

A seed is a living material used for growing a new crop. It carries the genetic characteristics of the parent plant and plays an important role in crop production.

1.1. Types of Seeds

Seed Class	Characteristics
1. Breeder Seed	• Produced under the supervision of plant breeders • Maintains genetic purity (highest purity level) • Used for production of foundation seed
2. Foundation Seed	• Produced from breeder seed • Maintains high genetic purity and quality • Used for production of certified seed
3. Certified Seed	• Produced from foundation seed • Distributed to farmers for crop production

4. Truthfully Labeled Seed

- Sold with proper labelling by the producer
- Quality is the responsibility of the producer (not government-certified)

1.2. Key Features of Quality Seeds

1 High germination percentage  Most seeds sprout and grow into healthy plants. ✓	2 Genetic purity  Same variety (Uniform plants) Same variety (Uniform plants) ✓	3 Physical purity  Seeds are clean, well-filled and free from broken seeds, shriveled seeds and other crop seeds. ✓	4 Healthy and disease-free condition  Seeds are free from diseases, insect pests and damage. ✓
5 Proper moisture content  Seeds have right amount of moisture for safe storage and long shelf life. ✓	6 Good vigor and uniform growth  Seeds produce strong plants and healthy, uniform crops. ✓	7 Free from weed seeds and inert materials  Pure seed Weed seeds Inert materials ✓ Seeds are free from weed seeds, soil, stones and other inert matter. ✓	

Benefits of Using Quality Seeds

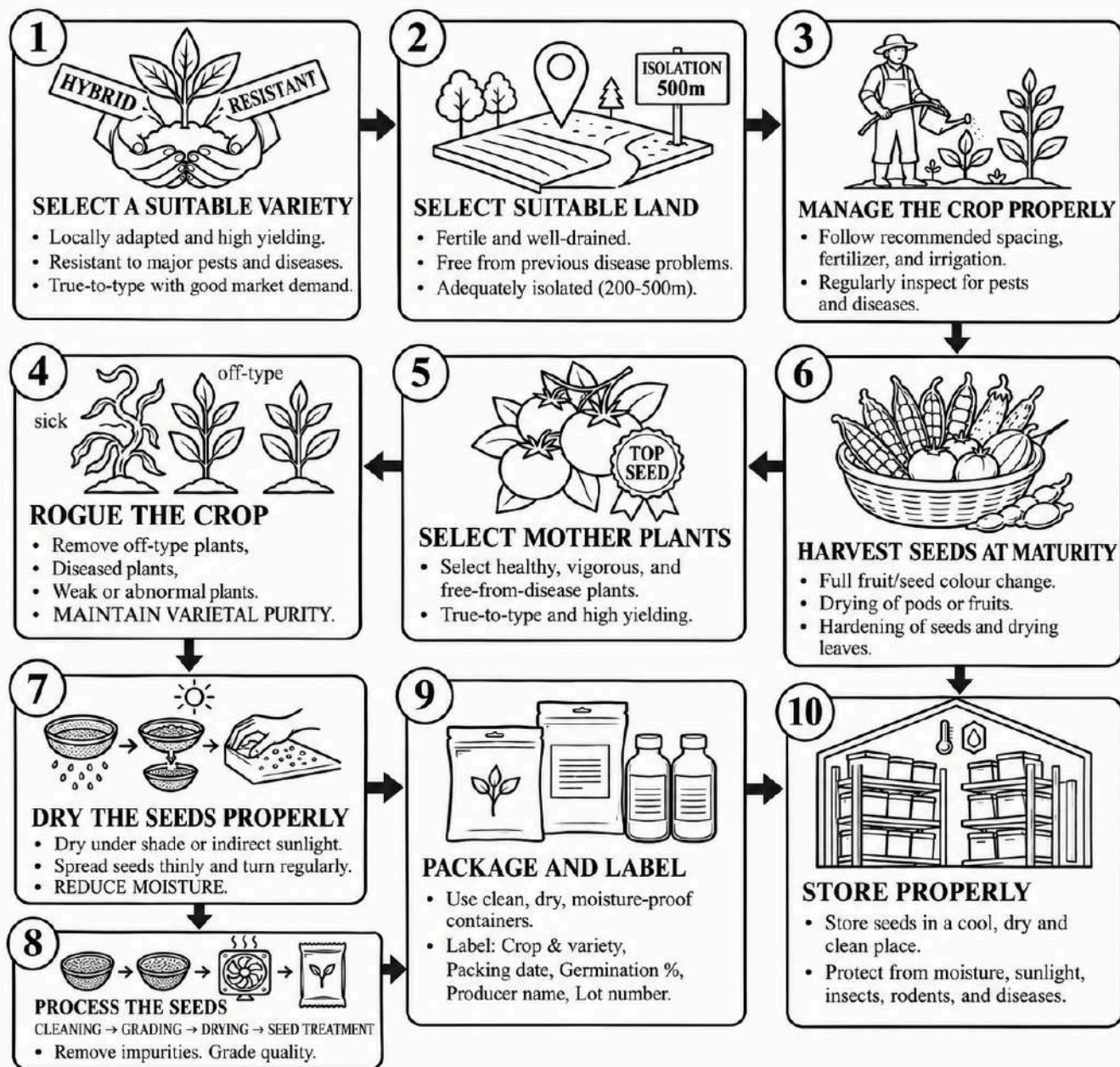
- Higher crop yield
- Better germination and uniform growth
- Strong and healthy plants
- Resistance to pests and diseases
- Better adaptability to local conditions
- Early maturity and better-quality produce
- Increased farmer income
- Reduced seed rate requirement

Importance of Seed Production

- Ensures the availability of quality planting materials
- Conserves local and improved varieties
- Supports food security and sustainable agriculture
- Reduces dependency on outside seed sources

2. Seed Production Methods

2.1. Vegetable Seed Production Key Steps



2.2. Field Crop Seed Production

MAIZE COB SELECTION (Good Seed, Better Yield)			
Characteristics of Good Maize Cobs		Steps in Maize Seed Selection	
1	Medium to large in size	1	Select healthy plants before harvest
2	Well-filled from tip to base	2	Marked vigorous and true-to-type plants
3	Uniform in kernel and color	3	Harvest mature cobs separately
4	Free from pest and diseases	4	Dry cobs properly before shelling
5	Well dried and mature	5	Store seeds in clean and dry containers
 Good cobs produce good seeds Good seeds produce better yield!			

SELECTION OF GOOD PANICLES (Quinoa, Rice, and Buckwheat)

1. SELECTION OF GOOD PANICLES				2. STEPS IN PANICLE SELECTION		3. AVOID SELECTING			
Choose panicles that are:				1 Observe the crop during flowering and maturity.					
 Healthy and disease free				2 Mark healthy and uniform plants.					
 Well-filled with grains				3 Select fully mature panicles.					
 Uniform in size and shape				4 Harvest selected panicles separately.					
 Mature and properly dried				5 Dry and thresh carefully.					
 From vigorous and true-to-type plants				6 Store cleaned seeds properly.					
									
									
									

2.3. Potato Seed Production

1	Seed Selection Use certified, healthy, and disease-free seed tubers.
2	Land Preparation Prepare well-drained ridges before planting.
3	Planting Plant sprouted seed tubers with proper spacing between rows and plants.
4	Crop Care Carry out timely irrigation, weeding, fertilization, and earthing up.
5	Roguing / Field Inspection Walk the field regularly and remove diseased or off-type plants.
6	Pest & Disease Management Monitor the crop closely and manage pests and diseases promptly.
7	Haulm Cutting Cut the vines (haulm) 10–14 days before harvest to help skins set.
8	Harvesting Harvest only matured, healthy tubers, handling them carefully to avoid damage.
9	Grading Sort healthy seed tubers by size and quality before storage.
10	Storage Store graded seed tubers in a cool, dry, and well-ventilated place.

3. Seed Certification

Seed certification is required to ensure genetic purity, provide disease-free planting material, and protect national food security under the Seeds Act of Bhutan 2000. It ensures that commercial growers and farmers use only high-performing, officially approved crop varieties.

Seed certification is mandatory only for the commercial sale, distribution or import /export of seeds.

Importance of Seed Certification

- Ensures varietal purity.
- Produces high-quality seed.
- Improves crop productivity.
- Builds farmer confidence.
- Prevents distribution of poor-quality seed.
- Supports national seed security and sustainable agricultural development.

3.1. Seed Certification Process

1 Apply & Register the Field

Tell BFDA about your crop, variety, seed source, and field. Your field gets registered for certification.

2 Verify the Seed Source

BFDA checks that the seed you used to grow your crop came from an approved, genuine source.

3 Field Inspection

BFDA officials visit your field at key stages (growth, flowering, harvest, and after harvest) to check spacing, off-type plants, weeds, pests, and disease.

4 Rouging

Walk your field often. Pull out any off-type, diseased, or weak plants to keep the seed pure. This is the grower's responsibility.

5 Harvest & Process Separately

Harvest your certified crop on its own. Clean, grade, dry, and pack it carefully so it stays pure.

6

Sample & Lab Testing

Request sampling. BFDA sends samples to a lab to test purity, germination, moisture, and seed health.

7

Certification & Labeling

If your seed passes all standards, BFDA issues an official certificate and label for your seed lot.

8

Storage & Distribution

Store certified seed in a cool, dry place and sell it only through authorised channels to farmers.

Session Three: Farm Business Management

Time:	3 hrs.	Delivery Methods:	Theory: 40% Practical: 60%
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This session is designed to transform subsistence farmers into market-oriented farmers by equipping them with practical farm business management skills and strategic decision-making capabilities. It provides essential knowledge and tools to plan, manage, and optimise farm enterprises in a competitive, evolving agricultural market. The session emphasises a shift from production-focused approaches to market-led farming systems, enabling farmers to align production with market demand, improve profitability, and enhance income stability. Key areas include value chain analysis, cost of production, farm record keeping, and business planning to improve efficiency and reduce risks. It also promotes collective action, market linkages, and enterprise development, enabling farmers to access better markets, engage in contract farming, and leverage partnerships, thereby increasing rural employment, income, and sustainable agricultural and economic growth.

Session Content:	1. Introduction to farm business management 2. Value chain analysis 3. Farm business plan development 4. Market Risk Assessment
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Materials Required

Chart paper (5), marker pen (5), whiteboard (1)

INFORMATION

1. Farm Business Management

A farm is a business enterprise that combines land, labour, capital, and management to produce crops and livestock for income and sustainability.

1.1. Farm Business Management Framework

The curriculum follows the Farm Business Cycle:



2. Mindset Transformation – From Farmer to Agri-preneur

For generations, farming has been seen primarily as a lifestyle, growing enough food to feed the household, selling whatever small surplus remains at the local market, and accepting whatever price traders offer.

An agri-preneur flips this mindset entirely. They view land, labor, and seeds not as traditional obligations, but as capital investments expected to yield a clear financial return.

Aspect	Traditional Farmer	Agri-preneur
<i>Primary Goal</i>	Family subsistence and survival	Profitable, sustainable business
<i>Production Focus</i>	“I plant what I know how to grow.”	“I plant what buyers demand.”
<i>Risk Approach</i>	Avoids change to stay safe	Takes calculated, tested risks
<i>Post-Harvest</i>	Sacks raw crop for bulk sale	Grades, packages, or processes

3. Market Analysis and Opportunity Identification

Understanding customer needs and market conditions is the foundation of a successful farm business. Farmers should assess market demand, seasonal price trends, consumer preferences, and buyer requirements before deciding what, when, and how much to produce. Access to reliable and timely market information enables farmers to identify profitable opportunities, reduce marketing risks, and make informed production decisions.

Adopt the following key measures to tap into market potential:

3.1. Market Demand and Price Tracking

Crop prices can fluctuate significantly throughout the year, largely due to seasonal changes in supply and demand. Selling crops such as cabbage or tomato when many farmers are harvesting at the same time can result in low prices and reduced profits. By regularly monitoring market prices at major urban markets, such as the Centenary Farmers' Market (CFM) in Thimphu, farmers can identify periods of limited supply when prices are more favourable.

Farmers should:

- Monitor prices regularly in major local and urban markets.
- Identify seasonal periods when demand is high and supply is low.
- Consider production timing based on anticipated market opportunities.
- Compare prices offered by different buyers before making sales.
- Maintain simple records of prices to identify recurring seasonal trends.

3.2. Staggered Production Calendars

Instead of planting an entire field at the same time, farmers can use staggered planting schedules. This involves planting the same crop at different intervals so that harvesting takes place over an extended period.

Staggered production helps farmers:

- Avoid a large harvest arriving in the market at the same time.
- Reduce the risk of market gluts and price declines.
- Maintain a more consistent supply for regular buyers.
- Spread labor requirements over a longer period.
- Generate more regular farm income.

3.3. Post-Harvest Loss Control

A significant portion of farm income can be lost after harvesting due to poor handling, inadequate packaging, transportation, and storage. Vegetables placed roughly into sacks or poorly ventilated containers can suffer bruising, wilting, and rotting, resulting in quality deterioration and rejection by buyers.

Farmers should:

- Harvest crops carefully at the appropriate maturity stage.
- Sort and grade produce according to quality and size.
- Remove damaged or diseased produce before packing.
- Use suitable crates or containers to minimise bruising and compression.
- Keep produce shaded and cool after harvest.
- Handle, transport, and store produce carefully to maintain quality.

4. Farm Costing and Record Keeping

Understanding the costs and returns associated with each farm enterprise is essential for running a profitable farm business. Farmers should regularly record their expenses, income, production volumes, and selling prices. This information helps them determine which crops or enterprises are profitable and where costs can be reduced.

Farmers should understand two important types of costs:

- **Fixed Costs:** Expenses that generally do not change with the volume of production, such as the purchase of a power tiller, land lease payments, fencing, irrigation infrastructure, or farm equipment.
- **Variable Costs:** Expenses that change with the level of production, such as seeds, fertilizers, crop protection materials, fuel, packaging, hired labor, and transportation.

If farmers do not record the money spent on seeds, fertilizer, fuel, labor, transportation, and other inputs, it is difficult to determine whether the farm is generating a genuine profit or operating at a loss.

Calculating Basic Profitability Indicators

Farmers can use simple financial measures to assess the performance of their farm enterprises.

Gross Margin = Total Revenue – Total Variable Costs

Break-Even Selling Price = Total Production Cost ÷ Total Quantity Produced (kg)

For example, if the total cost of producing chili results in a break-even price of Nu. 45/kg, selling the crop at Nu. 40/kg means the farmer is not covering the full cost of production.

Note: Gross margin focuses on the return after variable costs, while break-even price indicates the minimum average selling price required to recover the total production cost.

Practice Daily Farm Record Keeping

Every farmer should maintain a simple farm logbook to record income and expenses. Records should be updated regularly rather than relying on memory.

Date	Farm Activity / Item	Category	Cash Out (Nu.)	Cash In (Nu.)
3-May	Purchased 3 bags of organic fertilizer	Input Expense	1,050	—

3-Dec	Hired 2 laborers for bed preparation	Labor Expense	800	—
20-Jun	Sold 120 kg of beans @ Nu. 60/kg	Crop Income	—	7,200

Net Cash Flow = Total Cash In – Total Cash Out

Keeping accurate records enables farmers to:

- ❖ Calculate the actual cost of producing each crop.
- ❖ Identify profitable and unprofitable enterprises.
- ❖ Monitor cash flow throughout the production cycle.
- ❖ Plan future production and investments.
- ❖ Support applications for loans or other forms of financing.
- ❖ Make better decisions about input use and marketing.

5. Risk Management and Value Addition

Farm businesses are exposed to various risks, including unpredictable weather, pest and disease outbreaks, input price increases, crop failures, and sudden changes in market prices. Smart agripreneurs reduce these risks by diversifying their production, improving post-harvest management, exploring value addition, and developing multiple marketing channels.

5.1. Diversification Strategy

Farmers should avoid relying entirely on a single crop or enterprise for household income. A diversified farm can generate income at different times of the year and reduce the financial impact of crop failure or unfavorable market prices.

A practical approach is to combine three broad categories:

- **Fast-Cash Crops (30–60 days):** Radish, spinach, coriander, and other short-duration vegetables that can provide frequent income for household expenses.
- **Seasonal Main Crops (90–120 days):** Potato, cabbage, chili, maize, and other crops that provide the main seasonal revenue.
- **Perennial and High-Value Crops:** Cardamom, fruit trees, avocado, asparagus, and other long-term enterprises that can contribute to future household wealth.

Where feasible, farmers can also consider livestock, poultry, beekeeping, processing, or other complementary enterprises to further diversify income.

5.2. Value Addition

Farmers can increase the value of their produce by undertaking simple processing, grading, packaging, or branding activities. Instead of selling all produce as raw commodities, suitable products can be processed or packaged to meet specific consumer needs.

6. Collective Action and Cooperatives

A smallholder farmer negotiating alone with large buyers, wholesalers, or urban traders often has limited bargaining power. Working together through a Farmer Group, Producer Group, or Cooperative can significantly strengthen farmers' ability to access markets and negotiate better terms.

Collective action can help farmers:

- ❖ Aggregate larger volumes of produce to meet buyer requirements.
- ❖ Negotiate better prices through bulk sales.
- ❖ Reduce transportation and marketing costs.

For more information on group & cooperatives formation visit Department of Agriculture and Marketing Cooperatives under Ministry of Agriculture and Livestock

7. Product Certification and Standards

Product certification and standards ensure that agricultural products meet required quality, safety, and production requirements. Certification builds buyer confidence, improves market access, and can increase product value.

IMPORTANCE OF CERTIFICATION	IMPORTANCE OF STANDARDS
 1. Builds consumer trust Assures buyers that products are safe and reliable.	 1. Ensures consistent quality Products meet defined quality requirements.
 2. Improves market access Opens local and international/export opportunities.	 2. Promotes food safety Ensures safe and hygienic products.
 3. Enhances product value Certified quality can attract better prices and buyers.	 3. Meets market requirements Helps comply with national and international standards.
	 4. Protects consumers Assures safety and reliable product quality.

7.1. Certification

Different certification systems may be followed depending on the target market. The appropriate certification should be selected based on the destination country, regulatory requirements, industry standards, and customer expectations to ensure compliance and facilitate market access. Common certification system in Bhutan are as given below:

1. Organic certification



2. Good Agricultural Practices (GAP) certification



3. Food safety and quality certification



8. Green Economy and Green Taxonomy

8.1. Green Economy in Agriculture

Promotes environmentally sustainable and climate-resilient farming practices.

Practices	Benefits
• Organic farming • Composting • Water conservation • Integrated pest management • Agroforestry and renewable energy	• Protects natural resources • Improves soil health • Reduces environmental impact • Creates sustainable income opportunities

8.2. Green Taxonomy

A framework used to identify and support environmentally sustainable agricultural activities.



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Thank you for your commitment
to learning and sharing knowledge.

Your role as a Community Resource Person
is vital to building a resilient, productive
and sustainable agriculture for our communities
and our nation.



*Together, let us grow knowledge,
strengthen communities,
and nurture a thriving Bhutan.*



Learn
Continuously



Share
Generously



Apply
Practically



Inspire
Others

