Draft Study Material

ORGANIC GROWER

Qualification Pack Code: AGR/Q1201

Sector: Agriculture

Class XI

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION

(A constituent unit of NCERT, under Ministry of Education, Government of India)

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PREFACE

Skill Education is a dynamic and evolving field, and ensuring that every learner has access to quality learning resources is of paramount importance. The absence of finalized study material should not hinder the educational progress of students in the schools. To address this need, the PSS Central Institute of Vocational Education (PSSCIVE) presents this Draft Study Material, a provisional yet comprehensive resource, designed to support the teaching-learning process until the official study materials or textbooks are released by the National Council of Educational Research and Training (NCERT).

This draft study material provides a structured, accessible, and curriculum-aligned framework for both teachers and students during the interim period. The content has been carefully developed to ensure continuity of learning and to help students achieve the prescribed learning outcomes. The content of the draft study material covers essential concepts, practical competencies, and skill-based knowledge in accordance with the curriculum and established educational standards.

The primary objective of this material is to sustain the momentum of skill education and facilitate effective classroom transactions while the finalized textbooks are under preparation. It serves as a guiding resource that can be adapted and enriched to meet the diverse learning needs of students.

We express our sincere gratitude to the academicians, educators, subject matter experts, industry professionals, academic consultants, and all other contributors whose expertise and valuable insights have made the development of this draft study material possible.

Teachers are encouraged to use this draft study material as a guiding resource and to supplement it with additional learning materials, practical activities, and contextual examples that cater to the unique needs and learning styles of their students. We welcome constructive feedback and suggestions, particularly from teachers and practitioners, to further enhance the content and effectiveness of this study material.

We hope that this draft study material serves as a valuable resource in fostering knowledge, skills, and employability among learners, while supporting the successful implementation of skill education programmes across the country.

Deepak Paliwal
Joint Director
PSS Central Institute of Vocational Education

03 August 2026
Bhopal

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ABOUT THE BOOK

An Organic Grower plays a significant role in producing safe, nutritious, and environmentally sustainable crops by adopting scientifically sound organic farming practices. The "Organic Grower" book for Class XI provides a systematic introduction to the principles and practices of organic farming through four comprehensive units.

Unit 1 on *Crops and Cropping Systems* introduces the major groups of agricultural crops, including cereals, pulses, oilseeds, vegetables, flowers, and cash crops, highlighting their importance in food security, nutrition, and economic development. It also explains different farming systems, such as subsistence, commercial, mixed, and integrated farming, along with cropping systems including crop rotation, intercropping, mixed cropping, and multiple cropping.

Unit 2 on *Principles and Practices of Organic Farming* deals with the fundamental concepts of organic agriculture based on the internationally accepted principles of health, ecology, fairness, and care. It explains the components of an organic farming ecosystem, including soil, microorganisms, crops, livestock, and natural inputs, and describes their interactions in maintaining ecological balance, improving soil health, and supporting sustainable crop production.

Unit 3 on *Water, Nutrient, Weed, and Pest Management* discusses the efficient management of water, nutrients, weeds, and pests in organic farming systems. It covers various irrigation methods, including surface, drip, and sprinkler irrigation, for efficient water use. It also introduces sustainable weed management through cultural, manual, mechanical, and biological methods, along with integrated pest management (IPM), biological control agents, and botanical pesticides for environmentally friendly crop protection.

Unit 4 on *Organic Crop Production Practices* covers the practical application of organic farming principles through crop-specific packages of practices. It describes organic cultivation techniques for vegetable crops, including land preparation, seed treatment, compost application, nutrient management, irrigation, and pest management. It also covers organic production practices for flower and introduces protected cultivation technologies such as polyhouses, shade-net houses, and other controlled-environment production systems that enhance productivity.

The textbook integrates theoretical concepts with practical applications, enabling students to develop the knowledge, technical skills, and professional competencies required for organic farming.

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ACKNOWLEDGEMENTS

The PSS Central Institute of Vocational Education (PSSCIVE) expresses its sincere gratitude to the Department of School Education and Literacy (DoSE&L), Ministry of Education, Government of India, for the financial support provided through the project approved by the Project Approval Board (PAB) under the *Samagra Shiksha* for the development of curricula and textbooks aligned with various job roles across diverse sectors. This support has been instrumental in strengthening skill education by enabling the creation of high-quality, industry-relevant learning resources for students.

PSSCIVE places on record its special appreciation to Dr. Satendra Arya, Chief Executive Officer, Agriculture Skill Council of India (ASCI) for his invaluable support in the development of the Qualification Pack (QP) for the job role of Organic Grower. His expertise and continued involvement significantly contributed to strengthening the competency standards that form the foundation of the curriculum and the books.

PSSCIVE also gratefully acknowledges the valuable contributions of the subject experts for their technical inputs, and support in the development of this book.

The Institute places on record its deep appreciation for the dedicated efforts and valuable contribution of Dr. Deepti Kavathekar, Consultant (Contractual) and Dr.Saurabh Meshram, Assistant Professor (Contractual) in the review, and proofreading of the content.

PSSCIVE also gratefully acknowledges the contributions of Ms. Akansha Dubey, Senior Editor (Contractual), Mr. Jitendra Kumar, Graphic Designer (Contractual), and Mr. Mohit Jain, DTP Operator (Contractual), for their support in editing, formatting, graphic design, and typesetting of this book. Their commitment and expertise have significantly contributed to the quality and presentation of the publication.

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Unit 1	Introduction to Crops and Cropping Systems

Unit 1 on *Introduction to Crops and Cropping Systems* helps you understand agricultural practices, including the cultivation of crops and the management of livestock for the production of food, fibre, and other agricultural products.

Session 1 on *Introduction to Major Agricultural Crops*, introduces you to major crops such as cereals (rice, wheat, maize), pulses (lentils, beans), oilseeds (soybean, sunflower), and cash crops (cotton, sugarcane). It also highlights their importance in food production, industrial use, and economic development.

Session 2 on *Farming Systems and Their Importance*, familiarises you with different farming systems such as rain-fed farming, irrigated farming, commercial farming, plantation farming, mixed farming, intensive farming, extensive farming, and organic farming. It explains their characteristics based on water supply, production purpose, resource use, and farming techniques.

Session 3 on *Cropping Systems and Cropping Patterns*, introduces various cropping systems such as monocropping, multiple cropping, sequential cropping, intercropping, mixed intercropping, and relay intercropping. It also explains their role in efficient land use, maintaining soil fertility, managing pests, and increasing agricultural productivity.

Session 1: Introduction to Major Agricultural Crops

Agriculture is one of the most fundamental activities for human survival, providing food, raw materials, and resources essential for economic development and societal progress. It encompasses the cultivation of crops, the rearing of livestock, and related activities that contribute to the production of food, fibre, fuel, and medicinal plants.

1. Classification of Major Agricultural Crops

Agricultural crops are classified into four main categories based on their usage and purpose in agriculture. These categories are food crops, cash crops, plantation crops, and vegetables (Fig. 1.1). Food crops are grown mainly for human consumption, while cash crops are cultivated for commercial and industrial purposes. Plantation crops are generally grown on a large scale and are important for trade and processing industries. Vegetables are cultivated for their nutritional value and form an essential part of a balanced diet. This classification helps in understanding the importance and uses of different crops in agriculture and everyday life.

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Fig 1.1: Classification of major agricultural crops

a) Classification based on season

Crops can be classified based on the season in which they are grown. The following is an overview of the classification of major agricultural crops by season:

i) ***Kharif* crops:** Crops that are grown during the monsoon season from June to October. Examples of *kharif* crops include rice, *jowar, bajra*, and groundnut.
ii) ***Rabi* crops:** The crops grown during the winter season from October to March. Examples include wheat, gram and safflower.
iii) ***Zaid* or summer crops:** Crops grown during the summer season from March to June. Examples of *zaid* or summer crops include summer groundnut, watermelon, melon and cucumber.

b) Agronomic classification of crops based on economic importance

Agronomic classification refers to the grouping of crops according to their usefulness and economic value to humans. Crops are classified based on the purpose for which they are cultivated, such as food, fibre, oil, fodder, medicinal use, or industrial raw

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materials. This classification helps you in understanding the importance and utilisation of different crops in agriculture and daily life. The classification is as follows:

i) **Cereal Crops (Grain crops):** Grasses belonging to the family *Poaceae*, grown for edible seeds. Examples include wheat, rice, maize, barley, oats, rye, sorghum, millet, and triticale.

ii) **Forage Crops**: Crops grazed by animals or harvested for hay, silage, or soiling. Examples include *berseem (Trifolium alexandrinum),* clover, and fodder cereals (when harvested for animal feed).

iii) **Fibre Crops:** Crops grown for their fibre, used in textiles, ropes, and mats. Examples include cotton, jute, flax, *sunhemp*, kenaf, and *sial.*

iv) **Sugar Crops**: Crops used for sugar production. Some of the examples include sugarcane, sugar beet, and sweet sorghum.

v) **Oilseed Crops**: Crops grown for extracting oil from seeds. Examples include mustard, groundnut, sunflower, safflower, soybean, sesame, castor, linseed, and flax.

vi) **Leguminous Crops (Legumes):** Crops belonging to the family Fabaceae (formerly known as *Leguminosae)* are grown for edible seeds, forage, or green manure. Examples include chickpea (*gram*), pea, pigeon pea, cowpea (*lobia*), mung bean, lentil, *faba* bean, field bean, lima bean, and *alfalfa.*

vii) **Root, Bulb and Tuber Crops**: Crops grown for edible underground parts. Some of the examples include the following:

- **Root Crops:** carrot, radish, turnip, beetroot
- **Bulb Crops:** onion, garlic
- **Tuber Crops:** potato, yam, sweet potato

viii) **Narcotic or Drug Crops**: Crops with narcotic, medicinal, or calming effects. Examples include poppy, tobacco, tea, coffee, and peppermint (mentha × piperita)

ix) **Vegetable or Garden Crops:** Crops grown for edible leaves, shoots, flowers, fruits, or seed. Examples include asparagus, broccoli, cabbage, cauliflower, spinach, cucumber, pumpkin, squash, tomato, eggplant, and okra (lady's finger).

x) **Condiment and Spices Crops:** Crops grown for culinary use, flavouring, or spices. Examples include coriander, mint, black pepper, cardamom, and chillies.

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xi) **Pulses:** Crops rich in protein, often improving soil fertility by fixing atmospheric nitrogen. Examples include chickpea, lentil, pigeon pea, mung bean, and kidney bean.

xii) **Tanning and Dye Crops:** Crops cultivated for natural dyes or tanning agents used in textiles and leather. Examples include indigo, henna, and myrobalan.

xiii) **Fruit Crops:** Plants grown primarily for their edible fruits, providing vitamins and minerals. Examples include mango, banana, apple, orange, and papaya.

xiv) **Medicinal and Aromatic Crops:** Crops grown for therapeutic properties or fragrant oils, used in medicines, perfumes, and cosmetics. Some of the examples are aloe vera, *tulsi* (holy basil), mint, and lemongrass.

xv) **Plantation Crops:** Perennial crops grown on large estates for commercial or industrial purposes. Examples include tea, coffee, rubber, coconut, oil palm, and cocoa.

c) Classification based on lifespan

The life span of a plant begins with the germination of the seed and continues through various stages of growth and development until the plant produces flowers and seeds or fruits. The duration of this life cycle differs from one crop to another. Some crops complete their life cycle within a single season, while others take two seasons or continue to grow and produce for many years. Based on the duration required to complete their life cycle, crops are classified into three groups: annual crops, biennial crops, and perennial crops (Fig. 1.2). These are explained below:

- **Annual crops:** Crops of this category complete their entire life cycle from seed to seed in a single growing season and then die.
- **Biennial crops:** These crops complete their life cycle in two different seasons. Vegetative growth occurs during the first season, resulting in a rosette form, but plants do not start flowering (blooming). In the second season, these plants bear flowers and seeds.
- **Perennial crops:** These crops are grown in the soil for more than two years (they can persist for more than two years). They may either produce seed or not every year. In other words, they have an indefinite life period. They do not die after reproduction but continue to grow continuously from year to year.

A list of annual, biennial and perennial crops is given in Table 1.1.

Table 1.1: Major agricultural crops based on life span

Annual Crops	Biennial Crops	Perennial Crops
Wheat, barley, rice, maize, soybean, sesame, watermelon, *faba* bean, peas and sunflower	Carrot, cabbage, radish, onion, Sweet William and hollyhocks	Sugarcane, alfalfa, ginger, banana, coconut and palm

Fig. 1.2: Classification of crops based on life span

2. Major Crops Grown Under Organic Farming

Organic farming is a holistic production-management system that promotes and enhances agroecosystem health. A variety of food and non-food crops are cultivated by organic methods in India, depending upon the differences in soil, climate and cultivation practices. The major crops under organic cultivation can be divided into five categories as field crops, vegetables, fruit, flowers and plantation crops (Table 1.2).

Table 1.2: Major agricultural crops of India grown under organic farming

S. No.	Crop category	Crops
1.	Field crops	Rice, wheat, cotton, sugarcane, millets, maize, pulses and oilseeds
2.	Vegetable crops	Onion, okra, cowpea, potato and tomato
3.	Fruit crops	Mango, banana, pineapple and passion fruit
4.	Plantation crops	Tea, coffee and coconut
5.	Flower crops	Rose, marigold, gerbera and carnations

a) Field crops

Field crops, also known as arable crops, are plants grown on a large scale in open fields for various uses such as food, fibre, fuel, and animal feed. These crops form the backbone of agricultural production worldwide, playing a critical role in ensuring food security and supporting industries related to textiles and livestock. Some of the major field crops grown in India are as follows:

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Rice: It is one of the most important cereal crops of India and is predominantly grown as a Kharif crop. It requires hot and humid climatic conditions for proper growth. A mean monthly temperature of around 24°C and an average temperature ranging from 22°C to 32°C are considered suitable for rice cultivation. Rice can be grown in different types of soils; however, deep clayey and loamy soils provide ideal growing conditions. In recent years, organic rice cultivation in India has gained popularity due to the increasing demand for healthy, chemical-free food and environmentally sustainable farming practices. Some key aspects of organic rice cultivation are as follows:

i. **Key regions:** Organic rice is cultivated in various regions across India, including West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala, Uttarakhand, and Punjab.

ii. **Popular varieties:** India grows a variety of organic rice, including *Sona Masoori, Gobindobhog*, and indigenous varieties like red rice and black rice.

Wheat: It is the second most important food crop of India after rice. It is mainly grown as a Rabi or winter season crop. Wheat is generally sown at the beginning of winter and harvested during the summer season. An ideal temperature of 20°C to 25°C is suitable at the time of sowing, while a temperature of 30°C to 32°C is considered favourable during maturity and harvesting. The crop grows well in regions receiving an annual rainfall of about 75 cm. In recent years, organic wheat cultivation in India has gained increasing importance due to the rising demand for chemical-free food and sustainable agricultural practices. The general aspects of organic wheat cultivation are given below:

i. **Key regions:** Organic wheat is predominantly cultivated in states like Madhya Pradesh, Rajasthan, Punjab, Uttar Pradesh, and Haryana, where traditional wheat farming is already strong.

ii. **Popular varieties:** Some of the commonly grown organic wheat varieties include *Sharbati, Lokwan*, and indigenous varieties like *Khapli*, which is known for its high nutritional value.

Millets: Millets include pearl millet (bajra), finger millet (ragi), foxtail millet, kodo millet, little millet, barnyard millet, proso millet and sorghum (jowar).

Millets are an important part of Indian agriculture and cuisine, particularly in arid and semi-arid regions. India is one of the leading producers of millets, with various types being grown across different states.

i. **Key regions:** Predominantly grown in the resource fragile agro climatic regions of the country. The important Indian states cultivating coarse cereals are Karnataka, Maharashtra, Tamil Nadu, Madhya Pradesh, Rajasthan and Gujarat.

ii. **Popular varieties:** Each millet variety, such as pearl millet (*bajra*), sorghum (*jowar*), finger millet (*ragi*), foxtail millet, and *kodo* millet, has been developed to

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suit the specific agricultural practices and environmental conditions of different regions.

Pulses: Pulses include a number of crops which are mostly leguminous and provide invaluable proteins to the vegetarian population of the country. Examples include Gram, *Tur* or *Arhar* (Pigeon Pea or Red Gram), *Urd* (Black Gram), *Mung* (Green Gram), *Masur* (Lentil), *Kulthi* (Horse Gram) and *Matar* (Pea). It is grown in a wide range of climatic conditions. A mild, cool and comparatively dry climate with 20°C-25°C temperature is appropriate. 40-45 cm of rainfall is favourable for gram cultivation.

i. **Key regions:** Pulses are grown across several states such as Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Karnataka, Punjab, Haryana, Andhra Pradesh, Telangana and Tamil Nadu.

i. **Popular varieties:** India grows a variety of pulses like Chickpeas, such as *Pusa* 256, JG 11, JG 16 and *Pusa* 372, which are commonly used. In pigeon pea cultivation, varieties like ICPL 87119 (*Asha*), UPAS 120 and *Maruti* are preferred. For green gram, farmers often select varieties such as *Pusa Vishal*, *Samrat* and SML 668, and in black gram cultivation, varieties like T9, PU 31 and LBG 20 are commonly used, while lentil varieties such as *Pusa Vaibhav* and DPL 62 are also suitable for organic farming.

b) Vegetable crops

Vegetables are important protective foods as they provide essential vitamins, minerals, and dietary fibre required for good health. They are also an affordable source of nutrition for the population. Since a large section of the Indian population follows a vegetarian diet, the demand for vegetables in domestic markets remains high. However, the per capita consumption of vegetables in India is still comparatively low, creating significant increasing vegetable production and productivity in the country. Major vegetable-producing states in India include West Bengal, Odisha, Uttar Pradesh, Bihar, and Maharashtra. Some of the major vegetables cultivated in India are as follows:

Onion: It can be grown in all types of soils such as sandy loam, clay loam, silt loam and heavy soils. However, the best soil for successful onion cultivation is deep, friable loam and alluvial soils with good drainage, moisture-holding capacity and sufficient organic matter.

i. **Key regions:** Onions are grown across several states, such as Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Gujarat, Haryana, and Uttar Pradesh.

ii. **Popular varieties:** Popular onion varieties in India are *Pusa Red* (widely grown in North India), *Agrifound Dark Red, NHRDF Red, Punjab Red Round,* and *N-53 (Niphad-53)* (commonly cultivated during the kharif season). *Pusa Ratnar* and *Bangalore Rose Onion* are known for their distinctive pink colour and strong flavour. *Agrifound White, Pusa White Round,* and *Pusa White Flat are* mainly grown for dehydration and processing. *Lasalgaon Onion and Alibag White Onion* are important local varieties widely cultivated in specific regions of India.

Okra: Cultivating organic okra can be a rewarding endeavour, as okra is a hardy and productive plant that thrives in warm climates. Okra is a tropical crop. The optimal temperature for germination, growth, and fruit setting is between 25 and 30°C. The plant needs warm weather and plenty of sunshine. It thrives well in different soil conditions, but it is best to grow it in well-drained soil, especially if it is rich in organic matter.

i. **Key regions:** Okra is particularly well-suited and commonly grown in regions like North India (Rajasthan, Punjab and Haryana), Central India (Madhya Pradesh, Chhattisgarh), Western India (Gujarat, Maharashtra), Southern India (Tamil Nadu, Karnataka, and Andhra Pradesh), Eastern India (West Bengal, Odisha).

ii. **Popular varieties:** *Pusa Sawani, Pusa Bhindi, Arka Anamika, Kranti, Gourmet, Dusheri and Parbhani Kranti.*

Potato: Growing potatoes requires a cool climate. Potatoes grow best in the temperature range of 15-20°C. Nevertheless, it can adapt to a wide range of climatic conditions. In well-drained soils, the potato grows best, and the optimum pH is about 4.8 to 5.8.

i. **Key regions:** Potato is cultivated across northern, eastern, western, southern, and central India.
ii. **Popular varieties:** *Kufri* Series *(Kufri Jyoti, Kufri Chandramukhi, Kufri Pukhraj),* Hp *Series* (Hp-12, Hp-8), *Pusa* Series *(Pusa Barpali, Pusa Lalit) and Indira* Series *(Indira Alankar, Indira Keshav).*

Cowpea *(Lobia):* It is adapted to the hot and dry conditions. It grows best at the lower altitudes with a precipitation of about 1000–1200 mm and temperatures between 22° and 30°C over 6 months.

i. **Key regions:** In India, organic cowpea is cultivated in several key regions due to its adaptability to diverse climatic conditions. The following are some of the prominent regions where cowpea is particularly well-suited and widely grown: Southern India (Tamil Nadu, Karnataka, Andhra Pradesh), Western India (Gujarat, Maharashtra), Central India (Madhya Pradesh, Chhattisgarh), Eastern India (Odisha, West Bengal), and Northern India (Rajasthan).

ii. **Popular varieties:** Popular cowpea varieties in India: *Pusa Komal, Pusa Phalguni, Kashi Unnati, Vamban 1, Vamban 2,* etc.

Tomato: Tomato is a warm-season crop, requiring a warm and cool climate. The plants cannot withstand frost and high humidity. Also, light intensity affects pigmentation, fruit colour and fruit set. The plant is highly affected by the adverse climatic conditions.

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i. **Key regions:** North India (Punjab, Haryana, Himachal Pradesh, Uttarakhand), Eastern India (West Bengal, Assam, Bihar), Southern India (Karnataka, Tamil Nadu, Andhra Pradesh), Western India (Maharashtra, Gujarat), and Central India (Madhya Pradesh, Chhattisgarh).

ii. **Popular varieties:** Popular organic tomato varieties in India are *Pusa Ruby, Pusa Rohini, Arka Vikas, Arka Rakshak and Arka Saurabh.*

c) Fruit crops

Fruit crops (mango, banana, apple, peach, pear, *ber and phalsa*) are quite common in the country. India accounts for 10% of the world's total fruit production. India ranks first in the production of mango, banana and lime. India records the highest productivity of grapes. The leading fruit-growing states in India are Maharashtra, Karnataka, Andhra Pradesh, Bihar and Uttar Pradesh. The following are major fruit crops of India:

Mango: Mango (*Mangifera indica*) is one of the most important and widely cultivated tropical fruit crops. Known as the "king of fruits," mango is prized for its delicious flavour, nutritional value, and versatility. It is a member of the *Anacardiaceae* family and is native to South Asia, particularly India, which is the world's largest producer of mango. The fruit is grown extensively in tropical and subtropical regions worldwide.

i. **Key regions:** Maharashtra, Gujarat, Punjab, Uttar Pradesh, Himachal Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Bihar, Assam.
ii. **Popular varieties:** Popular mango varieties in India; Alphonso (*Hapus*), *Langra, Dasheri, Banganapalli (Beneshan), Kesar, Chausa, Sindhri, Anwar ratol, and Himsagar*.

Banana: Banana is one of the most important and widely consumed fruit crops in the world. Bananas are grown in tropical and subtropical regions and are a staple food for millions of people. These are not only consumed as fresh fruit but are also used in processed forms, making them economically significant for many countries.

i. **Key regions:** Maharashtra, Gujarat, Kerala, Uttar Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu, Punjab, West Bengal, and Assam.

ii. **Popular varieties:** Popular organic banana varieties in India; Grand *Naine* (Cavendish group), Robusta, Dwarf Cavendish, *Nendran, Rasthali, Poovan*, and Red Banana.

d) Plantation crops

Plantation crops are typically grown on large estates or plantations and are usually cultivated for commercial purposes. These crops can be produced organically to meet the increasing consumer demand for chemical-free and sustainably sourced products. The major plantation crops are as follows:

Tea: India is famous for its tea gardens. You may have learned about the tea gardens of Assam and Darjeeling in West Bengal. Commercial tea cultivation in India was initiated by the British during the nineteenth century after the discovery of indigenous tea plants in Assam. Tea is prepared by drying the tender leaves and buds of the tea plant. At present, India is one of the leading tea-producing countries in the world. The geographical conditions required for the cultivation of tea are as follows:

i. **Temperature:** It requires a hot and wet climate. The ideal temperature for the growth of tea bushes and leaves varies between 20°C and 30°C. Temperatures above 35°C or below 10°C would be harmful for the growth of tea bushes and leaves.

ii. **Rainfall:** It requires 150-300 cm of rainfall. A long, dry spell is harmful for tea.

Coffee: Coffee is an indigenous crop of Ethiopia (Abyssinian Plateau). From Ethiopia, it was taken to Yemen in the 11th century. From Arabia, the seeds were brought to India by Baba Budan in the 17th century and were planted in the Baba Budan Hills of Karnataka. Later, British planters took a keen interest in its cultivation, and large coffee estates were established in the hills of the Western Ghats. The geographical conditions required for coffee cultivation are as follows:

i. **Temperature:** It requires a hot and humid climate with temperatures varying between 15°C and 28°C. It is generally grown under shady trees. Therefore, the strong sunshine, high temperatures above 30°C, frost and snowfall are harmful for coffee cultivation. Dry weather is necessary at the time of ripening of berries.

ii. **Rainfall:** For coffee production, rainfall between 150 and 250 cm is favourable.

e) Flower crops

Flowers have significant socio-cultural, cultural, and religious importance. The cultivation of flowers has been practised in India since ancient times. However, in recent years, the perspective of flower production has changed significantly. Floriculture has emerged as an important sector due to its high potential for generating income and employment opportunities. It also promotes the participation of rural women and youth in economic activities. In addition, this sector provides a wide scope for export and contributes to the growth of the agricultural economy

Traditionally, a variety of flowers such as Roses, Marigolds, Gerberas and Carnations have been grown in India. Nowadays, the commercial cultivation of flowers such as roses, Gladiolus, carnations, Anthurium, gerbera and Orchids has become increasingly popular. Let us now understand the varieties of flowers:

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Rose: Roses are among the most popular and widely grown flowers in farming due to their high demand in both domestic and international markets.

i. **Key Regions**: Maharashtra, Karnataka, Tamil Nadu, Himachal Pradesh.

ii. **Popular Varieties**: *Rosa hybrida* (*Pusa* Gold), *Rosa damascena* (Musk Rose).

Marigold: Marigolds are commonly cultivated in India due to their hardiness and ability to adapt to different climates.

i. **Key Regions:** West Bengal, Uttar Pradesh, Karnataka.

ii. **Popular Varieties:** *Tagetes erecta* (*Pusa Narangi Gainda*), *Tagetes erecta* (African Giant*), Tagetes patula* (*Pusa Basanti).*

Some of the geographical conditions required for flower cultivation are as follows:

i. Roses grow best in temperatures ranging between 15°C and 30°C.
ii. Marigolds can be grown successfully in a wide variety of soils. It requires well-drained, well-aerated, deep and fertile soil with good water-holding capacity and a neutral soil reaction (pH 6.5–7.5). The marigold varieties suitable for the winter season are *Pusa Narangi Gainda* and *Pusa Basanti*, while African Giant Tall Yellow and African Giant are suitable for the rainy season.
iii. In tropical climates, Gerbera flowers are grown in the open field. However, in subtropical and temperate climates, they are protected from frost and cultivated in greenhouses or shade-net houses. A day temperature of 22–25°C and a night temperature of 12–16°C are ideal for its cultivation.

3. Comparison Between Commodity Crops and Specialty Crops

Agricultural commodities include staple crops and animals raised on farms and plantations. The prices of agricultural commodities are influenced by several factors such as supply and demand, seasonal price cycles, weather conditions, droughts, floods, extreme cold and other natural disasters.

Commodity crops are generally non-perishable, storable, transportable and undifferentiated in nature. Examples of commodities include grains, precious metals, electricity, oil, beef, orange juice and natural gas. Today, foreign currencies, emission credits, bandwidth and certain financial instruments are also traded in commodity markets.

Specialty crops include fruits, vegetables, tree nuts, dried fruits, flowers, horticultural crops and nursery crops. Some specialty crops are cultivated, while others may also be collected from wild populations. These crops are usually grown on small or medium-sized farms and often require special care and management. Unlike commodity crops, specialty crops generally do not receive the same level of government support and incentives.

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Practical Exercise

Activity 1: Identifying plants using mobile apps

Materials Required:

1. Smartphone
2. Internet access
3. Plant identification applications (apps)

Procedure:

- Download and install a Plant Identification App.
- Use the app to take and upload clear photos of plants.
- Review the app's identification results (common name, scientific name, and characteristics)
- Record the plant's name and details in a document.
- Explore extra app features like habitat info and user photos.

Activity 2: Mapping staple foods in Indian states

Materials Required:

- Books/websites on Indian agriculture
- Internet access
- India map
- Chart/graph tools

Procedure:

- Research which states consume rice, wheat, or millets as staples.
- List the states under each grain category.
- Create a visual (map or chart) to show findings.
- Write a short summary (100–150 words) explaining the data and regional trends.

Check Your Progress

A. Multiple Choice Questions

1. Besides *Rabi* and *Kharif*, which is the third crop season in India?
   a) Zaid
   b) Barsati
   c) Sharad
   d) Jhum

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2. Rabi crops are sown in which months?
   a) March-April
   b) June-July
   c) October-November
   d) January-February

3. Which of the following is a *Rabi* crop?
   a) Wheat
   b) Maize
   c) Rice
   d) Cotton

4. Which of the following is an example of a *Kharif* crop?
   a) Wheat
   b) Rice
   c) Safflower
   d) Gram

5. What is the primary characteristic of biennial crops?
   a) They complete their life cycle in a single season
   b) They complete their life cycle in two seasons
   c) They grow for more than two years
   d) They do not require soil for growth

6. Which of the following is a major plantation crop of India grown under organic farming?
   a) Tomato
   b) Coconut
   c) Onion
   d) Maize

7. In which season are *Rabi* crops typically grown?
   a) Monsoon season
   b) Winter season
   c) Summer season
   d) Spring season

8. Which of the following crops is an example of a perennial crop?
   a) Wheat
   b) Maize
   c) Sugarcane
   d) Gram

9. Which crop is an example of a fruit crop that is grown under organic farming in India?
   a) Banana
   b) Maize

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c) Wheat
d) Onion

B. Fill in the Blanks

1. ____________________ provides food, raw materials, and resources essential for human survival, economic development and societal progress.
2. Kharif crops are grown during the _______ season from June to October.
3. _______ crops are cultivated during the winter season from October to March.
4. _______ crops complete their entire life cycle from seed to seed in a single growing season.
5. _______ is the most important cereal crop of India and is predominantly a Kharif crop.

C. State Whether the Following Statements are True or False

1. Agriculture only involves the cultivation of crops.
2. *Rabi* crops are grown during the monsoon season.
3. Perennial crops have an indefinite life period and do not die after reproduction.
4. *Basmati* and *Sona Masoori* are popular varieties of wheat grown in India.
5. Coffee cultivation requires a hot and humid climate and is generally grown under shady trees.

D. Subjective Questions

1. A farmer living in a region with heavy rainfall and clayey soil wants to practice organic farming during the monsoon season. Which type of crop would be most suitable and why?
2. A farming community wants to grow crops that improve soil fertility naturally and also provide nutritious food. Which category of crops would be most appropriate and why?
3. A farmer in a dry region with low rainfall wants to cultivate crops that require less water and can also be used as animal feed. Which type of crops would be suitable? Explain your answer.

What have you learned?

After completing this session, you will be able to:

- explain the fundamental role of agriculture in human survival;
- identify and differentiate between food crops, cash crops, plantation crops, and vegetables based on their usage;
- classify crops into *kharif, rabi, and zaid* crops based on their season of cultivation;
- describe the principles of organic farming and list major crops cultivated organically in India;

- describe the specific conditions suitable for the cultivation of major organic crops; and
- identify the leading regions of India known for organic farming.

Session 2: Farming Systems and their Importance

A farming system is a combination of interrelated components that work together to ensure sustainable agricultural production. Key components include crops and livestock, which provide food, income, and other resources. Soil, water, and climate are natural factors that influence crop and animal productivity. Supportive elements like tools and machinery, labour, and capital help carry out farm operations efficiently. Inputs such as seeds, fertilisers, and pesticides enhance production, while infrastructure like storage, transport, and markets ensure proper handling and sale of produce. The major components of a farming system include labour, soil, water, crops and livestock (Fig. 1.3).

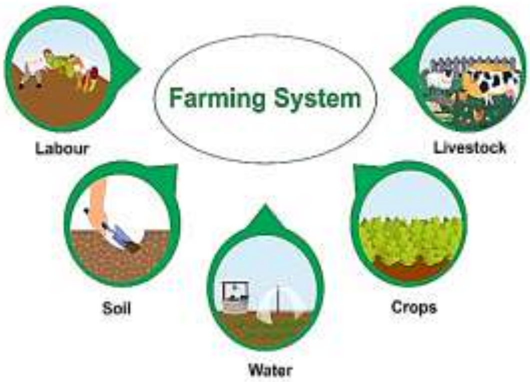

Fig. 1.3: Components of a farming system

1. Major Types of Farming Systems

Farming systems vary across the world depending on the environment, socio-economic conditions, and the available resources. Some of the major types of farming systems are as follows:

(i) Classification based on Water Supply

Based on the availability and source of water, farming systems are classified into the following types:

(i) Rainfed Farming

Rainfed farming is an agricultural system in which crops depend entirely on natural rainfall for their water requirements. No artificial irrigation is provided, making crop production highly dependent on the amount and distribution of rainfall. This type of farming is common in regions receiving moderate to high seasonal rainfall. Although

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it is relatively inexpensive, crop yields are often affected by droughts or irregular rainfall. Examples include wheat cultivation in parts of northern India and maize production in rainfed regions of Africa.

(ii) Irrigated Farming

Irrigated farming is a system in which crops are supplied with water through artificial sources such as canals, wells, tube wells, tanks, reservoirs, and modern irrigation methods like sprinkler and drip systems. Unlike rainfed farming, it does not rely solely on rainfall, allowing crops to be grown in areas with low or uncertain rainfall. Irrigation ensures a reliable water supply, increases agricultural productivity, reduces the risk of crop failure, and supports multiple cropping throughout the year. Examples include rice cultivation in Punjab, India, using canal irrigation and sugarcane farming in Egypt using water from the Nile River.

(iii) Dry Farming

Dry farming is practiced in regions with low annual rainfall, generally less than 750 mm, where irrigation facilities are limited or unavailable. It focuses on conserving soil moisture through suitable tillage practices, mulching, and growing drought-tolerant crops. Farmers usually cultivate crops that require less water, such as sorghum (jowar), pearl millet (bajra), chickpea, and other pulses. The success of dry farming depends on efficient soil and water conservation practices.

(iv) Wet Farming

Wet farming is carried out in regions receiving high annual rainfall, generally exceeding 1,150 mm, or where abundant irrigation water is available. The soil remains moist or waterlogged for much of the growing season, making it particularly suitable for crops that require large amounts of water. Rice is the principal crop grown under wet farming, along with crops such as jute and taro in suitable regions.

Table 1.3: Characteristics of farming systems based on water source and availability

Type of Farming	Water Source	Rainfall Requirement	Example of Common Crops Grown
Rainfed Farming	Natural rainfall only	Moderate to high	Wheat, maize, pulses
Irrigated Farming	Artificial irrigation (canals, wells, reservoirs, drip, sprinkler, etc.)	Any rainfall level	Rice, sugarcane, cotton, vegetables
Dry Farming	Conserved soil moisture with little or no irrigation	Low (<750 mm/year)	Sorghum, pearl millet, chickpea
Wet Farming	Heavy rainfall or abundant irrigation	High (>1,150 mm/year)	Rice, jute

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2. Classification based on the Value of Products

According to the value of products or income, or based on comparative advantages, farming systems can be classified as:

(i) Specialised Farming

This is also known as commercial farming. The main goal of commercial farming is high yield, so that the produce can be sold in local, national or international markets to earn profit. In this case, most of the produce is sold in the market to earn money. In this system, farmers use inputs like irrigation, chemical fertilisers, insecticides, pesticides and seeds of high-yielding varieties. Some examples of commercial crops grown in the different parts of India are cotton, jute, sugarcane and groundnut.

(ii) Plantation Farming

This type of farming involves the growing and processing of a single cash crop purely meant for sale. Large capital input, vast estates, managerial ability, technical know-how, sophisticated farm machinery, fertilisers, good transport facilities, and a factory for processing the produce are some of the essential features of plantation farming. There are plantations of rubber, tea, coffee, cocoa, banana, spices and coconut.

(iii) Diversified Farming

It involves growing multiple crops or combining crops with livestock to reduce risk; for example, vegetables and poultry on small farms in Kerala.

(iv) Mixed Farming

Combines crop cultivation with animal husbandry on the same farm; may also be called the Integrated Farming System (IFS). It integrates various components such as crops, livestock (like cattle, poultry, or goats), aquaculture (fish farming), horticulture, and sometimes even agroforestry within a single farm unit.

This integration ensures that the waste of one component becomes the input for another; for example, livestock manure can be used as organic fertiliser for crops, while crop residues can serve as feed for animals. Such as wheat and dairy cattle farming in Punjab.

3. Classification based on the Proportion of Land, Labour and Capital Investment

The proportion of land, labour, and capital investment refers to the relative share of natural resources, human effort, and man-made assets used in production.

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It determines whether a production process is land-, labour-, or capital-intensive. These are further classified as:

(i) Intensive Farming

It is practised in areas where the irrigated area has increased, and farmers use fertilisers and pesticides on a large scale. Most of the land area is covered by the high-yielding varieties of crops. The production of crops is highly mechanised for various practices of farming. The yield per unit area is generally high under these conditions. In some areas, this has led to the development of dairy farming.

(ii) Extensive Farming

Extensive farming is a system of agriculture in which large areas of land are used for cultivation or livestock rearing, while relatively small amounts of labour, capital, fertilisers, and irrigation are employed per unit of land. This type of farming is commonly practiced in regions where land is abundant and population density is low. Farmers rely more on the availability of large tracts of land than on intensive use of resources to increase production.

In extensive crop farming, crops such as wheat, maize, and barley are grown over vast areas. Modern machinery like tractors, seed drills, and combine harvesters are often used to manage these large farms efficiently. Although the yield per hectare is generally lower than in intensive farming, the total production can still be high because of the large area under cultivation. Extensive crop farming is widely practiced in the prairies of Canada, the Great Plains of the United States, and parts of Australia.

The main advantages of extensive farming are its lower labour requirements and reduced input costs per unit of land. It is particularly suitable for areas with abundant land resources. However, it also has some disadvantages. Productivity per hectare is usually lower than in intensive farming, and production may be affected by weather conditions such as droughts. Despite these limitations, extensive farming remains an important agricultural system in many parts of the world, contributing significantly to the production of food and livestock products.

Practical Exercise

Activity 1: Development of farming system model

Materials Required:

1. Chart paper or cardboard
2. Clay or coloured paper
3. Markers, scissors, glue
4. Small pictures or models of crops, animals, water bodies, tools, etc.

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Procedure:
- Draw a layout of a farm on the chart paper.
- Use clay or cut-outs to represent components like crops, livestock, water sources, and tools.
- Label each component clearly.
- Present how each part interacts within the farming system.

Activity 2: Farming system sorting game

Materials Required:
1. Printed cards with farming system names (e.g., Intensive)
2. Cards with features (e.g., "uses machinery", "for family use", "high input")

Procedure:
- Form small groups.
- Each group picks a system card.
- Match relevant feature cards to the system.
- Discuss the correct matches with the class.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following is a key natural factor influencing crop and animal productivity?
   a) Labour
   b) Soil
   c) Machinery
   d) Capital

2. Rainfed farming depends primarily on:
   a) Canals and tube wells
   b) Artificial fertilisers
   c) Natural rainfall
   d) Irrigation from rivers

3. Plantation farming is characterised by:
   a) Growing multiple crops with livestock integration
   b) Large estates for a single cash crop with high capital and technical input
   c) Small subsistence farming
   d) Dry farming in arid regions

4. Which type of farming uses small inputs of labour, fertilisers, and capital relative to land area?
   a) Intensive farming
   b) Extensive farming

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c) Organic farming
d) Mixed farming

5. In organic farming, which of the following is strictly avoided?
   a) Crop rotation
   b) Composting
   c) Synthetic fertilisers and pesticides
   d) Biological pest control

B. Fill in the Blanks

1. A farming system is a combination of interrelated components that work together to ensure __________ agricultural production.
2. Mixed farming, also called __________, integrates crops, livestock, aquaculture, horticulture, and sometimes agroforestry on the same farm.
3. Crops like __________ in northern India and maize in Africa are examples of rainfed farming.
4. Extensive farming is usually practiced on __________ and scattered holdings with primitive techniques.
5. In intensive farming, farmers use __________ and pesticides on a large scale to increase yield.

C. Subjective Questions

1. A farming system is planned in an area where farmers depend entirely on seasonal rainfall with no artificial irrigation facilities. What type of farming system is being practiced in such a situation?
2. In a region where farmers use canals, tube wells, and other artificial water sources to grow crops throughout the year, what type of farming system is being followed?
3. A farmer aims to earn maximum profit by producing a single crop on a large scale for sale in national and international markets using modern inputs and machinery. Which type of farming system does this represent?
4. On a small farm, a farmer grows multiple crops along with livestock such as poultry and cattle to reduce risk and improve income stability. What type of farming system is being practiced here?
5. In a dry region where farmers cultivate crops only using rainfall without irrigation, what type of farming system is suitable, and what are its main characteristics?

What have you learned?

After completing this session, you will be able to:

- explain the concept and components of a farming system;
- identify the role of natural and supportive elements in sustainable agriculture;

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- distinguish between different types of farming systems based on practices and objectives; and
- describe the features of integrated, organic, mixed, subsistence, commercial, intensive, extensive, and plantation farming.

Session 3: Cropping Systems and Cropping Patterns

A cropping system refers to the pattern and management of crops grown on a particular field or farm over a specific period. It includes the type of crops grown, crop rotation, and practices related to tillage, nutrient management, pest control and soil conservation. The main aim of a cropping system is to enhance productivity while maintaining soil health and environmental sustainability.

Excessive use of chemicals in agriculture has increased the risk of non-point source pollution. Therefore, the site-specific use of fertilisers and agrochemicals through precision farming, along with the adoption of suitable cropping systems, helps minimise environmental pollution.

1. Features of a Good Cropping System

A good cropping system is designed to maximise agricultural productivity, maintain soil health, ensure economic viability, and promote environmental sustainability. The key features of a good cropping system include the following:

- It maintains an adequate level of production and income.
- It minimises economic risks.
- It provides effective control of diseases and insect pests.
- It maintains good chemical, physical and biological conditions of the soil.

2. Types of Cropping Systems

Different cropping systems are followed depending on factors such as climate, soil type, water availability, farming practices and the needs of farmers. These systems help in improving productivity, maintaining soil fertility and making efficient use of available resources. The main types of cropping systems are as follows:

(i) Monoculture cropping systems: It is a cropping system in which the same crop is grown continuously on the same field year after year. It refers to the cultivation of a single crop on a particular piece of land. This practice is also known as continuous cropping or continuous monoculture. Monocropping is commonly followed for commercial and large-scale farming.

Cotton cultivation in Gujarat, India, is a classic example of a monocropping system, where the same crop is grown repeatedly over large areas. Another example is sugarcane cultivation in Uttar Pradesh and Maharashtra, where sugarcane is often cultivated as the dominant crop.

(ii) Multiple/intensive cropping systems: Growing two or more different crops on the same field in a year is called multiple cropping, or intensive cropping systems. Multi-cropping is only possible when we plant crops that require planting for a shorter period of time.

Example: Rice-wheat cropping system in which rice is planted during the *Kharif* season (monsoon), and wheat is sown in the *Rabi* season (winter). Multiple cropping systems are further divided into the following types:

(iii) Sequential cropping: It is considered the growing of crops in sequences or rotations. Crop rotations are systems in which different crops are grown sequentially on the same field in alternate seasons or years. The important characteristics of the sequential cropping are:

- More than one crop is grown on the same field in a year, but one after the other, not at the same time.
- No competition between crops, since only one crop grows in the field at a time.
- Farmers take care of one crop at a time, which makes management easier.

(iv) Intercropping: Growing of two or more crops in the same field at the same time, planted in an arrangement that where the crops may compete with one another (Fig. 1 .4). The intercrop is sown/planted in the inter-row spaces of the main (base) crop to utilise the space.

Examples of intercropping in India include sugarcane with piper mint, maize with potato, and cotton with black gram.

(v) Mixed intercropping:Mixed intercropping is a farming practice where two or more crops are grown together in the same field without any specific row arrangement. In this system, the crops are mixed randomly, allowing them to grow intermingled with each other.

This method aims to maximise the use of available space, water, and nutrients while reducing competition between crops. It also helps in minimising the risk of total crop failure, improves soil cover, which can reduce erosion, and often leads to better pest and disease management due to the diversity of plants in the field.

This traditional method is especially useful in rainfed and smallholder farming systems, where efficient use of limited resources is essential.

Example, *Bajra* + *Moong*, Maize + Groundnut.

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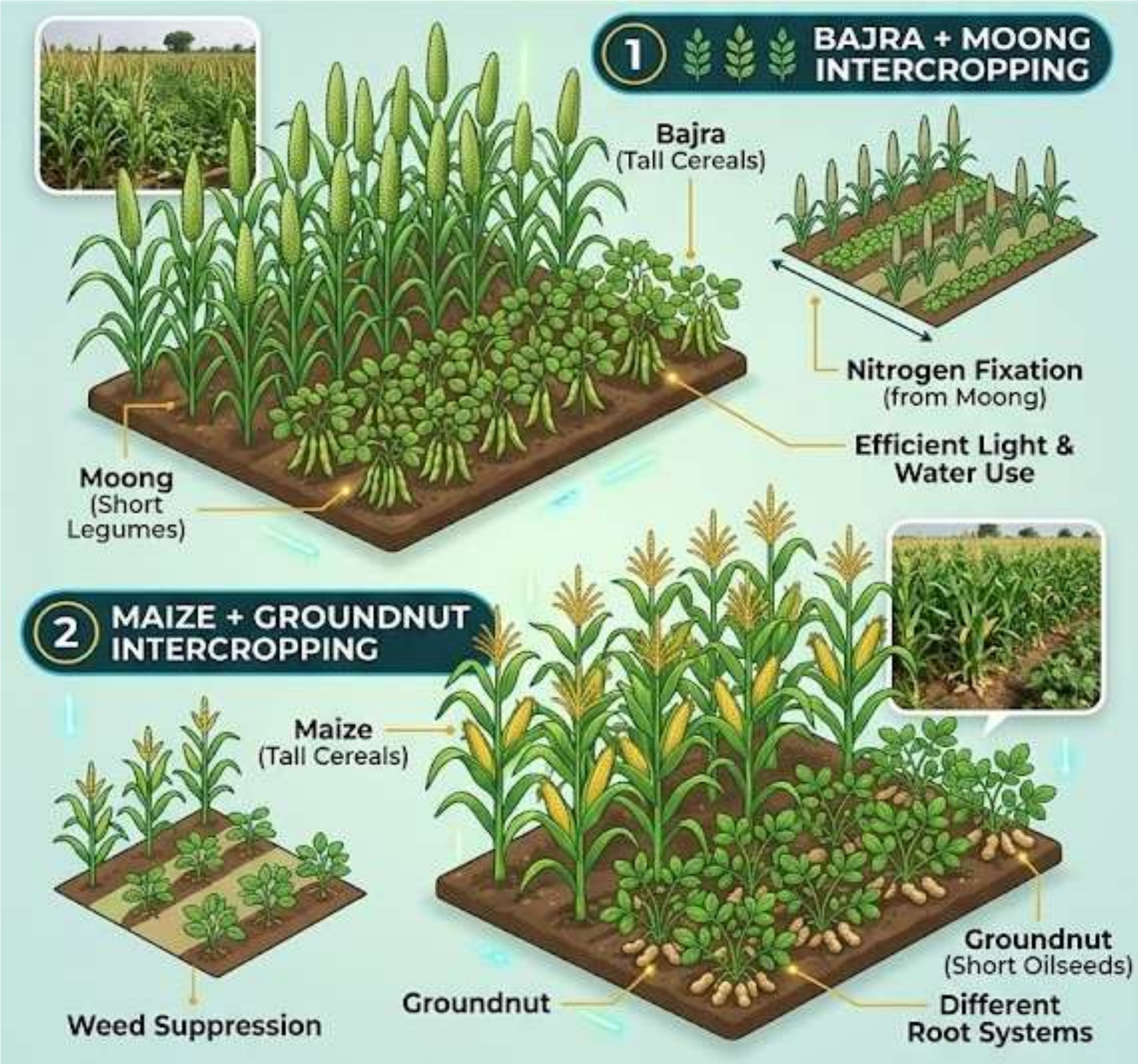

Fig. 1.4: Examples of intercropping

(vi) Relay intercropping: Relay intercropping is a farming practice where a second crop is planted before the first crop is harvested. The second crop is usually planted in the same field while the first crop is still growing. This method helps to maximise land use, reduce soil erosion, and increase overall productivity by ensuring that the field is always covered with crops. An example is maize followed by cowpea sown before maize harvest.

3. Principles of Crop Production

The principles of crop production are fundamental guidelines aimed at ensuring high productivity, maintaining soil health, conserving resources, and achieving sustainable agriculture. These principles help farmers optimise inputs, manage land efficiently, and increase yields while minimising negative environmental impacts.

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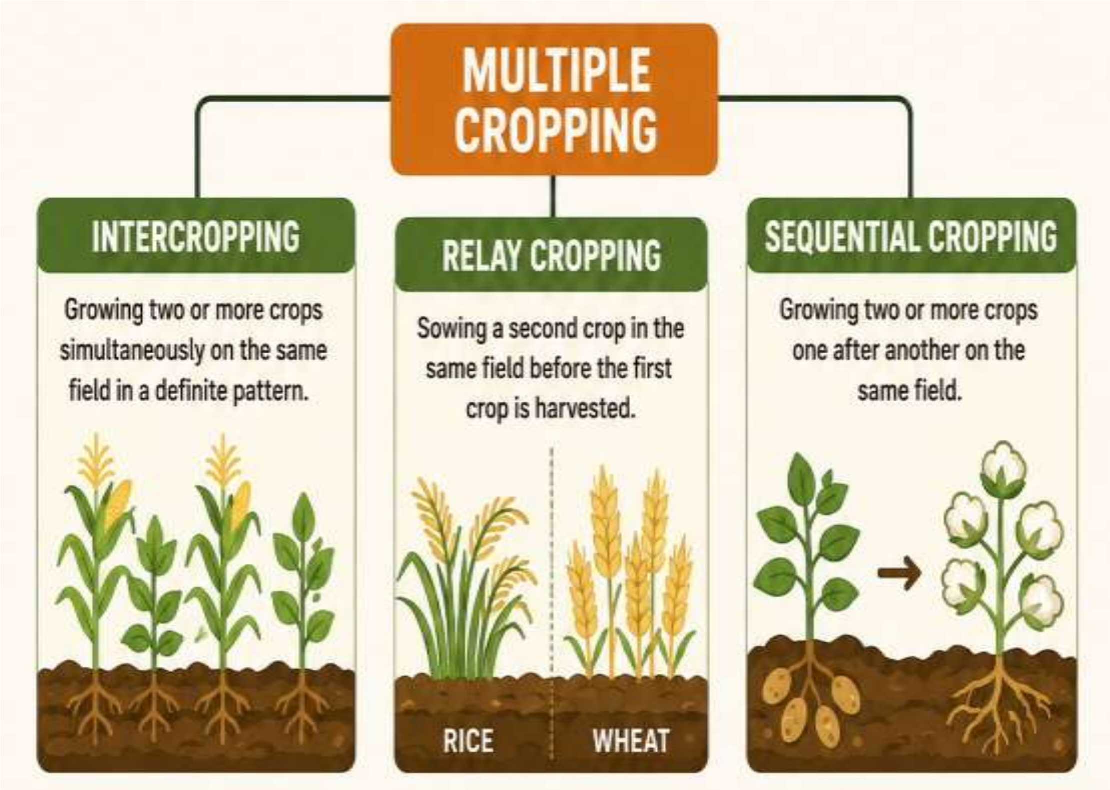

Fig. 1.5: Multiple cropping

The following principles should be adopted for crop production and agricultural field management:

- Maintain soil fertility through proper nutrient management and protect crops through disease, pest and weed management.
- Sow healthy seeds at the right time, with proper spacing and appropriate depth.
- Ensure a timely and adequate supply of water and fertilisers.
- Select suitable crop types based on soil conditions and climate variations.
- Harvest crops at the right stage of maturity.
- Store the harvested produce scientifically to reduce post-harvest losses.
- Practice multiple cropping and mixed farming to increase productivity and resource use efficiency.
- Follow crop rotation to maintain soil health and reduce pest cycles.
- Improve and manage soil through appropriate practices.
- Understand and define the cropping system being practiced.
- Apply scientific principles of crop production.
- Recognise and differentiate between various types of cropping systems.

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Practical Exercise

Activity 1: Intercropping demonstration with seeds

Material Required:

1. Small tray or pot
2. Soil
3. 2 types of seeds (e.g., maize and moong)

Procedure:

- Fill the pot with soil.
- Plant the first crop (e.g., maize) in a row.
- Plant the second crop (e.g., moong) in between the rows.
- Water the soil and watch how both crops grow together.
- Ask students how planting two crops in the same field might help the farmer.

Activity 2: Mixed cropping game

Material Required:

1. Paper
2. Crayons/markers/pencils

Procedure:

- Draw a field on the paper.
- Randomly colour small patches with different crops (e.g., red for maize, yellow for moong, green for bajra).
- Explain that in mixed cropping, crops grow together without a pattern**.**
- Ask students why this might help prevent total crop failure if one crop doesn't grow well.

Check Your Progress

A. Multiple Choice Questions

1. What is the main objective of a cropping system?
   a) To increase the number of crops cultivated annually
   b) To sustainably enhance agricultural productivity while preserving soil health and environmental sustainability
   c) To grow crops without relying on fertilisers
   d) To concentrate solely on monoculture farming

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2. What does a monoculture cropping system refer to?
   a) Growing multiple crops simultaneously
   b) Growing the same crop continuously on the same field
   c) Growing crops in alternating seasons
   d) Growing two crops in the same field

3. Which of the following is an example of a multiple/intensive cropping system?
   a) Cotton with soybean
   b) Rice-wheat cropping system
   c) Sugarcane with piper mint
   d) Maize with groundnut

4. What type of cropping system involves growing two or more crops simultaneously on the same field?
   a) Sequential cropping
   b) Monoculture cropping
   c) Intercropping
   d) Strip cropping

5. In intercropping, which of the following is true?
   a) Crops are grown only in separate fields
   b) Crops compete with each other in the same field
   c) Only one crop is grown in a field
   d) There is no intercrop competition

6. What type of intercropping involves growing crops simultaneously with no distinct row arrangement?
   a) Mixed intercropping
   b) Row intercropping
   c) Strip intercropping
   d) Relay intercropping

7. Which of the following is an example of relay intercropping?
   a) Maize with groundnut
   b) Cotton with pigeon pea
   c) Rice with pulses
   d) Cotton with soybean

8. A good cropping system should aim to:
   a) Maximise crop yield without concern for soil health
   b) Minimise the use of fertilisers only
   c) Maintain soil health and ensure economic viability
   d) Focus only on growing one type of crop

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B. Fill in the Blanks

1. The term ________ refers to the crops and crop sequences and the management techniques used on a particular field over time.
2. A cropping system aims to maximise ________ while maintaining soil health and environmental sustainability.
3. ________ cropping system involves growing the same crop on the same land continuously.
4. The practice of growing two or more different crops in the same field in a year is known as ________ cropping.
5. ________ cropping involves growing different crops in sequences or rotations on the same field in different seasons or years.

C. State Whether the Following Statements are True or False

1. A cropping system focuses only on growing crops and does not involve soil management techniques.
2. The excessive use of chemicals in cropping systems can lead to environmental pollution.
3. A good cropping system should maintain adequate production and minimise economic risks.
4. Monoculture cropping promotes biodiversity and reduces soil degradation.
5. Multiple cropping can be an effective solution for food scarcity.

D. Subjective Questions

1. A farmer continues to grow the same crop in the same field every year without changing it. What type of cropping system is being followed, and what could be one possible risk of this practice?
2. In a farming system, two crops are grown together in the same field at the same time without any specific row arrangement. What type of cropping practice is being followed, and what are its main advantages?
3. A farmer plants a second crop in the field while the first crop is still growing, so that the land is continuously used. What type of cropping system is this, and how does it improve land productivity?

What have you learned?

After completing this session, you will be able to:

- describe the concept of cropping systems and their role in sustainable agriculture;
- differentiate between various types of cropping systems;
- identify the features of a good cropping system;
- explain the principles of crop production; and
- recognise different intercropping methods.

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Unit 2 — Principles and Practices of Organic Farming

Unit 2 on *Principles and Practices of Organic Farming* provides an understanding of sustainable agricultural practices that help maintain soil fertility, protect the environment and produce safe and healthy food. In this unit, you will learn about the principles and practices of organic farming, different sources of organic manure, methods of manure preparation, and the integration of livestock into organic farming systems.

Session 1 on *Principles and Components of Organic Farming*, introduces you to the basic principles of organic farming and its holistic approach towards agriculture. It explains important components such as the use of organic inputs, biodiversity conservation, soil health management, crop rotation, and natural pest management practices. The session also discusses the harmful effects of chemical-based farming systems, different types of organic farming, and the machinery and equipment used in organic farming.

Session 2 on *Components of an Organic Farming Ecosystem*, focuses on the major components of organic farming along with its advantages and limitations. This session explains how organic farming supports sustainable agricultural production.

Session 3 on *Sources and Preparation Methods of Organic Manures*, familiarises you with different sources of organic manure, such as animal waste, green manure, compost and biofertilisers. It also explains various production methods, including composting techniques and the preparation of liquid manures.

Session 4 on *Integration of Livestock in Organic Farming*, highlights the role of livestock in organic farming systems. It explains how livestock contribute to soil fertility through manure and help in the natural management of pests and weeds.

Session 1: Principles and Components of Organic Farming

Organic farming is a holistic and sustainable agricultural approach that works in harmony with nature. It involves the cultivation of crops and rearing of livestock using natural methods without the use of synthetic chemicals such as artificial fertilisers, pesticides, herbicides and Genetically Modified Organisms (GMOs). The main principles of organic farming focus on maintaining soil health, conserving biodiversity and preserving ecological balance.

In organic farming, practices such as crop rotation, composting and biological pest control are used to improve soil fertility and manage pests and diseases naturally. By avoiding harmful chemicals, organic farming reduces environmental pollution,

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protects water resources and helps maintain long-term soil productivity. Organic farming not only benefits the environment but also provides safer and healthier food products for consumers. It supports sustainable agriculture by conserving natural resources, improving soil structure and promoting biodiversity.

1. Fundamentals of Organic Farming

Organic farming aims to produce healthy, safe, and nutritious food while maintaining the health of the environment (Fig. 2.1). It is guided by fundamental principles that promote ecological balance, conserve natural resources, enhance biodiversity, and ensure that farming systems are environmentally sustainable, socially responsible, and economically viable.

Fig. 2.1: Organic farming

Organic farming aims to produce safe and nutritious food while conserving biodiversity and maintaining ecological balance. The important fundamentals of organic farming are as follows:

a) ***Soil health and fertility**:* Organic farming places a strong emphasis on building and maintaining healthy soil through natural processes. Techniques like composting, crop rotation, green manuring, and the use of organic fertilisers (such as animal manure and plant-based compost) help maintain soil fertility.
b) ***Biodiversity**:* Organic farming encourages biodiversity by using a variety of crops and promoting the presence of different plant, insect, and animal species on farms. This diversity helps maintain ecosystem balance, reduces pest outbreaks, and supports pollinators and beneficial organisms.
c) ***Chemical-free farming**:* Organic farms avoid the use of synthetic pesticides, herbicides, and fertilisers. Instead, they rely on natural alternatives, such as biological pest control, organic manure, and companion planting, to manage pests and improve crop yields.
d) ***Environmental sustainability**:* Organic farming aims to minimise the environmental impact of agriculture by using practices that conserve water, reduce soil erosion, and reduce greenhouse gas emissions. Avoiding harmful

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chemicals helps protect water quality, reduce pollution, and maintain healthy ecosystems.

e) ***Animal welfare**:* In organic livestock farming, animal welfare is given priority. Livestock is raised in conditions that allow for natural behaviour, access to pasture, and organic feed. Antibiotics and growth hormones are avoided, and natural methods are used to prevent diseases.

f) ***Prohibit genetically modified organisms**:* Organic farming strictly prohibits the use of GMOs. All seeds, plants, and livestock used in organic production are naturally bred without any genetic modification, which aligns with the principle of maintaining natural biodiversity.

2. Detrimental Effects of Chemical-Based Farming Systems

In organic farming, the detrimental effects of chemical-based farming systems are widely recognised, as they go against the core principles of sustainability, natural balance, and ecological health. The over-reliance on synthetic chemicals in conventional farming systems has significant negative consequences that pose a threat to the organic farming environment. The main detrimental effects of chemical-based farming on organic farming systems are as follows:

(i) ***Depletion of soil health:*** Soil health depletion refers to the deterioration of the soil's physical, chemical, and biological properties, which ultimately reduces its capacity to support plant growth, maintain biodiversity, and regulate environmental functions. Several factors contribute to the depletion of soil health, and this issue is a major concern for sustainable agriculture and ecosystem stability.

(ii) ***Environmental pollution*:** Environmental pollution refers to the introduction of harmful substances or pollutants into the environment, which can adversely affect ecosystems, human health, and the overall balance of natural processes. The primary types of pollution include water, air and soil pollution.

(iii) ***Reduction of natural enemies:*** Natural enemies are essential in maintaining ecological balance, as they regulate populations of herbivorous pests, ensuring they do not grow to harmful levels. Pesticides used in chemical farming often indiscriminately kill both pests and beneficial insects.

(iv) ***Pesticide consumption and residues:*** Pesticide use refers to the quantity of chemicals applied in agricultural, industrial, or residential environments to control pests, diseases, and weeds. Pesticide residues are the traces of these chemicals that remain on or in crops, soil, water, and animal products after pesticide application.

(v) ***Threat to biodiversity:*** Biodiversity refers to the variety of life forms on Earth, including the diversity of species, genetic variability, and the ecosystems they inhabit. The decline in biodiversity poses significant threats to ecological balance, food security, and human health. Chemical farming systems often encourage monocultures (the cultivation of a single crop over large areas), which reduces genetic diversity in crops and leads to habitat destruction.

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3. Natural vs. Organic Foods and Farm Production Systems

The terms "natural" and "organic" are often used interchangeably in food and farming discussions, but they represent different concepts, practices, and standards. Understanding the distinction between natural and organic foods, as well as their respective farming systems, is crucial for consumers and producers alike. Let us understand these terms in the following section:

(i) ***Natural foods**:* Natural foods may or may not be produced using chemical fertilisers, pesticides, and genetically modified organisms. The farming system behind natural foods is not regulated by specific standards like organic farming. Natural foods, being less processed, may retain more nutrients than heavily processed foods. However, there is no guarantee that natural foods are free from pesticides or synthetic chemicals unless they are certified organic or non-GMO. The absence of artificial additives may make natural foods healthier compared to processed foods, but they may still contain pesticide residues or other non-organic substances.

(ii) ***Organic foods**:* Organic farming uses natural inputs, crop rotations, composting, and biological pest control. Soil health, biodiversity, and ecosystem preservation are central to organic farming principles. Studies have shown that organic foods may contain higher levels of certain nutrients, such as antioxidants, vitamins, and minerals, compared to conventionally grown foods. Organic livestock products, such as milk and meat, often have higher omega-3 fatty acid content due to better feeding practices. Organic foods are free from synthetic pesticide residues, GMOs, and antibiotics, making them potentially safer for consumers concerned about chemical exposure and hormone disruption.

4. Types of Organic Farming

Organic farming, which emphasises ecological sustainability, biodiversity, and the avoidance of synthetic inputs, can be categorised into two main types: (a) Pure Organic Farming, and (b) Integrated Organic Farming.

***(a) Pure Organic Farming**:* Pure organic farming is a method of farming that strictly excludes the use of synthetic chemicals such as fertilisers, pesticides, and Genetically Modified Organisms (GMOs). The focus is entirely on natural inputs and techniques to enhance soil fertility, manage pests, and improve crop yields. The following are the key characteristics of pure organic farming:

(i) **Exclusion of chemicals**: No synthetic inputs such as chemical fertilisers, pesticides, herbicides, or growth hormones are used. Only natural alternatives like compost, green manure, and natural pest control methods are employed.
(ii) **Natural fertilisers**: Organic fertilisers such as compost, biofertiliser, farmyard manure, bone meal, and organic mulches are used to maintain soil fertility.

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(iii) **Pest control**: Biological pest control methods are employed. This includes using beneficial insects, crop rotation, and natural predators to manage pests.

(iv) **No GMOs**: The use of genetically modified organisms is strictly prohibited in pure organic farming.

(v) **Biodiversity**: Crop rotation and polyculture are emphasised to maintain biodiversity and reduce the risk of pests and diseases.

(vi) **Soil health**: Techniques like cover cropping, mulching, and compost application are done to maintain and improve soil health over time.

Pure organic farming relies exclusively on natural inputs and ecological processes to maintain soil fertility, manage pests and diseases, and produce healthy crops. Instead of using synthetic fertilizers, pesticides, or genetically modified organisms, it emphasizes sustainable agricultural practices that protect the environment while enhancing long-term productivity. The adoption of pure organic farming offers numerous benefits, including improved soil health, enhanced biodiversity, efficient nutrient cycling, and reduced environmental pollution. Some of the key practices and their benefits are described below:

(i) **Crop rotation:** It prevents soil nutrient depletion by alternating nutrient-demanding crops with soil-enriching crops. It also disrupts pest and disease cycles and helps manage weeds naturally without relying on synthetic herbicides or pesticides.

(ii) **Use of organic fertilizers:** Organic fertilizers provide essential nutrients such as nitrogen, phosphorus, and potassium in a slow-release form. They improve soil structure, increase organic matter, stimulate beneficial microbial activity, and enhance long-term soil fertility.

(iii) **Green manuring:** Green manuring involves incorporating fresh green plants into the soil to enrich it with organic matter. This practice improves soil fertility, enhances water-holding capacity, prevents soil erosion, and reduces the need for chemical fertilizers.

(b) Integrated Organic Farming: Integrated organic farming is a more holistic approach that incorporates the integration of different farming components, such as crops, livestock, fish, and trees, to create a more sustainable, self-sufficient farming system. The goal is to optimise the use of on-farm resources and minimise waste through recycling and reuse. The following are the key characteristics of integrated organic farming:

(i) **Resource recycling**: The by-products of one component are used to benefit another (e.g., soil enrichment for crops), creating a closed-loop system.

(ii) **Multiple outputs**: Integrated organic farms produce a diverse range of outputs (food crops, livestock, fish, timber, etc.), reducing economic risks for the farmer.

(iii) **Natural synergy**: Integrated systems create natural synergies between different components, such as using animal manure for crop fertilisation, or fish farming in irrigated rice paddies.

(iv) **Pest and disease management**: The integration of diverse crops and animals can help to naturally control pests and diseases through ecosystem balance.

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(v) **Energy efficiency**: Integrated farming reduces dependency on external inputs by efficiently managing available resources. For example, crop residues can be used as animal feed, and animals can help with natural pest control and fertilisation.

Integrated organic farming combines different farm enterprises and ecological components to create a sustainable and self-sufficient agricultural system. By integrating crops, trees, livestock, fisheries, and other farm components, it enhances the efficient use of natural resources, improves nutrient recycling, and reduces dependence on external inputs. These integrated components work together to improve soil health, conserve biodiversity, increase farm productivity, and provide diversified sources of income. The important components of integrated organic farming include agroforestry, aquaculture, and livestock which offers several environmental, economic, and social benefits. Let us understand each of these.

(i) **Agroforestry**: Agroforestry involves growing trees along with crops or livestock on the same farm. The trees help improve soil fertility by adding organic matter through fallen leaves and reducing soil erosion. They also provide shade, conserve moisture, act as windbreaks and create habitats for birds and beneficial organisms. In addition, agroforestry provides extra income through fruits, timber, fuelwood and fodder.

(ii) **Aquaculture integration**: Aquaculture integration combines fish farming with crop production systems. In this method, water enriched with nutrients from fish waste is used for irrigating and fertilising crops (Fig. 2.2).

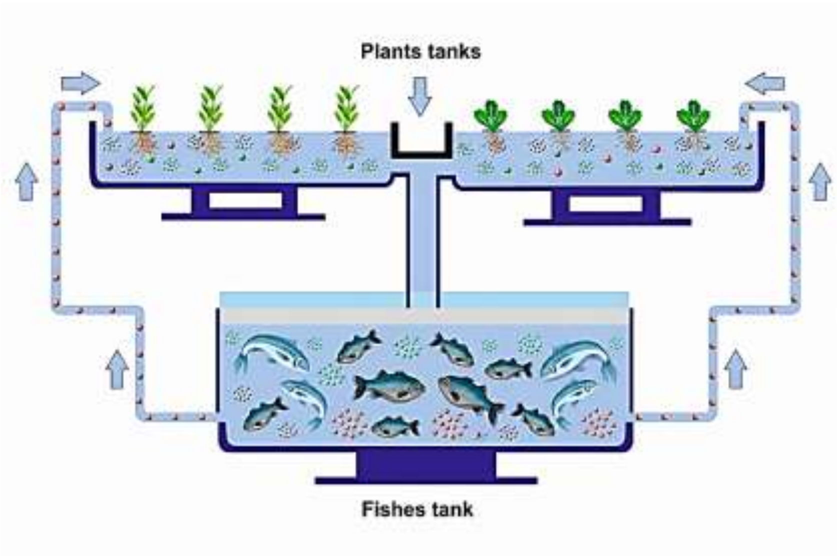

Fig 2.2: Aquaculture integration

(iii) **Crop-livestock integration**: Crop-livestock integration involves combining crop cultivation with livestock rearing on the same farm. In this system, livestock provide manure that is used as an organic fertiliser to improve soil fertility and crop productivity. At the same time, crop residues and agricultural by-products are used as feed for animals. This integration helps in efficient recycling of farm resources, reduces waste, lowers input costs and increases overall farm sustainability and income.

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5. Organic Farm Machinery and Equipment

Organic farming, though focused on natural inputs and sustainability, still benefits from the use of modern farm machinery and equipment to improve efficiency, productivity, and sustainability. Machinery in organic farming assists with soil preparation, planting, crop management, weed control, and harvesting. It follows organic standards, avoiding synthetic chemicals and GMOs. The key types of farm machinery and equipment commonly used in organic farming:

(a) Ploughing and Soil Preparation Equipment

Ploughing and soil preparation are critical steps in organic farming to create optimal conditions for crop growth. These practices help aerate the soil, control weeds, incorporate organic matter, and prepare the seedbed for planting. Some of the essential ploughing and soil preparation equipment commonly used in an organic farming system are as follows:

(i) Moldboard plough: Used for primary tillage, the Moldboard plough turns over the top layer of soil, burying weeds and organic matter while loosening the soil for planting (Fig. 2.3). Organic farmers often use ploughing to improve soil aeration and mix organic materials like compost into the soil**.**

Fig. 2.3: Moldboard plough, used for primary tillage

i) **Chisel plough**: It loosens the deeper layers of the soil without completely turning them over, which helps break the hard pan, improve water infiltration and reduce soil erosion. This practice also helps maintain soil structure and preserve the natural soil layers and beneficial microorganisms, making it suitable for organic farming systems (Fig. 2.4).

Fig. 2.4: Chisel plough, used to loosen the deeper layer of soil

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ii) **Rotary tiller**: It is a versatile tool used for soil preparation and weed control. It helps break down soil clods, incorporate organic matter, and prepare seedbeds for planting. In organic farming, shallow tillage is useful to avoid disrupting beneficial soil organisms

a) Planting and Seeding Equipment

Planting and seeding equipment are essential in organic farming for ensuring accurate seed placement, depth, and spacing. This precision helps optimise crop yields, minimise competition from weeds, and enhance the overall efficiency of the farm. The following are some of the key types of planting and seeding equipment used in organic farming:

Fig. 2.5: Seed drill, used for sowing seeds uniformly at proper depth and spacing

i. **Seed drills**: Seed drills are used to plant seeds in rows at the proper depth and spacing. In organic farming, accurate seed placement is crucial for optimising plant growth and minimising competition with weeds (Fig. 2.5).

ii. **Precision planters:** Precision planters help in placing seeds with exact spacing and depth, ensuring uniform growth and efficient use of space (Fig. 2.6). This precision reduces the need for thinning and manual adjustments, leading to better crop performance

Fig. 2.6: Precision planters ensure accurate seed placement

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6. Weed Control Equipment

Weed control equipment refers to tools and machines used to remove or manage unwanted plants (weeds) from agricultural fields. These weeds compete with crops for nutrients, sunlight, water, and space, which can reduce crop yields. Weed control equipment includes manual tools like hoes and weeders, as well as mechanical or powered machines like rotary weeders, power weeders, and sprayers.

The use of such equipment ensures timely and efficient weed removal, reduces labour, and improves overall farm productivity. Weed management is one of the biggest challenges in organic farming, as herbicides are not permitted. Organic farmers rely on mechanical methods to manage weeds, which are as follows:

a) **Mechanical weeders:** Mechanical weeders, such as harrows, cultivators, and weeders, are used to remove weeds between rows of crops. These machines disturb the soil surface, uprooting weeds without damaging the crops. The following are popular mechanical weeders:

(i) **Harrows**: They can break up soil clods and weeds on the soil surface, making them less competitive with crops.

(ii) **Manual weeder**: A hand-operated farming tool used to remove unwanted plants (weeds) from the soil around crops. Examples are *Khurpi*, Hand Hoe, Wheel Hoe, and Cono Weeder.

(iii) **Flame weeders:** Flame weeders use propane-fueled flames to kill weeds by applying heat to the plant tissues. This non-chemical approach is effective for controlling weeds without harming the crops or soil (Fig. 2.7).

Fig. 2.7: Flame weeder used for chemical-free weed control

(iv) **Mulching machines:** Mulching machines are used to spread organic mulches (straw, leaves, or crop residues) over the soil to suppress weeds, retain moisture, and add organic matter to the soil. Mulching is a common practice in organic systems to reduce weed pressure and improve soil health.

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7. Fertilisation and Composting Equipment

Organic farming relies on natural fertilisers such as compost, manure, and green manure to nourish the soil. Equipment that facilitates the application and preparation of these inputs is vital:

a) **Compost spreaders:** They distribute organic compost or manure evenly across fields. These machines help enrich the soil with organic matter, enhancing soil structure and fertility.

b) **Manure spreaders:** They are used to apply animal manure as a natural fertiliser. They ensure that the manure is evenly spread over the fields, improving nutrient availability for crops without relying on synthetic fertilisers.

c) **Liquid fertiliser applicators:** These applicators can distribute liquid organic fertilisers, such as compost tea or liquid manure, across crops. This ensures even nutrient distribution and improves crop growth.

Practical Exercise

Activity 1: Case studies of organic farmers.

Materials Required:

1. Notebook
2. Pen

Procedure:

Look for case studies or success stories of organic farmers from local areas or well-known farms in India and worldwide. Use documentaries, articles, interviews, or websites. For each farmer, note:

- Who they are and why they chose organic farming
- The organic techniques they use (e.g., composting, crop rotation)
- Challenges they faced during the transition
- Positive results they achieved (better soil, higher yields, community benefits)
- Lessons others can learn from their experience
- Compile the gathered information into concise case studies or success stories, each around 200–300 words, emphasising the unique aspects of each farmer's journey.
- Reflect on common themes across the stories, highlighting how they demonstrate the benefits of organic farming—such as environmental sustainability, economic viability, and community development.
- Present the case studies in a format suitable for sharing, such as a class presentation, a small booklet, or a poster showcasing the organic farming success stories.

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Activity 2: Identification of farm machinery used in organic farming

Material Required:

1. Images/charts of machinery
2. Notebook
3. Pen

Procedure:

- Observe different farm machinery.
- Identify their uses (ploughing, seeding, weeding).
- Match equipment with functions.
- Record observations.

Activity 3: Study of weed control methods in organic farming

Materials Required:

1. Notebook
2. Pen

Procedure:

- Identify weed control methods (manual, mechanical, mulching).
- Note tools used, like weeders and harrows.
- Record advantages of non-chemical methods.

Check Your Progress

A. Multiple Choice Questions

1. What is the primary goal of organic farming?
   a) Maximising production using chemical inputs
   b) Enhancing soil health, biodiversity, and ecological balance
   c) Producing genetically modified crops
   d) Minimising labour in agriculture

2. Which of the following is NOT permitted in organic farming?
   a) Crop rotation
   b) Genetically Modified Organisms (GMOs)
   c) Composting
   d) Biological pest control

3. One key difference between natural and organic foods is:
   a) Organic foods are always processed
   b) Natural foods are regulated by government standards
   c) Organic foods follow strict certification standards, while natural foods may not
   d) Natural foods are always chemical-free

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4. What is an example of pure organic farming practice?
   a) Use of genetically modified seeds
   b) Application of synthetic fertilisers
   c) Use of farmyard manure and green manuring
   d) Spraying of chemical herbicides

5. Which farming system integrates livestock, crops, and aquaculture for resource recycling?
   a) Pure organic farming
   b) Monoculture farming
   c) Integrated organic farming
   d) Hydroponic farming

6. What is the purpose of using a flame weeder in organic farming?
   a) To apply liquid fertilisers
   b) To spray pesticides
   c) To kill weeds using heat without chemicals
   d) To irrigate crop rows

7. Which of the following is a detrimental effect of chemical-based farming?
   a) Reduction in natural enemies of pests
   b) Soil enrichment
   c) Improved biodiversity
   d) Higher water retention

8. What is the function of compost spreaders in organic farming?
   a) To harvest crops
   b) To plough the field
   c) To distribute synthetic fertilisers
   d) To evenly apply compost for soil enrichment

B. Fill in the Blanks

1. Organic farming emphasises the use of _______ inputs and processes to grow crops and raise livestock.
2. The fundamentals of organic farming aim to promote _______, environmental health, and the well-being of both farmers and consumers.
3. Organic farms avoid the use of synthetic pesticides, herbicides, and fertilisers, relying instead on _______ pest control and organic manure.
4. Organic farming prohibits the use of _______ to maintain natural biodiversity.
5. In organic livestock farming, _______ is given priority to ensure animals are raised in natural conditions.

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C. State Whether the Following Statements are True or False

1. Organic farming encourages monoculture farming to maximise crop yields.
2. Biodiversity in organic farming helps reduce pest outbreaks and supports pollinators.
3. Organic farming allows the use of synthetic pesticides in limited quantities.
4. Pesticide residues from conventional farming can be harmful to human health and the environment.
5. Natural foods are always free from synthetic chemicals and pesticide residues.

D. Subjective Questions

1. A farmer wants to adopt a farming system that avoids synthetic fertilisers and pesticides while maintaining soil fertility through natural methods. Which type of farming system is being described?
2. In an agricultural field, farmers use crop rotation, composting, and biological pest control instead of chemical inputs. What is the main objective of such farming practices?
3. A farming system integrates crops, livestock, and fish so that waste from one component is used as input for another. What type of organic farming system is this, and what is its main advantage?
4. A farmer strictly avoids the use of genetically modified seeds and relies only on natural inputs like manure and compost. Which principle of organic farming is being followed in this case?
5. In a farming system, farmers use mechanical tools instead of chemical herbicides to remove weeds and rely on natural methods to improve soil health. What does this approach indicate about the type of farming being practiced?

What have you learned?

After completing this session, you will be able to:

- explain the core principles of organic farming;
- identify the harmful effects of conventional chemical farming;
- distinguish between pure organic farming and integrated organic farming;
- describe the role of various tools and equipment used in organic farming systems; and
- explain the distinction between natural and organic foods in terms of production standards, inputs used, and health implications for consumers.

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Session 2: Components of an Organic Farming Ecosystem

An organic farming ecosystem is a sustainable approach to agriculture that focuses on maintaining soil health, conserving biodiversity and protecting the environment through natural farming practices. It emphasises the use of natural inputs and ecological processes for the production of food, fibre and other agricultural products.

The following are the key principles and components of an organic farming system:

1. Key Principles of Organic Farming

Organic farming is based on four key principles: health, ecology, fairness and care. These principles guide organic farming practices and help ensure environmental sustainability, social responsibility and economic viability. As agricultural development and technological advancement continue to grow, there is an increasing need to adopt farming practices that are sustainable and environment-friendly. The following is a detailed description of each principle:

a) Principle of Health

Organic farming seeks to sustain and enhance the health of soils, plants, animals, humans, and the entire ecosystem. This principle emphasises that the health of all living beings is interconnected and that agricultural practices should promote ecological well-being and prevent harm.

(i) **Soil health**: Soil health refers to the ability of soil to support plant growth, maintain nutrients, store water and sustain living organisms while maintaining environmental balance. Organic farming improves soil fertility and structure through practices such as composting, crop rotation and cover cropping while avoiding synthetic chemicals that may damage soil quality (Fig. 2.8). Soil contains various living organisms, broadly classified as soil flora and soil fauna, which play an important role in nutrient cycling and maintaining soil fertility.

(ii) **Plant health**: By avoiding synthetic pesticides and fertilisers, organic farming nurtures healthier crops and animals, which, in turn, provide nutritious and safe food for humans.

(iii) **Human health**: Healthier soil and plants lead to safer, more nutritious food, contributing to better overall human health. Organic farming practices aim to reduce exposure to harmful chemicals for both farmworkers and consumers.

b) Principle of Ecology

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The Principle of Ecology emphasises that organic farming should be based on natural ecological systems and cycles, working in harmony with nature rather than disrupting it. It promotes the protection of the environment, conservation of natural resources, and enhancement of biodiversity to ensure sustainable agricultural production. Organic farming seeks to maintain healthy relationships among soil, plants, animals, humans, and the wider ecosystem.

This principle provides the following key benefits:

(i) Ecological Balance:

Organic farmers strive to create self-sustaining farming systems by promoting biodiversity and maintaining natural predator–prey relationships. These natural processes help control pests and diseases, reducing the need for synthetic pesticides and other chemical inputs.

(ii) Sustainable Resource Use:

Organic farming encourages the efficient use of renewable resources, the recycling of organic materials, and the minimisation of waste. Practices such as composting, crop rotation, green manuring, and integrating livestock with crop production help recycle nutrients naturally and maintain long-term soil fertility and ecological balance.

(iii) Biodiversity Conservation:

Organic farming supports a wide variety of crops, livestock, beneficial insects, and microorganisms. Greater biodiversity improves resilience to pests, diseases, and climate variability while contributing to healthier soils, stronger ecosystems, and enhanced environmental sustainability.

c) Principle of Fairness

Fairness in organic farming refers to the establishment of equitable relationships and respect for all participants in the farming process, including farmers, workers, consumers, and the environment. It promotes social justice, economic fairness, and animal welfare. These involves:

(i) **Fair working conditions**: Organic farming should ensure that farmworkers are treated ethically, with fair wages, safe working conditions, and respect for their labour.

(ii) **Animal welfare**: Livestock in organic systems should be raised in ways that respect their natural behaviours and health, with access to outdoor spaces and without the use of synthetic growth hormones or antibiotics.

(iii) **Consumer trust**: Organic farming practices should provide consumers with healthy, safe, and ethically produced food, and organic labels should reflect true environmental and social sustainability.

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d) Principle of Care

The principle of care encourages organic farming to manage its practices with responsibility and foresight, to avoid harm to future generations and the environment. It emphasises a precautionary approach, where the long-term impacts of farming activities are carefully considered before implementation. This may lead to the following:

(i) **Environmental stewardship**: Environmental stewardship is the responsible management and protection of natural resources to ensure sustainability and health for future generations. Organic farming is committed to caring for the environment by minimising pollution, protecting natural resources like soil and water, and enhancing biodiversity.

(ii) **Precautionary approach**: Organic farmers avoid practices that may have uncertain or irreversible impacts, such as the use of Genetically Modified Organisms (GMOs) or synthetic chemicals, because the long-term effects on health and the environment are unknown.

(iii) **Sustainable development**: The care principle emphasises long-term sustainability, ensuring that organic farming can meet the needs of the present without compromising the ability of future generations to farm and access clean, healthy food.

2. Components of Organic Farming

Organic farming is built upon three main components: agronomic, biological, and mechanical. Each of these components contributes to a sustainable and environmentally friendly agricultural system, which is as follows:

a) Agronomic Components

Agronomic practices in organic farming focus on the management of crops and soil to enhance fertility, reduce pest pressure, and improve overall productivity without relying on synthetic chemicals. These practices aim to maintain ecological balance while ensuring long-term sustainability. These practices are:

(i) **Crop rotation**: Alternating crops in the same field across seasons to prevent pest buildup, improve soil fertility, and reduce erosion.

(ii) **Intercropping**: Growing two or more crops in proximity to enhance biodiversity, reduce pests, and optimise resource use.

(iii) **Cover cropping**: Planting cover crops (such as legumes) between main crop cycles to prevent soil erosion, fix nitrogen, and improve soil health.

(iv) **Green manuring**: Growing specific crops and ploughing them back into the soil to add organic matter and nutrients.

(v) **Mulching**: Using organic materials like straw or leaves to cover the soil surface, conserving moisture and suppressing weeds.

b) Biological Components

Biological components focus on using natural organisms and biological processes to promote farm productivity and control pests or diseases. These methods help maintain biodiversity and ecological balance on the farm, including:

(i) **Biological pest control**: Using beneficial organisms, such as predators, parasitoids, and natural enemies, to control pest populations without synthetic pesticides. Examples include releasing ladybugs to control aphids or using predatory mites to reduce mite infestations.

(i) **Organic fertilisers**: Application of compost, animal manure, and plant residues to improve soil fertility naturally. These inputs add essential nutrients and enhance microbial activity in the soil.

(ii) **Beneficial micro-organisms**: Introducing beneficial bacteria and fungi, such as azatobacter, rhizobium, mycorrhizae, to promote plant health, increase nutrient uptake, and improve soil structure.

(iii) **Biodiversity conservation**: Creating habitats for wildlife, such as birds, insects, and pollinators, which contribute to natural pest control and improve ecosystem balance.

c) Mechanical Components

Mechanical practices in organic farming involve using tools, machinery, and physical methods to manage crops, control weeds, and improve soil structure, all without the use of chemical inputs. These include the following:

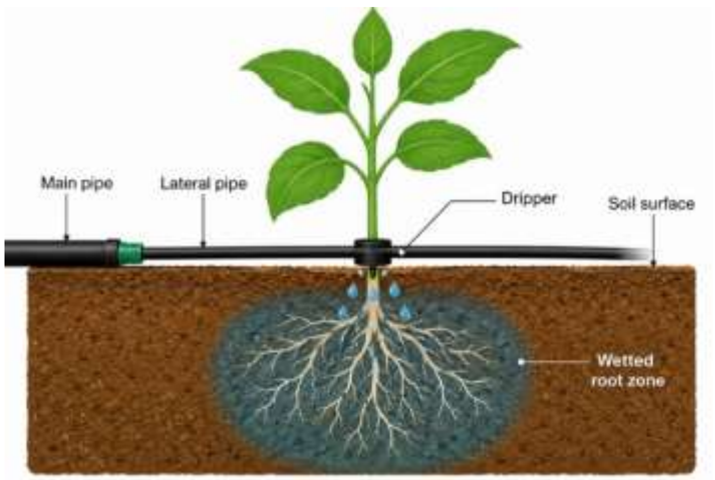
(i) **Tillage and ploughing**: Minimal tillage or conservation tillage practices help prepare the soil for planting while reducing soil disturbance. Ploughing is often minimised to protect soil structure and reduce erosion.

(ii) **Weed control equipment**: Tools like rotary hoes, cultivators, and flame weeders are used to physically manage weeds in organic systems. These mechanical weed control methods replace the need for herbicides.

(iii) **Mechanical harvesting**: For larger farms, mechanical harvesters are used to efficiently gather crops without the use of chemicals for ripening or preservation.

(iv) **Mulching machines**: Equipment that spreads organic mulch to suppress weeds, retain moisture, and enhance soil health.

(v) **Drip irrigation**: Efficient water management systems like drip irrigation help conserve water by delivering it directly to the plant's root zone, reducing wastage and promoting healthy crop growth **(Fig. 2.9)**.



3. **Fig. 2.9:** Watering plants drop by drop with drip irrigation

Organic farming ensures environmental sustainability, improved soil health, biodiversity conservation, and health benefits for consumers. The key advantages include the following:

Advantages

Organic farming offers several advantages, both for the environment and for human health. Some key advantages of organic farming are:

(i) Reduces pollution from synthetic chemicals.
(ii) Enhances biodiversity and promotes ecological balance.
(iii) Conserves soil and water resources.
(iv) Organic foods are free from harmful chemical residues.
(v) Reduced exposure to synthetic pesticides benefits both farmers and consumers.
(vi) Organic farming can be more sustainable in the long term.
(vii) Promotes rural development and can generate higher incomes due to premium prices for organic products.

Limitations

Despite the many advantages of organic farming, it faces several challenges and limitations that affect its widespread adoption and scalability. Some of the key limitations include:

(i) Produces lower yields compared to conventional farming.
(ii) Higher labour requirements.
(iii) Relies heavily on manual labour for tasks.
(iv) Often more viable in developed markets where consumers are willing to pay premium prices.
(v) Organic fertilisers, such as compost or manure, release nutrients more slowly than synthetic fertilisers.

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(vi) Shorter shelf life due to the absence of chemical preservatives.
(vii) The certification process is complicated for organic produce.

4. Recycling Nutrients in an Organic Farm

In organic farming, nutrient recycling is a key principle aimed at maintaining soil fertility, promoting plant growth, and ensuring long-term sustainability. Organic farmers rely on natural processes to return nutrients to the soil, avoiding the use of synthetic fertilisers. The following are the key methods of recycling nutrients in organic farming:

(i) **Composting:** It involves the decomposition of organic materials such as crop residues, animal manure, kitchen waste, and plant matter. This process produces nutrient-rich compost, which can be applied to fields to improve soil structure and provide essential nutrients. Compost adds organic matter to the soil, enhances microbial activity, and provides slow-releasing nutrients like nitrogen, phosphorus, and potassium.

(ii) **Vermicomposting:** It is the process of using earthworms to decompose organic waste into nutrient-rich vermicast or worm castings. Vermicast acts as an excellent organic manure that improves soil fertility, enhances nutrient availability and promotes healthy plant growth (Fig. 2.10).

(iii) **Green manuring:** It is the practice of growing plants to improve soil fertility by adding organic matter and enhancing soil health. Organic farmers plant green manure crops (such as legumes, clover, or mustard) during off-seasons. These crops are later ploughed into the soil to decompose, enriching the soil with organic matter and nutrients. Leguminous plants (like clover or peas) have symbiotic relationships with nitrogen-fixing bacteria, which convert atmospheric nitrogen into forms that plants can absorb, enhancing nitrogen availability in the soil.

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Fig. 2.10: Worms turning waste into rich compost

(iv) **Animal manure and animal integration:** Animal manure from livestock (such as cows, sheep, or chickens) is a valuable source of nutrients like nitrogen, phosphorus, and potassium. When applied to fields, it helps to replenish the soil fertility. In mixed farming systems, animals graze in different fields in rotation, naturally fertilising the soil with their manure, improving nutrient cycling, and promoting soil health.

(v) **Crop rotation:** It is the practice of growing different crops in a specific sequence on the same field. Different crops have varying nutrient demands, and some (like legumes) can restore nutrients, particularly nitrogen, to the soil. This practice helps balance nutrient use and prevents soil depletion. Crop rotation also helps manage pests and diseases, reducing the need for chemical inputs, which further protects soil health.

(vi) **Mulching:** A process of covering soil with organic or inorganic materials to retain moisture, suppress weeds, and improve soil health. Applying organic mulches (such as straw, leaves, or grass clippings) helps conserve moisture and suppress weeds. As the mulch decomposes, it adds organic matter and nutrients back into the soil, contributing to nutrient recycling. Mulching also prevents soil erosion and promotes better water retention, enhancing nutrient availability.

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(vii) **Use of bio-fertilisers:** Bio-fertilisers containing microorganisms like nitrogen-fixing bacteria (e.g., Rhizobium, Azotobacter, Azospirilium) and phosphate-solubilising bacteria help convert atmospheric nitrogen and insoluble phosphorus into forms that plants can use. This promotes natural nutrient cycling without the need for synthetic inputs.

5. Organic Farming in India

Organic farming has seen significant growth in India in recent years, driven by increasing awareness of the environmental impact of conventional farming, consumer demand for chemical-free food, and government initiatives promoting sustainable agriculture. India's diverse climate and rich biodiversity offer favourable conditions for organic farming.

Many organic farming programmes are running in India that provide guidelines and certification standards for organic farming. It sets national standards for organic production and helps facilitate the export of organic products. These are:

i) ***Paramparagat Krishi Vikas Yojana*** **(PKVY)**: Launched by the Indian government, this scheme promotes cluster-based organic farming, providing financial assistance and training to farmers. It encourages the use of organic inputs like bio-fertilisers and compost.

ii) **Mission Organic Value Chain Development for North Eastern Region (MOVCDNER)**: This initiative focuses on developing organic farming in the northeastern states, providing farmers with support for organic certification, value addition, and market linkages.

iii) ***Jaivik Bharat***: Under this initiative, the Food Safety and Standards Authority of India (FSSAI) ensure that organic products are properly labelled and certified, protecting consumers and promoting trust in organic products.

Organic farming in India is closely linked to traditional agricultural practices that involve natural processes, such as crop rotation, intercropping, green manuring, and the use of compost and animal manure.

Indian organic farmers use bio-fertilisers like vermicompost, farmyard manure, and *neem*-based bio-pesticides to control pests and enhance soil fertility.

Practical Exercise

Activity 1: Understanding organic farming values

Materials Required:

1. Chart paper or cardboard

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2. Scissors and glue
3. Colored markers
4. Old magazines/newspapers (for cut-outs)

Procedure:

- Cut the chart paper into four pieces, title each one with the fundamental principle, such as Health, Ecology, Fairness, and Care.
- Draw or paste cut-outs showcasing each principle (e.g., healthy food, animals, trees, happy farmers).
- Below each picture, write one important sentence depicting that principle.
- Display the charts in class and have each student explain his/her work to others.

Activity 2: Organic vs. traditional farming- a comparison game

Materials Required:

1. Flashcards with farming/agricultural practices (e.g., "uses compost," "uses chemical fertilisers," "encourages biodiversity")
2. Two baskets labelled "Organic" and "Traditional"

Procedure:

- Mix all flashcards and place them in a single pile.
- Participants take turns picking a card and deciding whether the practice belongs to "Organic" or "Traditional" farming.
- Each choice is explained before placing the card in the appropriate basket.
- At the end, review all cards as a group and correct any that were placed incorrectly.

Activity 3: Building an organic farm plan

Materials Required:

1. Cardboard or thermocol sheet (as base)
2. Glue, scissors, sketch pens
3. Colored paper, toy animals, seeds, dried leaves, small sticks

Procedure:

- Draw a layout of an organic farm on the basis.
- Create zones depicting agronomic (crop rotation, mulching), biological (vermicomposting, biopesticides), and mechanical components (tillage tools, drip irrigation).
- Use materials with creativity – e.g., leaves for mulch, sticks for tillage tools.
- Label each component with its role in organic farming.

Check Your Progress

A. Multiple Choice Questions

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1. Which of the following is an example of a biological method of pest control in organic farming?
   a) Use of synthetic pesticides
   b) Planting monoculture crops
   c) Releasing ladybugs to control aphids
   d) Frequent use of chemical fertilisers

2. Which of the following is NOT an agronomic component of organic farming?
   a) Crop rotation
   b) Green manuring
   c) Vermicomposting
   d) Intercropping

3. In organic farming, green manuring is primarily used for:
   a) Weed control
   b) Soil erosion prevention
   c) Adding organic matter and enhancing soil health
   d) Pest management

4. Which method of nutrient recycling in organic farming involves the decomposition of organic matter such as crop residues and animal manure?
   a) Vermicomposting
   b) Green manuring
   c) Composting
   d) Drip irrigation

5. Which one is a mechanical method of weed control in organic farming?
   a) Use of herbicides
   b) Use of genetically modified crops
   c) Rotary hoes and cultivators
   d) Crop rotation

6. Organic farming prioritises:
   a) The use of synthetic fertilisers and pesticides
   b) The use of chemical preservatives
   c) The long-term health of soil, plants, animals, and humans
   d) Maximizing immediate yields through artificial methods

7. Which of the following is a limitation of organic farming?
   a) It produces higher yields than conventional farming
   b) It is less labour-intensive than conventional farming
   c) It requires higher labour inputs and may face pest control challenges
   d) It uses fewer natural resources than conventional farming

8. Which of the following organic farming programmes promotes cluster-based organic farming in India?

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a) Mission Organic Value Chain Development for North Eastern Region (MOVCDNER)
b) Jaivik Bharat
c) *Paramparagat Krishi Vikas Yojana* (PKVY)
d) National Organic Programme (NOP)

9. Organic farming in India is largely based on:
   a) Large-scale monoculture farming
   b) Traditional agricultural practices like crop rotation and intercropping
   c) Heavy use of synthetic fertilisers and pesticides
   d) Use of genetically modified seeds

10. Which of the following is an advantage of organic farming?
   a) Higher reliance on synthetic fertilisers
   b) Reduced pollution from synthetic chemicals
   c) Reduced biodiversity
   d) Increased dependence on imported seeds

B. Fill in the Blanks

1. The four key principles of organic farming are health, ____, fairness, and care.
2. Organic farming avoids the use of ____, which can harm soil health and biodiversity.
3. The principle of ____ in organic farming emphasises sustainable resource use and biodiversity conservation.
4. ____ is the practice of growing different crops in the same field across seasons to improve soil fertility and reduce pests.
5. Organic farming promotes ____ pest control, which relies on natural predators instead of chemical pesticides.

C. State Whether the Following Statements are True or False

1. Organic farming relies heavily on synthetic fertilisers to enhance soil fertility.
2. The principle of care in organic farming emphasises environmental stewardship and precautionary approaches.
3. Organic farming encourages the use of chemical pesticides to control pests and diseases.
4. Drip irrigation is used in organic farming to conserve water and promote healthy crop growth.
5. The use of bio-fertilisers, such as Rhizobium, helps in natural nutrient cycling in organic farming.

D. Subjective Questions

1. A farmer adopts practices such as crop rotation, composting, green manuring, and biological pest control to improve soil fertility naturally. What is the main objective of these practices in farming?

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2. In an agricultural system, farmers rely on earthworms, compost, animal manure, and crop residues to recycle nutrients back into the soil. What principle of farming is being followed here?
3. A group of farmers notices that organic farming produces lower yields but improves long-term soil health and reduces environmental pollution. What does this indicate about the advantages and limitations of such a farming system?

What have you learned?

After completing this session, you will be able to:

- identify the key principles and components of organic farming;
- explain the advantages of organic farming in terms of sustainability and environmental impact; and
- describe the limitations and challenges associated with organic farming.

Session 3: Sources and Preparation Methods of Organic Manures

Organic manures are natural substances obtained from plant, animal and human wastes that contain nutrients in organic form. These manures release nutrients slowly into the soil and help improve soil fertility over time. Examples of organic manures include compost, farmyard manure, green manure and vermicompost.

Fertilisers, on the other hand, are naturally occurring or manufactured chemical substances that supply specific nutrients directly to plants. They usually contain nutrients in concentrated form and provide quick results for plant growth.

1. Major Sources of Manure

Manures play a crucial role in organic farming by improving soil fertility, enhancing microbial activity, and providing essential nutrients for plant growth. The major sources of manure in organic farming include:

(i) **Cattle shed waste**: Dung, urine, and slurry from biogas plants.
(ii) **Crop waste**: Sugarcane trash, stubble, and other related materials.
(iii) **Agro-industrial by-products**: Oil cakes, bagasse, press mud, and fruit/vegetable processing wastes.

2. Types of Organic Manures

Organic manures are natural materials derived from plant, animal, or mineral sources that improve soil fertility and structure by adding essential nutrients and organic matter. The various types of organic manure:

a) ***Farm yard manure:*** Farmyard Manure (FYM) is primarily made from cow dung, cow urine, waste straw, and other dairy by-products. It contains 0.5% nitrogen (N), 0.2% phosphorus (P_2O_5), and 0.5% potassium (K_2O). Cow urine, with 1.0% nitrogen and 1.35% potassium, primarily contains urea, which can undergo volatilisation losses (Fig. 2.11). By using improved methods for preparing FYM, losses due to leaching and volatilisation can be minimised.

Fig. 2.11: FYM: a natural fertiliser for healthy soil and crops

b) ***Vermicompost:*** It is a nutrient-rich organic fertiliser produced through the process of composting with earthworms. It plays a vital role in organic farming and gardening, offering numerous benefits to growers. Vermicompost is created by decomposing organic waste such as kitchen scraps, garden waste, and agricultural residues with the help of earthworms. The worms break down the organic materials into a dark, nutrient-dense materials called castings.

c) ***City compost:*** Metropolitan areas are facing a major problem in the disposal of large volumes of liquid and solid wastes generated by urban and industrial activities. Sewage and sludge are broadly made up of liquid waste. Sewage is spent water consisting of water carrying waste from commercial and industrial areas, and surface and ground water that enter the sewage system. The sewage and sludge are useful sources of water for irrigation and nutrients, and the urban solid wastes can serve as a nutrient source.

d) ***Green manure:*** Green manuring can be defined as a practice of ploughing or turning into the soil unrecompensed green plant tissues for improving physical structure as well as soil fertility. Green manuring, wherever feasible, is the principal supplementary means of adding organic matter to the soil. The green-manure crop supplies organic matter as well as additional nitrogen, particularly if it is a legume crop, due to its ability to fix nitrogen from the air with the help of its root nodule bacteria. Plants used for green manuring are mainly fast-growing legumes that fix nitrogen or succulent crops that add organic matter to the soil. Examples include *Sunhemp* (*Crotalaria juncea*), Dhaincha (*Sesbania aculeata*), Cowpea (*Vigna sinensis*), Berseem (*Trifolium alexandrinum*), and Cluster bean (*Cyamopsis tetragonoloba*) (Fig. 2.12).

Sunnhemp (*Crotalaria juncea*)

Dhaincha (*Sesbania aculeate*)

Cowpea (*Vigna sinensis*)

Berseem (*Trifolium alexandrinum*)

Cluster bean (*Cyamopsis tetragonoloba*)

Fig. 2.12: Green manure plants

3. Method of Preparation of Farm Yard Manure (FYM)

Farmyard manure (FYM) is one of the most widely used organic manures in agriculture. It is prepared by the decomposition of cattle dung, urine, bedding materials, and farm wastes under controlled conditions. Proper preparation of FYM helps retain nutrients, promotes efficient decomposition, and produces a well-rotted manure that improves soil fertility, soil structure, and microbial activity. Several methods are used for the preparation of farmyard manure, depending on local conditions, available resources, and management practices. The different methods of preparing farmyard manure are described below:

a) ***Pit method:*** For better quality farm yard manure, the use of the pit method for areas with less than 1000 mm precipitation and the heap method for other places is recommended. The right method to make farm yard manure properly is given below:

i. **Gathering of animal excreta:** Efficient collection of animal excreta without losing urine is achieved by spreading straw, waste fodder, or crop remnants under animals to absorb the urine, with paddy straw being ideal. One kilogram

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of straw can absorb approximately 1.5 kg of urine, aiding in faster decomposition. A solid floor can collect about 50% of urine, which can then be added to farm waste using buckets.

ii. **Pit digging:** The dimensions of the pit will depend upon the number of animals and the amount of excreta. Mainly for 3-5 animal excreta, a 6-7 m long, 1-1.5 m wide, and 3-foot deep pit is enough. The depth of the pit from one side should be 3 feet, and from the other side it should be 3.5 feet. Dig the pit at a place where rainwater cannot gather. Ridges should be made around the pit.

iii. **Pit filling:** Start filling the pit with a low deep side and fill it up to 1.5 feet high from the ground, and then make a 1.5-2-inch-thick soil layer above it. By doing this, the seeds of the farm waste will be degraded, and the useful plant nutrients will be protected from the sunlight.

iv. **Number of pits:** Every farmer must have at least 2-3 pits so that the first pit gets covered after adding soil, and then the second pit should start filling. During this time, the farm yard manure from the first pit will be ready to be added to the field, which will again be free after using manure.

b) ***Trench method:*** This method is also called the Dr C. N. Acharya method. In this method, trenches of 6 to 8 m length, 1.5 to 2 m width, and 1 to 1.25 m depth are prepared.

A mixture of dung and urine-soaked litter is deposited in layers in these trenches until it becomes 50 cm above the ground layer. Now it is covered with a 50 cm deep soil or wood ash-soil layer and then plastered with mud paste. Manure becomes ready for use after about 150 – 160 days of plastering (Fig. 2.13).

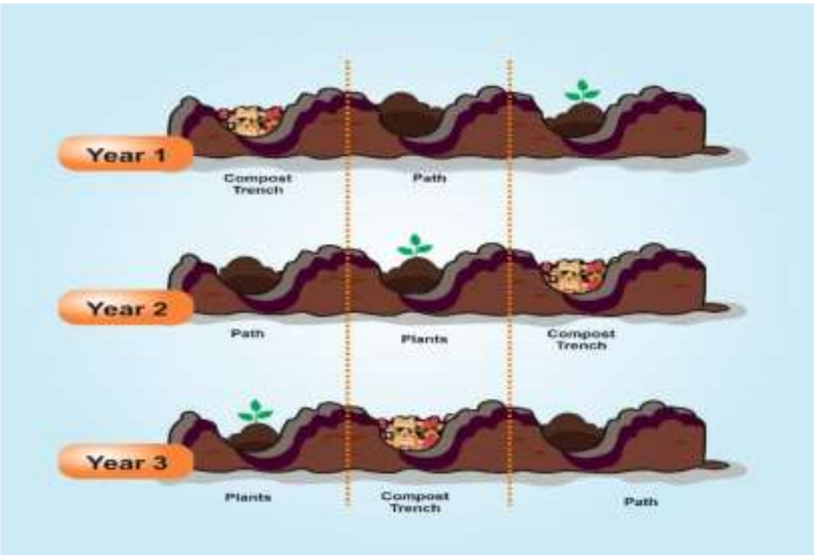

Fig. 2.13: Trench compost, a natural way to feed the soil

c) Heap method

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This method is commonly used by farmers. Every day, sweepings, cow dung and litter are collected and heaped at any fixed place. After about 6 to 9 months, the rotten manure is used. The heap composting method is the oldest and simplest method of composting organic waste, requiring neither a pit nor a container. Under this system, biodegradable materials such as crop residues, kitchen waste, animal manure, dried leaves, and green plant materials are collected and heaped in either a conical or rectangular pile on the ground; it should preferably be done under shade. Normally, the heap is made in layers - alternating green (wet) and brown (dry) materials for a good carbon-to-nitrogen ratio.

Moisture and aeration are the key factors in this process; regular watering of the heap and turning it every few weeks provides sufficient aeration. In about 5-6 months, microbial action will have led to dark, crumbly, nutrient-rich compost by working upon the organic matter. This way is cheap, easy to take care of, and best for little farms or gardens at home, but it might be slower and not as safe from rain or bugs when one sees the pit or bin composting ways.

Practical Exercise

Activity 1: The manure hunt

Materials Required:

1. Small containers or paper bags
2. Labels/tags
3. Notebook and pen
4. Gloves

Procedure:

- Visit the school garden.
- Search for things like cow dung, compost, fallen leaves, etc.
- Gather small samples (wear gloves while collecting the sample).
- Label each sample appropriately.
- Observe the texture, colour, and smell from time to time.
- Note down findings in a notebook.
- Present the collected samples and observations in class, explaining the experience of real-life identification of organic manures, the changes in texture and composition, and how these can be used in farming.

Activity 2: Compost layering game (mini compost bin model)

Materials Required:

1. Cut open a transparent plastic jar or bottle
2. Dry leaves/shredded newspaper
3. Vegetable/fruit peels
4. Garden soil
5. Spray bottle of water
6. Labels or paper strips for naming the layers

Procedure:

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- Select a transparent jar/bottle to observe the layers.
- 1st layer – dry leaves or newspaper (Carbon)
- 2nd layer – peels of fruits or vegetables (Nitrogen)
- 3rd layer – a small amount of soil (it contains microorganisms).
- Repeat steps 2-3 two to three times.
- Sprinkle with a little water to keep it moist.
- Label each layer with small paper strips.
- Cover lightly and place in a warm spot.
- Every week, stir gently, and observe the changes.

Check Your Progress

A. Multiple Choice Questions

1. What is the primary difference between manure and fertilisers?
   a) Manure is synthetic, and fertilisers are organic
   b) Manure contains complex organic nutrients, while fertilisers contain simple inorganic nutrients
   c) Manure is used only for plant growth, while fertilisers are for soil health
   d) There is no difference

2. Which of the following is a source of manure?
   a) Plastic waste
   b) Animal excreta
   c) Chemical fertilisers
   d) Pesticides

3. Which of the following materials is primarily used in the preparation of Farm Yard Manure (FYM)?
   a) Cow dung and urine
   b) Animal hides
   c) Industrial waste
   d) Plastic

4. What is the role of vermicompost in agriculture?
   a) It is a synthetic fertiliser
   b) It enriches the soil with nutrients and improves its biological activity
   c) It is only used as a pesticide
   d) It provides only nitrogen to the soil

5. What is the primary benefit of using green manure?
   a) It only improves soil water retention
   b) It adds organic matter and nitrogen to the soil
   c) It is used for pest control

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d) It is a source of phosphorus

6. Which of the following is a key characteristic of rural composting?
   a) It is a method of preparing synthetic fertilisers
   b) It is used only for improving water retention in soil
   c) It is a biochemical process that turns organic materials into humus-like substances
   d) It is only used in industrial farming

7. What are the main ingredients used to make liquid manure?
   a) Cow dung and water
   b) Molasses, distillery slop, and sugarcane leaves
   c) Green plants only
   d) Animal excreta

8. Which of the following materials can be used as a source of farmyard manure?
   a) Sugarcane trash
   b) Animal urine and dung
   c) Green plants
   d) All of the above

9. What is the primary purpose of using pit methods in farmyard manure preparation?
   a) To store the manure
   b) To prevent the manure from being exposed to sunlight and improve decomposition
   c) To increase the nutrient content of the manure
   d) To reduce the water content in manure

10. Which of the following is an example of an agro-industrial by-product used in manure preparation?
    a) Oil cakes
    b) Sugarcane trash
    c) Cow urine
    d) Green manure

B. Fill in the Blanks

1. Organic manures are derived from animal, human and __________ residues.
2. Fertilisers are organic or __________ chemicals containing plant nutrients.
3. Manures with low nutrient content have a longer __________ effect compared to fertilisers.
4. The major sources of manure include __________________, human habitation waste, crop waste, and agro-industrial by-products.
5. __________ is primarily made from cow dung, cow urine, waste straw, and other dairy by-products.

C. State Whether the Following Statements are True or False

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1. Organic manures contain plant nutrients in complex organic forms.
2. Farmyard manure has a higher nutrient content compared to chemical fertilisers.
3. Vermicomposting involves the use of bacteria to decompose organic waste.
4. Green manuring is the process of growing green plant tissues into the soil to improve fertility.
5. City compost includes only solid waste from urban areas and does not include sewage or sludge.

D. Subjective Questions

1. A farmer wants to prepare a nutrient-rich soil amendment using natural waste materials such as dung, crop residues, and kitchen waste. What general term is used for such organic inputs in agriculture?
2. In an organic farm, a farmer collects cow dung, urine, straw, and other dairy waste and allows it to decompose slowly in a pit to improve soil fertility. What type of organic manure is being prepared?
3. A village faces problems in managing large amounts of urban waste and decides to convert sewage and sludge into a useful agricultural input. What farming practice does this represent?
4. A farmer grows fast-growing leguminous plants and ploughs them back into the soil to increase nitrogen content and improve soil structure. What type of manure practice is being followed?

What have you learned?

After completing this session, you will be able to:

- identify different sources of organic manures, including animal waste, green manures, compost, and bio-fertilisers;
- explain the significance of organic manures in improving soil fertility and plant health; and
- describe various composting techniques and their applications in organic farming.

Session 4: Integration of Livestock in Organic Farming

Livestock integration is an important part of farming systems in developing countries like India. Farmers rear livestock such as cows, buffaloes, goats, sheep and poultry along with crop cultivation to support their livelihood. Livestock provide food products such as milk, meat and eggs, and also generate income and employment opportunities for farming families. Animal waste is used as organic manure, which helps improve soil fertility and supports sustainable agriculture.

In organic farming, livestock are reared using natural and eco-friendly methods without the use of synthetic chemicals, antibiotics, growth hormones or chemically treated feed. Organic livestock farming aims to produce high-quality and healthy food products while maintaining animal welfare and environmental sustainability.

Animals in organic farming systems are provided with sufficient open space, natural shelter and access to grazing areas. They are mainly fed on natural and organic feed products. Proper care, hygiene and natural disease management practices are followed to maintain the health and well-being of animals.

1. Principles of Organic Livestock Production

Principles guide practices in organic farming, ensuring that livestock are raised in a manner that aligns with natural processes and the health of the ecosystem. The following are some of the key principles of organic livestock production:

(i) Organic livestock farming emphasises the well-being and natural behaviour of animals. Farmers are required to provide animals with conditions that allow them to express their natural behaviours, such as grazing, rooting, and social interaction.
(ii) Organic livestock production is designed to be sustainable, minimising the impact on the environment. This involves practices that promote biodiversity, protect water resources and maintain soil health.
(iii) The principle of using natural and preventive health care methods is fundamental in organic livestock farming. This includes disease prevention through proper nutrition, clean housing, low animal stress and appropriate stocking densities.
(iv) Organic livestock production aims to integrate animals into the farming system in ways that maintain or enhance the ecological balance. This includes using animals for weed and pest control, manure management and enhancing soil fertility.
(v) Organic livestock farming supports biodiversity by promoting the use of diverse breeds that are well-suited to local conditions and by encouraging diverse habitats on the farm.

2. Characteristics of Organic Livestock Production

Organic livestock production has distinct characteristics that differentiate it from conventional farming. These characteristics are rooted in the principles of sustainability, animal welfare, environmental conservation, and natural production processes. The following are some of the key characteristics of organic livestock production:

(i) Animals in organic systems must have regular access to pasture and outdoor areas, allowing them to graze and engage in natural behaviour. This is a major characteristic that differentiates organic livestock farming from conventional intensive systems, where animals are often confined indoors.

(ii) Organic farming follows strict animal welfare guidelines, ensuring that animals are treated humanely throughout their lives. This includes providing spacious housing, adequate bedding, and minimising stress during transport and slaughter.

(iii) Feed should be devoid of any chemical or antibiotics. Feed with organically grown fodder.

(iv) Organic farmers often choose breeds that are well-adapted to local conditions, resistant to disease, and able to thrive on natural pasture systems. This helps to minimise the need for medical interventions and ensures that animals are suited to the organic system.

(v) Natural breeding is encouraged in organic farming, and the use of artificial reproductive technologies like cloning or genetic modification is banned.

(vi) In organic farming, animal waste (manure) is viewed as a valuable resource rather than waste. Livestock manure is recycled as organic fertiliser, helping to improve soil fertility and structure.

3. Types of Livestock Farming

Different types of livestock farming systems are differentiated by the production processes that take place in each of them. Some of these are given below:

(a) ***Intensive livestock farming:*** Intensive livestock farming is one in which the animals are housed with adequate temperatures, feed and healthcare necessary for the production of animals to be healthy and faster. In this system, the selection of breeds is made for different types of production. It is both capital and labour-intensive.

(b) ***Semi-intensive livestock farming:*** Semi-intensive livestock farming is one in which the animals are housed and fed, but are allowed to graze or move around the farm to scavenge within an enclosed area within the farm.

(c) ***Extensive livestock farming:*** Extensive livestock farming is one that is carried out on large areas of land, such as meadows, pastures or mountains, so that animals graze and take advantage of the natural resources of various areas. It is usually carried out with animals that are adapted to the type of field to which they are intended to be taken. This system promotes the conservation of the ecosystem.

(d) ***Nomadic livestock farming:*** It is characterised by the grazing of animals like cattle on a large expanse of land so that they have a natural diet. In this system, the animals are taken to different lands to eat various foods and resources. This type of livestock farming is known as nomadic or semi-nomadic.

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4. Subsidiary Enterprises Based on Animals in Organic Farming

Subsidiary enterprises based on animals in organic farming involve integrating livestock and other animal-related activities with crop production to create a balanced and self-sustaining farming system. Instead of treating crops and animals as separate enterprises, organic farming encourages their integration so that the waste or by-products of one component become valuable inputs for another. Such integration improves resource use efficiency, reduces production costs, and enhances the overall productivity and profitability of the farm.

Animal-based enterprises play a significant role in maintaining soil fertility, recycling nutrients, conserving biodiversity, and improving the resilience of farming systems. Livestock produce manure and urine that can be converted into farmyard manure (FYM), compost, vermicompost, liquid manures, and bio-enhancers such as *Jeevamrit* and *Panchagavya*. These organic inputs improve soil structure, increase microbial activity, enhance nutrient availability, and reduce dependence on synthetic fertilisers. In addition, many animals contribute to natural weed and pest management, while some improve pollination, thereby increasing crop productivity.

Besides supporting crop production, subsidiary animal enterprises provide farmers with regular income through the sale of milk, eggs, meat, honey, fish, wool, and other products. They also generate year-round employment for farm families, improve nutritional security, and diversify farm income, making farming more sustainable and economically viable. Some important animal-based subsidiary enterprises commonly practised in organic farming are described below.

(a) Dairy farming: Dairy farming is one of the most important subsidiary enterprises in organic agriculture. Cows, buffaloes, goats, and sheep provide organic milk that can be consumed directly or processed into value-added products such as curd, yoghurt, butter, ghee, paneer, and cheese. The sale of milk and milk products provides farmers with a regular source of income throughout the year.

Apart from milk production, dairy animals supply dung and urine, which are valuable raw materials for preparing farmyard manure, compost, vermicompost, biogas slurry, *Jeevamrit*, *Beejamrit*, *Panchagavya*, and other organic formulations. These materials enrich the soil with essential nutrients such as nitrogen, phosphorus, and potassium, improve soil organic matter, and promote beneficial microbial activity. Crop residues can be used as fodder for animals, while animal manure is returned to the fields, creating an efficient nutrient recycling system.

b) Poultry farming: Organic poultry farming involves raising chickens, ducks, geese, turkeys, or quails under natural and welfare-friendly conditions. These birds provide eggs and meat, which are valuable sources of nutrition and income.

Poultry also contributes significantly to crop production by feeding on insects, larvae, weed seeds, and other pests, thereby helping to reduce pest populations naturally.

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Their droppings are rich in nitrogen and other nutrients and can be composted or applied to fields as organic manure after proper decomposition. Poultry can also be integrated into orchards and vegetable farms, where they help in weed control, pest management, and nutrient recycling while reducing the need for chemical inputs.

c) Beekeeping (Apiculture): Beekeeping is an important subsidiary enterprise that complements organic farming by enhancing pollination. Honeybees are among the most efficient natural pollinators of flowering plants and play a vital role in increasing the yield and quality of many fruit, vegetable, oilseed, spice, and pulse crops.

Improved pollination results in better fruit set, larger fruits, higher seed production, and improved crop quality. Beekeeping also provides valuable products such as organic honey, beeswax, pollen, propolis, royal jelly, and bee venom, which have commercial value. Since organic farming avoids harmful chemical pesticides, it provides a safer environment for bees, helping to conserve pollinator populations and biodiversity.

d) Fish farming (Aquaculture): Fish farming can be successfully integrated with organic farming to utilise water resources efficiently and enhance farm productivity (Fig. 2.14). Fish are reared in ponds where nutrients from livestock manure or compost support the growth of plankton, which serves as natural fish food. Integrated farming systems such as rice–fish farming allow fish and paddy to be cultivated together in the same field. Fish help control insects, mosquito larvae, and certain aquatic weeds, while their excreta enrich the water with nutrients that support crop growth. Pond water rich in nutrients can also be used for irrigating crops, thereby recycling nutrients within the farming system. Integrated aquaculture improves farm income, increases resource-use efficiency, and provides a nutritious source of protein for farm families.

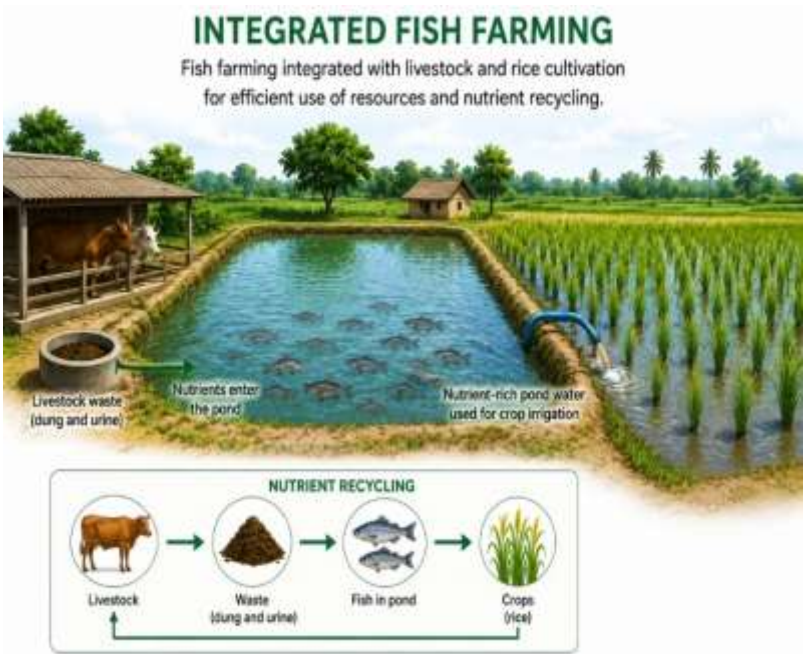

Fig. 2.14: Integrated fish farming, fish farming and crop farming in one place

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(e) ***Vermiculture (earthworm farming):*** Earthworms are used to convert organic waste and animal manure into high-quality compost (vermicompost), which enhances soil fertility and structure. Vermicompost is a nutrient-rich, organic fertiliser that improves plant growth while also reducing waste on the farm.

(f) ***Goat/sheep rearing:*** Goats and sheep provide milk, meat, wool, and manure. They are highly adaptable and can graze on land unsuitable for crops, turning marginal land into productive use. Their manure enriches the soil, and they help control weeds, reducing the need for mechanical weeding.

(g) ***Pig farming:*** Pigs can be raised organically for meat production. They can also consume farm waste and leftover crops, converting them into meat and manure. Pigs help in waste recycling and provide high-quality manure to fertilise crops.

(h) ***Silkworm farming (Sericulture):*** Silkworms can be raised on organic farms for silk production. Mulberry trees, used to feed silkworms, can be integrated with other crops or livestock systems. This provides an additional income source and helps maintain a diverse farming system.

5. Role and Benefits of Livestock in Organic Farming

Livestock play an essential role in organic farming, contributing to the overall health and sustainability of the farming system. Their integration into the farm promotes ecological balance, enhances soil fertility and offers various benefits that align with the principles of organic agriculture. The role of livestock in organic farming is as follows:

(i) **Nutrient cycling and soil fertility:** Livestock contribute significantly to nutrient cycling by providing manure, which is a vital source of organic matter and nutrients like nitrogen, phosphorus and potassium. This manure helps improve soil structure, fertility, and water retention capacity.

(ii) **Natural grazing and weed control:** Livestock, particularly herbivores like cattle, sheep, and goats, play a key role in weed control. By grazing on fields and pastures, they consume unwanted vegetation, reducing the need for herbicides. Livestock grazing also helps maintain pasture health by preventing overgrowth and encouraging the growth of nutrient-rich plants.

(iii) **Pest control:** Certain types of livestock, such as chickens, ducks, and guinea fowl, can naturally control pests by foraging on insects, slugs and other pests in the fields. This reduces the reliance on chemical pesticides, contributing to a healthier and more balanced farm ecosystem.

(iv) **Crop residue management:** Livestock can be used to consume crop residues after harvest, such as leftover stubble, weeds and cover crops. This not only provides animals with additional feed but also helps break down plant materials and incorporate it into the soil as organic matter.

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Practical Exercise

Activity 1: Organic farmers' meet (organic farming with animals)-role play

Material Required:

1. Notebook
2. Pen
3. Animal props or badges
4. Craft materials
5. Pictures or flashcards of farm animals and organic farming practices

Procedure:

- Each group will choose one type of livestock to represent (e.g., dairy cows, bees, chickens, goats, or fish).
- Decide who will speak on behalf of the group as an organic farmer.
- Talk about how animals help the farm—do they provide manure, improve soil, assist in pollination, or control pests?
- Use simple props, drawings, or badges to represent an animal (e.g., paper wings for bees or a cow tag).
- Each group presents as if at a village meeting, explaining how their animal supports organic farming.

Activity 2: Design a green farm with animals and crops

Materials Required:

1. A big sheet of chart paper or A3-size paper
2. Pencil, eraser, ruler, sketch pens or crayons
3. Stickers or cut-outs

Procedure:

- Imagine you are designing a real organic farm.
- Include elements like a dairy barn, beehives, a fish pond, a chicken coop, a compost pit, and a garden.
- Show how animals and plants support each other (e.g., bees near flowers, chickens in the garden).
  Sketch the farm on paper and clearly label each area.
- Fill in colours and small notes explaining how your farm works.
- Present your farm design to the class or display it on the wall.

Activity 3: Analysis of the role of livestock in organic farming

Materials Required:

1. Notebook
2. Pen

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Procedure:

- Identify roles such as nutrient cycling, pest control, and weed management.
- Match each role with its benefit.
- Write examples for each role.
- Record observations.

Activity 4: Identification of benefits of livestock integration

Materials Required:

1. Notebook
2. Pen

Procedure:

- List benefits like manure production, income generation, and biodiversity improvement.
- Identify how livestock supports crop production.
- Summarise the advantages of integration.
- Record findings in points.

Check Your Progress

A. Multiple Choice Questions

1. What is strictly avoided in organic livestock farming?
   a) Natural grazing
   b) Synthetic pesticides
   c) Use of manure
   d) Outdoor access for animals

2. In organic livestock systems, animals must be given:
   a) Artificial supplements only
   b) Confined indoor spaces
   c) Regular access to pasture and outdoor areas
   d) Cloned offspring

3. Which of the following is a principle of organic livestock production?
   a) Maximising production using synthetic inputs
   b) Encouraging high-density indoor rearing
   c) Promoting natural behaviour of animals
   d) Use of genetically modified organisms

4. Which type of livestock farming allows animals to graze and roam in open lands like meadows or pastures?
   a) Intensive livestock farming

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b) Nomadic livestock farming
c) Extensive livestock farming
d) Semi-intensive livestock farming

5. Which of the following is a subsidiary enterprise in organic farming that helps in pollination?
   a) Goat rearing
   b) Fish farming
   c) Poultry farming
   d) Beekeeping

6. What is one major benefit of using livestock manure in organic farming?
   a) It attracts pests
   b) It reduces soil fertility
   c) It improves soil structure and fertility
   d) It leads to water pollution

7. In organic livestock production, natural breeding is encouraged and ______ is banned.
   a) Manure use
   b) Feeding animals grass
   c) Use of artificial reproductive technologies
   d) Pest control by ducks

B. Fill in the Blanks

1. Organic farming is a livestock production system that avoids the use of synthetic chemicals such as fertilisers and _______.
2. In organic livestock farming, animals must have regular access to _______ and outdoor areas to engage in natural behaviour.
3. _______ livestock farming is characterised by raising animals in enclosed spaces with controlled feed and healthcare.
4. The integration of livestock into organic farming systems helps in _______ cycling and enhances soil fertility.
5. In organic livestock farming, _______ breeding is encouraged, while artificial reproductive technologies like cloning are banned.

C. State Whether the Following Statements are True or False

1. Organic livestock farming promotes the use of synthetic fertilisers and pesticides.
2. Nomadic livestock farming involves moving animals from one place to another in search of food and water.
3. Poultry farming in organic systems plays a role in pest control by consuming insects.
4. Artificial reproductive technologies like cloning and genetic modification are encouraged in organic farming.

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5. Fish farming (aquaculture) in organic systems can be integrated with rice farming to utilise water efficiently.

D. Subjective Questions

1. A farmer wants to reduce the use of chemical fertilisers on his organic farm. Which livestock-based practice can help improve soil fertility naturally, and how?
2. An organic poultry farmer notices an increase in insects damaging vegetable crops. How can poultry birds help in pest management on the farm?
3. A farmer in a dry, hilly area wants to start livestock farming with minimum medical intervention. Which type of livestock system and animal breed characteristics would be most suitable?
4. After harvesting crops, a farmer allows goats and sheep to graze on leftover plant materials in the field. Explain how this practice benefits both livestock and soil health.
5. A farmer plans to integrate dairy farming with vermiculture in an organic farming system. How can these two enterprises work together to improve farm sustainability?

What have you learned?

After completing this session, you will be able to:

- describe the principles and characteristics of organic livestock farming;
- identify different types of livestock farming systems;
- explain the role of livestock in organic farming for nutrient recycling, weed and pest control, and improving soil fertility;
- describe animal-based subsidiary enterprises that support organic farming systems; and
- explain the various factors that affect livestock farming.

Unit 3 | Water, Nutrient and Pest Management

Unit 3 on *Water, Nutrient and Pest Management,* focuses on different sources and methods of irrigation, types and uses of bio-fertilisers, methods of weed control and various pest control practices used in agriculture. In this unit, you will understand efficient water management techniques, sustainable nutrient management practices and eco-friendly methods for controlling weeds and pests in agricultural fields.

Session 1 on *Sources and Methods of Irrigation*, introduces you to different sources of water used for irrigation, such as rivers, lakes, canals, wells and groundwater sources. It also explains traditional and modern irrigation methods, including surface irrigation (furrow, basin and border irrigation), sub-surface irrigation, drip irrigation

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and sprinkler irrigation. The session further discusses irrigation scheduling, irrigation intervals and drainage management for efficient water use.

Session 2 on *Types and Application of Bio-fertiliser*, familiarises you with different types of bio-fertilisers and their methods of application. It explains how beneficial microorganisms help improve soil fertility, increase nutrient availability and promote plant growth.

Session 3 on *Methods of Weed Management*, explains the different methods used to control weeds in agricultural fields. You will also understand mechanical, chemical, cultural and biological weed control methods. The session further highlights integrated weed management practices that combine different methods to reduce herbicide dependence and maintain ecological balance.

Session 4 on *Methods of Pest Management and Control*, introduces you to different types of agricultural pests such as insects, nematodes and rodents along with various pest control strategies. It also explains chemical, biological and cultural methods of pest control and familiarises you with Integrated Pest Management (IPM), which combines multiple methods for effective and environmentally safe pest management.

Session 1: Sources and Methods of Irrigation

Irrigation is the artificial application of water to agricultural land to support the growth and development of crops when natural rainfall is insufficient or irregular. It is an important agricultural practice that helps maintain adequate soil moisture for healthy plant growth and improved crop production.

Water for irrigation is supplied through different sources and methods such as canals, wells, tanks, sprinklers and drip irrigation systems. Proper irrigation ensures that crops receive the required amount of water at the right time, which helps improve crop yield, maintain soil fertility and support stable agricultural production.

The requirement, timing and frequency of irrigation depend on various factors such as the type of crop, soil condition, climate and season. Efficient irrigation management also helps conserve water and prevents problems such as waterlogging and soil erosion. Let us now understand irrigation in detail.

1. Source of Irrigation

Various sources of surface water and groundwater are used for irrigation purposes. These sources include tanks, canals, wells, lakes, rivers, ponds, reservoirs and streams.

Irrigation water is obtained from these natural and artificial sources to meet the water requirements of crops during different stages of growth. Surface water generally contains impurities such as soil particles, organic matter and other contaminants. Therefore, it is often filtered or treated before being used for irrigation. Proper selection and management of irrigation water sources help ensure efficient water use and healthy crop production.

2. Methods of Irrigation

Various irrigation techniques differ in the method by which water obtained from the source is distributed to crops in the field. The selection of an irrigation technique depends on factors such as the type of crop, soil condition, availability of water and topography of the land. The various irrigation techniques are as follows:

(a) Surface irrigation: In surface irrigation systems, water is allowed to flow naturally over the surface of the field by the force of gravity in order to wet the soil and allow water to infiltrate into the root zone of crops (Fig. 3.1). It is one of the oldest and most commonly used methods of irrigation.

The movement and distribution of water depend on the slope, soil type and field layout. Surface irrigation is suitable for a wide variety of crops and is generally practised in areas where sufficient water is available. Based on the method of water distribution, surface irrigation can be subdivided into furrow irrigation, border strip irrigation and basin irrigation.

Fig. 3.1: Surface irrigation in agricultural fields

(b) Sub-irrigation: It is also sometimes called seepage irrigation and has been used for many years in field crops in areas with high water tables. It is a method of artificially raising the water table to allow the soil to be moistened from below the plants' root zone (Fig. 3.2). In this method, water reaches the plant roots through upward movement of moisture within the soil.

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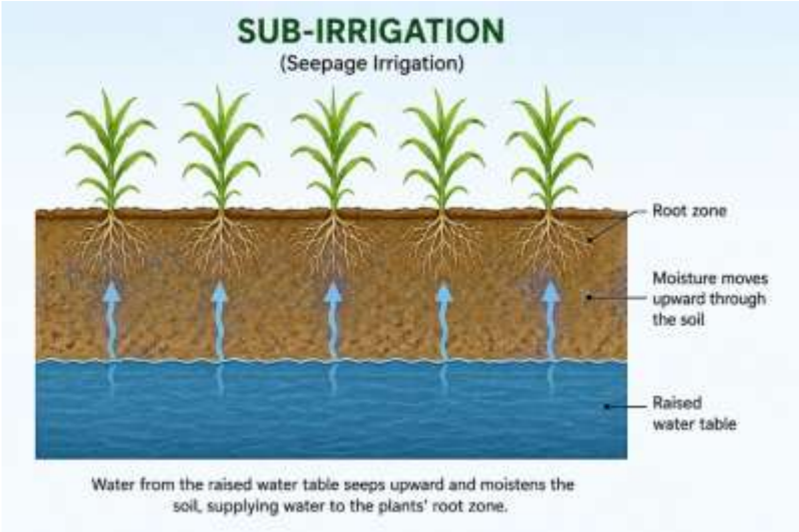

Fig. 3.2: Sub-irrigation, gives water to roots directly

(c) Microirrigation: It is also known as localised or low-volume irrigation. It is a highly efficient method of irrigation where water is delivered directly to the root zone of plants in small, precise quantities. This system is ideal for areas with limited water resources, as it minimises water wastage by reducing runoff, evaporation and deep percolation. The two main types of micro-irrigation systems are drip irrigation and sprinkler irrigation are as follows:

(i) **Drip irrigation system:** It is the most widely used form of micro-irrigation. It involves a network of tubes, pipes, and emitters that deliver water directly to the base of plants in small, frequent doses (Fig. 3.3). The water "drips" slowly at the plants' root zone. It is also known as a ‘trickle irrigation system. It is a method of applying the required water through drippers or emitters at frequent intervals. In this system, water is applied drop-by-drop or by a micro jet on the soil surface or sub-surface at a rate lower than the infiltration rate of the soil.

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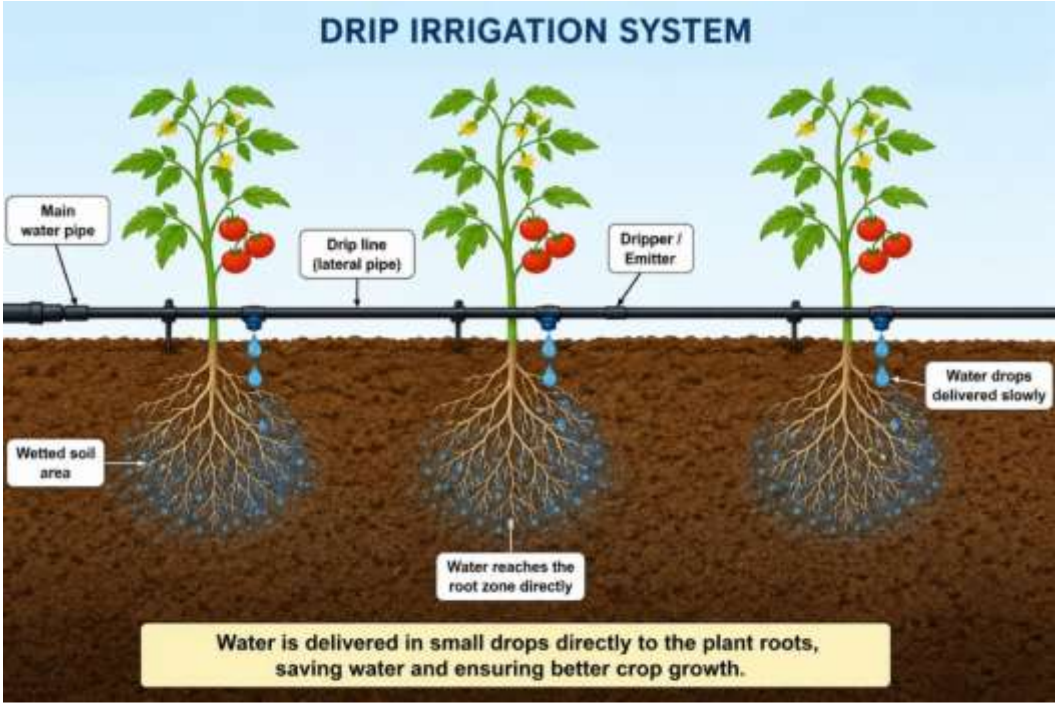

Fig. 3.3: Water drops go directly to plant roots in drip irrigation system

It helps in saving water by reducing evaporation and runoff, making it highly efficient, especially in areas with limited water resources. This method improves crop growth by providing a constant supply of water right where it is needed. It also reduces weed growth since water does not spread across the entire field.

Drip irrigation saves labour, energy, and allows for the easy application of fertilisers through the water (called fertigation). It is suitable for all types of soil and is especially beneficial for vegetable crops, fruit trees, and gardens.

(ii) **Sprinkler irrigation system:** Micro-sprinkler irrigation uses small, low-pressure sprinklers that spray water over a limited area, usually over the root zone of plants. These sprinklers release a gentle, fine mist or stream of water. Sprinkler irrigation is a method of applying water in a manner similar to rain (Fig. 3.4). It is suited for most row, field and tree crops. Water can be sprayed over or under the crop canopy. If a site is known to be windy most of the time, sprinkler irrigation will not be suitable. The sprinkler breaks up the water into droplets sized 0.5–4 mm. The drop size is controlled by pressure and the nozzle size of the sprinklers. The average rate at which water is sprayed onto the crops is measured in mm/hour.

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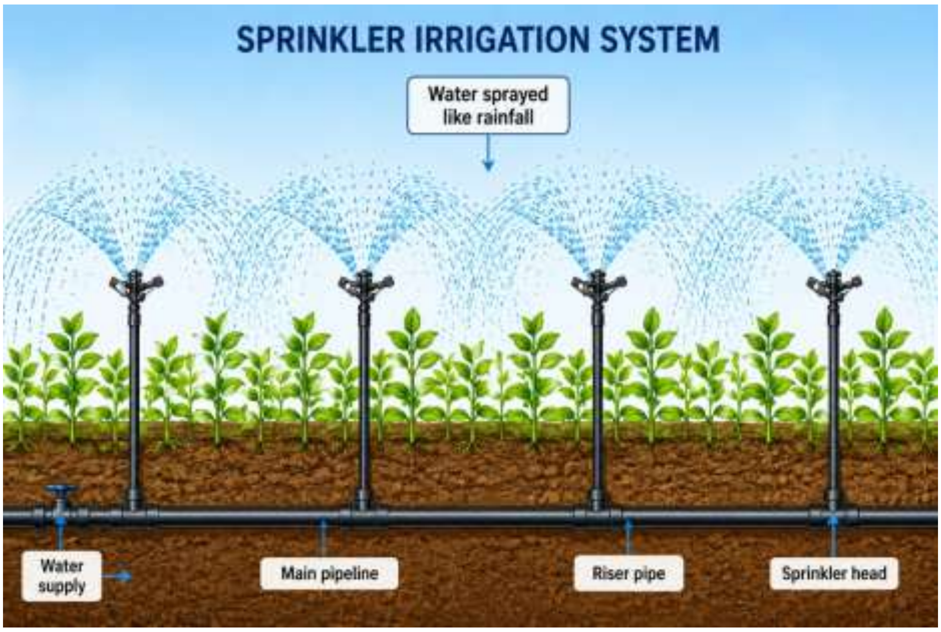

Fig. 3.4: Water is sprayed like rainfall using a sprinkler system to irrigate crops evenly

3. Factors Affecting Irrigation Interval

The irrigation interval refers to the time between successive irrigation applications. The irrigation frequency depends on several factors that influence how much water crops need and how quickly the water in the soil is depleted. The following are the key factors affecting the irrigation interval:

(i) **Climate:** It is responsible for causing variations in consumptive use rate and frequency of irrigation. High temperature, low humidity, high wind velocity and greater solar radiation in a place emphasise the need to irrigate crops more frequently as evapotranspiration takes place at a higher rate due to greater evaporative demand of the atmosphere.

(ii) **Soil:** Water retentive capacity of soil is considered the most important soil factor deciding the frequency and interval of irrigation. The frequency is higher in porous sandy soils with coarse texture, poor structure and low organic matter content. Retention of a greater amount of available water is considered more important than the total quantity of water retained by a soil.

(iii) **Crop characteristics:** Crops vary in their consumptive use of water, sensitivity to water stress, water extraction capacity and optimum water regime. The frequency of irrigation thus varies with crops. Crops like vegetables, onion and sugar beet that require a higher level of water to be maintained in the soil need frequent irrigations than other field crops.

(iv) **Management practice:** Soil water conservation practices such as artificial or soil mulching and crop cultural practices like weeding and hoeing help to reduce the evaporation loss and conserve more soil water for crop use. Thus, there is a reduction in the irrigation requirement of crops. Method of irrigation, depth of water applied each time, and the water distribution efficiency influence the frequency of irrigation.

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(v) **Irrigation period**: It is the time, usually expressed in days, that can be allowed for applying one irrigation to a given design crop area during the peak consumptive use period of the crop. It is a function of the peak-period consumptive use rate. It is considered for designing the irrigation system capacity and equipment.

4. Irrigation Scheduling

Irrigation scheduling is the process used by irrigation system managers to determine the correct frequency and duration of watering. The following methods of scheduling may be adopted as per the crops grown under the organic production system:

(i) **Feel and appearance of soil method:** This method involves assessing soil texture and structure by observing its touch, moisture, and appearance to determine suitability. The scheduling of the irrigation can also be done by observing the appearance of the surface soil. If small cracks are seen on the surface soil, then irrigation is needed.
(ii) **Growing of indicator plants:** The sunflower plants show early symptoms of moisture deficiency in the field; accordingly, the irrigation is scheduled for the main crop.
(iii) **Micro-plot technique:** In this method, a pit of 1m long, 1m wide and 1m deep is dug out in the field. Thereafter, 5% sand is mixed in the soil obtained from a 1 cubic meter area. This mixture of soil and sand is again filled into the same pit. This small pit is called the micro-plot, which is used for observing the water deficiency in the field. The sowing of the crop is done in the entire field, including the micro-plot. The crop plants grown in this pit will show the symptoms of moisture deficiency in advance due to a change in the texture of the soil, having more sand in these micro-plots; accordingly, irrigation is done in the whole field.
(iv) **Critical stages for irrigation*:*** The irrigation can also be scheduled based on different critical stages of different crops, which are more sensitive to moisture stress. If irrigation is not given during these critical stages, there may be a drastic reduction in crop yields. Having passed this critical stage of crop growth, the irrigation in the next stage will not be of any use, as the loss in the critical stage is irreversible.
(v) **Drainage**: The excess water, which is more than the needs of a crop, is to be removed artificially from the field through surface (land smoothening, levelling, grading, random ditches and bedding) and sub-surface methods (mole drain, sub-soiling and deep trenches) to maintain sufficient moisture and aeration in the root zone.

Practical Exercise

Activity 1: Create an irrigation model

Materials Required:

1. Cardboard tray or wooden box

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2. Sketch pens, labels, tape, scissors
3. Soil or sand
4. Small plants or seedlings
5. Straws, syringes, droppers, plastic bottles

Procedure:

- Spread soil on the tray to depict farmland.
- Label various zones like surface, drip, and sprinkler irrigation to show methods.
- Use droppers for drip, a perforated bottle for sprinkler, and gently pour water for surface irrigation.
- Observe how water is flowing or is getting absorbed.
- Present the model to the class and explain which method saves the most water.

Activity 2: Mapping of the water source

Materials Required:

1. A map of local area or state
2. Coloured pens and stickers
3. Internet access/library books (optional)

Procedure:

- Identify the various water sources in the locality, such as tanks, rivers, wells, etc.
- On the map, mark surface sources (sky blue), underground sources (brown).
- Write one advantage and one disadvantage for each source.
- Share findings in class and suggest the best source for sustainable irrigation.

Activity 3: Study of sprinkler irrigation system

Materials Required:

1. Notebook
2. Pen

Procedure:

- Identify working of sprinkler irrigation.
- Note how water is sprayed like rainfall.
- List suitable crops and conditions for its use.
- Record key points.

Activity 4: Identification of factors affecting irrigation interval

Materials Required:

1. Notebook
2. Pen

Procedure:

- List factors such as climate, soil, crop type, and management practices.

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- Explain how each factor affects irrigation frequency.
- Record observations in brief points.

Activity 5: Study of irrigation scheduling methods

Materials Required:
1. Notebook
2. Pen

Procedure:
- Identify methods like soil feel method, indicator plants, micro-plot technique, and critical stages.
- Note how each method helps decide irrigation timing.
- Record the methods with short explanations.

Activity 6: Identification of drainage methods in irrigation

Materials Required:
1. Notebook
2. Pen

Procedure:
- List drainage methods such as surface and sub-surface drainage.
- Identify techniques like levelling, ditches, mole drains, and trenches.
- Note their importance in removing excess water.
- Record findings.

Check Your Progress

A. Multiple Choice Questions

1. What is the primary source of irrigation water?
   a) Rainwater
   b) Groundwater
   c) Rivers, lakes, and canals
   d) Dew

2. What is the main characteristic of surface irrigation?
   a) Water is delivered directly to the plant roots
   b) Water flows over the land by gravity to infiltrate the soil
   c) Water is sprayed through sprinklers
   d) Water is supplied under low pressure through pipes

3. Which of the following is an advantage of drip irrigation?
   a) It requires more water than other methods
   b) It minimises evaporation and runoff
   c) It is only suitable for large fields
   d) It requires more labour for operation

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4. Which irrigation system is best suited for areas with limited water resources?
   a) Sub-irrigation
   b) Drip irrigation
   c) Surface irrigation
   d) Sprinkler irrigation

5. What is the role of microirrigation?
   a) To increase the frequency of irrigation
   b) To deliver water in small, precise quantities directly to the root zone
   c) To increase the runoff water
   d) To irrigate large fields efficiently

6. What does the "Feel and Appearance (soil) Method" of irrigation scheduling involve?
   a) Monitoring plant growth
   b) Observing cracks on the soil surface
   c) Measuring water levels in canals
   d) Using an automated irrigation system

7. What is the purpose of irrigation scheduling?
   a) To determine the amount of water needed for crop irrigation
   b) To decide the type of irrigation system to be used
   c) To determine the planting time for crops
   d) To choose the irrigation source

8. What is the purpose of sub-irrigation?
   a) To raise the water table and moisten the soil from below
   b) To reduce evaporation
   c) To apply water using sprinklers
   d) To increase water runoff

B. Fill in the Blanks

1. ________ is the process of supplying water to crops at different intervals.
2. Irrigation where water flows over the soil surface by gravity is known as ______________ irrigation.
3. In _____________________ irrigation, water is applied through narrow channels between crop rows.
4. Surface irrigation is most suitable for fields with a __________________ slope.
5. ________ irrigation is also known as trickle irrigation.
6. Surface irrigation commonly used for orchards and fruit trees is ______________ irrigation.
7. The two main types of micro-irrigation systems are drip and ___________________.

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C. State Whether the Following Statements are True or False

1. Drip irrigation is the least water-efficient method.
2. Sprinkler irrigation is suitable for most row, field, and tree crops.
3. The frequency of irrigation is higher in sandy soils than in clay soils.
4. Micro-irrigation is also called high-volume irrigation.
5. Surface irrigation relies on pumps for water distribution.

D. Subjective Questions

1. A farmer in a dry area with limited water wants to reduce water wastage in vegetable cultivation. Which irrigation method would you recommend and why?
2. During summer, a farmer notices that crops require watering more frequently than in winter. Which climatic factors are responsible for this change?
3. Small cracks appear on the soil surface of a field. According to irrigation scheduling methods, what does this indicate and what should the farmer do?
4. A farmer's field remains waterlogged after heavy irrigation, affecting crop growth. Which farm practice should be adopted to solve this problem and why?

What have you learned?

After completing this session, you will be able to:

- describe irrigation and its importance in crop growth and yield enhancement;
- identify methods of irrigation;
- differentiate between traditional and micro-irrigation techniques;
- classify factors affecting irrigation frequency; and
- explain irrigation scheduling and drainage methods for efficient water use.

Session 2: Types and Application of Biofertiliser

Bio-fertilisers are substances containing microorganisms which increase the fertility when added to the soil and promote plant growth. 'Bio' means 'life'. Therefore, by definition, biofertilisers are living organisms that enrich the nutrient quality of the soil. It refers to the use of microbes instead of chemicals to enhance the nutrition of the soil. As a result, it is also less harmful and does not cause pollution.

1. Type of Biofertilisers

Biofertilisers are preparations containing living beneficial microorganisms that enhance soil fertility and promote plant growth by increasing the availability of essential nutrients. These microorganisms improve nutrient cycling through processes such as nitrogen fixation, phosphorus solubilisation, and the decomposition of organic matter. Biofertilisers play a vital role in sustainable agriculture by reducing dependence on chemical fertilisers, improving soil health, and supporting environmentally friendly crop production. Based on the type of microorganisms they contain and their mode of action, biofertilisers are classified into the following types:

(a) Bacteria: Bacterial biofertilisers contain beneficial bacteria that enhance nutrient availability, particularly through biological nitrogen fixation. Some bacteria, such as Rhizobium, form symbiotic associations with the roots of leguminous plants, producing nitrogen-fixing nodules that convert atmospheric nitrogen into forms usable by plants. Other bacteria, such as Azotobacter and Azospirillum, fix atmospheric nitrogen independently or in association with the roots of non-leguminous crops. *Azotobacter* is commonly used for crops such as cotton, wheat, mustard, and maize. Common bacterial biofertilisers include Rhizobium, Azotobacter, and Azospirillum.

(b) Fungi: Fungal biofertilisers mainly consist of mycorrhizal fungi, which form a symbiotic association known as mycorrhiza with plant roots. In this association, the fungal hyphae increase the root's ability to absorb water and nutrients, particularly phosphorus, from the soil, while the plant supplies carbohydrates to the fungus. Mycorrhizal fungi also improve soil structure and enhance plant resistance to drought and certain soil-borne diseases. Common examples include Glomus, Gigaspora, and Acaulospora.

(c) Cyanobacteria (Blue-green algae): Cyanobacteria are photosynthetic microorganisms commonly found in moist soils and aquatic environments. They fix atmospheric nitrogen, thereby enriching the soil with this essential nutrient. They are especially useful in paddy fields, where they naturally increase soil fertility and reduce the need for nitrogenous fertilisers. Common examples include Anabaena, Nostoc, and Aulosira.

2. Classification of Biofertiliser

Bio-fertilisers are natural substances that enhance soil fertility by promoting plant growth. They are classified into categories based on the microorganisms they contain, such as nitrogen-fixing bacteria (e.g., Rhizobium), phosphorus-solubilising bacteria, mycorrhizal fungi, and cyanobacteria. These organisms improve nutrient availability, soil health, and crop yields without chemical inputs. The various types of bio-fertilisers, which help the plant to grow at different levels of its growth, are provided in Table 3.1.

Table 3.1: Biofertilisers and their examples

Groups	Examples (Botanical name)
A. Nitrogen-fixing bio-fertilisers	
Free living	*Azotobacter, Anabaena, Nostoc*
Symbiotic	*Rhizobium, Frankia, Azolla*

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Associative symbiotic	*Azospirillum brasilense.*
B. Phosphorus-solubilising bio-fertilisers	
Bacteria	*Bacillus megatherium, Pseudomonas striata*
Fungi	*Penicillium digitatum, Aspergillus awamori*
C. Phosphorus-mobilising bio-fertiliser	
Arbuscular mycorrhiza	*Glomus fasciculatum, Glomusmosseae*
D. Plant growth-promoting rhizobacteria	
Psuedomonas	*Pseudomonas fluorescens*

3. Methods of Application of Biofertiliser

There are several methods for applying bio-fertilisers, each suitable for different crops, soil types, and farming practices. The following are the primary methods of biofertiliser application:

a) **Seed treatment:** In this method, a suspension of 1-2 kg bio-fertilisers [*Azotobacter*/Phosphate Solubilising Bacteria (PSB)/*Azospirillum*] is prepared in 10 to 15 litres of water in a plastic bucket. The seed treatment can be done with any of two or more bacteria. This method will provide the maximum number of bacteria required for better results.

b) **Seedling root dip:** Roots of seedlings of crop to be planted (vegetables, rice) are dipped in this suspension for some time and then transplanted in the field immediately. Seed treatment with *Rhizobium*, *Azotobacter*, and *Azospirillum*, along with phosphate-Solubilizing Microorganisms (PSM), can be done. The seedling roots of transplanted crops are treated for half an hour in a solution of bio-fertilisers before transplantation in the field. In this method, the seedlings required for one acre are inoculated using 2–2.5 kg biofertilisers. For this, a bucket having an adequate quantity of water is taken, and the biofertiliser is mixed properly. The roots of the seedlings are then dipped in this mixture to enable the roots to get inoculum. These seedlings are then transplanted. This method has been found very suitable for crops like tomato, rice, onion, *cole* crops and flowers.

   This method is used for the application of *Azospirillum* on paddy transplanting/ vegetable crops. The required quantity of *Azospirillum* has to be mixed with 5–10 litres of water at one corner of the field, and the roots of seedlings have to be dipped for a minimum of half an hour before transplantation.

c) **Direct application in soil:** Direct application in soil is mostly used for fruit crops, sugarcane and other crops where localised application is needed. At the time of planting fruit trees, 20 g of biofertiliser mixed with compost is to be added in the ring of one sapling. The same quantity of biofertiliser may be added to the ring soil of the seedling after it has attained maturity. The inoculants should be mixed with the desired quantity of well-decomposed granulated farmyard manure and

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incubated for 24 hours before use. The farm yard manure acts as a nutrient medium and an adjuvant (carrier) for bio-fertilisers.

4. Precautions in the Use of Biofertilisers

Using bio-fertilisers effectively requires specific precautions to ensure their benefits and avoid unintended issues. The following are some important considerations:

- Biofertiliser packets need to be stored in a cool and dry place away from direct sunlight and heat.
- Rhizobium cultures are different for different leguminous crops. Use the culture packet of the relevant crop only.
- Check the date of expiry of the culture before use.
- As far as possible, use fresh and standard products.
- Keep biofertiliser packets under shade and away from chemicals.
- Dry treated seeds in the shade.
- Sow treated seeds immediately after drying.

Practical Exercise

Activity 1: Identify the different types of bio-fertilisers and their benefits

Materials Required:
1. Reference materials (books, articles, or online resources) on bio-fertilisers
2. Samples or images of bio-fertilisers (optional: rhizobium, *azotobacter*, *azospirillum*)
3. Whiteboard and markers for note-taking
4. Chart paper
5. Notebooks to take notes

Procedure:
- Form groups having 4-5 members in each group and select one type of biofertiliser to research.
- Focus on key pointers like which type of crop benefits from the selected bio-fertiliser, what are the environmental advantages of using it and certain examples of using it in the field.
- Prepare an attractive presentation to share the research with the class. Try using visual aids like charts or diagrams.
- Present findings in the class and conduct a Q&A session to learn about the other group's findings.

Activity 2: Demonstration of seedling treatment with bio fertilisers

Materials Required:
1. Biofertiliser sample (*Azospirillum* or PSB, Rhizobium)

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2. Vegetable seedlings (e.g., tomato, onion, or gram)
3. Gloves, apron, and labels
4. Water bucket

Procedure:

- As per the teacher's instructions, mix biofertiliser in the water.
- For 30 minutes, dip the roots of seedlings in the mixture.
- After dipping, label the treated seedlings. Now, plant them in a garden bed or pots.
- Observe the growth of the seedlings over a week and compare with untreated seedlings.

Activity 3: Identification of seed treatment method

Materials Required:

1. Notebook
2. Pen

Procedure:

- Prepare a list of materials required for seed treatment.
- Identify steps for coating seeds with bio-fertiliser.
- Note precautions during treatment.
- Record the procedure briefly.

Activity 4: Study of precautions in using bio-fertilisers

Materials Required:

1. Notebook
2. Pen

Procedure:

- List important precautions like storage conditions and expiry checks.
- Identify proper handling and usage methods.
- Note safety measures during application.
- Record key precautions in points.

Check Your Progress

A. Multiple Choice Questions

1. What is bio-fertilisers?
   a) Synthetic chemicals that enhance soil fertility
   b) Natural substances containing microorganisms that enhance soil fertility
   c) Fertilisers made from animal products
   d) Fertilisers that only promote plant growth

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2. Which of the following is an example of a nitrogen-fixing bio-fertiliser?
   a) *Azospirillum*
   b) *Bacillus megatherium*
   c) *Glomus fasciculatum*
   d) *Pseudomonas fluorescens*

3. Which of the following bio-fertilisers is used for phosphorus solubilization?
   a) Azotobacter
   b) Bacillus megatherium
   c) Azospirillum
   d) Rhizobium

4. In the seedling root dip method, for which crops is this method most suitable?
   a) Rice, tomato, onion, cole crops, flowers
   b) Wheat, maize, mustard
   c) Fruits, sugarcane
   d) Cotton, maize, wheat

5. Which of the following is a precaution to take when using bio-fertilisers?
   a) Store biofertiliser packets in a cool and dry place
   b) Store in direct sunlight
   c) Use expired products for better results
   d) Use chemical fertilisers alongside bio-fertilisers for effectiveness

6. What is the role of farmyard manure when applied with inoculants?
   a) It acts as a nutrition medium and an adjuvant for bio-fertilisers
   b) It suppresses the growth of microorganisms
   c) It acts as a weed suppressant
   d) It enhances soil acidity

B. Fill in the Blanks

1. ________ are living organisms that enrich the nutrient quality of the soil.
2. The nitrogen-fixing bacteria found in the root nodules of legumes is called ________.
3. The fungi that form associations with plant roots to absorb phosphorus are called ________.
4. The example of cyanobacteria that helps fix atmospheric nitrogen is ________.
5. The method where seeds are coated with bio-fertilisers before planting is called ________.

C. State Whether the Following Statements Are True or False

1. Bio-fertilisers use chemical substances to improve soil fertility.
2. Mycorrhizae help in absorbing phosphorus from the soil.

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3. Azotobacter is used as a nitrogen-fixing biofertiliser for crops like cotton and wheat.
4. Cyanobacteria cannot fix atmospheric nitrogen.
5. Bio-fertilisers can be applied to seeds before sowing to improve nutrient availability.

D. Subjective Questions

1. A farmer growing wheat wants to improve soil fertility without using chemical fertilisers. Which type of biofertiliser would you recommend and why?
2. A rice farmer dips seedling roots in a biofertiliser solution before transplanting. What is the purpose of this method?
3. A farmer stores biofertiliser packets in direct sunlight for several days. How can this affect the effectiveness of the bio-fertiliser?
4. A legume farmer accidentally uses the wrong Rhizobium culture for his crop. What problem may arise from this mistake?
5. A fruit grower mixes biofertiliser with well-decomposed farmyard manure before applying it near saplings. Why is farmyard manure used in this method?

What have you learned?

After completing this session, you will be able to:

- explain bio-fertilisers and explain their role in enhancing soil fertility;
- identify different types of bio-fertilisers and their associated microorganisms; and
- describe the mechanisms by which bio-fertilisers promote plant growth and soil health.

Session 3: Methods of Weed Management

Weeds are the unwanted plants. They grow in fields where they compete with crops for water, soil nutrients, light and space and thus reduce crop yields. They also harbour insects, pests and microorganisms. Certain weeds release into the soil the inhibitors or poisonous substances which are harmful to the plants, human beings and livestock. The important characteristics of weeds are as follows:

(i) The weed seeds germinate early, and the seedlings grow faster. They are hardy and compete with the crop plants and deprive them of light, moisture and nutrients.

(ii) They flower earlier, run to seed in profusion and mature ahead of the crop. They are, therefore, difficult to control, and it may even be impossible to eradicate some weeds.

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(iii) They are unusual, unwanted and undesirable.
(iv) They are harmful to crops, cattle and human beings.
(v) They can survive even under adverse conditions.
(vi) They are prolific and have a very high reproductive capacity.

1. Importance of Weed Control

Weeds impact the growth of surrounding plants by competing for essential resources such as nutrients, water, soil, and space. In the case of younger or smaller plants, some weeds can even overpower their tender parts.

Weeds not only affect the plants around them, but they can also bring unnecessary trouble to the entire farm. For one, some types of weeds block drainage pipes, while some weeds, if left unchecked, may obstruct the function of farm machinery that is used for cultivation.

Weeds can increase the amount of manual labour required for farmers like him. If left uncontrolled, weeds may become hosts for various plant diseases and pests that will cause a more significant headache.

2. Classification of Weeds

Weeds can be classified based on various criteria such as their life cycle, habitat, morphology, and taxonomy. These classifications help in understanding their growth patterns, habitats, and how to manage them effectively. The classification of some common, weeds based on life cycle is shown in Fig. 3.5.

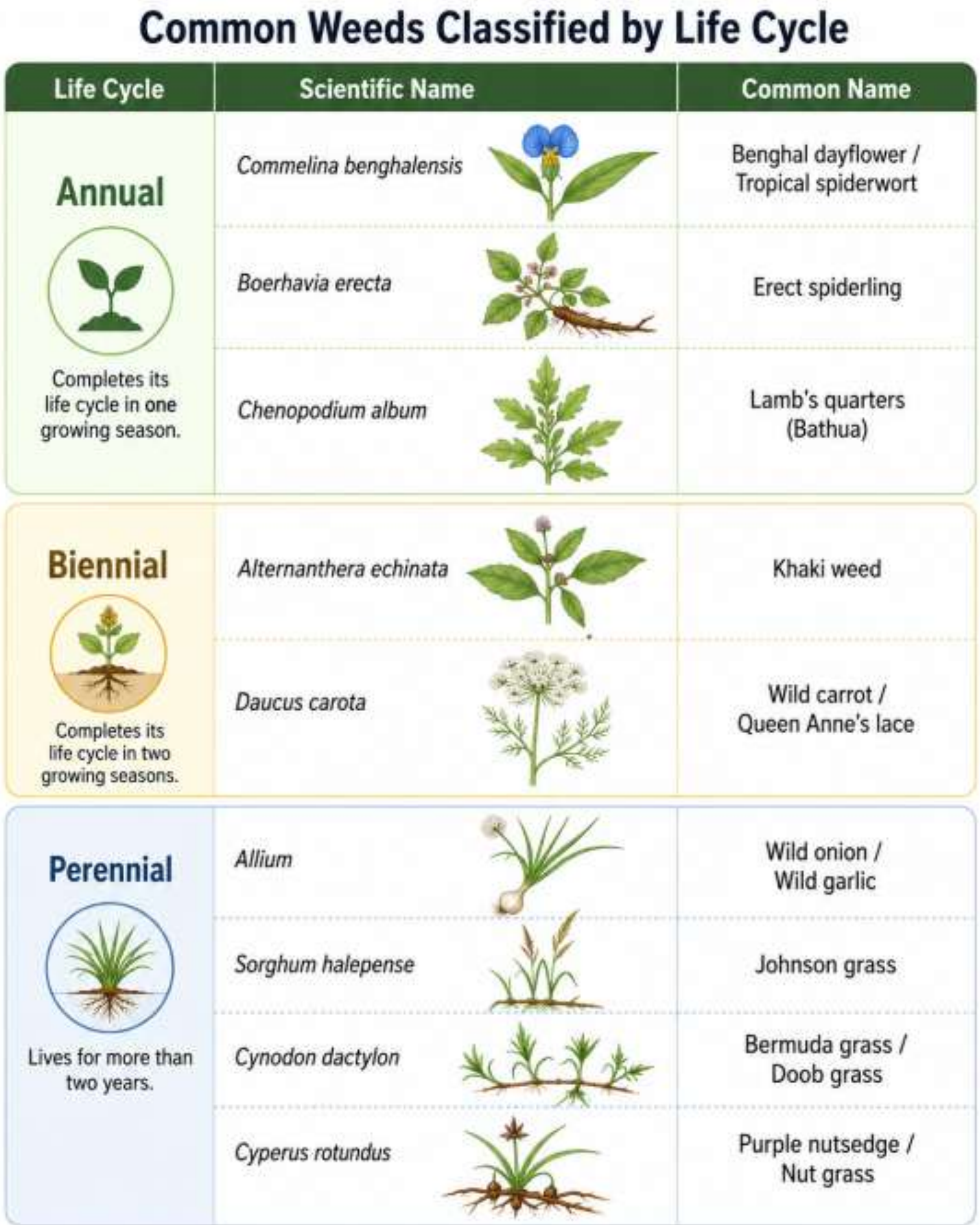
3. Methods of Weed Control

Weed control in organic farming is challenging since synthetic herbicides are not allowed. Organic farmers use various cultural, mechanical, biological and ecological methods to manage weeds effectively while maintaining soil health and ecological balance. The goal is to suppress weeds without harming crops or the environment.

Some essential weed control methods used in organic farming are as follows:

(a) Physical methods: Weed control is essential in agriculture to prevent unwanted plants from competing with crops for nutrients, water and sunlight. Physical methods of weed control offer non-chemical alternatives to manage weed populations.

The most common ones are hand pulling, hand weeding, burning, flooding, and ploughing. Pulling the weeds by hand or with the help of a sickle is the oldest and most efficient method. Weeds can be easily uprooted after a good soaking irrigation or rain. This method is costly and time-consuming.



Common Weeds Classified by Life Cycle

Life Cycle	Scientific Name	Common Name
Annual — Completes its life cycle in one growing season.	*Commelina benghalensis*	Benghal dayflower / Tropical spiderwort
	Boerhavia erecta	Erect spiderling
	Chenopodium album	Lamb's quarters (Bathua)
Biennial — Completes its life cycle in two growing seasons.	*Alternanthera echinata*	Khaki weed
	Daucus carota	Wild carrot / Queen Anne's lace
Perennial — Lives for more than two years.	*Allium*	Wild onion / Wild garlic
	Sorghum halepense	Johnson grass
	Cynodon dactylon	Bermuda grass / Doob grass
	Cyperus rotundus	Purple nutsedge / Nut grass

Fig. 3.5: Common weeds classified by life cycle

(b) Cultural method: Cultural methods of weed control involve adopting agronomic practices that create favourable conditions for crop growth while suppressing the establishment and spread of weeds. These methods reduce weed infestation through appropriate field management practices such as summer ploughing, crop rotation, intercropping, cover cropping, mulching, proper sowing time and methods, and efficient irrigation management.

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The major cultural methods of weed control are as follows:

(i) Crop Rotation: Crop rotation involves growing different crops on the same field in a planned sequence over successive seasons. Rotating crops disrupts the life cycles of weeds, reduces the build-up of weed populations and crop-specific pests, and improves soil fertility. It is an effective and environmentally friendly method of long-term weed management.

(ii) Intercropping: Intercropping is the practice of growing two or more crops simultaneously on the same field, usually with one crop planted between the rows of the main crop (Fig. 3.6). The intercrop suppresses weed growth by providing greater ground cover and competing with weeds for light, water, and nutrients. However, proper crop combinations and spacing are essential to minimise competition between the intercrop and the main crop.

(iii) Cover Crops: Cover crops are grown primarily to protect and improve the soil rather than for harvest. They can also serve as living mulch when grown alongside a cash crop, usually in alternate rows. Cover crops suppress weeds by covering the soil surface, reducing the amount of light reaching weed seeds, and conserving soil moisture. Care should be taken to prevent excessive competition between the cover crop and the main crop for water, nutrients, and sunlight.

(iv) Mulching: Mulching involves covering the soil surface with organic materials (such as straw, crop residues, or leaves) or synthetic materials (such as plastic sheets). Mulch suppresses weed growth by blocking sunlight, thereby preventing weed seed germination and seedling emergence. Organic mulches may also release allelopathic compounds that inhibit weed growth while helping conserve soil moisture and regulate soil temperature.

(v) Soil Solarisation: Soil solarisation is a non-chemical method of weed control commonly practised during the hot summer months. In this method, the soil is thoroughly tilled, irrigated if necessary, and then covered with a transparent polyethylene sheet (30–50 microns thick), with the edges tightly sealed. Solar heat trapped beneath the plastic raises the soil temperature to levels that kill weed seeds, soil-borne pathogens, and certain insect pests, thereby reducing weed infestation before planting.

(c) Biological method: Biological methods utilise living organisms to suppress or control weed populations. This approach is eco-friendly and sustainable. The following are various methods:

(i) Beneficial microorganisms: Introducing specific fungi or bacteria that can hinder weed growth or promote crop health. For example, mycorrhizal fungi improve nutrient uptake for crops, indirectly enhancing competition against weeds.

(ii) Natural predators: Introducing or encouraging the presence of insects or animals that feed on weed seeds or plants. Examples such as certain beetles and insects can help control specific weed species.

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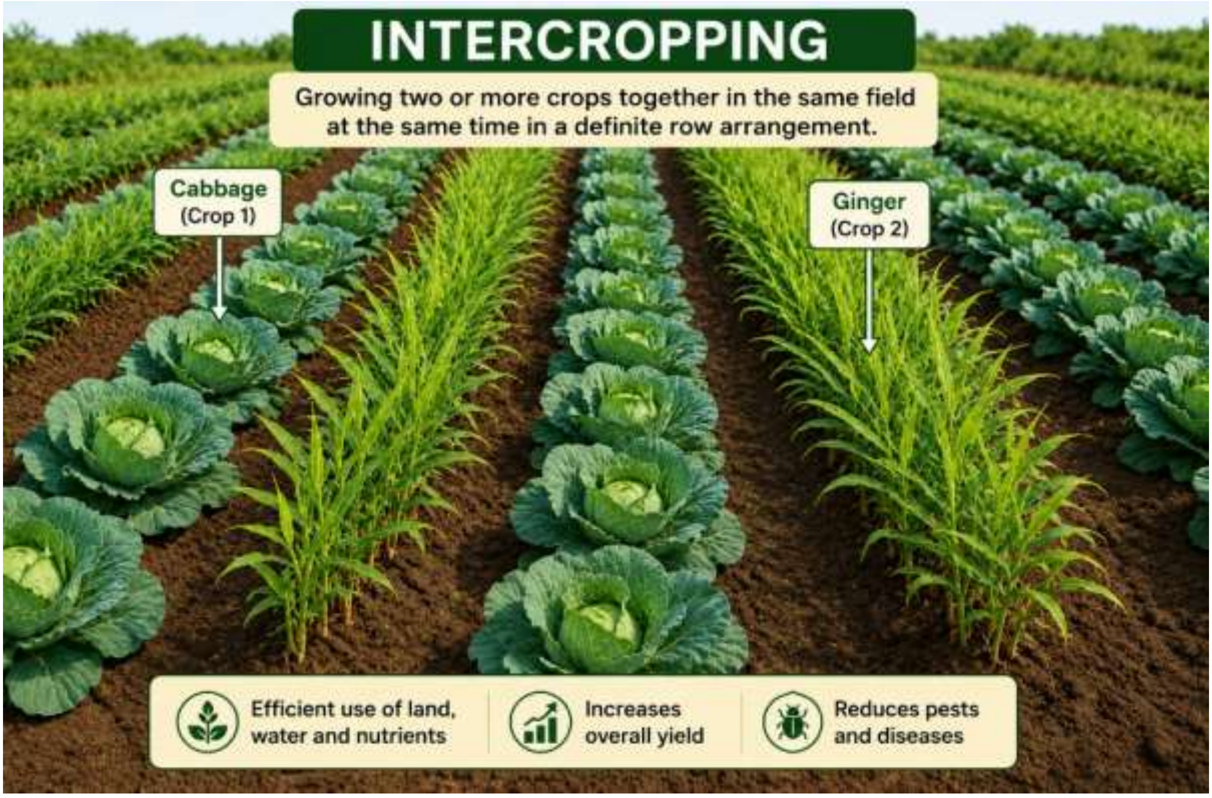

Fig. 3.6: Intercropping, growing a smaller crop between rows of the main crop

(d) Mechanical method: Mechanical weed control involves the removal or destruction of weeds using manual or mechanical implements instead of chemical herbicides. These methods physically eliminate weeds from the field, thereby reducing competition with crops for water, nutrients, sunlight, and space. Mechanical weed control is widely practised in both conventional and organic farming systems and is particularly effective when weeds are controlled at their early growth stages. The major mechanical methods include:

(i) **Tillage and Ploughing:** Tillage and ploughing involve turning and loosening the soil using implements such as mouldboard ploughs, disc ploughs, or cultivators. These operations uproot, bury, or expose weeds to sunlight, causing them to dry out and die. They are generally carried out before sowing to prepare a weed-free seedbed.

(ii) **Harrowing:** Harrowing is performed after ploughing to break up soil clods, level the field, and uproot or bury young weed seedlings. It is most effective against newly emerged annual weeds and helps provide a favourable seedbed for crop establishment.

(iii) **Flame Weeding:** Flame weeding is a thermal weed control method in which a propane-fuelled flame is directed onto weeds. The intense heat ruptures plant cells by causing the cell sap to expand rapidly, leading to dehydration and death of the plant. Unlike burning the weeds completely, flame weeding usually kills them by damaging their tissues rather than reducing them to ash. It is particularly effective for controlling young broadleaf weeds and is widely used in organic farming as a non-chemical alternative to herbicides.

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Practical Exercise

Activity 1: Field observation of weed and pest management practices

Materials Required:

1. Notebook
2. Pencil or pen
3. Camera or mobile phone (optional)
4. List of practices (e.g., mulching, crop rotation, biological control).

Procedure:

- Review the concept of integrated weed and pest management before the visit.
- During the field visit, observe and record the following:
  a) Weed control methods (e.g., mulching, hand weeding, crop rotation).
  b) Pest control practices (e.g., biological control, trap crops).
  c) Any innovative or eco-friendly techniques used.
- Take notes on the effectiveness of each method and its impact on sustainability.
- After the visit, join a group discussion to:
  a) Share observations and compare practices.
  b) Identify which methods were most effective.
  c) Discuss challenges and benefits of sustainable weed and pest control.

Activity 2: Classification of weeds based on life cycle

Materials Required:

1. Notebook
2. Pen
3. Chart

Procedure:

- Classify weeds into annual, biennial, and perennial.
- List examples under each category.
- Prepare a table showing classification.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following is a mechanical method of weed control?
   a) Cochineal insects
   b) Hand pulling
   c) Systemic herbicides
   d) Soil fumigants

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2. Which of the following is an example of biological weed control?
   a) Cochineal insects
   b) Contact herbicide
   c) Systemic herbicides
   d) Hand pulling

3. What is the characteristic of a contact herbicide?
   a) Kills all parts of the plant
   b) Affects only the parts it touches
   c) Forms vapour or gas in the soil
   d) Targets only the roots of the plant

4. Weeds are the __________ plants.
   a) Useful
   b) Unwanted
   c) Rare
   d) Beneficial

5. Weeds can be classified on the basis of __________.
   a) Soil type
   b) Plant structure
   c) Growth habit
   d) Climate

B. Fill in the Blanks

1. ________ are unwanted plants that compete with crops for water, nutrients, light, and space.
2. Some weeds release ________ or poisonous substances into the soil, which are harmful to plants, humans, and livestock.
3. The viability of weed seeds remains intact even if they are buried ________ in the soil.
4. Based on their life cycle, weeds are classified into annual, biennial and ________ weeds.
5. An example of an annual weed usually found in wheat fields is _____________ ________________.

C. State Whether the Following Statements are True or False

1. Weeds help increase crop yields by providing additional nutrients to the soil.
2. Some weeds can block drainage pipes and obstruct farm machinery.
3. Cover crops compete with cash crops for resources and should never be used.
4. Crop rotation helps in disrupting the life cycle of weeds.
5. Mulching prevents weed seed germination by blocking light transmission.

D. Subjective Questions

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1. A farmer notices that weeds in his field are growing faster than the crop and reducing yield. Explain how weeds affect crop growth.
2. After heavy rainfall, a farmer removes weeds manually from the field. Why is hand weeding easier after rain or irrigation?
3. A farmer grows legumes and cereals alternately every season. Which weed control method is this, and how does it help control weeds?
4. A vegetable grower covers the soil around plants with dry straw. How does this practice help in weed management?
5. During summer, a farmer covers moist soil with transparent plastic sheets to kill weed seeds. Identify this method and explain its purpose.

What have you learned?

After completing this session, you will be able to:

- explain weeds and explain their impact on crop productivity;
- identify different types of weed management techniques; and
- evaluate the advantages and limitations of various weed control methods.

Session 4: Methods of Pest Management and Control

A pest refers to any organism, such as insects, rodents, birds, nematodes, fungi, or weeds, that damages crops, reduces yield, or hinders plant health. Organic growers face unique challenges in pest management because they avoid synthetic pesticides and chemicals. Pests are unwanted organisms which reduce the economic yield of crops. Crop pests may include insects, weeds, nematodes and arthropods.

1. Need for Management

Pest management is essential for maintaining healthy crops, ensuring high yields, and preserving the ecological balance of the farm. Since organic farming avoids synthetic chemicals, it relies on sustainable methods to control pests while protecting the environment, soil health, and biodiversity. Importance of management in organic agriculture:

- Pest management minimises yield losses.
- It also minimises environmental pollution.
- It is essential as it approaches sustainable crop production.
- Pest management is required to maintain the quality as well as the quantity of produce.
- It is done to ensure food security.
- It is utilised to decrease bio-hazards created in the food chain due to the presence of chemicals

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2. Common Insect-Pests and Diseases

Effective pest and disease management in agriculture begins with the accurate identification of the common insect pests and diseases that affect crops. This knowledge helps in selecting appropriate control measures, whether through chemical, biological or cultural practices. Many types of insects have the potential to damage fruit and vegetable crops. Various grasshoppers, weevils, beetles and small insects like thrips, aphids, mealy bugs and certain fly larvae can cause significant damage. Other insects cause various types of damage, including defoliation or stem and fruit tunnelling. When investigating insect damage, look for weak or stunted plants with damaged leaves or fruit. Check the base of the plant near the ground and check the undersides of leaves for insects and insect eggs. Often, the best time to spot insects in the process of feeding is at dusk or in the early morning.

Many insects are beneficial, either for crop pollination or as predators of nuisance insects. Never use pesticides on an insect if one cannot identify it, and only use pesticides labelled for that insect. Some of the pests and their host are listed in Table 3.2.

Table 3.2: Crops and related pests

Crops	Insect Pest (Common Name)	Damage
Rice	Brown planthopper	Sap sucking, yellowing, wilting
Rice	Stem borer	Stem tunnelling, dead hearts
Wheat	Wheat aphid	Leaf curling, stunted growth
Maize	Maize stem borer	Stem tunnelling, reduced yield
Cotton	Cotton bollworm	Bores into boll and flowers
Cotton	Cotton mealy bug	Sap sucking, leaf curling
Tomato	Tomato fruit borer	Fruit boring, yield loss
Tomato	Aphid	Sap sucking, virus transmission
Potato	Potato tuber moth	Tuber tunnelling, leaf damage
Mango	Mango hoppers	Sap sucking, flower drop
Mango	Fruit fly	Fruit tunnelling, rotting
Cabbage	Cabbage butterfly	Leaf defoliation

3. Diseases of agricultural crops

Any abnormal condition in crops caused by pathogens (like fungi, bacteria, viruses, or nematodes) or environmental factors, which interferes with the normal growth, development, and yield of the plants. Major classifications of plant diseases are as follows:

1. Based on Host Plants Affected
2. Based on Mode of Spread
3. Based on Prevalence and Periodicity
4. Based on Plant Parts Affected

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5. Based on Parasitic Nature

Causative reason for the disease is taken into consideration for understanding the plant disease:

Disease in plants, which are those caused by living organisms, like fungi, bacteria, and even viruses. Diseases usually appear on random plants throughout a field and affect different plants with different levels of severity. In general, fungal diseases can often be recognised by visible mould, powdery mildew, rust, orange pustules, and round leaf spots. Bacterial diseases are often characterised by wet, or "water-soaked," lesions or by irregular-shaped leaf spots. Citrus canker viruses often cause irregular colour changes like mosaic patterns on leaves, or unusual foliage colours like red leaves. Nematodes, a microscopic worm, are also classified as a biotic disease. They often cause root rots or irregular root growth.

Disease in plants, which are those caused by non-living entities like herbicides, pollution, road salt, and too much or too little of certain nutrients that plants require for growth. These diseases usually appear in a distinct pattern, only alongside a road, for example, and they affect all the plants in the area similarly. These diseases also often affect other types of plants in the area, including weeds and other nearby crops. One common symptom of abiotic disease is brown, dead or wilted leaf tips. Another common symptom is the yellowing of older leaves.

4. Methods of Pest Management

Pest management involves various strategies for controlling and preventing pests that damage crops. In organic farming, pest management focuses on natural and sustainable approaches that minimise harm to the environment. The methods are often grouped under Pest Management, a holistic approach combining multiple techniques. The following are some common methods of pest management:

(a) Cultural measures: Practices that modify the growing environment to reduce pest outbreaks or make conditions less favourable for pests.
Some important preventive crop protection measures are as follows:

(i) **Crop rotation:** Planting different crops in succession to disrupt pest life cycles and reduce pest buildup.

(ii) **Intercropping/companion planting:** Growing different crops together to repel pests or confuse them, as well as attract beneficial organisms.

(iii) **Sanitation:** Removing crop residues, weeds, and infected plant material that could harbour pests.

(iv) **Proper irrigation:** Preventing over-watering or under-watering, this can stress plants and make them more susceptible to pests.

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(b) Mechanical/physical measures: Methods that physically remove or create barriers to pests, or make the environment less conducive to pest activity. Some measures are as follows:

(i) **Hand-picking:** Manually removing pests from plants, especially larger ones like caterpillars and beetles.

(ii) **Traps:** Using traps such as light traps, pheromone traps, or yellow sticky traps to capture or kill pests.

Light trap is one of the very effective tools of insect pest management in organic agriculture, as it mass-traps both the sexes of insect pests and also substantially reduces the carryover pest population.

Light traps can be used to catch moths such as armyworms, cutworms, stem borers and other night-flying insects.

Sticky traps (Fig. 3.7) are very good at monitoring and trapping insect pests threatening ornamental plants, fruit trees and vegetables. These traps are made up of plastic semi-rigid supports covered with glue on one or both sides. Depending on their colour, they attract and trap one insect pest or another.

Fig. 3.7: Sticky trap (yellow) for insects.

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(c) Biological Control Measures: Biological control is an environmentally friendly method of pest management that uses living organisms or their natural products to suppress populations of insect pests, plant pathogens, and weeds. Instead of relying on synthetic pesticides, biological control harnesses natural ecological interactions to maintain pest populations below economically damaging levels. It is an important component of Integrated Pest Management (IPM) and organic farming because it is target-specific, environmentally safe, and helps conserve beneficial organisms. The major biological control agents are described below.

(i) Predators

Predators are beneficial organisms that actively hunt, kill, and consume insect pests. They naturally regulate pest populations and reduce the need for chemical pesticides. Most predators are generalists, feeding on a wide range of pests at different stages of their life cycle, including eggs, larvae, nymphs, and adults. Examples include the following:

- **Ladybugs (Ladybird beetles):** Feed on aphids, whiteflies, mites, mealybugs, and other soft-bodied insects.
- **Lacewings:** Their larvae, commonly known as *aphid lions*, prey on aphids, thrips, whiteflies, caterpillars, mealybugs, and spider mites.
- **Predatory mites:** Feed on harmful mites, particularly spider mites, in crops such as strawberries, tomatoes, peppers, cucumbers, and ornamentals.
- **Spiders:** Generalist predators that feed on a wide variety of insect pests, including flies, moths, leafhoppers, and beetles.
- **Praying mantises:** Feed on moths, beetles, grasshoppers, caterpillars, and flies, although they may also consume other beneficial insects.

(ii) Parasitoids

Parasitoids are insects that lay their eggs on or inside the body of a host insect, usually a pest. The developing larvae feed on the host and eventually kill it. Unlike predators, each parasitoid generally completes its development on a single host. Examples include the following:

- **Parasitic wasps:** Attack the eggs of moths and butterflies, including pests such as the European corn borer and cabbage worm.
- **Braconid wasps:** Parasitise caterpillars, beetles, aphids, and other insect pests.
- **Tachinid flies:** Lay eggs on or inside caterpillars, beetles, and other insect pests.
- **Encarsia formosa:** A parasitic wasp widely used to control greenhouse whitefly by parasitising its larvae.

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(iii) Pathogens

Pathogens are disease-causing microorganisms that infect and kill insect pests without causing significant harm to crops or beneficial organisms. They include bacteria, fungi, viruses, and nematodes and are widely used as biological pesticides. Examples include the following:

- **Bacillus thuringiensis (Bt):** A soil bacterium that produces toxins lethal to the larvae of caterpillars, mosquitoes, and certain beetles. It is one of the most widely used microbial biopesticides.
- **Beauveria bassiana:** An entomopathogenic fungus that infects aphids, whiteflies, beetles, and several other insect pests.
- **Metarhizium anisopliae:** A fungus effective against termites, beetles, locusts, and other soil-dwelling insects.
- **Nucleopolyhedrovirus (NPV):** A virus used primarily to control caterpillar pests, especially *Helicoverpa* and *Spodoptera* species.
- **Entomopathogenic nematodes:** Beneficial nematodes that infect and kill soil-dwelling insect pests such as grubs and cutworms.

(iv) Competitors

Competitors are organisms that suppress pest populations by competing with them for food, nutrients, light, or space. By limiting the resources available to pests, they reduce pest establishment and spread. For example, non-invasive ground-cover plants or beneficial vegetation that suppress the growth of invasive weed species.

(v) Herbivores for Weed Control

Certain insects and grazing animals are used to control invasive or troublesome weeds by feeding specifically on them. This approach is particularly useful for managing invasive weeds in aquatic and natural ecosystems. For example, leaf-feeding beetles used to control invasive aquatic weeds such as water hyacinth.

(vi) Predatory Birds

Birds such as owls, kestrels, swallows, and insectivorous birds feed on insects and small rodents, helping to reduce pest populations naturally. Farmers often encourage these birds by providing nest boxes or maintaining suitable habitats.

(d) Plant-Based Extracts Used for Pest Control; Plant-derived extracts are widely used in organic farming because they are biodegradable, eco-friendly, and generally safer for humans, beneficial organisms, and the environment than synthetic pesticides. Many plant extracts possess insecticidal, repellent, antifeedant, or antifungal properties that help protect crops from pests. Some commonly used plant-based extracts are described below.

(i) Neem (*Azadirachta indica*)

Neem is one of the most effective botanical pesticides used in organic farming. Its active ingredient, azadirachtin**,** disrupts insect growth and development by interfering with moulting and reproduction. Neem also acts as a feeding deterrent and repellent,

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reducing pest infestation. Neem oil and neem-based biopesticides are applied as foliar sprays or soil treatments and are most effective when used during the early stages of pest infestation.

(ii) Garlic (*Allium sativum*)

Garlic contains sulphur compounds that emit a strong odour, repelling many insect pests. It also exhibits antifungal and antibacterial properties that help reduce certain plant diseases. Garlic extract is prepared by crushing garlic cloves and mixing them with water, sometimes with chilli or soap to enhance effectiveness, and is applied as a foliar spray. Regular reapplication is necessary, especially after rainfall.

(iii) Pongamia (*Pongamia pinnata*)

Pongamia oil contains karanjin**,** a bioactive compound with insecticidal and antifungal properties. It acts as an insect repellent and antifeedant, reducing pest feeding and reproduction. Pongamia oil is applied as a foliar spray or soil drench and is often used in combination with neem-based products to improve the spectrum of pest control.

Practical Exercise

Activity 1: Preparing plant-based pest repellents

Materials Required:

1. Fresh neem leaves or *neem* oil
2. Garlic cloves
3. Water
4. Mortar and pestle or blender
5. Spray bottles
6. Strainer
7. Small potted plants

Procedure:

- Crush garlic cloves using a mortar and pestle or blend them with a little water.
- Prepare a *neem* solution by mixing neem leaves or neem oil with water.
- Strain both mixtures and pour them into separate spray bottles.
- Spray the mixtures on potted plants.
- Observe and record any changes over 2–3 days, such as reduced pest activity or leaf damage.
- Discuss how plant-based extracts work and why they are preferred in organic farming.

Activity 2: Demonstrating biological control

Materials Required:

1. Images or videos of predators (ladybugs, spiders, lacewings)
2. Plastic containers or jars

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3. Small insect models or paper cut-outs representing pests
4. Notebook and pen

Procedure:

- Show students' images or videos of common biological control agents and explain their roles.
- Using insect models or cut-outs, simulate a pest outbreak in a jar or container.
- Introduce predator models (ladybugs, spiders) into the jar.
- Ask students to observe and record how predators' "control" the pest population.
- Discuss how this method reduces the use of chemicals and maintains ecological balance.

Check Your Progress

A. Multiple Choice Questions

1. What is a pest in agricultural terms?
   a) A plant that grows uncontrollably
   b) Any organism that damages crops or hinders plant health
   c) A beneficial insect for pollination
   d) A method of pest management

2. Why is pest management essential in organic farming?
   a) To ensure healthy crops while protecting the environment
   b) To increase the use of synthetic pesticides
   c) To speed up crop growth
   d) To reduce the number of pests in non-agricultural areas

3. Which of the following is NOT a common method of pest management in organic farming?
   a) Crop rotation
   b) Use of chemical pesticides
   c) Intercropping
   d) Hand-picking pests

4. What is the primary characteristic of biotic diseases in plants?
   a) Caused by living organisms such as fungi and bacteria
   b) Caused by non-living factors like pollution
   c) Caused by water stress
   d) Caused by nutrient imbalances

5. Which insect is commonly known for causing significant damage to crops by feeding on plant sap?
   a) Ladybug
   b) Aphid

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c) Praying mantis
d) Lacewing

6. What does crop rotation help in achieving?
   a) Increasing pest build-up
   b) Reducing soil fertility
   c) Disrupting pest life cycles
   d) Increasing water consumption by plants

7. Which of the following is a biological pest control method?
   a) Pheromone traps
   b) Neem oil
   c) Light traps
   d) Chemical fertilisers

8. What is one of the key benefits of using plant-based extracts like neem in pest control?
   a) They can disrupt the life cycle of insects without harming the environment
   b) They are highly toxic to humans
   c) They require heavy machinery for application
   d) They act as synthetic pesticides

9. What does the principle of biological control rely on?
   a) Using synthetic chemicals to kill pests
   b) Introducing natural predators, parasites, or pathogens to control pest populations
   c) Changing plant genetics to resist pests
   d) Irrigating crops excessively to wash away pests

10. Which of the following is an example of a beneficial insect used in biological control?
    a) Aphid
    b) Parasitic wasps
    c) Grasshoppers
    d) Whiteflies

B. Fill in the Blanks

1. A pest refers to any organism, such as insects, rodents, birds, nematodes, fungi, or weeds, that damages _______ and reduces yield.
2. Organic growers face unique challenges in pest management because they avoid _______ pesticides and chemicals.
3. Pest management is essential for maintaining healthy crops, ensuring high yields, and preserving the _______ balance of the farm.
4. _______ diseases are caused by living organisms like fungi, bacteria, and viruses.

5. The principle of _______ control measures is to use living organisms such as predators, parasites, or pathogens to control pests.

C. State Whether the Following Statements are True or False

1. Nematodes are microscopic worms that can cause root rot and irregular root growth.
2. Organic farmers use synthetic pesticides to control pests.
3. Crop rotation helps in reducing pest build-up by alternating different crops over seasons.
4. Causative agents for plant disease are very few in number.
5. Neem oil disrupts the life cycle of insects and prevents them from developing into adults.

D. Subjective Questions

1. A tomato farmer notices fruits with holes and internal damage. Which pest is likely responsible, and what type of damage does it cause?
2. A farmer removes crop residues and infected plants after harvest. Which pest management method is this, and how does it help reduce pest problems?
3. A vegetable grower installs yellow sticky traps in the field. What is the purpose of using these traps in pest management?
4. A farmer sprays neem extract on crops during an early pest attack. How does neem help in controlling insect pests?
5. Ladybugs are released in a field heavily affected by aphids. Which biological control method is being used, and how does it help the farmer?

What have you learned?

After completing this session, you will be able to:

- identify different types of agricultural pests and weeds;
- explain the impact of pests and weeds on crop yield, quality, and overall farm productivity;
- classify agricultural pests based on their feeding habits and the type of damage they cause;
- describe the principles and components of Integrated Pest Management (IPM);
- explain the concept and importance of Integrated Weed Management (IWM);
- distinguish between cultural, mechanical, biological, and chemical methods of pest and weed control;
- identify common biological control agents, including predators, parasitoids, and pathogens, used in sustainable agriculture;
- explain the role of botanical pesticides and bio-pesticides in eco-friendly pest management; and
- select appropriate pest and weed management strategies based on the type of pest, crop, and farming system.

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Unit 4 — Package of Practices for Organic Farming

Unit 4 on *Package of Practices for Organic Farming,* provides comprehensive knowledge about organic farming practices, focusing specifically on the cultivation practices applicable to vegetable and flowering crops, along with the principles and practices of protected cultivation. In this unit, you will learn about sustainable crop production methods that improve crop quality and productivity while maintaining environmental safety and soil health.

Session 1 on *Organic Cultivation Practices for Vegetable Crops*, describes the comprehensive package of practices essential for the successful cultivation of vegetable crops. In this session, you will learn about site selection, climatic requirements, nursery and land preparation, seed treatment, transplanting, irrigation, nutrient management, weed and pest management, harvesting practices, and post-harvest management techniques for various vegetable crops.

Session 2 on *Organic Cultivation Practices for Flower Crops*, focuses on the specific practices tailored for flowering crops, which are important for ornamental horticulture and floriculture industries. In this session, you will learn about the cultivation requirements of major flower crops such as rose, chrysanthemum, and marigold, including climatic requirements, land preparation, propagation, irrigation, nutrient management, harvesting, and post-harvest management practices.

Session 3 on *Principles and Practices of Protected Cultivation*, introduces you to the principles and practices of protected cultivation, an important component of modern horticulture that improves crop productivity and quality while reducing the effects of unfavourable weather conditions and pest infestations. This session explains different greenhouse structures, greenhouse equipment, cultural practices, and greenhouse management techniques used for protected crop production.

Session 1: Organic Cultivation Practices for Vegetable Crops

Organic vegetable crop production essentially excludes the use of synthetic pesticides and fertilisers. Organic farming systems mostly rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rock powders and biological pest control. Organic vegetable production must be focused on the demand of the local populace. Crops should be selected based on market demand, with vegetables like beans, carrots, peas, spinach, cabbage, and tomatoes popular for organic production.

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1. Popular Varieties of Important Vegetable Crops

Selecting the varieties is critical for the success of organic cultivation. Preferred varieties and crops for organic farming are beans, carrots, peas, spinach, cabbage, cauliflowers, chilli, tomatoes, okra and many more. Popular varieties of the crops are listed in Table 4.1.

Table 4.1: Popular Varieties of Vegetables

S.No.	Name of Vegetable	Popular Varieties of Vegetable
1.	Beans	*Arka Anoop*, Contender, *Pusa Parvati*, *Arka Komal*, *Arka Sunidhi*
2.	Carrot	Hills: Ooty-1, Early Nantes, New *Koroda* Plains: India Gold, *Pusa Kesar* and Half Long Danvers
3.	Peas	*Arkel, Azad* pea-1, *Azad* pea-2, Bonneville, Early Giant *Jawahar Matar*-2, *Kashi Nandini*, *Kashi Shakti* and *Palam Priya*
4.	Cabbage	*Pusa Mukta*, Red Dum Head, Sure Head, Express mail
5.	Cauliflower	*Pusa Subhra,* KW-5, KW-8, EMS and Early Patna
6.	Chilli	*Pusa jwala*, *Pusa sadabhar*, *Pujab lal,* LCA 235 and Punjab *sukh*
7.	Okra	*Varsha Uphar, Arka Anamika, Punjab Padmani*
8.	Tomato	BT1, BT10, *Arka Alok, Arka vardhan*, TRB1 and TRB 2

2. Climatic requirements

Climate is one of the most important factors influencing the growth, development, yield, and quality of vegetable crops. Different vegetable crops have specific requirements for temperature, rainfall, humidity, sunlight, and day length. Matching crops to suitable climatic conditions promote healthy plant growth, improves productivity, and reduces the incidence of pests and diseases. Therefore, understanding the climatic requirements of vegetable crops is essential for selecting suitable crops and adopting appropriate cultivation practices. Based on their temperature requirements, vegetable crops are broadly classified into two groups:

(i) **Cool-season vegetables:** These crops grow best at a mean daily temperature below **21°C**. They perform well under cool climatic conditions and are generally cultivated during the winter season. Examples include cabbage, cauliflower, broccoli, spinach, pea, carrot, radish, lettuce, and beetroot.

(ii) **Warm-season vegetables:** These crops require a mean daily temperature above **21°C** for optimum growth. They are sensitive to frost and are generally grown during the summer or rainy season. Examples include tomato, brinjal (eggplant), chilli, okra, cucumber, pumpkin, bottle gourd, watermelon, and muskmelon.

3. Site Selection for Vegetable Production

Proper site selection is essential for successful and profitable organic vegetable production. A suitable site provides favourable conditions for healthy crop growth while minimising problems related to soil, water, pests, and diseases. When selecting a field for vegetable cultivation, the following factors should be carefully considered:

(i) **Field topography:** The field should be level or gently sloping to ensure good drainage, facilitate irrigation, and minimise soil erosion.
(ii) **Soil type:** The soil should be fertile, well-drained, rich in organic matter, and have a suitable texture (preferably loam or sandy loam) for optimum root growth and nutrient availability.
(iii) **Water availability and quality:** A reliable source of clean, good-quality irrigation water should be available throughout the growing season to meet the crop's water requirements.

4. Land Preparation

Nursery bed preparation is the first and one of the most critical steps in establishing a successful vegetable nursery (Fig. 4.1). A well-prepared nursery provides favourable conditions for rapid seed germination, healthy seedling growth, and the production of vigorous seedlings capable of withstanding transplanting stress. Proper nursery management also reduces seedling mortality, minimizes disease incidence, and ensures uniform crop establishment in the main field.

The nursery site should be selected on well-drained, fertile soil with easy access to irrigation and protection from strong winds and livestock. Raised nursery beds, generally 15–20 cm high and 1.0–1.2 m wide, are preferred as they facilitate good drainage, aeration, and ease of intercultural operations. The soil should be thoroughly pulverized and made free from weeds, stones, and crop residues before sowing. During unfavourable weather conditions, such as heavy rainfall, low temperatures, or extremely hot summers, seedlings can be raised in protected structures using seedling trays, wooden boxes, earthen pots, flower pots, polythene bags, potting plugs, or protrays (Fig. 4.1).

A suitable growing medium should be prepared by mixing soil, sand, and well-decomposed farmyard manure (FYM) or leaf mould in the ratio of 1:1:1**.** This mixture provides good drainage, adequate aeration, and sufficient nutrients for healthy seedling development. The prepared medium should be filled uniformly into the seedling-raising containers and lightly compacted before sowing.

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Fig. 4.1: Preparation of nursery beds and seedling raising structures for vegetable crops

5. Seed treatment: It is an important pre-sowing operation that improves seed germination, enhances seedling vigour, and protects emerging seedlings from seed- and soil-borne pathogens. It also promotes uniform crop establishment and reduces the incidence of damping-off and other nursery diseases. The following seed treatment practices are recommended:

(i) **Cow pat pit (CPP) treatment:** Soak the seeds in a solution prepared by dissolving 3 g of cow pat pit culture in 1 litre of water for 24 hours before sowing. This treatment enhances seed germination and encourages beneficial microbial activity around the seed.

(ii) **Biological seed treatment:** Treat the seeds with *Trichoderma viride* @ 10 g per kg of seed. *Trichoderma viride* acts as an effective biocontrol agent against several seed- and soil-borne fungal pathogens and promotes healthy root development.

After completion of the seed treatment, the seeds should be sown immediately in the prepared nursery beds. Sowing may be done either by broadcasting or preferably in rows**,** depending on the crop and season. Line sowing facilitates better spacing, easier intercultural operations, improved aeration, and convenient removal of diseased or weak seedlings.

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6. Watering

Proper watering is essential for maintaining optimum soil moisture, ensuring uniform seed germination, and promoting healthy seedling growth. Immediately after sowing, nursery beds should be irrigated gently using a watering can fitted with a rose head or a fine-nozzle sprinkler to prevent the displacement of seeds and damage to emerging seedlings.

Light and frequent irrigation should be provided until germination is complete to keep the soil uniformly moist. Once the seedlings are established, the frequency and quantity of irrigation should be adjusted according to the prevailing weather conditions, soil type, and stage of seedling growth. During hot, dry, and windy weather, more frequent watering may be necessary to prevent moisture stress, whereas irrigation should be reduced during cool, humid, or rainy conditions to avoid excess soil moisture.

Overwatering should be avoided, as waterlogged conditions reduce soil aeration and create a favourable environment for diseases such as damping-off and root rot, leading to poor seedling growth and increased mortality. Similarly, prolonged moisture deficiency should also be avoided, as it can inhibit germination, restrict root development, and weaken seedlings. Therefore, proper drainage should be maintained to remove excess water and ensure optimum moisture conditions throughout the nursery period.

7. Thinning

Thinning is an important nursery management practice that involves the selective removal of excess, weak, unhealthy, diseased, or overcrowded seedlings after germination. This operation reduces competition among seedlings for sunlight, water, nutrients, and space, thereby promoting uniform and vigorous growth.

Thinning should be carried out when the seedlings are sufficiently established, retaining healthy seedlings at a spacing of approximately 0.5–1.0 cm between plants, depending on the crop. Proper thinning improves air circulation within the nursery, reduces disease incidence, and facilitates better root and shoot development. The removed seedlings should be discarded to prevent the spread of pests and diseases.

8. Seedling Transplanting

Transplanting is a critical operation that determines the successful establishment of vegetable crops in the main field. Healthy, disease-free, and well-hardened seedlings of the recommended age should be selected for transplanting. Before uprooting, the nursery beds should be irrigated lightly to facilitate easy removal of seedlings with minimal root damage. Prior to transplanting, the seedling roots should be dipped in a 5% suspension of *Pseudomonas fluorescens* (Fig. 4.2). This biological treatment helps suppress soil-borne pathogens, enhances root establishment, and improves seedling survival after transplanting. Transplanting is preferably carried out during the late afternoon or on cool, cloudy, and calm days**,** when evaporation losses are low and transplant shock is minimized. If such weather conditions are not available,

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transplanting should be undertaken during the early morning, followed immediately by light irrigation to ensure proper root–soil contact and adequate hydration. Newly transplanted seedlings may also be protected from intense sunlight for a few days using temporary shade, where necessary, to improve establishment and reduce moisture loss. Proper spacing, immediate irrigation, and careful post-transplant management are essential for rapid establishment, vigorous growth, and optimum crop performance in the field.

Fig. 4.2: Transplantation of seedlings

9. Irrigation

In organic vegetable farming, irrigation is very important after transplanting a field (Fig. 4.3). Vegetables need very careful irrigation, which is just sufficient water at the right time. It is necessary to maintain an even moisture supply. During the summer season, irrigation at every 5 to 7 days interval is necessary, whereas in winter, a 10 to 15 days interval is sufficient. A period of drought followed by sudden heavy watering during the fruiting period may cause cracking of fruits like tomatoes.

Fig. 4.3: Irrigation of vegetable seedlings after transplanting

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10. Nutrient Management

It is the strategic application of essential nutrients to crops in order to optimise their growth, yield, and quality while minimising environmental impact. Proper nutrient management involves understanding the specific needs of plants, soil conditions, and the timing of fertiliser application to ensure that crops receive the right balance of nutrients at the right time. Proper nutrient management helps prevent physiological diseases and disorders that result from nutrient imbalances or deficiencies. These disorders are non-pathogenic and often arise due to environmental factors, including improper soil nutrient levels, water stress, or extreme temperatures. Some of the physiological diseases and disorders, their causes, and control measures through effective nutrient management are as follows:

a) **Blossom-End Rot (BER):** Blossom-End Rot is a common physiological disorder affecting fruit-bearing crops, particularly tomatoes, peppers, and eggplants (Fig. 4.4)**.** It is not caused by pests or pathogens, but is caused by a calcium deficiency in developing fruits. This disorder is often exacerbated by environmental stress, especially irregular watering or drought conditions.

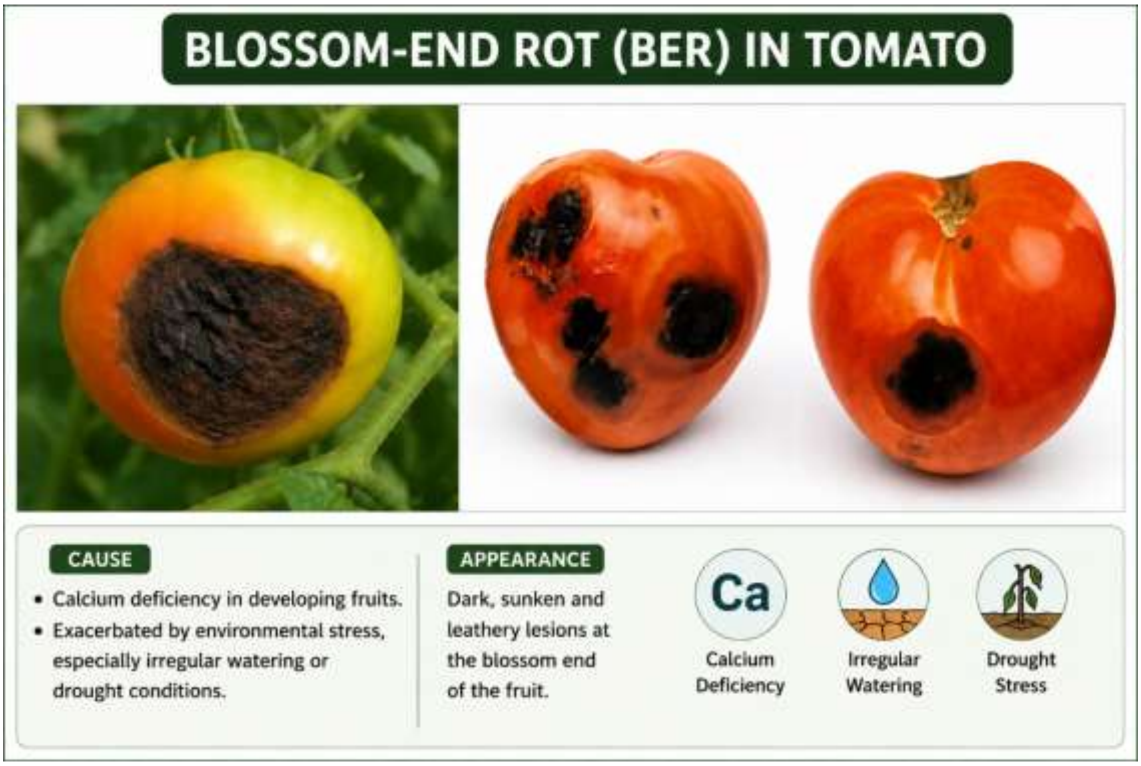

Fig. 4.4: Tomato Fruits Affected by Blossom-End Rot

b) **Tip burn:** It is a physiological disorder that primarily affects leafy vegetables such as cabbage, lettuce, spinach**,** and other crops like strawberries (Fig. 4.5)**.** It is caused by a localised calcium deficiency in the rapidly growing tissues of young leaves, even when there is sufficient calcium in the soil. The disorder typically affects the edges or tips of leaves, hence the name "tip burn".

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Fig. 4.5: Tip Burn Symptoms in Leafy Vegetables and Strawberry

c) **Bitter pit:** It is a physiological disorder that affects apples, primarily caused by a calcium deficiency in the fruit (Fig. 4.6).

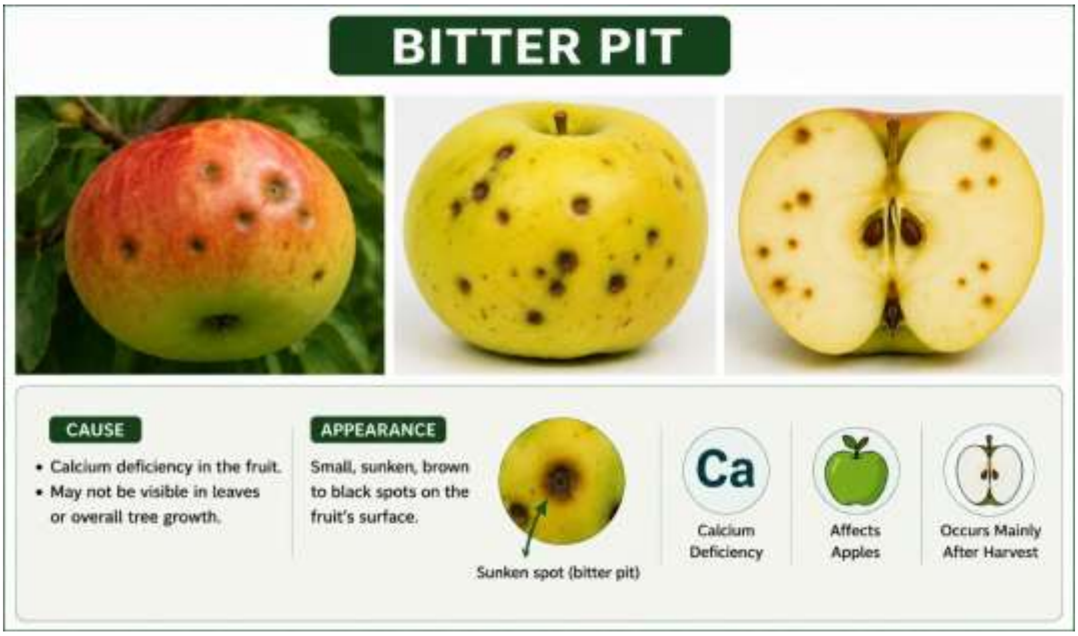

Fig. 4.6: Bitter pit symptoms in apple fruits

While calcium deficiency may not be apparent in the leaves or overall tree growth, it leads to issues with the development of fruit, especially after harvest. Bitter pit impacts the quality and marketability of apples, manifesting as small, sunken spots on the fruit's surface, often accompanied by a bitter taste.

d) **Hollow heart:** It is a physiological disorder that affects root and tuber crops, particularly potatoes (Fig. 4.7). It is characterised by the formation of hollow, brownish cavities in the centre of the tuber. While the exact cause of hollow heart is not fully understood, it is often associated with rapid or uneven growth of the tuber, which creates an internal space that does not fill properly during development.

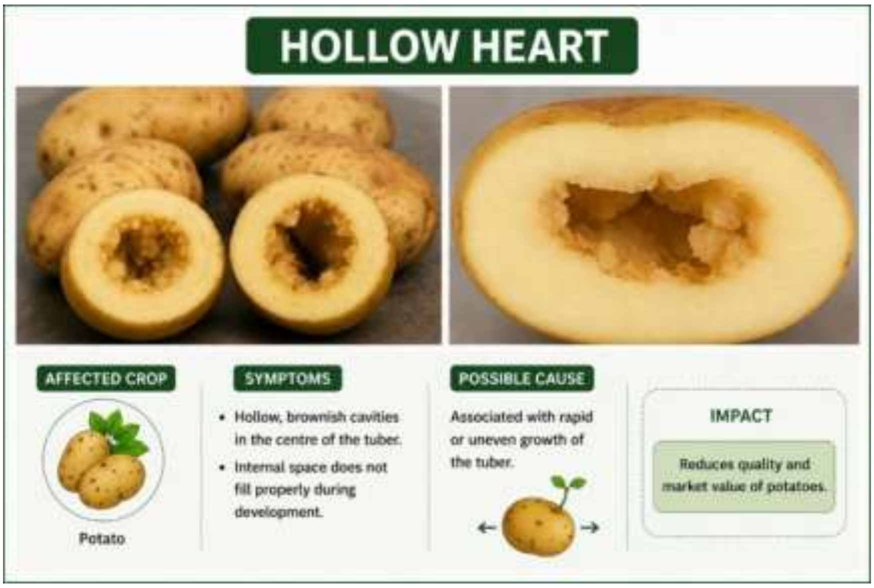

Fig. 4.7: Hollow heart symptoms in potato tubers

11. Management of Weeds, Insect Pests, and Diseases

Management of weeds, insect pests, and diseases in agriculture involves implementing various strategies to control or reduce the impact of these factors on crop productivity, quality, and overall health. Managing these challenges is crucial for maintaining crop yields, reducing the spread of diseases, and improving long-term soil and ecosystem health. Effective management integrates a combination of biological, mechanical, chemical, and cultural practices that are sustainable and minimise environmental impacts.

The following are some key practices for managing each of these challenges:

(i) **Regular monitoring**: Keep a close watch on crops to detect the early signs of weeds, pests, and diseases. Early intervention can prevent infestations or outbreaks from spreading.

(ii) **Pest and disease management**: Combine various control methods such as physical and biological, excluding chemical application, in a balanced, environmentally sustainable manner to reduce the likelihood of pest and disease resistance, while minimising environmental damage.

(iii) **Sustainable practices**: Using sustainable practices such as organic methods, biological control, crop rotation, intercropping, and the use of resistant varieties helps reduce dependence on chemical pesticides and herbicides (Fig. 4.8). These practices promote ecological balance, improve soil health, and support environmentally safe crop production.

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Fig. 4.8: Biological control, using helpful insects to control harmful ones

(iv) **Use of resistant varieties**: Planting disease-resistant and pest-resistant crop varieties minimises the need for chemical treatments.

12. Harvesting Practices in Organic Vegetable Farming

Under organic farming, harvesting of vegetables at the right stage of maturity ensures the best taste and quality. Harvesting should be done at a proper stage where there is minimum damage and loss, as rapidly as possible and at minimum cost. Harvesting should be done in early morning or late evening hours. The time, frequency, and method of harvesting vary depending on species. Vegetables, such as many of the root crops, can remain in the garden for several weeks with little effect on their taste. Some vegetables, like chilli and okra, have to be harvested almost daily. Other plants, such as tomatoes, can be harvested weekly. Harvesting at the optimum stage of maturity ensures maximum quality and yield. Some harvesting practices of vegetables are listed below:

a) **Cabbage:** The cabbage heads should be harvested when they attain full size and are solid. The best time for harvesting is in the afternoon or early in the morning. The early crop may require 2-3 cuttings, whereas the late crop should be harvested only in one operation.
b) **Carrots:** Carrots are ready when 1 inch in diameter. They may be left in the ground for later harvest during cool, dry periods.
c) **Onions:** Harvest when tops fall over and begin to die. Dig bulbs and dry for several days. Cut off the tops and roots and store in a cool, dry place. Harvest green onions when they are 6 to 8 inches tall.

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d) Spinach: Leaves are ready when 4 to 6 inches long. Pull out larger, whole plants or harvest older leaves to allow new growth.

e) Tomatoes: Tomatoes are harvested at different stages of maturity. The interval between picking depends on the weather. Tomatoes are normally picked at four-day intervals during the warm season and at weekly intervals when the weather is cool. Tomatoes are harvested at several stages, i.e., mature green, turning pink, red ripe and overripe. The stage of harvesting depends on the purpose for which the tomatoes are harvested.

13. Post-Harvest Management

Post-Harvest Management includes the processes done immediately after harvesting the produce, including cooling, cleaning, sorting and packing. The instant a crop is removed from the ground or separated from its parent plant, it begins to deteriorate. The following practices are used for post-harvest management:

(a) **Cleaning:** Cleaning is used not only to remove field soil and surface micro-organisms but also to discard damaged fruits and pods to prevent future rotting.

(b) **Blanching:** The special heat treatment to inactivate enzymes is known as blanching. Small vegetables may be adequately blanched in boiling water in a minute or more; large vegetables may require several minutes.

(c) **Packaging:** The packaging of vegetables should protect them from damage and water loss, and be convenient for handling and marketing. Organic food should be packaged in reusable, recycled, recyclable and biodegradable packaging.

(d) **Fresh vegetable storage:** In long-term storage of fresh fruit and vegetables, it is necessary to reduce respiration and transpiration rate to a minimum possible, and this can be achieved by:

- Maintaining a temperature near 0°C
- Increasing the relative humidity of the air to 85-95%
- Modifying the CO_2 percentage in the air

(e) **Transportation:** Fresh horticultural products should be cooled after harvest and during transport. The cold chain must be continuous. Trucks for road transport may be refrigerated or may sometimes just be insulated. It is difficult to control the temperature of air shipments, but produce shipped by air should be covered and precooled.

Practical Exercise

Activity 1: Hands-on demonstration of basic crop practices

Materials Required:

1. Small garden plot or containers
2. Shovels, rakes, hoes

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3. Compost or organic manure
4. Seeds (e.g., tomato, spinach)
5. Nursery trays or beds
6. Saplings for transplanting
7. Watering cans

Procedure:

Group 1: Land Preparation

- Loosen soil, remove weeds
- Mix compost to improve fertility
- Level the soil for sowing

Group 2: Nursery Bed Setup

- Fill trays or beds with soil and compost
- Sow seeds at proper depth and spacing
- Water gently and label plantings

Group 3: Sowing Methods

- Practice broadcasting, line sowing, and pit sowing techniques
- Sow seeds in prepared plots

Group 4: Transplanting

- Carefully lift saplings
- Dig and prepare planting holes
- Transplant and water the saplings

Activity 2: Visit to an organic farm

Materials Required:

1. Notebook
2. Pen
3. Camera or mobile phone
4. Water bottle

Procedure:

- Observe practices like composting, mulching, pest control, and crop diversity
- Take notes and photos of key techniques
- Interact with farmers to understand challenges and benefits
- Reflect on the role of organic farming in sustainable agriculture
- Write a brief summary of observations and discuss how these methods can be applied locally.

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Check Your Progress

A. Multiple Choice Questions:

1. Which of the following is excluded from organic vegetable crop production?
   a) Synthetic pesticides
   b) Organic fertilisers
   c) Crop rotations
   d) Animal manures

2. Which vegetable is not listed as popular for organic production in the region?
   a) Carrot
   b) Cabbage
   c) Potato
   d) Tomato

3. Which of the following is a is not caused by a calcium deficiency?
   a) Blossom-End Rot
   b) Tip Burn
   c) Bitter Pit
   d) Hollow Heart

4. Which type of irrigation system is known for delivering water directly to the plant's root zone through tubes and emitters?
   a) Surface irrigation
   b) Drip irrigation
   c) Sprinkler irrigation
   d) Subsurface irrigation

5. What is the best time for harvesting cabbage?
   a) During midday
   b) In the afternoon or early morning
   c) In the evening
   d) During rainfall

6. In organic farming, how often should tomatoes typically be harvested during warm weather?
   a) Weekly
   b) Every 4 days
   c) Every month
   d) Daily

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B. Fill in the Blanks

1. Organic farming relies on methods such as crop rotations, crop residues, green manure, and biological _______ control.
2. _______ irrigation delivers water directly to the root zone of plants through tubes and emitters.
3. Organic farming excludes the use of synthetic _______ and pesticides.
4. Crop _______ helps maintain soil fertility and reduces the build-up of pests and diseases.
5. Green manure is incorporated into the soil to improve soil _______.
6. Biological pest control uses natural _______ and parasites to manage pest populations.
7. Vegetables such as cabbage, cauliflower, and broccoli are examples of _______-season vegetables.
8. Organic farming promotes the use of _______ inputs instead of synthetic chemicals.
9. Organic farmers often use _______ crops to suppress weeds and protect the soil.
10. Crop residues left on the soil surface help reduce soil _______.

C. State Whether the Following Statements are True or False

1. Organic vegetable production can include synthetic fertilisers if used in small quantities.
2. Crop selection for organic vegetable production should be based on market demand.
3. Drip irrigation is one of the most water-efficient methods for organic farming.
4. Bitter pit in apples is caused by a deficiency of potassium.
5. In organic farming, the best time for harvesting vegetables is during midday when temperatures are highest.

D. Subjective Questions

1. A farmer in a water-scarce area wants to grow tomatoes organically with minimum water loss. Which irrigation method would be most suitable and why?
2. A tomato crop develops dark, sunken patches at the bottom of fruits after irregular watering. Identify the disorder and explain its main cause.
3. During the rainy season, a vegetable grower prepares raised nursery beds instead of flat beds. Why are raised beds preferred in this season?
4. A farmer harvests spinach by removing only the older leaves instead of uprooting the whole plant. How does this practice benefit crop production?
5. An organic vegetable farmer regularly checks crops for early signs of pests and diseases. Why is regular monitoring important in sustainable crop management?

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What have you learned?

After completing this session, you will be able to:

- describe the key principles of organic farming;
- identify suitable crops and varieties for organic cultivation;
- demonstrate knowledge of nursery management and crop establishment; and
- apply techniques for post-harvest management and storage.

Session 2: Organic Cultivation Practices for Flower Crops

Flowering crops are cultivated primarily for their attractive blooms, which are widely used for ornamental purposes, landscaping, religious ceremonies, floral decorations, perfumes, and the cut-flower industry. These crops play a vital role in horticulture and the floriculture sector due to their aesthetic appeal, commercial value, and economic importance. They are grown under diverse agro-climatic conditions and are appreciated for their flower colour, fragrance, size, shape, and vase life. Numerous flowering crops are cultivated across the world, each possessing unique characteristics and specific cultivation requirements. Some are valued as cut flowers, while others are preferred for loose flowers, potted plants, or landscape gardening. The choice of crop and variety depends on climatic conditions, market demand, intended use, and consumer preference.

Flowering Crops Grown Organically

Rose, chrysanthemum, marigold, jasmine, gladiolus, carnation, gerbera, tuberose, lily, orchid, sunflower, and bougainvillea are among the most popular flowering crops cultivated organically for ornamental, commercial, landscaping, and decorative purposes. These crops are valued for their attractive flowers, fragrance, diverse colours, and wide range of uses in floristry, religious ceremonies, festivals, cosmetics, and the cut-flower industry. The important varieties, suitable growing conditions, organic production practices, and harvesting methods of these flowering crops are discussed in the following sections.

Rose

Rose (*Rosa* spp.) is popularly known as the "Queen of Flowers" because of its beauty, attractive colours, elegant form, and pleasant fragrance. It is one of the most important ornamental crops grown for cut flowers, loose flowers, landscaping, and garden decoration. Hybrid Tea roses are mainly cultivated for the cut flower industry, while Floribunda roses are preferred for mass planting because they produce clusters of attractive blooms.

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(a) Popular varieties and classification of roses

Several rose varieties are cultivated for their attractive colours, fragrance, flower size, shape, and suitability for garden decoration and cut-flower production. Popular varieties include Mr. Lincoln, Queen Elizabeth, Peace, Double Delight, Sonia, Taj Mahal, First Red, Grand Gala, and *Arka Parimala*. Mr. Lincoln is a popular red rose known for its large, fragrant flowers, while Queen Elizabeth produces attractive pink blooms on strong, upright plants. Peace is valued for its large, multicoloured flowers with yellow and pink shades. Double Delight is notable for its fragrant red-and-white blooms, whereas Sonia is widely grown as a cut flower because of its attractive pink flowers and long stems. Taj Mahal is preferred for its elegant red flowers and good vase life. These varieties are selected according to the intended purpose, climatic conditions, market demand, and suitability for organic cultivation.

(b) Climatic requirements

Rose grows well under tropical and subtropical climatic conditions. A temperature between 15°C and 28°C is ideal for healthy plant growth and good-quality flowers. The crop requires 5–6 hours of direct sunlight every day for proper growth and abundant flowering. Moderate humidity and well-drained soil favour healthy plant development, while prolonged waterlogging should be avoided. Roses can tolerate temperatures below 15°C**,** although growth and flowering may be reduced under cooler conditions.

(c) Preparation for planting

Deep, fertile, well-drained soil rich in organic matter is best suited for rose cultivation. Before planting, the land should be thoroughly prepared and mixed with 10–15 kg of well-rotted farmyard manure (FYM) per square metre**.** To protect young plants from soil-borne diseases, prepare a suspension by mixing 10 g of *Trichoderma* powder and 100 g of well-rotted FYM in 1 litre of water**.** Dip the cuttings or seedlings in this solution for about 10 minutes before planting.

The spacing between plants depends on the growth habit of the variety. Generally, Hybrid Tea roses are planted at 75 cm × 75 cm, while Floribunda roses are planted at 60 cm × 60 cm for mass planting.

(d) Planting and propagation

The best time for planting roses is from late September to mid-October**.**

Prepare planting pits measuring 45 cm × 45 cm × 45 cm at a spacing of 2.0 m × 1.0 m**.** Mix about 10 kg of well-rotted FYM with the soil in each pit before planting.

Roses are commonly propagated by T-budding (shield budding) on suitable rootstocks. The commonly used rootstocks are Rosa *bourboniana* and Rosa multiflora.

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In many areas, Rosa *indica* var. *odorata* has proved to be a superior rootstock because of its better adaptability and vigorous growth.

(e) Irrigation

The water requirement of roses varies according to soil type, climate and season. Sandy soils require more frequent irrigation than heavy soils.

During summer**,** irrigation should be given at an interval of 5–6 days, whereas during winter it is usually required every 7–10 days**.** In the rainy season, irrigation is generally not necessary unless there is a prolonged dry spell. The soil should be kept uniformly moist, but waterlogging must be avoided as it adversely affects root growth.

(f) Harvesting

Flowers should be harvested during the early morning or late evening when temperatures are low and moisture loss is minimal. A sharp knife or secateurs should be used to obtain clean cuts without damaging the plants.

The stage of harvesting depends on the intended use.

- **For the local market:** Harvest flowers when the outer petals begin to unfurl.
- **For distant markets:** Harvest flowers at the tight bud stage, when the buds are fully developed but the petals have not yet opened.
- **For loose flowers:** Harvest blooms after they have opened fully.

(g) Post-harvest management

Immediately after harvesting, the flower stems should be placed in clean water for a few hours to maintain freshness and improve vase life. The flowers may then be stored at 2–10°C for three hours or longer before packing and transportation. Proper handling and cold storage help maintain flower quality and reduce post-harvest losses.

Chrysanthemum

Chrysanthemum (*Chrysanthemum morifolium*), commonly known as "mum," is one of the most popular ornamental flowering plants because of its attractive blooms, wide range of colours, and excellent vase life. It is extensively cultivated as a garden plant, as well as for cut flowers and loose flowers used in floral decorations.

(a) Popular varieties

Popular chrysanthemum varieties include Kirti, Arka Swarna, Shanti, Y2K, Arka Ganga, Appu, Sadbhavana, Bindiya, MDU 1 (yellow flowers), CO 1 (yellow flowers), CO 2 (purple flowers), Indira, Red Gold, Ravi Kiran, Akash, Yellow Star, Rakhee, and Chandrakand**.**

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(b) Climatic requirements

Chrysanthemum grows well under tropical and subtropical climatic conditions. The optimum temperature for growth and flowering is 20–28°C during the day and 15–20°C at night. Since chrysanthemum is a short-day plant, planting should be scheduled so that flowering coincides with the shorter days of winter. Adequate sunlight during the vegetative stage and cool weather during flowering help produce high-quality blooms.

(c) Preparation for planting

Chrysanthemum is commonly propagated through terminal cuttings measuring 5–7 cm in length or through suckers. Planting is generally carried out during June–July at a spacing of 30 × 30 cm on one side of the ridges, accommodating approximately 111,000 plants per hectare.

A well-drained loamy soil with a pH of 6.0–7.0 is ideal for cultivation. The land should be thoroughly prepared with 2–3 ploughings, followed by harrowing to obtain a fine tilth.

Incorporate 20–25 tonnes of well-rotted farmyard manure (FYM) per hectare or 8–10 tonnes of vermicompost per hectare during the final land preparation.

For better nutrient availability, apply 5 kg each of Azotobacter and Phosphobacteria per hectare, mixed with 100 kg of well-rotted FYM, at the time of planting.

(d) Irrigation

Irrigation should be given twice a week during the first month after planting. Thereafter, irrigation at weekly intervals is generally sufficient. The frequency of irrigation should be adjusted according to the stage of crop growth, soil type, and prevailing weather conditions. Proper irrigation promotes healthy plant growth, improves flower quality, and enhances plant vigour, while excessive watering should be avoided.

(e) Harvesting

Depending on the variety, flowering begins 3–4 months after transplanting.

For cut flowers, stems should be harvested by cutting them about 10 cm above ground level to avoid damaging the woody portion of the stem. Immediately after harvest, place the lower one-third of the stems in clean water to maintain freshness and extend vase life. Bunches are best protected by covering them with transparent plastic sleeves during handling and transport.

The appropriate stage of harvest depends on the cultivar, market distance, and intended use.

(f) Post-harvest management

After harvesting, the stems should be trimmed to a uniform length, 90 cm being the standard for cut flowers. The stems are tied into bunches of five, secured with a rubber band at the base, covered with plastic sleeves, and placed upright in buckets containing clean water.

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Mature chrysanthemum flowers can be stored dry at 0.5°C for 6–8 weeks without significant loss of quality. On the day of shipment, or the previous evening, the bunches should be packed carefully in suitable cartons for transport.

Loose flowers are generally packed in bamboo baskets or gunny bags for marketing. Bamboo baskets usually have a capacity of 1–7 kg**,** whereas gunny bags can accommodate up to 30 kg of loose flowers.

Marigold

Marigold (*Tagetes* spp.) is one of the most widely cultivated ornamental flowering plants because of its bright, attractive flowers, ease of cultivation, and wide adaptability. It is commonly grown for garden decoration, landscaping, loose flowers, garland making, and religious and ceremonial purposes. In addition to its ornamental value, marigold is also used as a companion crop because of its natural pest-repellent properties.

(a) Popular varieties

The two main cultivated species of marigold are:

African Marigold (*Tagetes erecta*): Popular varieties include Cracker Jack, Climax, Pusa Narangi, Pusa Basanti, Golden Age, Chrysanthemum Charm, and Crown of Gold.

French Marigold (*Tagetes patula*): Popular varieties include Red Brocade, Rusty Red, Butter Scotch, and Susanna.

(b) Climatic requirements

Marigold grows best under a mild climate and performs well under tropical and subtropical conditions. A moderate temperature encourages vigorous vegetative growth and profuse flowering. Very high temperatures reduce plant growth and adversely affect flower size, yield, and quality. During severe winters, especially under frost conditions, plants and flowers may be damaged, resulting in blackening and drying of the blooms.

(c) Preparation for planting

The land should be thoroughly prepared by **2**–3 ploughings to obtain a fine tilth. Incorporate 15–20 tonnes of well-rotted farmyard manure (FYM) per hectare during the final ploughing to improve soil fertility and structure.

Prepare beds of convenient length and about 1 m width to facilitate irrigation and other intercultural operations. Marigold seeds can be sown in pots, seed trays, or on flat or raised nursery beds. Nursery beds measuring 3 m × 1 m should be enriched with 10 kg of well-rotted FYM per square metre before sowing.

Marigold can be grown throughout the year under suitable climatic conditions. Approximately 1.5 kg of seed per hectare is required to raise the nursery. Seedlings are ready for transplanting after about four weeks and are planted on one side of the ridge at a spacing of 45 cm × 35 cm**.**

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Before sowing, treat the seeds with Azotobacter by mixing 1 kg of culture in 10 litres of water and soaking the seeds in the solution for 30 minutes**.** This treatment promotes better seedling establishment and healthy plant growth.

(d) Irrigation

Irrigation should be given once a week or whenever necessary, depending on the soil type and weather conditions. The soil should be kept adequately moist throughout the growing period, but waterlogging must be avoided as it adversely affects root growth and flower production.

(e) Harvesting

Flowers should be harvested when they attain full size and the blooms are fully developed. Harvesting is best carried out during the cool hours of the morning or evening to maintain freshness and reduce moisture loss.

A light irrigation before harvesting helps the flowers remain fresh for a longer period after picking. Flowers are harvested manually, and regular picking encourages continuous flowering and increases overall yield. If the harvested flowers are stored overnight before marketing, they should be covered with moist gunny bags to prevent wilting and maintain their quality.

(f) Post-harvest management

For garlands, decoration, and ceremonial purposes, marigold flowers should be harvested when they are fully open**.** When grown as a cut flower, stems should be cut early in the morning while the flowers are fresh. For maximum vase life, flowers should be harvested at the half-open stage and immediately placed in clean water.

For seed production, allow the flower heads to dry completely on the plant. The dried flower heads are then collected, and the seeds are separated, cleaned, and stored for the next planting season.

Practical Exercise

Activity 1: Preparation and application of organic manures and fertilisers

Materials Required:

1. Organic waste (vegetable scraps, dry leaves, grass clippings)
2. Compost bin or heap
3. Animal manure (e.g., cow dung)
4. Vermicomposting setup (worms, soil, organic matter)
5. Watering cans
6. Shovels and rakes
7. Gloves
8. Buckets for mixing fertilisers
9. Organic liquid fertilisers (compost tea/manure tea)

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10. Plant pots or a garden plot

Procedure:
- Make compost by layering nitrogen-rich and carbon-rich materials, keeping it moist and turning regularly.
- Set up a vermicompost bin using worms and organic matter; observe nutrient-rich output.
- Prepare compost tea (compost + water, steeped 1–2 days) and manure tea (cow dung + water, soaked for days).
- Apply compost and vermicompost around plant bases (avoid direct stem contact).
- Use compost/manure tea as a foliar spray or soil drench.
- Reflect on the use of organic vs. chemical fertilisers for sustainable farming.

Activity 2: Field visit to organic farms

Materials Required:
1. Notebook
2. Pen

Procedure:
- Observe soil quality, compost use, green manure, and bio-fertilisers.
- Note pest control methods (bio-pesticides, IPM, companion planting).
- Study farm layout, irrigation, and organic certification practices.
- Record varieties of flowers, farming techniques, and sustainability practices.
- Reflect on learnings about organic flower cultivation and farm management.

Activity 3: Study of land preparation and planting methods in floriculture

Materials Required:
1. Notebook
2. Pen

Procedure:
- Identify steps involved in land preparation.
- Note spacing and planting methods for each crop.
- Record use of farmyard manure and pit preparation.
- Summarise procedures briefly.

Activity 4: Identification of irrigation practices in flower crops

Materials Required:
1. Notebook
2. Pen

Procedure:
- Note irrigation intervals for rose, chrysanthemum, and marigold.

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- Identify factors affecting irrigation needs.
- Compare watering schedules among crops.
- Record observations.

Activity 5: Post-harvest management of flowers

Materials Required:
1. Notebook
2. Pen

Procedure:
- Identify post-harvest practices like storage, cooling, and packing.
- Note methods to maintain freshness and vase life.
- Record storage conditions for different flowers.
- Summarise in brief points.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following rose varieties is classified under 'Hybrid Tea'?
   a) Golden Splendour
   b) *Swati Rashmi*
   c) *Chandrama*
   d) Golden Shower

2. What is the ideal temperature range for growing roses?
   a) 10°C to 15°C
   b) 15°C to 28°C
   c) 20°C to 35°C
   d) 30°C to 40°C

3. Which of the following varieties of marigold is an African marigold variety?
   a) Cracker Jack
   b) *Pusa Narangi*
   c) Red Brocade
   d) Rusty Red

4. What is the best time for planting roses?
   a) January to February
   b) June to July
   c) September to October
   d) March to April

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5. What type of soil is ideal for chrysanthemum cultivation?
   a) Clayey soil
   b) Well-drained loamy soil
   c) Sandy soil
   d) Wet soil

6. Which of the following is NOT a variety of chrysanthemum?
   a) *Arka Swarna*
   b) *Shanti*
   c) Golden Splendour
   d) *Kirti*

7. Which of the following is the main method of propagating chrysanthemums?
   a) Budding
   b) Grafting
   c) Terminal cuttings
   d) Layering

8. Roses grow well in ________ weather conditions.
   a) Tropical and subtropical
   b) Temperate
   c) Polar
   d) Desert

B. Fill in the Blanks

1. Rose is popularly known as the __________ of flowers.
2. Roses are commonly propagated through __________.
3. African marigold plants generally produce __________ flowers than French marigold plants.
4. Marigold is commonly propagated through __________.
5. Chrysanthemum is mainly propagated through __________ cuttings.
6. The flowers of chrysanthemum are widely used for __________ flower production.
7. Rose, marigold, and chrysanthemum are important commercial crops in __________.
8. The scientific name of chrysanthemum is __________.
9. Regular __________ of rose plants encourages better flowering.

C. State Whether the Following Statements are True or False

1. Roses grow well in tropical and subtropical weather conditions.
2. Hybrid tea roses produce clusters of smaller blooms compared to floribundas.
3. Chrysanthemums are long-day plants, requiring extended sunlight exposure for flowering.
4. The cut flowers of chrysanthemums should be stored at 0.5°C for 6-8 weeks.

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5. Irrigation for the marigold plant should be done daily, irrespective of soil conditions.

D. Subjective Questions

1. A rose grower wants to send flowers to a distant market. At which stage should the roses be harvested and why?
2. A chrysanthemum farmer irrigates the crop more frequently during the first month after planting. Why is regular irrigation important at this stage?
3. A marigold grower notices poor flowering during very high temperatures. Explain how climate affects marigold flower production.
4. Before planting rose cuttings, a farmer dips them in a solution containing *Trichoderma* and farmyard manure. What is the purpose of this treatment?

What have you learned?

After completing this session, you will be able to:

- identify cultivation needs for annual and perennial flowering plants;
- describe ideal soil, nutrient, and irrigation practices;
- explain propagation methods like seed sowing, cuttings, grafting, and layering; and
- apply pest and disease management strategies for flowering crops.

Session 3: Principles and Practices of Protected Cultivation

Protected cultivation is a modern method of crop production in which plants are grown under controlled or partially controlled environmental conditions. Structures such as greenhouses, polyhouses, shade-net houses, and plastic tunnels are used to protect crops from adverse weather, insect pests, and diseases. These structures also provide favourable conditions for plant growth by regulating temperature, humidity, light, ventilation, and irrigation. As a result, protected cultivation enables farmers to produce high-quality crops throughout the year, including during the off-season, while improving productivity and resource-use efficiency.

1. Principles of Protected Cultivation

Protected cultivation is based on the principle of creating a favourable microclimate that supports healthy plant growth and development. By regulating environmental factors within the protected structure, crops receive optimum growing conditions regardless of fluctuations in the external climate. This leads to higher productivity, better-quality produce, efficient use of resources, and increased profitability, particularly for high-value horticultural crops.

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The main principles of protected cultivation are as follows:

- **Environmental control:** Maintain optimum levels of temperature, humidity, light, ventilation, and air circulation for healthy plant growth.
- **Protection from adverse weather:** Safeguard crops from heavy rainfall, strong winds, hailstorms, frost, and extreme temperatures.
- **Off-season production:** Enable the cultivation of crops beyond their normal growing season, ensuring a continuous supply to the market.
- **Improved yield and quality:** Provide uniform growing conditions that result in higher yields, superior-quality produce, and better market value.
- **Efficient use of resources:** Use water, fertilisers, and other inputs efficiently through modern irrigation and fertigation systems, thereby reducing wastage.
- **Cultivation of high-value crops:** Facilitate the production of vegetables, fruits, flowers, herbs, and nursery plants that require precise environmental conditions.
- **Labour efficiency:** Reduce manual labour through the use of automated or semi-automated systems for irrigation, fertigation, ventilation, and climate control.

2. Types of Greenhouse Structures

Protected cultivation structures are designed to create a favourable microclimate for crop growth by protecting plants from adverse weather conditions, insect pests, and diseases. Based on the level of environmental control and the covering material used, these structures can be classified as follows.

(a) Shade-net House: A shade-net house is a naturally ventilated protected structure covered with shade-net fabric that reduces the intensity of sunlight reaching the crop. It provides a favourable environment for crops requiring partial shade and moderate temperatures by reducing heat stress and protecting plants from strong winds. Shade-net houses are commonly used for raising nursery seedlings, vegetables, flowers, medicinal and aromatic plants, and planting materials of horticultural crops. The framework is generally constructed using galvanised iron (GI) pipes and covered with shade nets of different shading percentages (such as 35%, 50%, or 75%) according to crop requirements and local climatic conditions. These structures are economical, easy to maintain, and well suited for tropical and subtropical regions.

(b) Plastic Tunnels: Plastic tunnels are simple protected cultivation structures formed by covering a series of hoops or frames with transparent polyethylene film. They create a warmer and more stable microclimate around the crop, protecting plants from low temperatures, rainfall, wind, and certain insect pests.

Plastic tunnels are widely used for early crop establishment, season extension, off-season production, and improved crop quality. These are used for year-round organic vegetable production in hilly regions (Fig. 4.10). These tunnels, typically 1.0 m high and 1.5 m wide, are built with bamboo or wooden poles and covered with transparent UV-stabilised plastic sheets (35-45 GSM). The plastic traps heat, reduces water loss, and protects plants from adverse weather. Flexible plastic walls are added for ventilation, ensuring stability against wind, hail, or heavy rains.

Based on their size and design, plastic tunnels are classified into low tunnels and high tunnels.

Fig. 4.10: Low-cost plastic tunnels used for year-round organic vegetable production

(i) Low Tunnels: Low tunnels are small protective structures, usually 0.5–1.0 m high, made by covering wire, bamboo, or PVC hoops with transparent polyethylene film. They are installed directly over crop rows and provide protection during the early stages of plant growth.

Low tunnels increase air and soil temperature, promote early germination and faster plant growth, reduce frost injury, and protect crops from wind and heavy rainfall. They are widely used for vegetables such as cucumber, muskmelon, watermelon, capsicum, tomato, and other early-season crops. Due to their low construction cost, they are popular among small and marginal farmers.

(ii) High Tunnels (Walk-in Tunnels): High tunnels are larger plastic-covered structures that allow workers to walk inside for crop management operations. They consist of a galvanised iron (GI) or steel frame covered with UV-stabilised polyethylene film and rely mainly on natural ventilation through roll-up sidewalls or end openings. High tunnels provide better protection than low tunnels and are suitable for the cultivation of vegetables, flowers, herbs, and small fruits. They extend the growing season, improve crop quality, increase yields, and reduce damage caused by rain,

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wind, and moderate frost. Since they do not use active heating or cooling systems, they are relatively economical compared with fully controlled greenhouses.

(c) Naturally Ventilated Polyhouse: A naturally ventilated polyhouse is a framed protected cultivation structure covered with UV-stabilised polyethylene film that provides a partially controlled environment for crop production. It offers better protection against rain, wind, and temperature fluctuations than shade-net houses and plastic tunnels.

The framework is generally made of galvanised iron (GI) pipes. The roof is covered with 200-micron UV-stabilised polyethylene film, while the lower 90 cm (3 feet) of the side walls are also covered with the same material to prevent rain splash. The remaining side walls are fitted with 40-mesh insect-proof nets that permit natural ventilation while preventing the entry of insect pests.

Naturally ventilated polyhouses are widely used for cultivating high-value vegetables, flowers, herbs, and nursery crops. They improve crop quality, increase productivity, reduce pest and disease incidence, and facilitate off-season cultivation with low energy requirements.

Naturally ventilated polyhouses are widely used for cultivating high-value vegetables, flowers, and nursery plants because they provide a favourable microclimate, improve crop quality, and increase productivity. The major differences between a shade-net house and a naturally ventilated polyhouse are presented in Table 4.2.

Table 4.2. Difference between a Shade-net House and a Naturally Ventilated Polyhouse

Aspect	Shade-net House	Naturally Ventilated Polyhouse
Covering material	Shade net (generally green or black)	UV-stabilised polyethylene film
Main purpose	Reduces sunlight intensity and protects plants from excessive heat	Creates a favourable microclimate by retaining heat and protecting crops from rain and wind
Light penetration	Diffused light with partial shading	High light transmission with protection from harmful UV radiation
Temperature	Moderates temperature by reducing solar radiation	Maintains a warmer environment; ventilation prevents overheating
Ventilation	Natural air movement through the shade net	Natural ventilation through roof and side vents
Cost	Comparatively low	Comparatively high
Maintenance	Low	Moderate, as the plastic covering requires periodic replacement

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Suitable crops	Shade-loving vegetables, ornamentals and nursery plants	High-value vegetables, flowers and fruits requiring controlled conditions
Climate suitability	Suitable for warm regions with high solar radiation	Suitable for a wide range of climatic conditions
Protection	Protects from direct sunlight, birds and some insect pests	Provides better protection from rain, wind, pests and temperature fluctuations

(d) Climate-Controlled Greenhouse: A climate-controlled greenhouse is an advanced protected cultivation structure equipped with systems that regulate temperature, humidity, ventilation, light, irrigation, and carbon dioxide concentration to maintain optimum growing conditions throughout the year.

The structure is covered with transparent materials such as UV-stabilised polyethylene film, polycarbonate sheets, or glass and is fitted with equipment such as exhaust fans, evaporative cooling pads, fogging or misting systems, heaters, automated ventilation, shading systems, and environmental sensors. These systems are often integrated with computer-based monitoring and control units.

Climate-controlled greenhouses are primarily used for producing high-value vegetables, flowers, exotic crops, tissue culture plants, and export-quality produce. Although they require high initial investment and technical expertise, they provide superior crop quality, higher productivity, efficient resource utilisation, and reliable year-round production regardless of external weather conditions.

3. Practices of Protected Cultivation for Organic Crops

Protected cultivation of organic crops involves growing plants in structures such as shade-net houses, plastic tunnels, polyhouses, or climate-controlled greenhouses while following the principles of organic farming. The objective is to produce high-quality crops by creating a favourable growing environment and using only approved organic inputs and sustainable management practices.

(a) Site Selection and Structure Preparation: Select a well-drained site with good sunlight exposure and access to a reliable source of clean irrigation water. The protected structure should be properly oriented to maximise sunlight and ensure adequate natural ventilation. Before planting, the structure should be thoroughly cleaned and disinfected using approved organic methods to minimise the risk of pests and diseases.

(b) Soil Preparation: Healthy soil is the foundation of organic protected cultivation. The soil should be loose, fertile, and rich in organic matter. Incorporate well-decomposed farmyard manure (FYM), compost, vermicompost, or other organic amendments before planting. Green manures, crop residues, and biofertilisers can also be added to improve soil fertility and microbial activity.

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(c) Selection of Crops and Varieties: Choose crops and varieties that are well adapted to protected cultivation and local climatic conditions. Disease-resistant and high-yielding varieties are preferred to minimise pest and disease problems. Common organic crops grown under protected cultivation include tomato, cucumber, capsicum, lettuce, spinach, herbs, strawberries, flowers, and nursery plants.

(d) Seed and Planting Material: Use certified organic seeds whenever available. If organic seeds are unavailable, untreated conventional seeds may be used according to the applicable organic certification standards. Healthy, disease-free seedlings should be raised in organic growing media using compost, cocopeat, vermicompost, and biofertilisers.

(e) Nutrient Management: Nutrient requirements should be met using organic sources rather than synthetic fertilisers. Common nutrient sources include farmyard manure, compost, vermicompost, neem cake, oilseed cakes, poultry manure, bone meal, and liquid organic manures such as jeevamrit and panchagavya where appropriate. Biofertilisers such as *Rhizobium*, *Azotobacter*, *Azospirillum*, and phosphate-solubilising bacteria (PSB) help improve nutrient availability and soil health.

(f) Irrigation and Water Management: Efficient irrigation is essential in protected cultivation. Drip irrigation is the preferred method because it supplies water directly to the root zone, reduces water loss, and minimises weed growth. Organic liquid fertilisers may be applied through the irrigation system where permitted under organic standards. Irrigation scheduling should be based on crop growth stage and soil moisture.

(g) Mulching: Organic mulches such as straw, dried leaves, sugarcane trash, or other biodegradable materials help conserve soil moisture, suppress weeds, regulate soil temperature, and improve soil organic matter. Biodegradable mulch films approved for organic farming may also be used where permitted.

(h) Weed Management: Weeds should be controlled through preventive and mechanical methods rather than chemical herbicides. Hand weeding, hoeing, mulching, crop rotation, and proper sanitation within the protected structure effectively reduce weed infestation.

(i) Pest and Disease Management: Organic pest and disease management follows an integrated approach that emphasises prevention and biological control. Important practices include:

- Maintaining proper plant spacing and ventilation.
- Removing diseased plant parts and crop residues.
- Installing insect-proof nets and sticky traps.
- Using biological control agents such as *Trichoderma*, *Pseudomonas fluorescens*, *Bacillus subtilis*, and beneficial insects.

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- Applying botanical pesticides such as neem-based formulations and other approved plant extracts.
- Practising crop rotation and maintaining field hygiene.

(j) Training and Pruning: Vining crops such as tomato, cucumber, and capsicum require staking, trellising, pruning, and training to improve light penetration, air circulation, and fruit quality. Regular removal of old leaves and unproductive shoots also helps reduce disease incidence.

(k) Harvesting and Post-harvest Handling: Harvest crops at the appropriate stage of maturity to ensure optimum quality and shelf life. Harvested produce should be handled carefully to avoid mechanical damage and contamination. Clean containers, proper grading, and hygienic packaging should be used to maintain organic integrity and product quality.

(l) Record Keeping and Certification: Organic growers should maintain records of seed sources, organic inputs, irrigation, pest and disease management practices, harvesting, and marketing. These records are essential for traceability and compliance with organic certification standards. Regular inspection and certification ensure that production practices meet national or international organic farming requirements.

Practical Exercise

Activity 1: Chart preparation on organic greenhouse practices

Materials Required:
1. Chart paper
2. Markers
3. Pen

Procedure:
- Discuss the importance of organic farming and greenhouse benefits.
- Form groups (4–5 students), each covering a topic like soil management, pest control, irrigation, crop rotation, or plant nutrition.
- Research and summarise key practices.
- Design a chart with headings, bullet points, and relevant diagrams or images.
- Present charts to the class, explaining the topic's role in organic farming.
- Display all charts in the classroom and conclude with a class reflection.

Activity 2: Real-life organic greenhouse farming practices

Materials Required:
1. Notebook
2. Camera (optional)
3. Pen or pencil
4. Protective gear (hat, gloves, or weather-appropriate clothing).

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Procedure:

- Visit a greenhouse or organic poly-house farm.
- Observe practices like composting, organic pest control, irrigation, and crop management.
- Examine greenhouse structures and environmental controls.
- Note sustainability efforts like crop rotation and energy use.
- Interact with farm staff to understand daily operations and challenges.
- After the visit, reflect and compare organic practices with conventional farming.

Check Your Progress

A. Multiple Choice Questions

1. What is the main purpose of protected cultivation?
   a) To reduce water usage
   b) To protect crops from pests only
   c) To create controlled environments for optimal crop growth
   d) To prevent crops from sunlight

2. Which of the following is NOT a principle of protected cultivation?
   a) Control of environmental factors like temperature and humidity
   b) Protection from adverse weather conditions
   c) Continuous or off-season production
   d) Dependence on chemical fertilisers for plant growth

3. Which type of greenhouse structure is covered with UV-stabilised plastic films?
   a) Shade net house
   b) Naturally ventilated poly house
   c) Low-cost plastic tunnels
   d) All of the above

4. What is the primary function of low-cost plastic tunnels?
   a) Protect plants from direct sunlight
   b) Provide shelter from high winds only
   c) Provide year-round organic vegetable production in hilly regions
   d) Only protect plants from frost

5. What type of crops are commonly grown in greenhouses?
   a) Wheat and rice
   b) High-value crops like roses, gerbera, and cucumbers
   c) Only fruit crops
   d) Only medicinal plants

6. Which equipment is used for regulating temperature and humidity in greenhouses?
   a) Micro irrigation system
   b) Exhaust fans
   c) Khurpi
   d) Sprayer

7. What is the purpose of the roll-able flaps in greenhouse management?
   a) To enhance light penetration
   b) To regulate temperature, humidity, and airflow
   c) To shield plants from pests
   d) To increase CO2 concentration during the day

8. Which of the following is a key aspect of nursery raising in greenhouses?
   a) Seedlings are grown in open fields
   b) Seedlings are started under controlled environmental conditions
   c) Plants are directly sown into the field
   d) There is no need to control temperature or water

9. What materials is commonly used for covering poly house structures?
   a) Glass sheets
   b) UV stabilised polyethene film
   c) Metal sheets
   d) Shade net

10. Why are roll-able flaps closed in the evening in greenhouses?
    a) To allow more sunlight into the greenhouse
    b) To facilitate an increase in CO_2 concentration for plants during the night
    c) To prevent the temperature from rising
    d) To keep pests away

B. Fill in the Blanks

1. Protected cultivation allows farmers to extend __________ seasons and improve yields.
2. The principle of protected cultivation is based on creating an __________ environment.
3. __________ houses are designed to protect crops from excessive sunlight and UV rays.
4. Naturally ventilated poly houses are covered with __________ plastic film.

C. State Whether the Following Statements are True or False

1. Protected cultivation reduces crop yield and quality.
2. Shade net houses provide better temperature control than naturally ventilated poly houses.

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3. Low-cost plastic tunnels are mainly used in hilly regions for organic vegetable production.
4. Naturally ventilated poly houses require more maintenance than shade net houses.
5. Irrigation and nutrient management are unnecessary in greenhouse cultivation.

D. Subjective Questions

1. A farmer wants to grow tomatoes throughout the year in a controlled environment. Which protected cultivation structure would you suggest and why?
2. In a greenhouse, roll-able flaps are kept open during summer but closed at night. Explain the reason behind this management practice.
3. A grower uses UV-stabilised plastic films and exhaust fans in a polyhouse. Which environmental factors are being controlled, and how?
4. A farmer prepares nursery beds in a greenhouse using Trichoderma mixed with farmyard manure. What is the benefit of this practice?
5. A farmer notices poor crop growth due to excessive humidity and poor air circulation in a greenhouse. Which equipment or practice should be used to solve this problem?
6. What is the function of roll-able flaps in greenhouse management?

What have you learned?

After completing this session, you will be able to:

- explain the principles and benefits of protected horticulture;
- identify types of protected structures (greenhouses, polyhouses, shade nets); and
- describe climate control methods.

Answer Key

Unit 1: Introduction to Crops and Cropping Systems

Session 1: Introduction to Major Agricultural Crops

A. Multiple Choice Questions

1. a
2. c
3. a
4. b
5. b
6. b
7. b
8. c
9. a

`

B. Fill in the Blanks

1. Agriculture
2. Monsoon
3. Rabi
4. Annual
5. Rice

C. State Whether the Following Statements are True or False

1. False
2. False
3. True
4. False
5. True

Session 2: Farming Systems and their Importance

A. Multiple Choice Questions

1. b
2. c
3. b
4. b
5. c

B. Fill in the Blanks

1. Sustainable
2. Integrated Farming System (IFS)
3. Wheat
4. Large
5. Fertilisers

Session 3: Cropping Systems and Cropping Patterns

A. Multiple Choice Questions

1. b
2. b
3. b
4. c
5. b
6. a
7. c
8. c

`

B. Fill in the Blanks

1. Cropping system
2. Productivity
3. Monoculture
4. Multiple
5. Sequential

C. State Whether the Following Statements are True or False.

1. False
2. True
3. True
4. False
5. True

Unit 2: Principles and Practices of Organic Farming

Session 1: Principles and Components of Organic Farming

A. Multiple Choice Questions

1. b
2. b
3. c
4. c
5. c
6. c
7. a
8. d

B. Fill in the Blanks

1. Natural
2. Sustainability
3. Biological
4. Genetically Modified Organism (GMO)
5. Animal welfare

C. State Whether the Following Statements are True or False.

1. False
2. True
3. False
4. True
5. False

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Session 2: Components of an Organic Farming Ecosystem

A. Multiple Choice Questions

1. c
2. c
3. c
4. c
5. c
6. c
7. c
8. c
9. b
10. b

B. Fill in the Blanks

1. Ecology
2. Synthetic chemicals
3. Ecology
4. Crop rotation
5. Biological

C. State Whether the Following Statements are True or False.

1. False
2. True
3. False
4. True
5. True

Session 3: Sources and Preparation Methods of Organic Manures

A. Multiple Choice Questions

1. b
2. b
3. a
4. b
5. b
6. c
7. a
8. d
9. b
10. a

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B. Fill in the Blanks

1. Plant
2. Inorganic
3. Residual
4. Animal excreta
5. Farm Yard Manure

C. State Whether the Following Statements are True or False.

1. True
2. False
3. False
4. True
5. False

Session 4: Integration of Livestock in Organic Farming

A. Multiple Choice Questions

1. b
2. c
3. c
4. c
5. d
6. c
7. c

B. Fill in the Blanks

1. Pesticides
2. Pasture
3. Intensive
4. Nutrient
5. Natural

C. State Whether the Following Statements are True or False

1. False
2. True
3. True
4. False
5. True

`

Unit 3: Water, Nutrient and Pest Management

Session 1: Sources and Methods of Irrigation

A. Multiple Choice Questions

1. b
2. b
3. b
4. b
5. b
6. b
7. a
8. a

B. Fill in the Blanks

1. Irrigation
2. Surface
3. Furrow
4. Uniform
5. Drip
6. Basin
7. Sprinkler

C. State Whether the Following Statements are True or False.

1. False
2. True
3. True
4. False
5. False

Session 2: Types and Application of Biofertiliser

A. Multiple Choice Questions

1. b
2. a
3. b
4. a
5. a
6. a

B. Fill in the Blanks

1. Bio-fertilisers
2. Rhizobium

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3. Mycorrhizae
4. Anabaena
5. Seed treatment

C. State Whether the Following Statements are True or False

1. False
2. True
3. True
4. False
5. True

Session 3: Methods of Weed Management

A. Multiple Choice Questions

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

B. Fill in the Blanks

1. Weeds
2. Toxins
3. Deeply
4. Perennial
5. *Philaris minor*

C. State Whether the Following Statements are True or False

1. False
2. True
3. False
4. True
5. True

Session 4: Methods of Pest Management and Control

A. Multiple Choice Questions

1. b
2. a
3. b
4. a
5. b
6. c

`

7. b
8. a
9. b
10. b

B. Fill in the Blanks

1. Crops
2. Synthetic
3. Ecological
4. Biotic
5. Biological

C. State Whether the Following Statements are True or False

1. True
2. False
3. True
4. False
5. True

Unit 4: Package of Practices for Organic Farming

Session 1: Organic Cultivation Practices for Vegetable Crops

A. Multiple Choice Questions

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

B. Fill in the Blanks

1. Pests
2. Drip
3. Fertilisers
4. Rotation
5. Fertility
6. Predators
7. Cool
8. Natural
9. Cover
10. Erosion

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C. State Whether the Following Statements are True or False.

1. False
2. True
3. True
4. False
5. False

Session 2: Organic Cultivation Practices for Flower Crops

A. Multiple Choice Questions

1. b
2. b
3. a
4. c
5. b
6. c
7. c
8. a

B. Fill in the Blanks

1. Queen
2. Budding
3. Larger
4. Seeds
5. Terminal
6. Cut
7. Floriculture
8. Chrysanthemum
9. Pruning

C. State Whether the Following Statements are True or False.

1. True
2. False
3. False
4. True
5. False

Session 3: Principles and Practices of Protected Cultivation

A. Multiple Choice Questions

1. c
2. d

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3. d
4. c
5. b
6. b
7. b
8. b
9. b
10. b

B. Fill in the Blanks

1. Growing
2. Optimal
3. Shade net
4. UV stabilised

C. State Whether the Following Statements are True or False

1. False
2. False
3. True
4. True
5. False

Glossary

Agricultural Practices: Techniques and activities involved in the cultivation of crops and livestock management to produce food, fibre, and other agricultural products.

Annual Crops: Crops that complete their life cycle within one growing season, dying after seed production.

Biennial Crops: Crops that require two growing seasons to complete their life cycle, with vegetative growth in the first season and flowering in the second.

Biodiversity: The variety of life forms in a given ecosystem, including different species of plants and animals, is crucial for sustainable agriculture.

Cash Crops: Non-food crops grown for commercial value, including cotton and sugarcane.

Cereals: Grasses cultivated for their edible grains, such as rice, wheat, and maize.

Clayey soil: Fine-textured soil with small particles, high water retention, poor drainage, and rich in nutrients.

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Compost: A mixture of organic materials used to enrich soil, created through the decomposition of plant and animal matter.

Cropping Patterns: Strategies for planting crops, including mono cropping, multiple cropping, intercropping, and crop rotation, aimed at optimising land use and productivity.

Crop Rotation: Alternating the types of crops grown in a specific area across different growing seasons to maintain soil health and prevent pest cycles.

Field Crops: Crops grown on a large scale in open fields for food, fibre, and other uses, such as rice, wheat, and cotton.

Farming Systems: Various approaches to agriculture, categorised based on production scale and purpose, such as subsistence farming, commercial farming, mixed farming, and organic farming.

Fresh Water Management: Techniques for efficiently using water in agriculture, including irrigation methods like drip irrigation and rainwater harvesting.

Green Manure: Cover crops that are grown to improve soil fertility and are later tilled back into the soil.

Inoculum: It refers to a substance containing microorganisms or cells used to introduce or propagate these organisms in a new environment, such as in fermentation, vaccination, or laboratory experiments.

Life Span: The duration of a plant's life cycle, often classified into annual, biennial, and perennial categories.

Loamy soil: Balanced mixture of sand, silt, and clay, offering good drainage, aeration, water retention, and nutrient content.

Mole drain: It is a narrow, shallow tunnel created underground to improve soil drainage and prevent waterlogging in fields.

Mono Cropping: Growing a single crop in a given area, often leading to higher yields but potentially exhausting soil nutrients.

Multiple Cropping: Growing two or more crops in the same field during a single growing season.

Nutrient Management: The process of managing soil nutrients to ensure optimal crop growth and sustainability.

Oilseeds: Crops grown for oil extraction, such as soybean and sunflower.

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Organic Farming: A holistic production management system that enhances agro-ecosystem health and emphasises the use of management practices over synthetic materials.

Organic Manures: Natural fertilisers derived from plant or animal materials used to improve soil health and provide nutrients to crops.

Pest Management: Strategies for controlling pests through natural or organic methods, such as using neem oil, intercropping, and biological pest control.

Perennial Crops: Crops that live for more than two years, often producing seeds or fruits each year without dying after reproduction.

Pulses: Leguminous crops grown primarily for their seeds, which are high in protein. Examples include lentils, beans, and chickpeas.

Resource fragile: It refers to a situation or area that has limited natural resources and is highly vulnerable to environmental or economic stress.

Seed Selection: The process of choosing seeds that are well-suited to local conditions, resistant to pests, and suitable for organic farming practices.

Soil Fertility: The capacity of soil to provide essential nutrients to plants, influenced by organic matter, pH, and soil structure.

Soil Preparation: The process of preparing the soil for planting crops, often involving tillage, composting, and other methods to enhance fertility.

Vermicomposting: The process of using earthworms to decompose organic waste, producing nutrient-rich vermicompost.

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