La-Net

CPS 303

Crop Pests and Diseases

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Course code: CPS 303

Course title: Crop Pests and Diseases

Course credit load: 2 Units

Series 1: Definition And Classification of Crop Pests and Diseases

Part 1.1 Definition of crop pests and diseases

1.1.1 Meaning of pests

1.1.2 Meaning of diseases

1.1.3 Distinction between pests and diseases

Part 1.2 Classification of crop pests

1.2.1 Insect pests

1.2.2 Vertebrate pests

1.2.3 Other pest categories (nematodes, mites, etc.)

Part 1.3 Classification of crop diseases

1.3.1 Fungal diseases

1.3.2 Viral diseases

1.3.3 Bacterial diseases

1.3.4 Nematode infestations

Part 1.4 Importance of definitions and classifications in crop protection

1.4.1 Role in identification

1.4.2 Role in diagnosis and management

1.4.3 Role in integrated pest management

Introduction

Background In every crop production field, farmers encounter a wide range of organisms that either damage plants directly or cause diseases that reduce yield. These organisms occur naturally and form part of the agricultural environment. To manage them effectively, it is essential to first define what we mean by pests and diseases, and then classify them according to their characteristics. This Series sets the foundation for the rest of the course by helping you recognise the basic concepts and categories involved.

Series aim the aim of this Series is to introduce you to the definitions and classifications of crop pests and diseases, and to equip you with the knowledge needed to identify them and appreciate their significance in crop protection.

Series synopsis We shall commence this Series by defining crop pests and diseases, and distinguishing between the two. Next, we will classify crop pests into categories such as insects, vertebrates, and other groups. Following that, we will classify crop diseases into fungal, viral, bacterial, and nematode types. Finally, we will wrap up by examining why these definitions and classifications are important for identification, diagnosis, and integrated management in crop protection.

Series learning outcomes

Upon completing this Series, you should be able to:

SLO 1.1 define crop pests and crop diseases,

SLO 1.2 explain the distinction between pests and diseases,

SLO 1.3 classify crop pests into major categories such as insects, vertebrates, and other groups,

SLO 1.4 classify crop diseases into fungal, viral, bacterial, and nematode types,

SLO 1.5 analyse the importance of definitions and classifications in crop protection and integrated pest management.

1.1 Definition of Crop Pests and Diseases

1.1.1 Meaning of pests

A **pest** is any organism that causes damage to crops, either by feeding on them directly or by interfering with their growth and productivity. Pests may include insects, vertebrates such as rodents and birds, or other small organisms like mites and nematodes. They are considered harmful because they reduce yield, lower quality, and increase production costs.

Pests are defined as organisms that cause _____ to crops, reducing yield and quality.

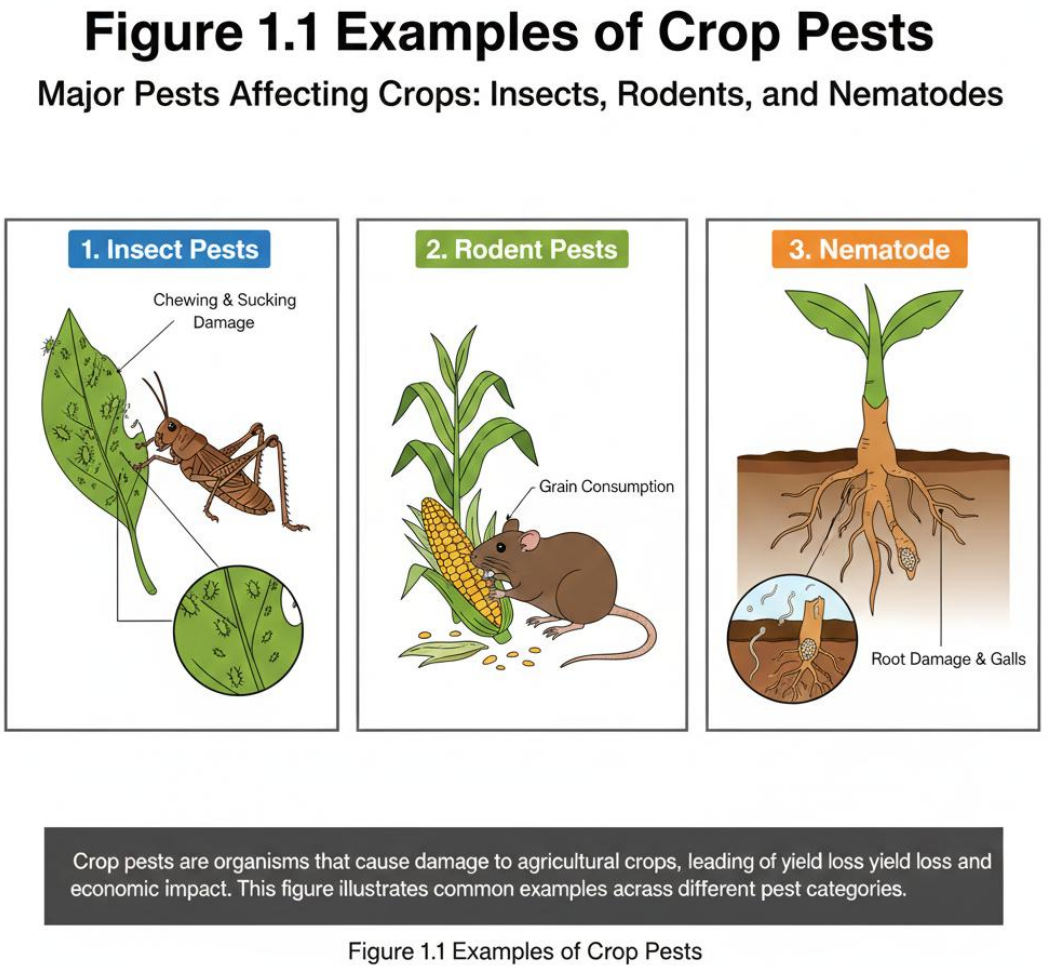

Figure 1.1 Examples of crop pests

1.1.2 Meaning of diseases

A **disease** in crops refers to any abnormal condition that disrupts the normal functioning of plant tissues, usually caused by pathogens such as fungi, bacteria,

viruses, or nematodes. Diseases manifest through symptoms like wilting, leaf spots, blights, or rots, and they often spread rapidly under favourable environmental conditions.

Crop diseases are abnormal conditions caused by _____ such as fungi, bacteria, viruses, or nematodes.

Plate 1.1 Symptoms of crop diseases

A close-up view illustrating common crop disease symptoms including lspts, wiliting, and blight, leading to plant damage and yield loss.

Plate 1.1 Symptoms of crop diseases

Plate 1.1 Symptoms of crop diseases

1.1.3 Distinction between pests and diseases

It is important to distinguish between pests and diseases. **Pests** are living organisms that physically attack crops, while **diseases** are conditions caused by pathogens that disrupt plant physiology. For example, an insect chewing maize leaves is a pest, whereas a fungal infection causing leaf blight is a disease. Recognising this distinction helps farmers apply the correct management strategies.

Pests are living organisms that attack crops, while diseases are _____ caused by pathogens that disrupt plant physiology.

Box 1.1 Distinction between pests and diseases

Aspect	Pests	Diseases
Nature	Living organisms	Abnormal conditions caused by pathogens
Examples	Insects, rodents, mites	Fungal blight, bacterial wilt, viral mosaic
Mode of damage	Physical feeding or destruction	Physiological disruption of tissues

Pilot questions 1.1

Define the term pest in crop production.

What is meant by crop disease?

Give two examples of organisms considered as pests.

Mention two common symptoms of crop diseases.

State one key distinction between pests and diseases.

1.2 Classification of Crop Pests

1.2.1 Insect pests

Insect pests are small arthropods that feed on crops, causing direct damage to leaves, stems, roots, or fruits. Examples include stem borers in maize, aphids in vegetables, and bollworms in cotton. They are often the most destructive group of pests due to their rapid reproduction and wide distribution.

Insect pests are small arthropods that feed on crops, causing _____ damage to plant parts.

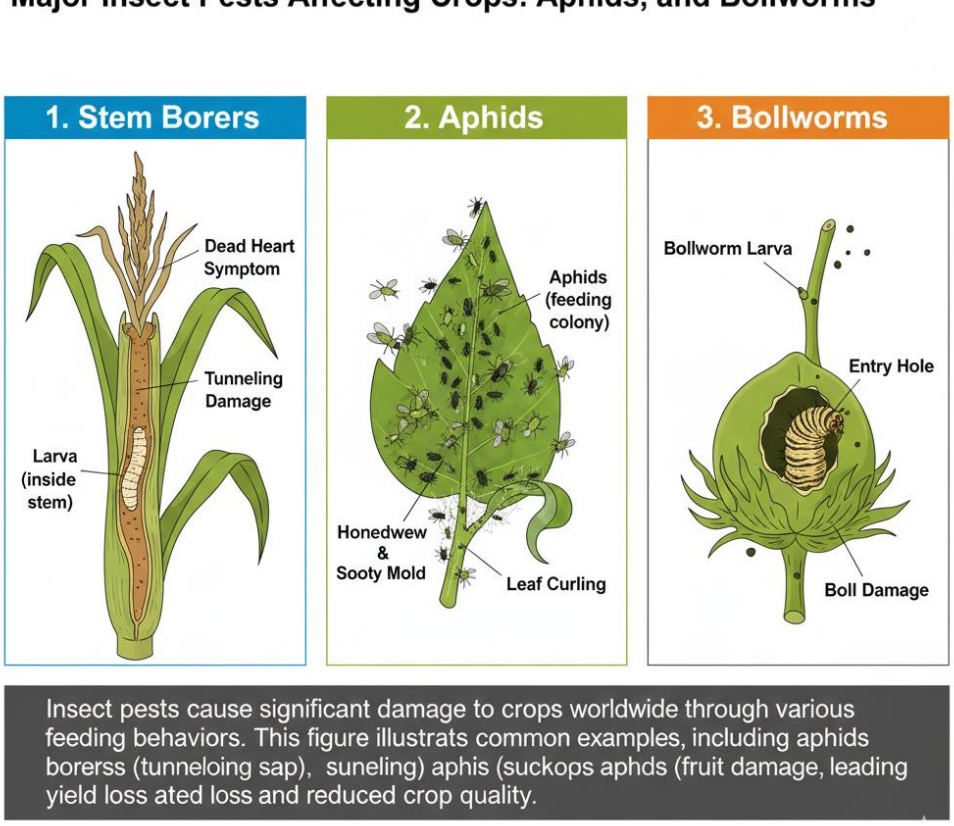

Figure 1.2 Common insect pests of crops

1.2.2 Vertebrate pests

Vertebrate pests include animals such as rodents, birds, and monkeys that feed on crops or destroy them during feeding. Rodents may gnaw at stored grains, while birds can damage standing crops by feeding on seeds or fruits. Vertebrate pests are significant because they cause both field and storage losses.

Vertebrate pests include animals such as _____, birds, and monkeys that damage crops in the field or storage.

Plate 1.2 Vertebrate pests affecting crops

1.2.3 Other pest categories

Other categories of pests include **nematodes**, which are microscopic worms that attack plant roots, and **mites**, which damage leaves and stems. These pests are less visible but can cause severe yield losses by weakening plants and making them more susceptible to diseases.

Other categories of pests include nematodes and _____, which damage plant roots and leaves respectively.

Box 1.2 Other categories of crop pests

Pest Category	Description	Common Examples	Typical Damage Symptoms
Nematodes	Microscopic, worm-like organisms that live in the soil or within plant tissues. Often called "roundworms."	Root-knot nematode, Cyst nematode, Lesion nematode.	Stunted growth, yellowing leaves, and characteristic **galls or knots** on roots that prevent water uptake.
Mites	Tiny, eight-legged arachnids (related to spiders). Usually found on the undersides of leaves.	Red spider mite, Broad mite, Rust mite.	**Fine webbing** on leaves, silvery or bronze speckling (stippling), and leaf curling or premature drop.

Pilot questions 1.2

Define insect pests and give two examples.

Mention two vertebrate pests that damage crops.

State one-way rodents affect stored grains.

Identify two other categories of crop pests apart from insects and vertebrates.

What type of damage does nematodes cause to crops?

1.3 Classification of Crop Diseases

1.3.1 Fungal diseases

Fungal diseases are caused by fungi that invade plant tissues, leading to symptoms such as leaf spots, blights, wilts, and rots. Examples include rice blast, maize leaf blight, and groundnut leaf spot.

Fungal diseases are caused by _____ that invade plant tissues, producing symptoms such as leaf spots and wilts.

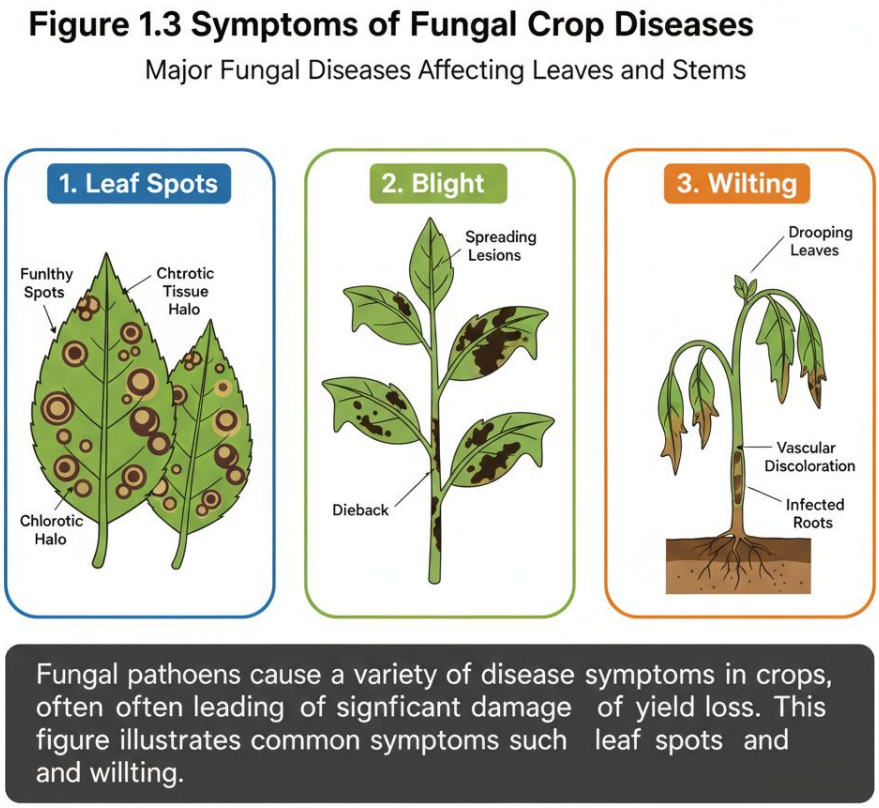

Figure 1.3 Symptons of fungal crop diseases

Figure 1.3 Symptoms of fungal crop diseases

1.3.2 Viral diseases

Viral diseases are caused by viruses that interfere with plant metabolism. They often result in mosaic patterns, leaf curling, and stunted growth. Examples include cassava mosaic disease and maize streak virus.

Viral diseases often result in mosaic patterns, leaf curling, and _____ growth in crops.

Plate 1.3 Viral disease symptoms in crops

Cassava Mosaic Disease (CMD) with characteristic mosaic leaf patterns

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Plate 1.3 Viral disease symptoms in crops

1.3.3 Bacterial diseases

Bacterial diseases are caused by bacteria that infect plant tissues, leading to wilts, blights, and soft rots. Examples include bacterial wilt in tomato and blight in rice.

Bacterial diseases are caused by _____ that infect plant tissues, leading to wilts and rots.

Box 1.3 Examples of bacterial crop diseases

Disease Name	Causative Bacteria	Primary Symptoms
Bacterial Wilt	*Ralstonia solanacearum*	Sudden drooping and **wilting of the entire plant** while leaves remain green; internal browning of the stem.
Bacterial Blight	*Xanthomonas spp.*	Water-soaked spots on leaves that turn brown or yellow; often leads to **large necrotic (dead) patches** on foliage.
Bacterial Canker	*Clavibacter michiganensis*	Yellowing of leaf margins ("firing") and **sunken, crusty lesions** or cracks on stems and fruit.
Black Rot	*Xanthomonas campestris*	**V-shaped yellow lesions** starting from leaf margins, moving inward toward the veins; veins turn black.
Crown Gall	*Agrobacterium tumefaciens*	Large, **woody tumor-like swellings** (galls) at the base of the plant or on the roots.

1.3.4 Nematode infestations

Nematode infestations occur when microscopic worms attack plant roots, causing root galls, poor nutrient uptake, and stunted growth. Root-knot nematodes are common examples.

Nematode infestations cause root galls, poor nutrient uptake, and _____ growth in crops.

Figure 1.4 Nemtoode Infstations in Crop Roots: Illustration of Root-Knot Nomode Damage

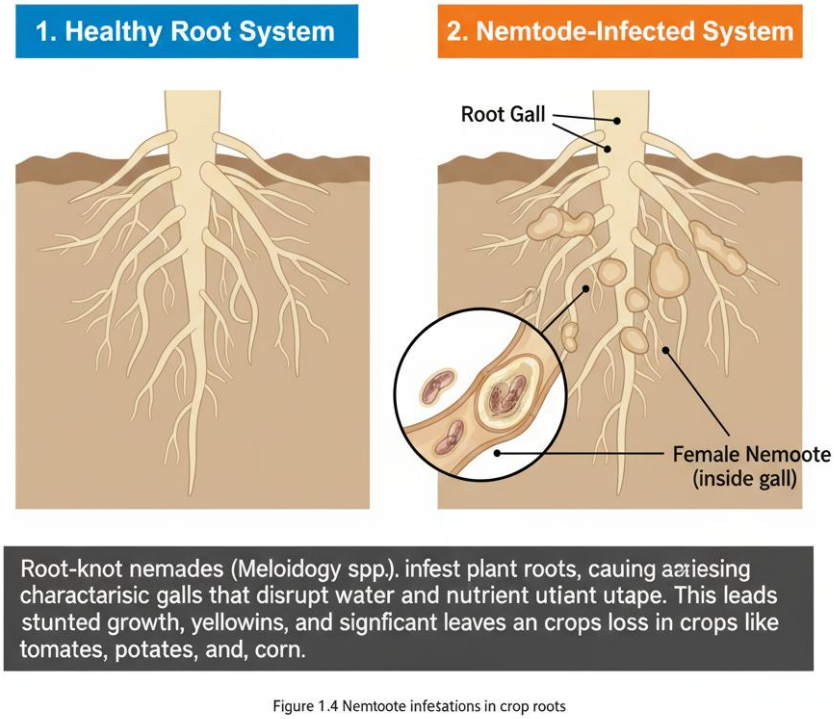


Figure 1.4 Nematode infestations in crop roots

Pilot questions 1.3

Give two examples of fungal crop diseases.

What are the common symptoms of viral diseases?

Mention one bacterial disease of tomato.

What damage do nematodes cause to crop roots?

State one example of a viral disease in cassava.

1.4 Importance of Definitions and Classifications in Crop Protection

1.4.1 Role in identification

Definitions and classifications help farmers and researchers correctly identify pests and diseases. Accurate identification is the first step in effective crop protection.

Correct identification of pests and diseases is the first step in effective _____ protection.

1.4.2 Role in diagnosis and management

Classifying pests and diseases allows for proper diagnosis of crop problems and guides the choice of management strategies. For example, fungal diseases may require fungicides, while insect pests may require insecticides or biological control.

Classifying pests and diseases allows for proper diagnosis and guides the choice of _____ strategies.

Table 1.1 Importance of classification in crop protection

Reason for Classification	**Importance in Crop Protection**	**Practical Examples**
Host Specificity	Many pests and pathogens only attack specific families or species. Classification helps identify potential "targets."	**Clubroot disease** primarily affects the *Brassicaceae* family (cabbage, broccoli). Knowing this prevents planting susceptible crops in infected soil.
Pesticide Selection	Herbicide and insecticide labels are often categorized by crop type to prevent phytotoxicity (plant damage).	Some herbicides are safe for **Monocots** (grasses) but will kill **Dicots** (broadleaf plants). Classification ensures the right chemical is used.

Reason for Classification	Importance in Crop Protection	Practical Examples
Integrated Pest Management (IPM)	Helps in designing **crop rotation** cycles to break the life cycles of soil-borne pests.	Rotating **Legumes** (which fix nitrogen) with **Cereals** (like maize) prevents the buildup of cereal-specific stem borers.
Quarantine & Regulation	Governments use classification to restrict the movement of specific "host" plants to prevent the spread of invasive species.	Restricting the transport of **Citrus** species to prevent the spread of Citrus Greening disease across borders.
Resistance Breeding	Related species often share genetic traits. Scientists look at wild relatives in the same genus to find resistance genes.	Using wild **Solanum** (potato) species to breed resistance against Late Blight into commercial potato varieties.
Predicting Life Cycles	Knowing if a crop is **annual, biennial, or perennial** helps determine the timing of protection measures.	Perennial crops like **Mangoes** require long-term fungal management, whereas annuals like **Beans** require protection mainly during the seedling stage.

1.4.3 Role in integrated pest management

Definitions and classifications are essential for **integrated pest management (IPM)**, which combines cultural, biological, and chemical methods to control pests and diseases sustainably. Without clear classification, IPM strategies cannot be effectively designed or implemented.

Integrated pest management combines cultural, biological, and _____ methods to control pests and diseases sustainably.

Box 1.4 Importance of definitions and classifications in IPM

Climatic Factor	Description	Influence on Crop Growth & Management
Photoperiod	The duration of daily exposure to light (day length).	Influences the transition from vegetative growth to flowering. "Short-day" crops like **Sorghum** flower as days get shorter, while "long-day" crops like **Wheat** require longer light periods.
Wind	The movement of air at various speeds.	Moderate wind helps in pollination (maize) and CO2 exchange. High winds cause **lodging** (breaking of stems), physical damage to leaves, and increased soil moisture evaporation.
Relative Humidity	The amount of moisture present in the air.	High humidity encourages the spread of fungal and bacterial diseases (e.g., blights). Low humidity increases **transpiration** rates, potentially leading to wilting if water is scarce.
Solar Radiation	The intensity and quality of sunlight.	The primary energy source for **photosynthesis**. It determines the accumulation of dry matter and final grain or tuber yield. Shading significantly reduces yield in most arable crops.

Climatic Factor	Description	Influence on Crop Growth & Management
Altitude	The height of the land above sea level.	Higher altitudes typically have cooler temperatures and different light intensities. This allows for the cultivation of "temperate" crops in tropical regions (e.g., wheat or Irish potatoes in the Jos Plateau, Nigeria).

Pilot questions 1.4

Why is identification important in crop protection?

How does classification help in diagnosis of crop problems?

Give one example of a management strategy for fungal diseases.

What does IPM stand for?

State one reason why definitions and classifications are important for IPM.

Series summary

This Series has introduced you to the fundamental definitions and classifications of crop pests and diseases, setting the stage for effective crop protection. We began by defining pests as organisms that damage crops and diseases as abnormal conditions caused by pathogens. Then we classified pests into insects, vertebrates, and other categories such as nematodes and mites. Following that, we examined crop diseases, grouping them into fungal, viral, bacterial, and nematode infestations. Finally, we discussed why definitions and classifications are important, particularly for identification, diagnosis, and integrated pest management.

By completing this Series, you should now be able to define pests and diseases, explain their distinctions, classify them into major categories, and analyse the importance of these classifications in crop protection. These abilities directly align

with the Series Learning Outcomes, ensuring you are well prepared to progress into later Series that explore specific pests, diseases, and their management.

Glossary of terms

Bacterial diseases: Crop diseases caused by bacteria, leading to symptoms such as wilts, blights, and rots.

Disease: An abnormal condition in plants caused by pathogens such as fungi, bacteria, viruses, or nematodes.

Fungal diseases: Crop diseases caused by fungi, producing symptoms like leaf spots, blights, and wilts.

Integrated pest management (IPM): A sustainable approach to controlling pests and diseases using cultural, biological, and chemical methods.

Insect pests: Small arthropods that feed on crops, causing direct damage to plant parts.

Mites: Tiny arthropods that damage crops by feeding on leaves and stems.

Nematodes: Microscopic worms that attack plant roots, causing galls and stunted growth.

Pest: Any organism that damages crops, reducing yield and quality.

Vertebrate pests: Larger animals such as rodents and birds that damage crops in the field or storage.

Viral diseases: Crop diseases caused by viruses, often resulting in mosaic patterns, leaf curling, and stunted growth.

Concept check questions [Series 1]

Objective questions

Define a pest in crop production. (Linked to SLO 1.1)

Which pathogen group causes mosaic patterns in crops? (Linked to SLO 1.4)

State one example of a vertebrate pest. (Linked to SLO 1.3)

What does IPM stand for? (Linked to SLO 1.5)

Which group of pests includes root-knot nematodes? (Linked to SLO 1.3)

Short-answer questions

Explain the difference between a pest and a disease. (Linked to SLO 1.2)

Mention two examples of fungal crop diseases. (Linked to SLO 1.4)

Describe one-way rodents affect stored grains. (Linked to SLO 1.3)

State one reason why classification is important in crop protection. (Linked to SLO 1.5)

Identify one bacterial disease of tomato. (Linked to SLO 1.4)

Long-answer questions

Analyse the importance of definitions and classifications in crop protection. (Linked to SLO 1.5)

Evaluate the categories of crop pests and explain their significance. (Linked to SLO 1.3)

Discuss the main types of crop diseases and their symptoms. (Linked to SLO 1.4)

Answers to concept check questions [Series 1]

Objective answers

A pest is any organism that damages crops.

Viruses.

Rodents or birds.

Integrated pest management.

Nematodes.

Short-answer answers

Pests are living organisms that attack crops, while diseases are abnormal conditions caused by pathogens.

Rice blast, maize leaf blight.

Rodents gnaw at stored grains, reducing quantity and quality.

Classification ensures accurate identification and guides management strategies.

Bacterial wilt.

Long-answer answers

Basic response: Definitions and classifications help identify pests and diseases, diagnose problems, and guide management. *Value-added response*: They also support integrated pest management, breeding programmes, and sustainable agriculture.

Basic response: Crop pests include insects, vertebrates, nematodes, and mites, each causing specific damage. *Value-added response*: Understanding categories allows targeted control, reduces losses, and improves crop protection strategies.

Basic response: Crop diseases include fungal, viral, bacterial, and nematode infestations, each with distinct symptoms. *Value-added response*: Recognising symptoms helps farmers apply appropriate treatments and prevent spread, ensuring food security.

Answers to pilot questions [Series 1]

Pilot questions 1.1

A pest is any organism that damages crops.

A crop disease is an abnormal condition caused by pathogens.

Examples: stem borers, aphids.

Symptoms: wilting, leaf spots.

Distinction: pests attack physically, diseases disrupt physiology.

Pilot questions 1.2

Insect pests are small arthropods; examples: bollworms, aphids.

Vertebrate pests: rodents, birds.

Rodents gnaw stored grains.

Other categories: nematodes, mites.

Nematodes cause root galls.

Pilot questions 1.3

Examples: rice blast, maize leaf blight.

Symptoms: mosaic patterns, leaf curling.

Tomato bacterial wilt.

Nematodes cause root galls and stunted growth.

Cassava mosaic disease.

Pilot questions 1.4

Identification ensures correct crop protection.

Classification guides diagnosis.

Example: fungicides for leaf spot.

IPM stands for integrated pest management.

Importance: ensures sustainable and effective control.

References and attributions [Series 1]

Figure 1.1 Examples of crop pests: Suggested AI prompt "Generate a labelled diagram showing insect pests, rodents, and nematodes affecting crops."

Plate 1.1 Symptoms of crop diseases: Suggested AI prompt "Generate an image showing crop plants with leaf spots, wilting, and blight symptoms."

Box 1.1 Distinction between pests and diseases: Suggested AI prompt "Generate a box comparing crop pests and crop diseases with examples."

Figure 1.2 Common insect pests of crops: Suggested AI prompt "Generate a labelled diagram showing stem borers, aphids, and bollworms as crop pests."

Plate 1.2 Vertebrate pests affecting crops: Suggested AI prompt "Generate an image showing rodents eating stored grains and birds feeding on standing crops."

Box 1.2 Other categories of crop pests: Suggested AI prompt "Generate a box summarising nematodes and mites as crop pests with examples."

Figure 1.3 Symptoms of fungal crop diseases: Suggested AI prompt "Generate a diagram showing leaf spots, blight, and wilting caused by fungal infections."

Plate 1.3 Viral disease symptoms in crops: Suggested AI prompt "Generate an image showing cassava mosaic disease with mosaic leaf patterns."

Box 1.3 Examples of bacterial crop diseases: Suggested AI prompt "Generate a box listing bacterial crop diseases with symptoms."

Figure 1.4 Nematode infestations in crop roots: Suggested AI prompt "Generate a diagram showing root galls caused by nematode infestations in crops."

Table 1.1 Importance of classification in crop protection: Suggested AI prompt "Create a table showing importance of classification in crop protection with examples."

Box 1.4 Importance of definitions and classifications in IPM: Suggested AI prompt "Generate a box summarising importance of definitions and classifications in IPM."

Series 2: Major Pests of Tropical Crops

Part 2.1 Insect pests of tropical crops

2.1.1 Field insect pests (e.g. stem borers, leaf miners)

2.1.2 Storage insect pests (e.g. weevils, beetles)

Part 2.2 Vertebrate pests of tropical crops

2.2.1 Rodents

2.2.2 Birds

2.2.3 Other vertebrates (e.g. monkeys, bats)

Part 2.3 Nematode pests of tropical crops

2.3.1 Root-knot nematodes

2.3.2 Other nematode infestations

Part 2.4 Mite and miscellaneous pests of tropical crops

2.4.1 Mites

2.4.2 Other minor but significant pests

Introduction

Background In tropical agriculture, farmers face a wide range of pests that attack crops both in the field and in storage. These pests reduce yield, lower quality, and increase production costs. Understanding the major categories of tropical crop pests is crucial for effective crop protection and food security.

Series aim the aim of this Series is to introduce you to the major pests of tropical crops, highlighting their types, examples, and the damage they cause.

Series synopsis We shall commence this Series by examining insect pests of tropical crops, focusing on those that attack in the field and in storage. Next, we will explore vertebrate pests such as rodents, birds, and other animals that damage crops. Following that, we will consider nematode pests, particularly root-knot nematodes and other infestations. Finally, we will wrap up by discussing mites and miscellaneous pests that, although less prominent, still contribute significantly to crop losses.

Series learning outcomes

Upon completing this Series, you should be able to:

SLO 2.1 describe the major insect pests of tropical crops and explain the damage they cause,

SLO 2.2 identify vertebrate pests of tropical crops and analyse their impact on crop production,

SLO 2.3 explain the role of nematode pests in tropical crop damage,

SLO 2.4 classify mites and other miscellaneous pests and evaluate their significance in crop protection.

2.1 Insect Pests of Tropical Crops

2.1.1 Field insect pests

Field insect pests are insects that attack crops while they are growing in the field. They feed on leaves, stems, roots, or reproductive structures, reducing photosynthesis and yield. Examples include stem borers in maize, leaf miners in vegetables, and bollworms in cotton. These pests are often seasonal and their damage is influenced by environmental conditions.

Field insect pests are insects that attack crops while they are growing in the _____.

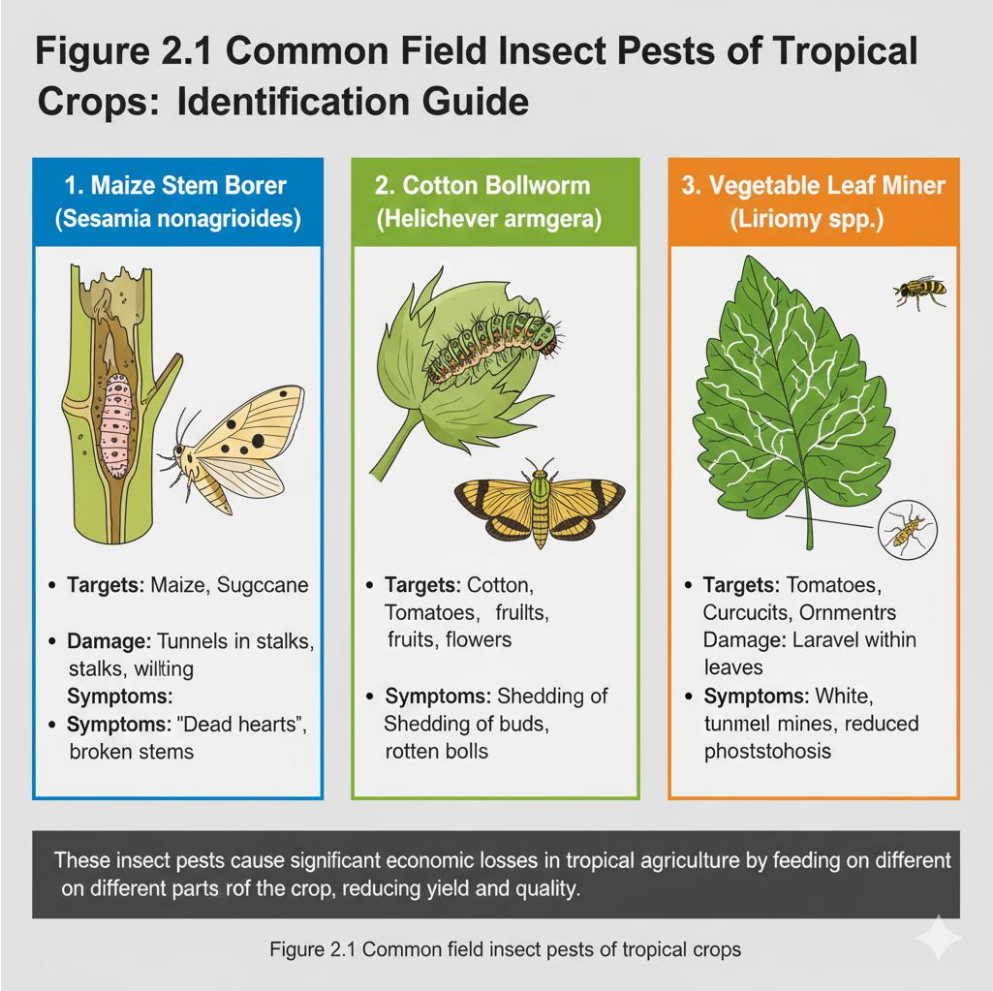


Figure 2.1 Common field insect pests of tropical crops

Damage symptoms

Stem borers: tunnelling inside stems, causing wilting and poor grain filling.

Leaf miners: creating winding trails inside leaves, reducing photosynthetic area.

Bollworms: feeding on cotton bolls, reducing fibre quality and yield.

Stem borers cause tunnelling inside stems, while bollworms feed on _____, reducing fibre quality.

2.1.2 Storage insect pests

Storage insect pests are insects that attack crops after harvest, particularly in storage facilities. They reduce both the quantity and quality of stored produce. Common examples include weevils in maize and cowpea, and beetles in stored

grains. These pests are especially problematic because they continue to reproduce in storage, leading to cumulative losses.

Storage insect pests attack crops after _____, reducing both quantity and quality of stored produce.

Plate 2.1 Storage insect pests of tropical crops

Damage symptoms

Weevils: bore holes in grains, leaving powdery residues.

Beetles: feed on stored seeds, reducing viability.

Moths: larvae feed on stored produce, contaminating with webbing.

Weevils bore holes in grains, leaving _____ residues that reduce quality.

Box 2.1 Distinction between field and storage insect pests

Aspect	Field insect pests	Storage insect pests
Stage of attack	Growing crops in the field	Harvested crops in storage
Examples	Stem borers, leaf miners, bollworms	Weevils, beetles, moths
Type of damage	Reduced photosynthesis, poor grain filling	Loss of stored produce, reduced seed viability

Pilot questions 2.1

Define field insect pests and give two examples.

What type of damage do stem borers cause in maize?

Mention two examples of storage insect pests.

State one symptom of damage caused by weevils in stored grains.

Distinguish between field and storage insect pests.

2.2 Vertebrate Pests of Tropical Crops

2.2.1 Rodents

Rodents are small mammals such as rats and mice that feed on crops both in the field and in storage. They gnaw at stems, roots, and stored grains, causing significant losses. Their rapid reproduction makes them difficult to control.

Rodents are small mammals that feed on crops both in the _____ and in storage.

Plate 2.2 Rodents as vertebrate pests of tropical crops

2.2.2 Birds

Birds such as sparrows, starlings, and parrots damage crops by feeding on seeds, fruits, and young plants. They are particularly destructive in cereal fields where they consume ripening grains.

Birds damage crops by feeding on _____, fruits, and young plants.

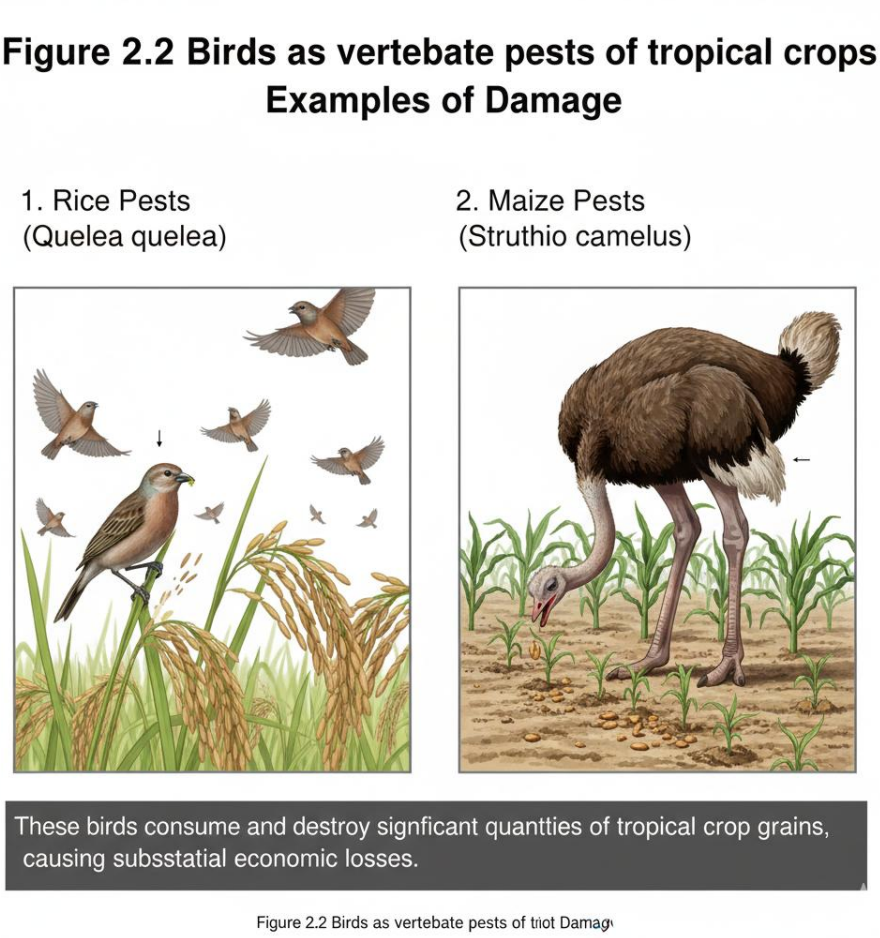


Figure 2.2 Birds as vertebrate pests of tropical crops

2.2.3 Other vertebrates

Other vertebrate pests include **monkeys**, which raid fruit crops, and **bats**, which damage fruits such as mango and banana. These pests are less common but can cause severe localised damage.

Other vertebrate pests include monkeys and _____, which damage fruit crops such as mango and banana.

Box 2.2 Examples of vertebrate pests of tropical crops

Pest type	Example	Damage caused
Rodents	Rats, mice	Gnawing stems, roots, stored grains
Birds	Sparrows, starlings	Feeding on seeds and fruits
Others	Monkeys, bats	Raiding fruit crops

Pilot questions 2.2

Define vertebrate pests and give two examples.

What type of damage does rodents cause to crops?

Mention two bird species that damage cereal crops.

State one fruit crop commonly raided by monkeys.

Distinguish between rodents and birds as crop pests.

2.3 Nematode Pests of Tropical Crops

2.3.1 Root-knot nematodes

Root-knot nematodes are microscopic worms that attack plant roots, causing galls, poor nutrient uptake, and stunted growth. They are among the most damaging nematode pests in tropical agriculture.

Root-knot nematodes attack plant _____, causing galls and poor nutrient uptake.

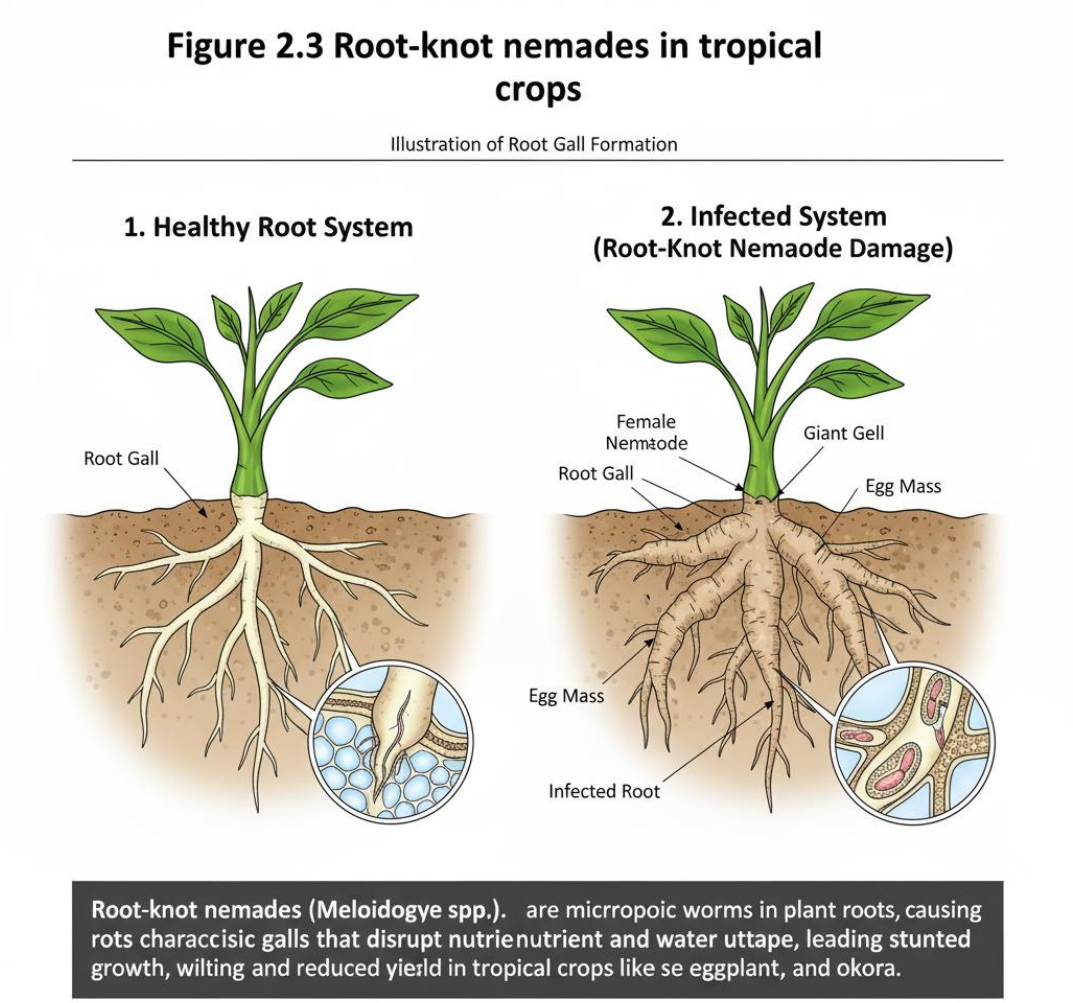


Figure 2.3 Root-knot nematodes in tropical crops

2.3.2 Other nematode infestations

Other nematodes include **cyst nematodes** and **lesion nematodes**, which damage roots and reduce crop vigour. Their presence often predisposes crops to secondary infections by fungi and bacteria.

Other nematodes such as cyst nematodes and lesion nematodes damage _____ and reduce crop vigour.

Box 2.3 Examples of nematode pests of tropical crops

Pest type	Example	Damage caused
Root-knot nematodes	Meloidogyne spp.	Root galls, stunted growth
Cyst nematodes	Heterodera spp.	Reduced nutrient uptake
Lesion nematodes	Pratylenchus spp.	Root lesions, poor vigour

Pilot questions 2.3

Define nematode pests in tropical crops.

What damage do root-knot nematodes cause?

Mention two other nematode pests apart from root-knot nematodes.

State one effect of lesion nematodes on crop roots.

Why are nematode infestations particularly harmful to crops?

2.4 Mite and Miscellaneous Pests of Tropical Crops

2.4.1 Mites

Mites are tiny arthropods that feed on crop leaves and stems, causing yellowing, reduced photosynthesis, and poor growth. Spider mites are common in vegetables and fruit crops.

Mites feed on crop leaves and stems, causing _____ and reduced photosynthesis.

Plate 2.3 Mites as pests of tropical crops

2.4.2 Other minor but significant pests

Other minor pests include **grasshoppers**, which feed on leaves, and **termites**, which damage stems and roots. Although less prominent, these pests can cause serious localised damage if uncontrolled.

Other minor pests include grasshoppers and _____, which damage stems and roots.

Box 2.4 Miscellaneous pests of tropical crops

Pest type	Example	Damage caused
Mites	Spider mites	Leaf yellowing, reduced photosynthesis
Grasshoppers	Locusts	Feeding on leaves
Termites	Macrotermes spp.	Stem and root damage

Pilot questions 2.4

Define mites as crop pests.

What damage do spider mites cause to crop leaves?

Mention two examples of miscellaneous pests of tropical crops.

State one effect of termites on crop stems.

Why are miscellaneous pests considered significant despite being minor?

Series summary

This Series has explored the major pests that affect tropical crops, highlighting their categories, examples, and the damage they cause. We began with insect pests, distinguishing between those that attack crops in the field and those that damage produces in storage. Then we examined vertebrate pests such as rodents, birds, and other animals that feed on crops and fruits. Following that, we studied nematode pests, focusing on root-knot nematodes and other infestations that weaken plant roots. Finally, we considered mites and miscellaneous pests, including grasshoppers and termites, which although less prominent, still contribute significantly to crop losses.

By completing this Series, you should now be able to describe insect pests and their damage, identify vertebrate pests and analyse their impact, explain the role of nematode pests, and classify mites and other miscellaneous pests while evaluating their significance. These abilities directly align with the Series Learning Outcomes and provide you with a strong foundation for understanding pest problems in tropical agriculture.

Glossary of terms

Beetles: Insects that feed on stored grains and seeds, reducing their viability.

Birds: Vertebrate pests such as sparrows and starlings that feed on seeds, fruits, and young plants.

Bollworms: Insect pests that feed on cotton bolls, reducing fibre quality and yield.

Grasshoppers: Insects that feed on crop leaves, sometimes causing widespread defoliation.

Mites: Tiny arthropods that feed on crop leaves and stems, causing yellowing and reduced photosynthesis.

Monkeys: Vertebrate pests that raid fruit crops such as mango and banana.

Nematodes: Microscopic worms that attack plant roots, causing galls and poor growth.

Rodents: Small mammals such as rats and mice that damage crops in the field and storage.

Stem borers: Insect pests that tunnel inside stems, causing wilting and poor grain filling.

Termites: Insects that damage stems and roots, weakening crop plants.

Weevils: Storage insect pests that bore holes in grains, leaving powdery residues.

Concept check questions [Series 2]

Objective questions

Define insect pests of tropical crops. (Linked to SLO 2.1)

Which vertebrate pest commonly damages stored grains? (Linked to SLO 2.2)

State one example of a nematode pest. (Linked to SLO 2.3)

What type of pest is a spider mite? (Linked to SLO 2.4)

Which insect pest feeds on cotton bolls? (Linked to SLO 2.1)

Short-answer questions

Explain the difference between field insect pests and storage insect pests. (Linked to SLO 2.1)

Mention two examples of bird pests in tropical crops. (Linked to SLO 2.2)

Describe one symptom of damage caused by root-knot nematodes. (Linked to SLO 2.3)

State one effect of termites on crop stems. (Linked to SLO 2.4)

Identify one vertebrate pest that raids fruit crops. (Linked to SLO 2.2)

Long-answer questions

Analyse the impact of vertebrate pests on tropical crop production. (Linked to SLO 2.2)

Evaluate the significance of nematode pests in tropical agriculture. (Linked to SLO 2.3)

Discuss the importance of recognising mites and miscellaneous pests in crop protection. (Linked to SLO 2.4)

Answers to concept check questions [Series 2]

Objective answers

Insect pests are insects that damage crops in the field or storage.

Rodents.

Root-knot nematodes.

Mite.

Bollworm.

Short-answer answers

Field insect pests attack crops during growth, while storage insect pests damage harvested produce.

Sparrows, starlings.

Root galls and stunted growth.

Termites weaken stems and roots, reducing plant vigour.

Monkeys.

Long-answer answers

Basic response: Vertebrate pests such as rodents and birds reduce yield by feeding on crops and stored produce. *Value-added response*: They also cause economic losses, contaminate food supplies, and require integrated control measures.

Basic response: Nematode pests damage roots, reducing nutrient uptake and crop vigour. *Value-added response*: They predispose crops to secondary infections and are difficult to detect, making them highly significant in tropical agriculture.

Basic response: Mites and miscellaneous pests cause leaf yellowing, stem damage, and localised crop losses. *Value-added response*: Recognising their presence ensures comprehensive pest management and prevents overlooked damage that can accumulate over time.

Answers to pilot questions [Series 2]

Pilot questions 2.1

Field insect pests are insects that attack crops in the field; examples include stem borers and bollworms.

Stem borers tunnel inside stems, causing wilting and poor grain filling.

Storage insect pests include weevils and beetles.

Weevils bore holes in grains, leaving powdery residues.

Field pests attack growing crops, storage pests attack harvested produce.

Pilot questions 2.2

Vertebrate pests include rodents, birds, and monkeys.

Rodents gnaw stems, roots, and stored grains.

Sparrows and starlings damage cereal crops.

Monkeys raid fruit crops such as mango.

Rodents damage stored grains, birds feed on seeds and fruits.

Pilot questions 2.3

Nematode pests are microscopic worms that attack plant roots.

Root-knot nematodes cause root galls and poor nutrient uptake.

Other nematodes include cyst nematodes and lesion nematodes.

Lesion nematodes cause root lesions and poor vigour.

They weaken crops and predispose them to secondary infections.

Pilot questions 2.4

Mites are tiny arthropods that feed on crop leaves and stems.

Spider mites cause leaf yellowing and reduced photosynthesis.

Miscellaneous pests include grasshoppers and termites.

Termites damage stems and roots.

They are significant because they cause localised but serious damage.

References and attributions [Series 2]

Figure 2.1 Common field insect pests of tropical crops: Suggested AI prompt "Generate a labelled diagram showing maize stem borer, cotton bollworm, and vegetable leaf miner."

Plate 2.1 Storage insect pests of tropical crops: Suggested AI prompt "Generate an image showing maize weevils and cowpea weevils damaging stored grains."

Box 2.1 Distinction between field and storage insect pests: Suggested AI prompt "Generate a box comparing field and storage insect pests with examples and damage symptoms."

Plate 2.2 Rodents as vertebrate pests of tropical crops: Suggested AI prompt "Generate an image showing rats feeding on stored grains and damaging crop fields."

Figure 2.2 Birds as vertebrate pests of tropical crops: Suggested AI prompt "Generate a labelled diagram showing birds feeding on rice and maize grains."

Box 2.2 Examples of vertebrate pests of tropical crops: Suggested AI prompt "Generate a box listing vertebrate pests of tropical crops with examples and damage."

Figure 2.3 Root-knot nematodes in tropical crops: Suggested AI prompt "Generate a diagram showing root galls caused by root-knot nematodes in tropical crops."

Box 2.3 Examples of nematode pests of tropical crops: Suggested AI prompt "Generate a box listing nematode pests of tropical crops with examples and damage."

Plate 2.3 Mites as pests of tropical crops: Suggested AI prompt "Generate an image showing spider mites feeding on crop leaves."

Box 2.4 Miscellaneous pests of tropical crops: Suggested AI prompt "Generate a box listing miscellaneous pests of tropical crops with examples and damage."

Series 3: Specific Insect Pests of Major Crops

Part 3.1 Insect pests of cereal crops

3.1.1 Maize stem borers

3.1.2 Rice leaf folders and stem borers

3.1.3 Sorghum shoot flies

Introduction

Background Insect pests are among the most destructive agents in tropical agriculture, attacking crops at different stages of growth and storage. Their impact is felt across cereals, legumes, root and tuber crops, as well as fruits and vegetables. Farmers often struggle with these pests because they reduce yield, lower quality, and increase production costs.

Series aim the aim of this Series is to familiarise you with specific insect pests of major tropical crops, highlighting their examples, symptoms of damage, and their significance in crop production.

Series synopsis We shall commence this Series by examining insect pests of cereal crops such as maize stem borers, rice leaf folders, and sorghum shoot flies. Next, we will explore insect pests of legume crops, including cowpea weevils, groundnut leaf miners, and pod borers. Following that, we will consider insect pests of root and tuber crops, focusing on cassava mealybugs, sweet potato weevils, and yam

beetles. Finally, we will wrap up by studying insect pests of fruit and vegetable crops, such as tomato fruit borers, mango fruit flies, and cabbage aphids.

Series learning outcomes

Upon completing this Series, you should be able to:

SLO 3.1 describe the major insect pests of cereal crops and explain the damage they cause,

SLO 3.2 identify insect pests of legume crops and analyse their impact on yield and quality,

SLO 3.3 explain the role of insect pests in damaging root and tuber crops,

SLO 3.4 classify insect pests of fruit and vegetable crops and evaluate their significance in crop protection.

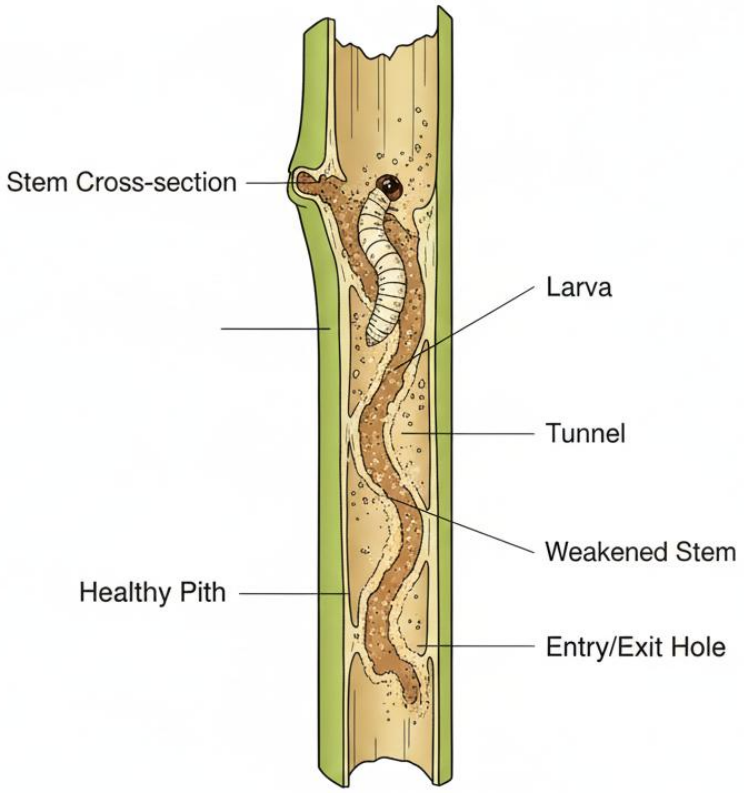
3.1 Insect Pests of Cereal Crops

3.1.1 Maize stem borers

Maize stem borers are caterpillars that tunnel inside maize stems, disrupting water and nutrient flow. This leads to wilting, poor grain filling, and reduced yield.

Maize stem borers tunnel inside maize _____, causing wilting and poor grain filling.

Figure 3.1 Maize stem borer damage in cereal crops: Internal Tunnelling



The maize stem borer larva tunnels inside the stem, disrupting nutrient flow, flow, causthe plant to weaken and dieleading the significant yield loss.

Figure 3.1 Maize stem borer damage in cereal crops

Figure 3.1 Maize stem borer damage in cereal crops

3.1.2 Rice leaf folders and stem borers

Rice leaf folders fold leaves and feed inside, reducing photosynthetic area. **Rice stem borers** tunnel inside stems, causing dead hearts and white heads.

Rice leaf folders reduce photosynthetic area by folding and feeding inside _____.

Plate 3.1 Rice leaf folder and stem borer damage

Plate 3.1 Rice leaf folder and stener damage

Plate 3.1 Rice leaf folder and stem borer damage

3.1.3 Sorghum shoot flies

Sorghum shoot flies lay eggs on young sorghum plants. The larvae bore into shoots, causing dead hearts and poor tillering.

Sorghum shoot flies cause dead hearts in young _____ plants.

Box 3.1 Symptoms of cereal crop insect pests

Pest	Crop	Symptom
Maize stem borer	Maize	Stem tunnelling, wilting
Rice leaf folder	Rice	Folded leaves, reduced photosynthesis
Rice stem borer	Rice	Dead hearts, white heads
Sorghum shoot fly	Sorghum	Dead hearts, poor tillering

Pilot questions 3.1

Define maize stem borers and state their damage.

What symptom is caused by rice stem borers?

Mention one effect of rice leaf folders.

What damage do sorghum shoot flies cause?

Distinguish between rice leaf folders and rice stem borers.

3.2 Insect Pests of Legume Crops

3.2.1 Cowpea weevils

Cowpea weevils are storage pests that bore holes in cowpea seeds, leaving powdery residues and reducing seed viability.

Cowpea weevils bore holes in cowpea _____, leaving powdery residues.

Plate 3.2 Cowpea weeivl damage in legumes

A magniffed view of stored cowwa seeds infested with cowea weils, charactarcticeriistic emergerne holes and signficant destruction.

Plate 3.2 Cowpea weevil damage in legumes

3.2.2 Groundnut leaf miners

Groundnut leaf miners feed inside leaves, creating winding trails that reduce photosynthesis. Severe infestations cause leaf drying and yield loss.

Groundnut leaf miners create winding _____ inside leaves, reducing photosynthesis.

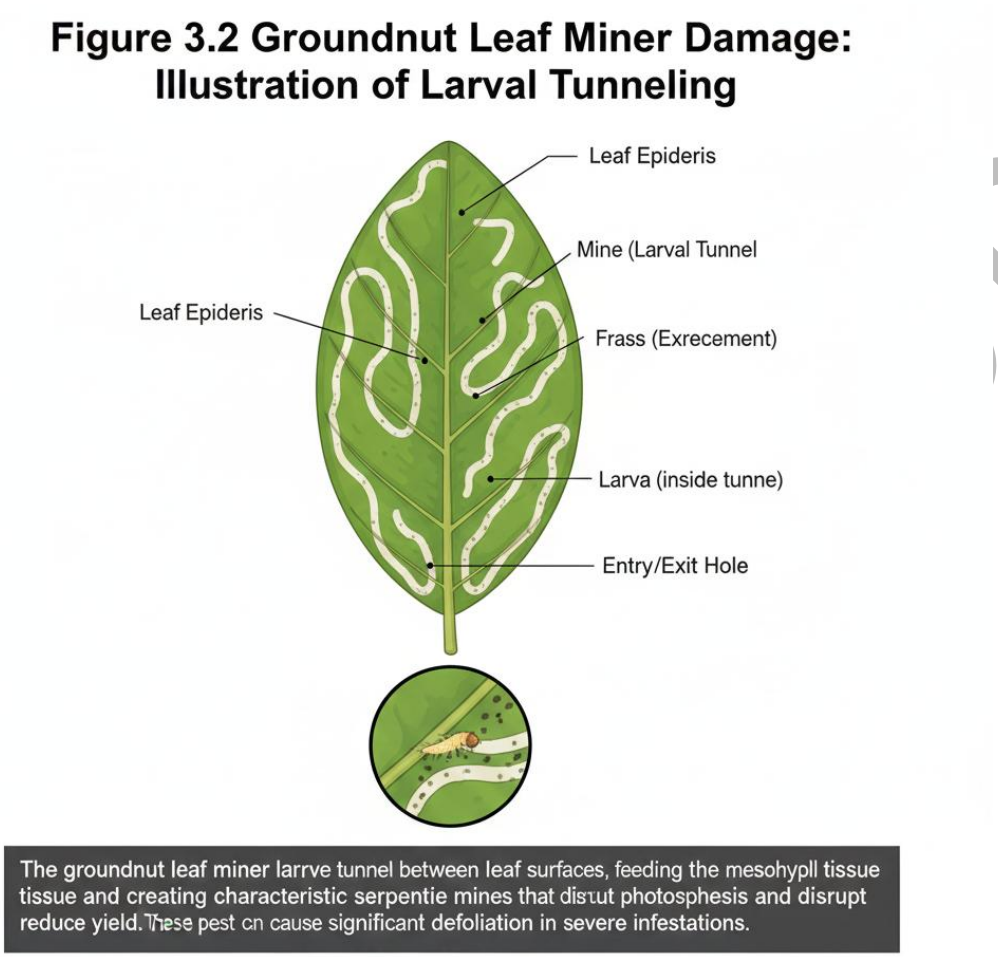


Figure 3.2 Groundnut leaf minor damage

3.2.3 Pod borers

Pod borers attack developing pods of legumes such as cowpea and pigeon pea. They feed on seeds inside pods, reducing yield and quality.

Pod borers feed on seeds inside developing _____ of legumes.

Box 3.2 Symptoms of legume crop insect pests

Pest	Crop	Symptom
Cowpea weevil	Cowpea	Holes in seeds, powdery residues
Groundnut leaf miner	Groundnut	Leaf trails, reduced photosynthesis
Pod borer	Cowpea, pigeon pea	Damaged pods, reduced seed quality

Pilot questions 3.2

Define cowpea weevils and state their damage.

What symptom is caused by groundnut leaf miners?

Mention one crop attacked by pod borers.

State one effect of cowpea weevils on stored seeds.

Distinguish between groundnut leaf miners and pod borers.

3.3 Insect Pests of Root and Tuber Crops

3.3.1 Cassava mealybugs

Cassava mealybugs suck sap from cassava leaves and stems, causing leaf curling, stunted growth, and reduced yield.

Cassava mealybugs suck sap from cassava _____ and stems, causing leaf curling.

Plate 3.3 Cassava meelybug damage in root crops

A macro view illustrating cassava meelybugs causing severe leaf curling and stunted growth in a a root crop, leading to significant yield loss.

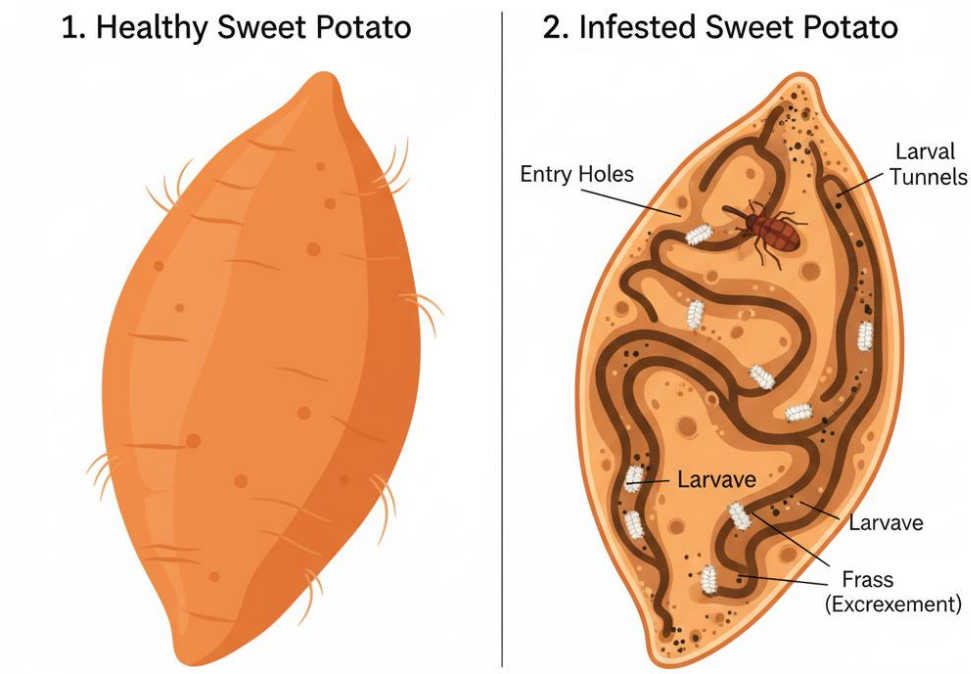
Plate 3.3 Cassava mealybug damage in root crops

3.3.2 Sweet potato weevils

Sweet potato weevils bore into tubers, causing tunnels, rotting, and reduced quality. Infested tubers are unsuitable for consumption or sale.

Sweet potato weevils bore into _____, causing tunnels and rotting.

Figure 3.3 Sweet Potato Wewil Damage:
Illustration of Tunneling in Tubers



The sweet potato weevil (Cylas spp.) larvetunnel through the tuber flesh, creating dark, , frass-filled tunnels that ol cause bittresss, decay, and signficant post-harvest [illegible].

Figure 3.3 Sweet potato weevil damage

3.3.3 Yam beetles

Yam beetles feed on yam tubers, causing holes and reducing market value. Severe infestations lead to poor storage quality.

Yam beetles feed on yam _____, causing holes and reducing market value.

Box 3.3 Symptoms of root and tuber crop insect pests

Pest	Crop	Symptom
Cassava mealybug	Cassava	Leaf curling, stunted growth
Sweet potato weevil	Sweet potato	Tunnels in tubers, rotting
Yam beetle	Yam	Holes in tubers, poor storage quality

Pilot questions 3.3

Define cassava mealybugs and state their damage.

What symptom is caused by sweet potato weevils?

Mention one effect of yam beetles on tubers.

State one crop attacked by cassava mealybugs.

Distinguish between sweet potato weevils and yam beetles.

3.4 Insect Pests of Fruit and Vegetable Crops

3.4.1 Tomato fruit borers

Tomato fruit borers are caterpillars that feed inside tomato fruits, creating holes and causing rotting. Their damage reduces both yield and market value, making tomatoes unsuitable for sale or consumption.

Tomato fruit borers feed inside tomato _____, causing holes and rotting.

Plate 3.4 Tomato fruit borer damage in vegetables

A close-up view showing tomato fruit borrer larrvie causing direct damage to tomato fruits, leading fruit to spoaige and significant yield loss.

Plate 3.4 Tomato fruit borer damage in vegetables

3.4.2 Mango fruit flies

Mango fruit flies lay eggs inside mango fruits. The larvae feed on the pulp, causing rotting, premature fruit drop, and reduced quality. Infested fruits are often unmarketable.

Mango fruit flies lay eggs inside mango _____, causing rotting and fruit drop.

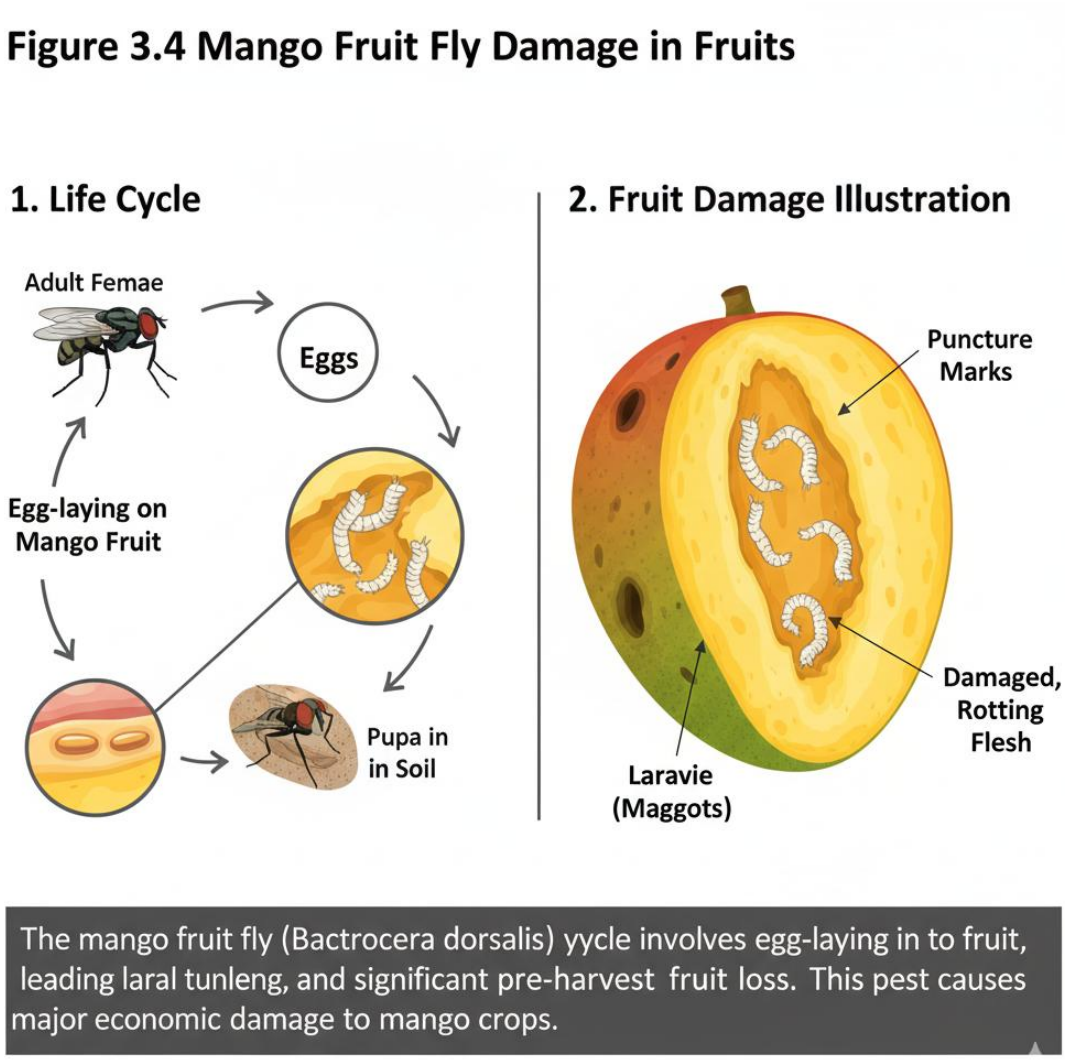


Figure 3.4 Mango fruit fly damage in fruits

3.4.3 Cabbage aphids

Cabbage aphids are small sap-sucking insects that attack cabbage leaves. They cause yellowing, curling, and stunted growth. Severe infestations reduce yield and make cabbages less marketable.

Cabbage aphids suck sap from cabbage _____, causing yellowing and curling.

Plate 3.5 Cabbage aphid damage in vegetables

Box 3.4 Symptoms of fruit and vegetable crop insect pests

Pest	**Crop**	**Symptom**
Tomato fruit borer	Tomato	Holes in fruits, rotting
Mango fruit fly	Mango	Larvae in pulp, fruit drop
Cabbage aphid	Cabbage	Leaf yellowing, curling, stunted growth

Pilot questions 3.4

Define tomato fruit borers and state their damage.

What symptom is caused by mango fruit flies?

Mention one effect of cabbage aphids on leaves.

State one crop attacked by fruit borers.

Distinguish between mango fruit flies and cabbage aphids.

Series summary

This Series has examined specific insect pests that attack major tropical crops, highlighting their examples, symptoms of damage, and significance in crop production. We began with cereal crop pests such as maize stem borers, rice leaf folders and stem borers, and sorghum shoot flies. Then we explored legume crop pests including cowpea weevils, groundnut leaf miners, and pod borers. Following that, we studied root and tuber crop pests such as cassava mealybugs, sweet potato weevils, and yam beetles. Finally, we considered fruit and vegetable crop pests, focusing on tomato fruit borers, mango fruit flies, and cabbage aphids.

By completing this Series, you should now be able to describe insect pests of cereals, identify pests of legumes, explain the role of pests in damaging root and tuber crops, and classify insect pests of fruits and vegetables while evaluating their significance. These abilities directly align with the Series Learning Outcomes and provide you with practical knowledge for recognising and managing insect pests in tropical agriculture.

Glossary of terms

Aphids: Small sap-sucking insects that attack leaves, causing yellowing and curling.

Cassava mealybugs: Insects that suck sap from cassava leaves and stems, causing leaf curling and stunted growth.

Cowpea weevils: Storage pests that bore holes in cowpea seeds, leaving powdery residues.

Groundnut leaf miners: Insects that feed inside groundnut leaves, creating winding trails that reduce photosynthesis.

Maize stem borers: Caterpillars that tunnel inside maize stems, causing wilting and poor grain filling.

Mango fruit flies: Insects that lay eggs inside mango fruits, with larvae feeding on pulp and causing rotting.

Pod borers: Insects that attack developing pods of legumes, feeding on seeds inside.

Rice leaf folders: Insects that fold rice leaves and feed inside, reducing photosynthetic area.

Rice stem borers: Insects that tunnel inside rice stems, causing dead hearts and white heads.

Sorghum shoot flies: Insects that bore into young sorghum shoots, causing dead hearts and poor tillering.

Sweet potato weevils: Insects that bore into sweet potato tubers, causing tunnels and rotting.

Tomato fruit borers: Caterpillars that feed inside tomato fruits, causing holes and rotting.

Yam beetles: Insects that feed on yam tubers, causing holes and reducing market value.

Concept check questions [Series 3]

Objective questions

Define maize stem borers and state their damage. (Linked to SLO 3.1)

Which insect pest folds rice leaves and feeds inside? (Linked to SLO 3.1)

State one example of a legume crop pest. (Linked to SLO 3.2)

Which insect pest bores into sweet potato tubers? (Linked to SLO 3.3)

What type of pest is a mango fruit fly? (Linked to SLO 3.4)

Short-answer questions

Explain the difference between rice leaf folders and rice stem borers. (Linked to SLO 3.1)

Mention two examples of insect pests of legumes. (Linked to SLO 3.2)

Describe one symptom of damage caused by cassava mealybugs. (Linked to SLO 3.3)

State one effect of yam beetles on tubers. (Linked to SLO 3.3)

Identify one vegetable crop attacked by aphids. (Linked to SLO 3.4)

Long-answer questions

Analyse the impact of insect pests on cereal crop production. (Linked to SLO 3.1)

Evaluate the significance of insect pests of legumes in tropical agriculture. (Linked to SLO 3.2)

Discuss the importance of recognising insect pests of root, tuber, fruit, and vegetable crops in crop protection. (Linked to SLO 3.3 & SLO 3.4)

Answers to concept check questions [Series 3]

Objective answers

Caterpillars that tunnel inside maize stems, causing wilting and poor grain filling.

Rice leaf folders.

Cowpea weevils.

Sweet potato weevils.

Fruit pest.

Short-answer answers

Leaf folders fold leaves and reduce photosynthesis, stem borers tunnel stems causing dead hearts.

Cowpea weevils, groundnut leaf miners.

Leaf curling and stunted growth.

Holes in tubers, reducing market value.

Cabbage.

Long-answer answers

Basic response: Cereal pests reduce yield by damaging stems, leaves, and shoots. *Value-added response*: They also affect food security and require integrated pest management strategies.

Basic response: Legume pests damage seeds, pods, and leaves, reducing yield and quality. *Value-added response*: They also affect storage viability and market value, making them economically significant.

Basic response: Root, tuber, fruit, and vegetable pests cause leaf curling, rotting, and reduced quality. *Value-added response*: Recognising them ensures comprehensive crop protection and prevents overlooked damage that accumulates over time.

Answers to pilot questions [Series 3]

Pilot questions 3.1

Maize stem borers tunnel inside stems, causing wilting.

Rice stem borers cause dead hearts and white heads.

Rice leaf folders reduce photosynthesis.

Sorghum shoot flies cause dead hearts.

Leaf folders attack leaves, stem borers attack stems.

Pilot questions 3.2

Cowpea weevils bore holes in seeds.

Groundnut leaf miners create trails in leaves.

Pod borers attack cowpea and pigeon pea pods.

Cowpea weevils leave powdery residues.

Leaf miners damage leaves, pod borers damage pods.

Pilot questions 3.3

Cassava mealybugs suck sap, causing leaf curling.

Sweet potato weevils cause tunnels and rotting.

Yam beetles cause holes in tubers.

Cassava is attacked by mealybugs.

Weevils damage tubers, beetles reduce storage quality.

Pilot questions 3.4

Tomato fruit borers feed inside fruits.

Mango fruit flies cause rotting and fruit drop.

Cabbage aphids cause leaf yellowing and curling.

Tomato is attacked by fruit borers.

Fruit flies damage fruits, aphids damage leaves.

References and attributions [Series 3]

Figure 3.1 Maize stem borer damage in cereal crops: Suggested AI prompt "Generate a labelled diagram showing maize stem borer tunnelling inside stems."

Plate 3.1 Rice leaf folder and stem borer damage: Suggested AI prompt "Generate an image showing rice leaf folder folded leaves and rice stem borer dead hearts."

Box 3.1 Symptoms of cereal crop insect pests: Suggested AI prompt "Generate a box summarising cereal crop insect pests and symptoms."

Plate 3.2 Cowpea weevil damage in legumes: Suggested AI prompt "Generate an image showing cowpea weevils damaging stored cowpea seeds."

Figure 3.2 Groundnut leaf miner damage: Suggested AI prompt "Generate a labelled diagram showing groundnut leaf miner trails inside leaves."

Box 3.2 Symptoms of legume crop insect pests: Suggested AI prompt "Generate a box summarising legume crop insect pests and symptoms."

Plate 3.3 Cassava mealybug damage in root crops: Suggested AI prompt "Generate an image showing cassava mealybugs causing leaf curling and stunted growth."

Figure 3.3 Sweet potato weevil damage: Suggested AI prompt "Generate a labelled diagram showing sweet potato weevil tunnels in tubers."

Box 3.3 Symptoms of root and tuber crop insect pests: Suggested AI prompt "Generate a box summarising root and tuber crop insect pests and symptoms."

Plate 3.4 Tomato fruit borer damage in vegetables: Suggested AI prompt "Generate an image showing tomato fruit borers damaging tomato fruits."

Figure 3.4 Mango fruit fly damage in fruits: Suggested AI prompt "Generate a labelled diagram showing mango fruit fly life cycle and fruit damage."

Plate 3.5 Cabbage aphid damage in vegetables: Suggested AI prompt "Generate an image showing cabbage aphids infesting cabbage leaves."

Box 3.4 Symptoms of fruit and vegetable crop insect pests: Suggested AI prompt "Generate a box summarising fruit and vegetable crop insect pests and symptoms."

All illustrations are placeholders intended for AI generation or sourcing from open educational resources (OER).

Series 4: Symptoms And Effects of Crop Diseases

Part 4.1 General symptoms of crop diseases

4.1.1 Leaf symptoms (spots, blights, wilting, chlorosis)

4.1.2 Stem and root symptoms (rots, galls, cankers)

4.1.3 Fruit and seed symptoms (moulds, shrivelling, discolouration)

Part 4.2 Physiological effects of crop diseases

4.2.1 Reduction in photosynthesis

4.2.2 Impaired nutrient and water uptake

4.2.3 Disruption of plant metabolism

Part 4.3 Economic effects of crop diseases

4.3.1 Yield losses

4.3.2 Quality reduction

4.3.3 Increased production costs

Part 4.4 Ecological and social effects of crop diseases

4.4.1 Impact on biodiversity and ecosystems

4.4.2 Food insecurity and livelihood challenges

4.4.3 Influence on farming practices and sustainability

Introduction

Background Crop diseases are not only identified by the pathogens that cause them but also by the visible symptoms and the wide-ranging effects they produce. Farmers often first notice diseases through changes in leaves, stems, roots, or fruits, which signal deeper physiological disruptions. These symptoms and effects are critical to recognise because they directly influence yield, quality, and food security.

Series aim the aim of this Series is to introduce you to the symptoms and effects of crop diseases, equipping you with the ability to recognise them and analyse their impact on crop production and livelihoods.

Series synopsis We shall commence this Series by exploring the general symptoms of crop diseases, focusing on leaves, stems, roots, fruits, and seeds. Next, we will examine the physiological effects of diseases, such as reduced

photosynthesis and impaired nutrient uptake. Following that, we will consider the economic effects, including yield losses, quality reduction, and increased costs. Finally, we will wrap up by discussing the ecological and social effects of crop diseases, highlighting their influence on biodiversity, food security, and farming practices.

Series learning outcomes

Upon completing this Series, you should be able to:

SLO 4.1 describe the general symptoms of crop diseases affecting leaves, stems, roots, fruits, and seeds,

SLO 4.2 explain the physiological effects of crop diseases on plant functions,

SLO 4.3 analyse the economic effects of crop diseases on yield, quality, and production costs,

SLO 4.4 evaluate the ecological and social effects of crop diseases on biodiversity, food security, and farming practices.

4.1 General Symptoms of Crop Diseases

4.1.1 Leaf symptoms

Leaves are often the first plant organs to show signs of disease. Common symptoms include **leaf spots** (small discoloured areas caused by fungi or bacteria), **blights** (large areas of dead tissue), **wilting** (loss of turgidity due to vascular blockage), and **chlorosis** (yellowing caused by reduced chlorophyll). These symptoms reduce photosynthesis and weaken the plant.

Leaf spots are small discoloured areas, while blights are _____ areas of dead tissue.

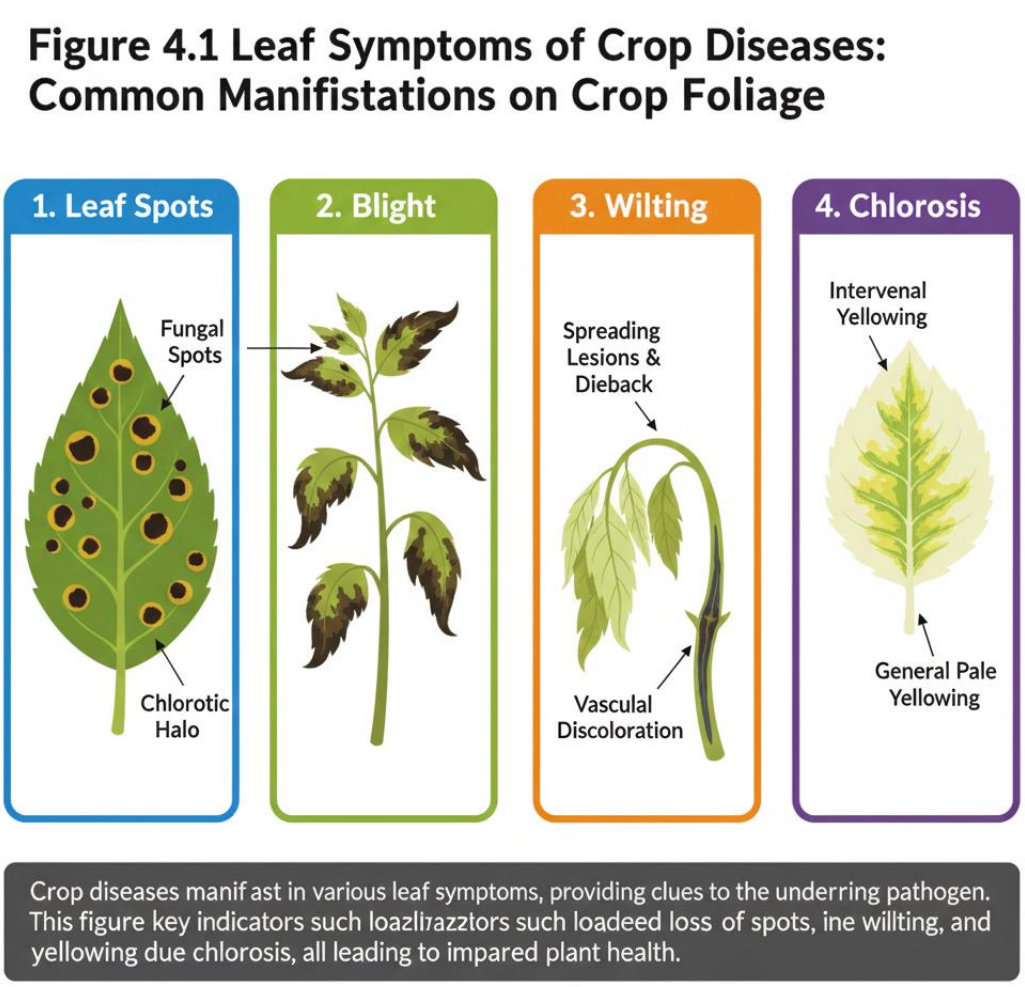


Figure 4.1 Leaf symptoms of Crop direases

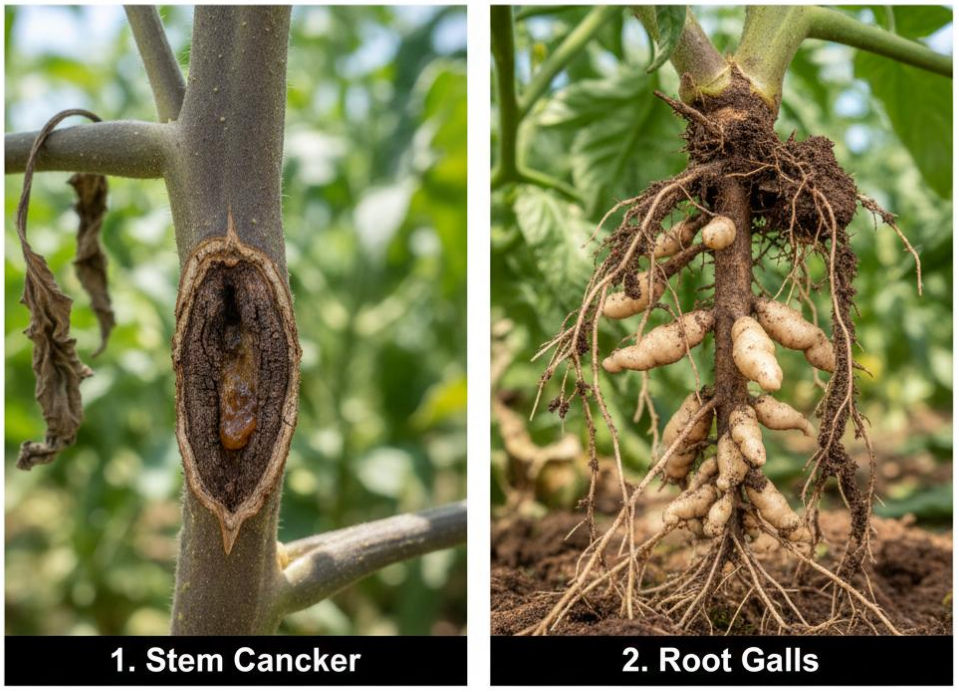
Figure 4.1 Leaf symptoms of crop diseases

4.1.2 Stem and root symptoms

Stems and roots also display disease symptoms. **Rots** are soft, decayed tissues caused by fungi or bacteria. **Galls** are abnormal swellings often induced by nematodes. **Cankers** are sunken lesions on stems that weaken structural support. These symptoms interfere with water and nutrient transport, leading to poor plant growth.

Rots are soft decayed tissues, while galls are abnormal _____ often induced by nematodes.

Plate 4.1 Stem and Root Symptoms of Crop Diseases



A photographic plate illustraing symptoms of crop diseases: sunken, atem cantic stem cankers, which impair nutrient transport and lead of plant decline.

Plate 4.1

Plate 4.1 Stem and root symptoms of crop diseases

4.1.3 Fruit and seed symptoms

Diseases also affect fruits and seeds. **Moulds** appear as fungal growth on surfaces, reducing market value. **Shrivelling** occurs when seeds lose viability due to infection. **Discolouration** is a change in colour caused by pathogens, often making produce unappealing. These symptoms reduce both yield and quality, affecting food security and trade.

Moulds appear as fungal growth, while shrivelling occurs when seeds lose _____ due to infection.

Box 4.1 Symptoms of crop diseases in plant organs

Plant Organ	Common Symptoms	Description & Appearance
Leaves	**Chlorosis / Necrosis**	Yellowing (chlorosis) or browning/death (necrosis) of tissue; leaf spots, blight, and mosaic patterns.
Stems	**Cankers & Ooze**	Sunken dead areas (cankers), vascular wilting, and bacterial ooze or fungal "bleeding" from the stalk.
Roots	**Galls & Rot**	Swellings (galls) caused by nematodes; soft, slimy, or discolored tissue (root rot) that smells foul.
Fruits	**Lesions & Scab**	Sunken spots, fuzzy mold growth, premature ripening, or corky/scabby patches on the skin.
Seeds	**Discoloration & Shriveling**	Darkened or molded seeds, reduced seed size, and "smut" (powdery black spore masses replacing grain).

Pilot questions 4.1

Define leaf spots and state one crop example.

What symptom is caused by vascular blockage in leaves?

Mention one abnormal swelling symptom in roots.

State one effect of moulds on fruits.

Distinguish between shrivelling and discolouration in seeds.

4.2 Physiological Effects of Crop Diseases

4.2.1 Reduction in photosynthesis

Diseases often reduce the ability of plants to carry out **photosynthesis**, the process by which plants produce food using sunlight. Leaf spots, blights, and chlorosis reduce the green surface area, while wilting prevents leaves from functioning effectively. This leads to poor growth and reduced yield.

Diseases reduce photosynthesis by decreasing the _____ surface area available for light absorption.

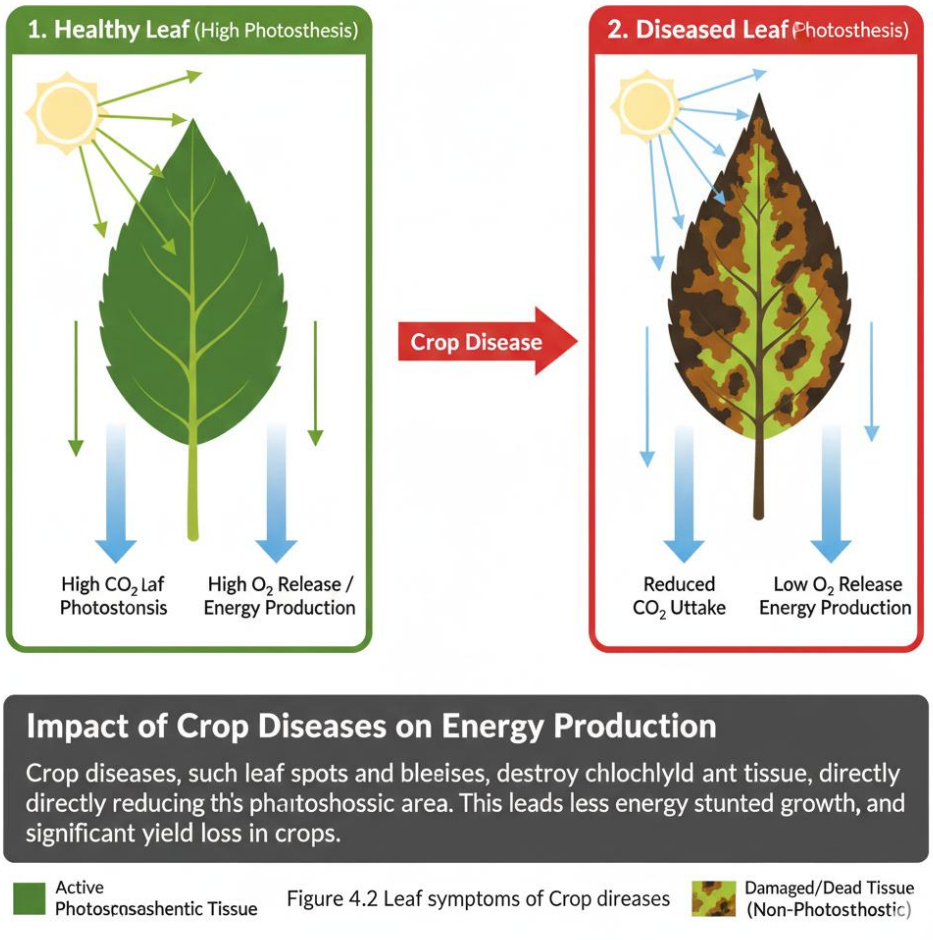


Figure 4.2 Reduction in photosynthesis due to crop diseases

4.2.2 Impaired nutrient and water uptake

Diseases affecting roots and stems interfere with the plant's ability to absorb water and nutrients. Root rots, galls, and vascular wilts block transport systems, leading to stunted growth and poor productivity.

Root rots and galls interfere with the plant's ability to absorb _____ and nutrients.

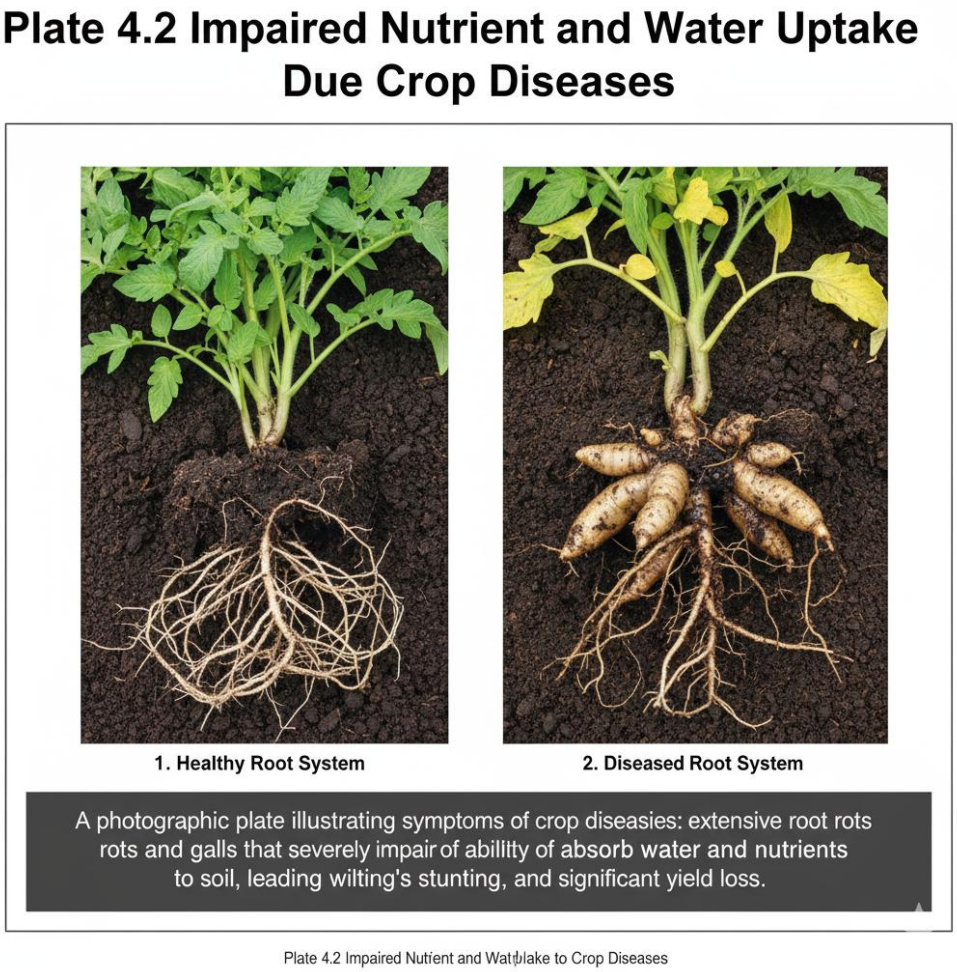


Plate 4.2 Impaired nutrient and water uptake due to crop diseases

4.2.3 Disruption of plant metabolism

Diseases can disrupt **plant metabolism**, including respiration, enzyme activity, and hormone balance. Viral infections often alter normal growth patterns, while bacterial toxins interfere with biochemical processes. This results in abnormal development and reduced productivity.

Diseases disrupt plant metabolism by interfering with _____ activity and hormone balance.

Box 4.2 Physiological effects of crop diseases

Physiological Process	Impact of Disease	Examples
Photosynthesis	Destruction of chlorophyll and leaf tissue reduces the plant's ability to convert sunlight into energy.	**Leaf Rust** in wheat or **Downy Mildew** on grapes creates necrotic spots that kill green tissue.
Water & Nutrient Transport	Blockage of the xylem (water-conducting tissue) or destruction of roots prevents water from reaching leaves.	**Bacterial Wilt** in tomatoes clogs the stems; **Root-Knot Nematodes** create galls that stop nutrient uptake.
Respiration	Many diseased plants show an abnormal increase in respiration, causing them to "burn through" energy reserves faster than they can replace them.	**Fungal infections** often trigger a high metabolic response as the plant tries to defend itself.
Translocation	Diseases affecting the phloem prevent the movement of sugars from leaves to the roots or developing grain/fruit.	**Maize Streak Virus** or **Potato Leafroll Virus** disrupts the "piping" system that moves food.
Hormonal Balance	Pathogens can release growth-regulating chemicals	**Bakanae Disease** in rice (Foolish Seedling) causes plants to grow

Physiological Process	Impact of Disease	Examples
	that cause abnormal cell division or stunted growth.	abnormally tall and thin until they collapse.

Pilot questions 4.2

Define photosynthesis and state how diseases affect it.

What symptom is caused by root rots?

Mention one way diseases disrupt plant metabolism.

State one physiological effect of viral infections.

Distinguish between impaired nutrient uptake and reduced photosynthesis.

4.3 Economic Effects of Crop Diseases

4.3.1 Yield losses

Diseases reduce crop yield by destroying plant tissues, interfering with growth, and causing premature death. Farmers often harvest less than expected, leading to food shortages and reduced income.

Diseases reduce crop yield by destroying plant _____ and interfering with growth.

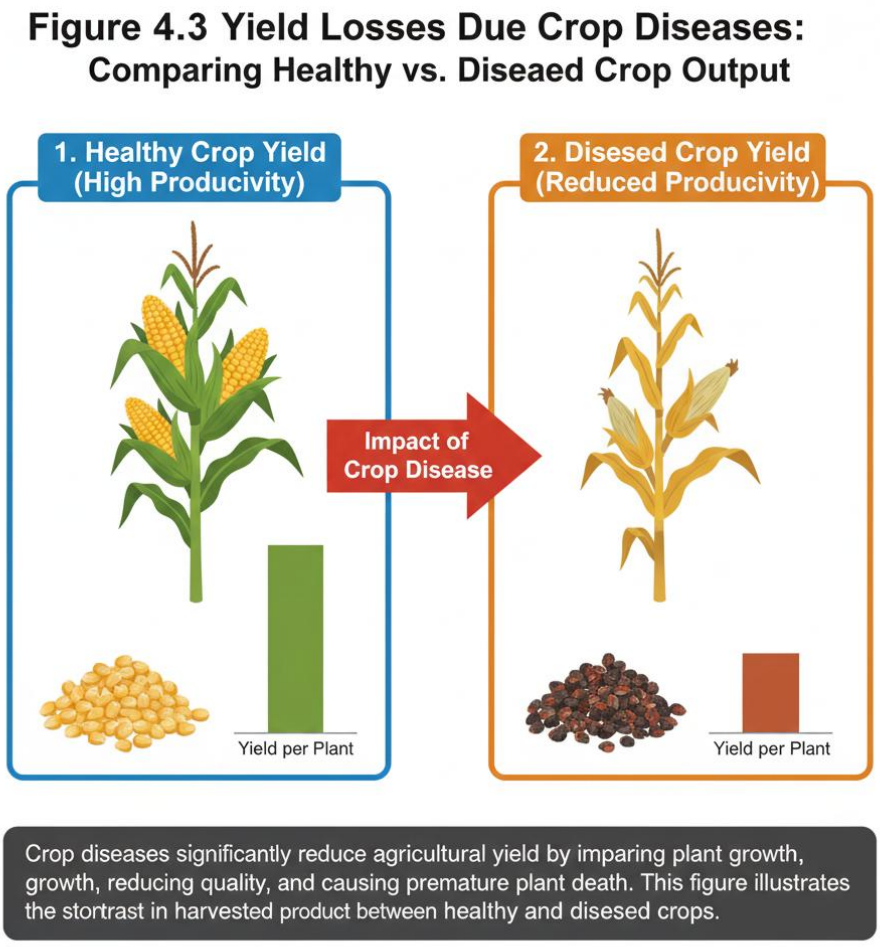


Figure 4.3 Yield losses due to crop diseases

4.3.2 Quality reduction

Diseases reduce the quality of produce by causing discolouration, rotting, and shrivelling. This makes crops less marketable and lowers their value in trade.

Diseases reduce quality by causing _____, rotting, and shrivelling of produce.

Plate 4.3 Quality reduction due to crop diseases

4.3.3 Increased production costs

Farmers spend more on pesticides, fungicides, and labour to manage diseases. This increases production costs and reduces profit margins.

Farmers spend more on pesticides and _____ to manage crop diseases.

Box 4.3 Economic effects of crop diseases

Impact Category	Description	Practical Examples
Direct Yield Loss	Reduction in the total volume of produce harvested due to plant death or stunted growth.	**Late Blight** in potatoes can destroy an entire field in days, resulting in 100% loss of harvestable tubers.
Quality Degradation	Produce is harvested but is unmarketable or fetches a lower price due to poor appearance, taste, or toxins.	**Aflatoxins** in maize caused by *Aspergillus* mold make the grain toxic, rendering it unfit for sale or human consumption.
Increased Production Costs	Farmers must spend more on inputs to manage the disease, reducing their overall profit margins.	High costs of frequent **fungicide applications** to control Coffee Leaf Rust or investing in expensive disease-free "certified seeds."
Market & Export Restrictions	Discovery of certain diseases can lead to trade bans, preventing farmers from accessing lucrative international markets.	Export bans on **Citrus** fruit from regions infected with Citrus Canker to prevent the spread to other countries.
Food Insecurity & Price Hikes	Widespread disease outbreaks reduce supply, causing food prices to rise for consumers.	The **Irish Potato Famine** is the historical extreme of how a single crop disease can lead to mass starvation and economic collapse.

Pilot questions 4.3

Define yield losses and state one cause.

What symptom reduces the quality of produce?

Mention one example of increased production costs.

State one economic effect of crop diseases on farmers.

Distinguish between yield losses and quality reduction.

4.4 Ecological and Social Effects of Crop Diseases

4.4.1 Impact on biodiversity and ecosystems

Diseases can alter ecosystems by reducing plant diversity and affecting associated organisms such as pollinators and soil microbes. This weakens ecological balance and reduces resilience.

Diseases alter ecosystems by reducing plant _____ and affecting associated organisms.

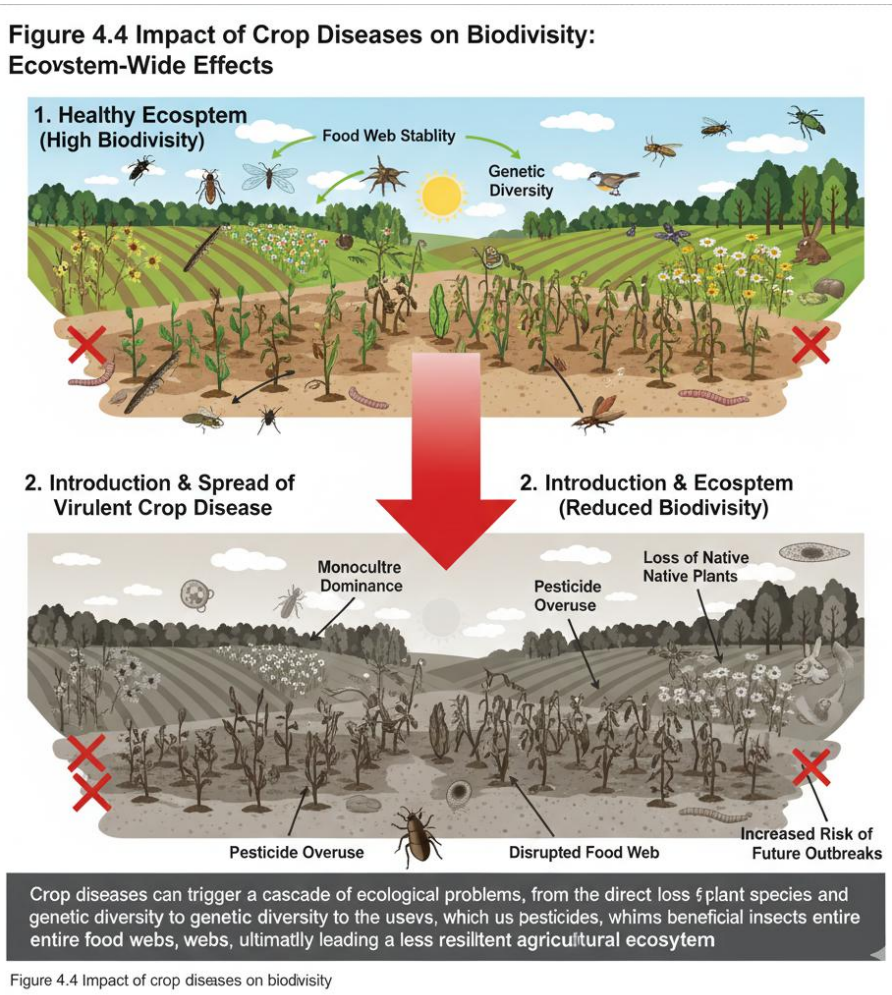


Figure 4.4 Impact of crop diseases on biodiversity

4.4.2 Food insecurity and livelihood challenges

Diseases reduce food availability and income for farming communities. This leads to hunger, poverty, and reduced living standards.

Diseases reduce food availability and income, leading to _____ and poverty.

Plate 4.4 Food insecurity due to crop diseases

4.4.3 Influence on farming practices and sustainability

Diseases influence farming practices by encouraging monocropping, heavy pesticide use, or adoption of resistant varieties. These practices affect sustainability and long-term productivity.

Diseases influence farming practices by encouraging heavy use of _____ or adoption of resistant varieties.

Box 4.4 Ecological and social effects of crop diseases

Category	Impact Factor	Description & Examples
Ecological	**Loss of Biodiversity**	Diseases can wipe out specific plant species, disrupting local food webs and reducing genetic diversity. *Example: The loss of American Chestnut trees due to blight altered entire forest ecosystems.*
Ecological	**Increased Chemical Use**	Outbreaks often lead to heavy reliance on pesticides, which can leach into soil and water, harming non-target species like bees. *Example: Intensive spraying for potato late blight affecting groundwater quality.*
Ecological	**Soil Degradation**	Certain soil-borne pathogens can render land unusable for specific crops for decades, forcing land clearing elsewhere. *Example: Panama Disease (Fusarium) in bananas leading to the abandonment of vast plantation areas.*
Social	**Food Insecurity**	Reduced harvests lead to shortages of staple foods, causing malnutrition and hunger in vulnerable communities. *Example: Cassava Mosaic Disease impacting food stability in sub-Saharan Africa.*
Social	**Rural-Urban Migration**	When crops fail repeatedly, farmers often lose their livelihoods and are forced to migrate to cities in search of work. *Example: Historical migrations following systemic failures in grain or potato production.*

Category	Impact Factor	Description & Examples
Social	**Cultural Loss**	Many traditional or indigenous crops hold ceremonial or cultural value; their loss to disease can erode community heritage. *Example: Diseases affecting Taro in Pacific Island cultures.*

Pilot questions 4.4

Define biodiversity impact of crop diseases.

What effect do diseases have on food security?

Mention one farming practice influenced by crop diseases.

State one social effect of cassava mosaic disease.

Distinguish between ecological and social effects of crop diseases.

Series summary

This Series has examined the visible symptoms and the wide-ranging effects of crop diseases. We began with general symptoms affecting leaves, stems, roots, fruits, and seeds, such as spots, wilting, rots, and moulds. Then we explored the physiological effects of diseases, including reduced photosynthesis, impaired nutrient uptake, and disrupted metabolism. Following that, we considered the economic effects, focusing on yield losses, quality reduction, and increased production costs. Finally, we discussed the ecological and social effects of crop diseases, highlighting their impact on biodiversity, food security, and farming practices.

By completing this Series, you should now be able to describe disease symptoms across plant organs, explain their physiological effects, analyse their economic consequences, and evaluate their ecological and social implications. These abilities

directly align with the Series Learning Outcomes and prepare you to recognise and assess the broader significance of crop diseases in agriculture.

Glossary of terms

Blight: Large areas of dead tissue on leaves, often caused by fungi or bacteria.

Canker: Sunken lesion on stems that weakens plant structure.

Chlorosis: Yellowing of leaves due to reduced chlorophyll.

Food insecurity: Lack of reliable access to sufficient food caused by reduced crop production.

Gall: Abnormal swelling of plant tissue, often induced by nematodes.

Mould: Fungal growth on fruits or seeds, reducing quality and market value.

Photosynthesis: The process by which plants produce food using sunlight, carbon dioxide, and water.

Rot: Soft, decayed tissue in stems, roots, or fruits caused by pathogens.

Shrivelling: Loss of seed viability due to infection, leading to reduced germination.

Wilt: Loss of leaf turgidity caused by vascular blockage or root damage.

Concept check questions [Series 4]

Objective questions

Define chlorosis and state its cause. (Linked to SLO 4.1)

Which symptom is characterised by sunken lesions on stems? (Linked to SLO 4.1)

State one physiological effect of crop diseases. (Linked to SLO 4.2)

Which economic effect involves reduced harvest quantity? (Linked to SLO 4.3)

What ecological effect results from reduced plant diversity? (Linked to SLO 4.4)

Short-answer questions

Explain the difference between leaf spots and blights. (Linked to SLO 4.1)

Mention two ways crop diseases impair nutrient uptake. (Linked to SLO 4.2)

Describe one symptom of quality reduction in produce. (Linked to SLO 4.3)

State one social effect of crop diseases on farming communities. (Linked to SLO 4.4)

Identify one example of a disease that causes food insecurity. (Linked to SLO 4.4)

Long-answer questions

Analyse the physiological effects of crop diseases on plant functions. (Linked to SLO 4.2)

Evaluate the economic consequences of crop diseases for farmers and markets. (Linked to SLO 4.3)

Discuss the ecological and social effects of crop diseases, highlighting their impact on sustainability. (Linked to SLO 4.4)

Answers to concept check questions [Series 4]

Objective answers

Chlorosis is yellowing of leaves due to reduced chlorophyll.

Canker.

Reduced photosynthesis.

Yield losses.

Impact on biodiversity.

Short-answer answers

Leaf spots are small discoloured areas; blights are large dead patches.

Root rots block absorption, galls interfere with root function.

Rotten fruits or shrivelled seeds.

Hunger and reduced income.

Cassava mosaic disease.

Long-answer answers

Basic response: Diseases reduce photosynthesis, impair nutrient uptake, and disrupt metabolism. *Value-added response*: They also alter enzyme activity and hormone balance, leading to abnormal growth.

Basic response: Diseases cause yield losses, reduce quality, and increase production costs. *Value-added response*: They also affect trade, reduce farmer profits, and increase reliance on inputs.

Basic response: Diseases reduce biodiversity, cause food insecurity, and influence farming practices. *Value-added response*: They also challenge sustainability, forcing adoption of resistant varieties and integrated management.

Answers to pilot questions [Series 4]

Pilot questions 4.1

Leaf spots are small discoloured areas; maize leaf spot is an example.

Wilting.

Galls.

Moulds reduce fruit quality.

Shrivelling reduces viability, discolouration changes appearance.

Pilot questions 4.2

Photosynthesis is food production using sunlight; diseases reduce it by damaging leaves.

Root rots cause stunted growth.

Diseases disrupt enzyme activity.

Viral infections cause abnormal growth.

Nutrient uptake affects roots, photosynthesis affects leaves.

Pilot questions 4.3

Yield losses are reduced harvest due to disease.

Discolouration.

Fungicide use.

Reduced income.

Yield losses reduce quantity; quality reduction affects market value.

Pilot questions 4.4

Biodiversity impact is reduction in plant diversity.

Diseases reduce food security.

Heavy pesticide use.

Cassava mosaic disease reduces food supply.

Ecological effects alter ecosystems; social effects affect livelihoods.

References and attributions [Series 4]

Figure 4.1 Leaf symptoms of crop diseases: Suggested AI prompt "Generate a labelled diagram showing leaf spots, blight, wilting, and chlorosis on crop leaves."

Plate 4.1 Stem and root symptoms of crop diseases: Suggested AI prompt "Generate an image showing stem cankers and root galls in diseased crops."

Box 4.1 Symptoms of crop diseases in plant organs: Suggested AI prompt "Generate a box summarising symptoms of crop diseases in leaves, stems, roots, fruits, and seeds."

Figure 4.2 Reduction in photosynthesis due to crop diseases: Suggested AI prompt "Generate a labelled diagram showing diseased leaves with reduced photosynthetic area."

Plate 4.2 Impaired nutrient and water uptake due to crop diseases: Suggested AI prompt "Generate an image showing diseased roots with rots and galls."

Box 4.2 Physiological effects of crop diseases: Suggested AI prompt "Generate a box summarising physiological effects of crop diseases with examples."

Figure 4.3 Yield losses due to crop diseases: Suggested AI prompt "Generate a diagram comparing healthy vs diseased crop yield."

Plate 4.3 Quality reduction due to crop diseases: Suggested AI prompt "Generate an image showing diseased fruits with rotting and discolouration."

Box 4.3 Economic effects of crop diseases: Suggested AI prompt "Generate a box summarising economic effects of crop diseases with examples."

Figure 4.4 Impact of crop diseases on biodiversity: Suggested AI prompt "Generate a diagram showing impact of crop diseases on biodiversity and ecosystems."

Plate 4.4 Food insecurity due to crop diseases: Suggested AI prompt "Generate an image showing farmers with diseased crops and reduced harvest."

Box 4.4 Ecological and social effects of crop diseases: Suggested AI prompt "Generate a box summarising ecological and social effects of crop diseases with examples."

All illustrations are placeholders intended for AI generation or sourcing from open educational resources (OER).

Series 5: Pest And Disease Control Methods and Integrated Management

Part 5.1 Cultural control methods

5.1.1 Crop rotation

5.1.2 Sanitation and field hygiene

5.1.3 Resistant crop varieties

Part 5.2 Biological control methods

5.2.1 Use of natural enemies

5.2.2 Microbial control agents

5.2.3 Conservation of beneficial organisms

Part 5.3 Chemical control methods

5.3.1 Insecticides

5.3.2 Fungicides

5.3.3 Herbicides and nematicides

Part 5.4 Integrated pest and disease management (IPM)

5.4.1 Principles of IPM

5.4.2 Combining control strategies

5.4.3 Sustainable crop protection

Introduction

Background In the last Series, we explored the symptoms and effects of crop diseases, learning how they impact plant physiology, yield, and farming communities. Recognising these problems is only the first step. Farmers must also adopt effective methods to control pests and diseases in order to protect crops and ensure food security.

Series aim the aim of this Series is to introduce you to the major methods of pest and disease control and to explain how these approaches can be combined into integrated management strategies for sustainable crop protection.

Series synopsis We shall commence this Series by examining cultural control methods such as crop rotation, sanitation, and resistant varieties. Next, we will explore biological control methods, including natural enemies, microbial agents, and conservation of beneficial organisms. Following that, we will consider chemical control methods such as insecticides, fungicides, and nematicides.

Finally, we will wrap up by discussing integrated pest and disease management, highlighting its principles, strategies, and role in sustainable agriculture.

Series learning outcomes

Upon completing this Series, you should be able to:

SLO 5.1 describe cultural methods of pest and disease control and explain their role in crop protection,

SLO 5.2 identify biological control methods and analyse their effectiveness in managing pests and diseases,

SLO 5.3 explain chemical control methods and evaluate their advantages and limitations,

SLO 5.4 apply the principles of integrated pest and disease management to design sustainable crop protection strategies.

5.1 Cultural Control Methods

5.1.1 Crop rotation

Crop rotation is the practice of growing different crops in succession on the same land. It helps break the life cycle of pests and diseases by removing their preferred host plants. For example, rotating maize with legumes reduces stem borer infestations and soil-borne diseases.

Crop rotation breaks the life cycle of pests by removing their preferred _____ plants.

Figure 5.1 Crop Rotation as a Cultural Control Method: An Example Sequene

Rotation between Maize and Legumes

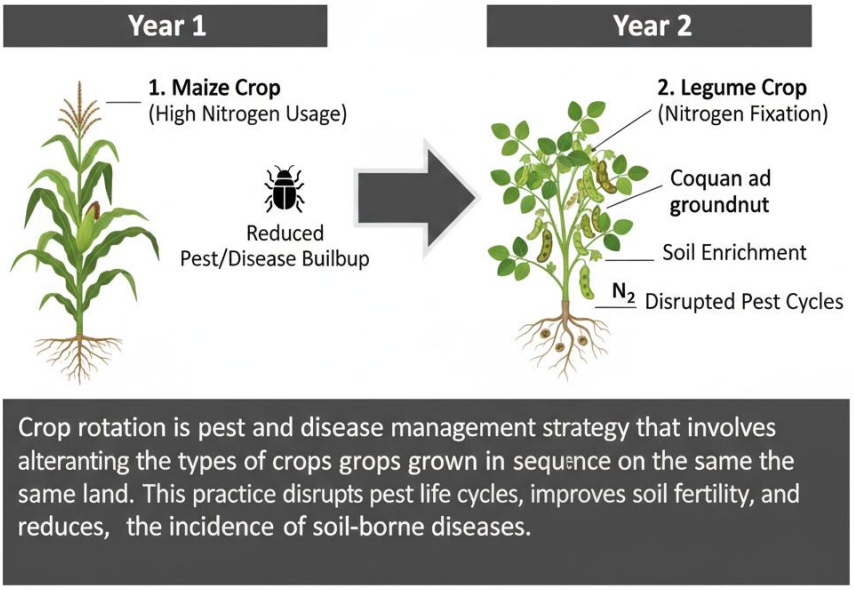


Figure 5.1 Corp rotation as a cultural control method

Figure 5.1 Crop rotation as a cultural control method

5.1.2 Sanitation and field hygiene

Sanitation and field hygiene involve practices such as removing diseased plant residues, weeding, and cleaning tools. These measures reduce sources of infection and prevent pests from breeding in crop fields.

Sanitation and field hygiene reduce sources of _____ and prevent pests from breeding.

Plate 5.1 Sanitation and field hygiene in crop protection

5.1.3 Resistant crop varieties

Resistant crop varieties are plant types bred to withstand specific pests or diseases. They reduce the need for chemical control and provide long-term protection. For example, cassava varieties resistant to mosaic disease are widely used in tropical regions.

Resistant crop varieties are bred to withstand specific _____ or diseases.

Box 5.1 Examples of cultural control methods

Control Method	How it Works	Practical Examples
Sanitation	Removing or destroying infected plant debris to eliminate "reservoirs" where pests or pathogens hide.	**Pruning** and burning diseased branches; clearing fallen fruits; cleaning farm tools to prevent cross-contamination.
Crop Rotation	Growing different types of crops in a sequence to break the life cycle of soil-borne pests and diseases.	Planting **Legumes** one season and **Maize** the next so that pests specialized for one cannot survive the other.
Intercropping	Growing two or more crops together to confuse pests or provide habitats for natural predators.	Planting **Marigolds** with vegetables to repel nematodes, or "Push-Pull" systems using Desmodium and Napier grass.
Tillage & Cultivation	Turning the soil to expose soil-dwelling pests (like grubs or pupae) to the sun and predators.	**Ploughing** fields after harvest to bring weed seeds and insect larvae to the surface.
Adjusting Planting Dates	Timing the planting or harvesting to avoid the peak activity period of a specific pest or disease.	Planting **Early-maturing** varieties of wheat to harvest before the peak season of stem rust infection.
Water Management	Controlling irrigation to prevent high-humidity	Using **Drip irrigation** instead of overhead sprinklers to keep foliage

Control Method	How it Works	Practical Examples
	microclimates that favor fungal growth.	dry and prevent Downy Mildew.

Pilot questions 5.1

Define crop rotation and state one example.

What is the role of sanitation in crop protection?

Mention one benefit of resistant crop varieties.

State one way crop rotation helps control pests.

Distinguish between sanitation and resistant varieties as cultural control methods

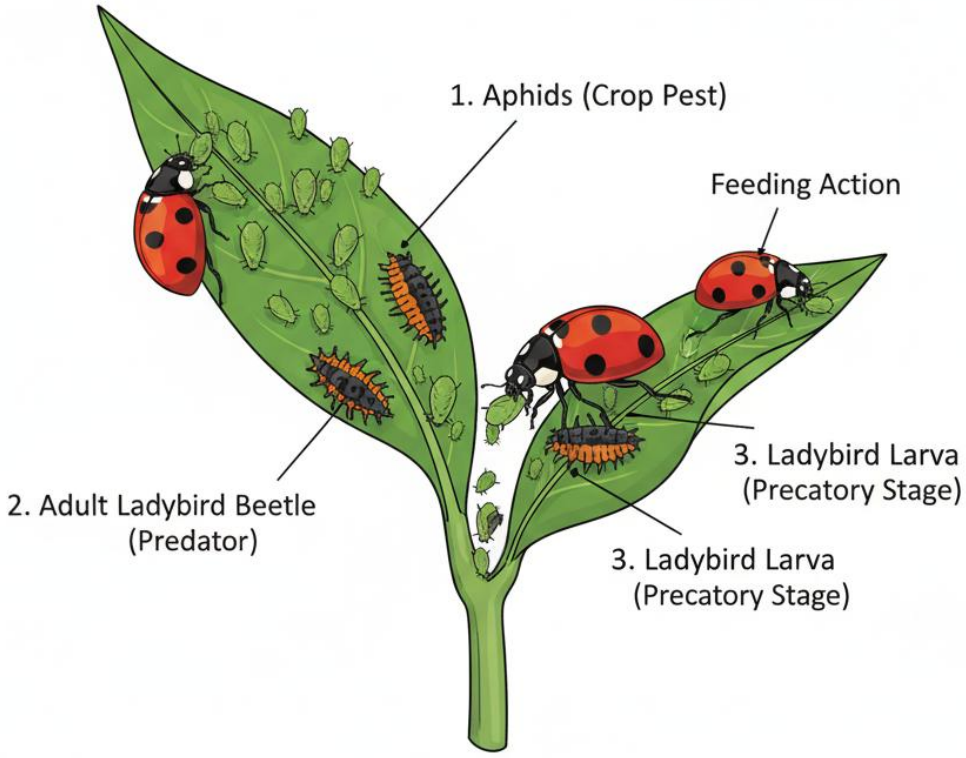
5.2 Biological Control Methods

5.2.1 Use of natural enemies

Natural enemies are organisms such as predators, parasitoids, and pathogens that attack pests. For example, ladybird beetles feed on aphids, while parasitic wasps lay eggs inside caterpillars. These natural enemies help keep pest populations under control without chemicals.

Natural enemies such as ladybird beetles feed on _____, reducing pest populations naturally.

Figure 5.2 Natural Enemies in Biological Control: Lady Betles & Aphids



A biological control illustration depcting the pretatory relationship between ladybird (betbird bettles (boult ɜnas arval stages) and aphids. Ladybirds are natural enemies that help regulate pest populations in agricultural ecosstems.

Figure 5.2 Natural enemies in conttorical

Figure 5.2 Natural enemies in biological control

5.2.2 Microbial control agents

Microbial control agents include fungi, bacteria, and viruses that infect and kill pests. For example, *Bacillus thuringiensis* (Bt) produces toxins that kill caterpillars. These agents are environmentally friendly and target specific pests.

Microbial control agents such as *Bacillus thuringiensis* produce toxins that kill _____.

Plate 5.2 Microbial control agents in pest management

5.2.3 Conservation of beneficial organisms

Conserving beneficial organisms such as pollinators and soil microbes ensures ecological balance. Practices like reduced pesticide use and planting flowering strips encourage natural enemies to thrive.

Conserving beneficial organisms ensures ecological _____ and supports natural pest control.

Box 5.2 Biological control methods

Method	Mechanism	Practical Examples
Predation	Larger organisms actively hunt and consume pests.	**Ladybird beetles** (ladybugs) or lacewings eating large quantities of aphids and scale insects.
Parasitoidism	An organism lives on or inside a host pest, eventually killing it to complete its own life cycle.	**Trichogramma wasps** laying eggs inside the eggs of moths (like the bollworm), preventing the larvae from hatching.
Microbial Control	Using microorganisms like bacteria, fungi, or viruses to infect and kill pests.	***Bacillus thuringiensis*** **(Bt)**, a bacterium that produces toxins specifically lethal to caterpillars and certain beetles.
Competition (Antagonism)	Introducing beneficial microbes that outcompete pathogens for space and nutrients on the plant surface.	***Trichoderma*** fungi used to protect roots from soil-borne diseases like *Fusarium* or *Rhizoctonia*.
Classical Biocontrol	Importing and releasing a natural enemy from a pest's native range to control it in a new area.	Releasing the **Cactoblastis moth** to control invasive prickly pear cactus.

Pilot questions 5.2

Define natural enemies and give one example.

What is the role of *Bacillus thuringiensis* in pest control?

Mention one way to conserve beneficial organisms.

State one advantage of biological control methods.

Distinguish between natural enemies and microbial agents.

5.3 Chemical Control Methods

5.3.1 Insecticides

Insecticides are chemicals used to kill insect pests. They may be contact, systemic, or fumigant types. While effective, they must be used carefully to avoid resistance and environmental harm.

Insecticides are chemicals used to kill _____ pests in crops.

Figure 5.3 Insecticide Application in Crop Protection: Chemical Pest Control

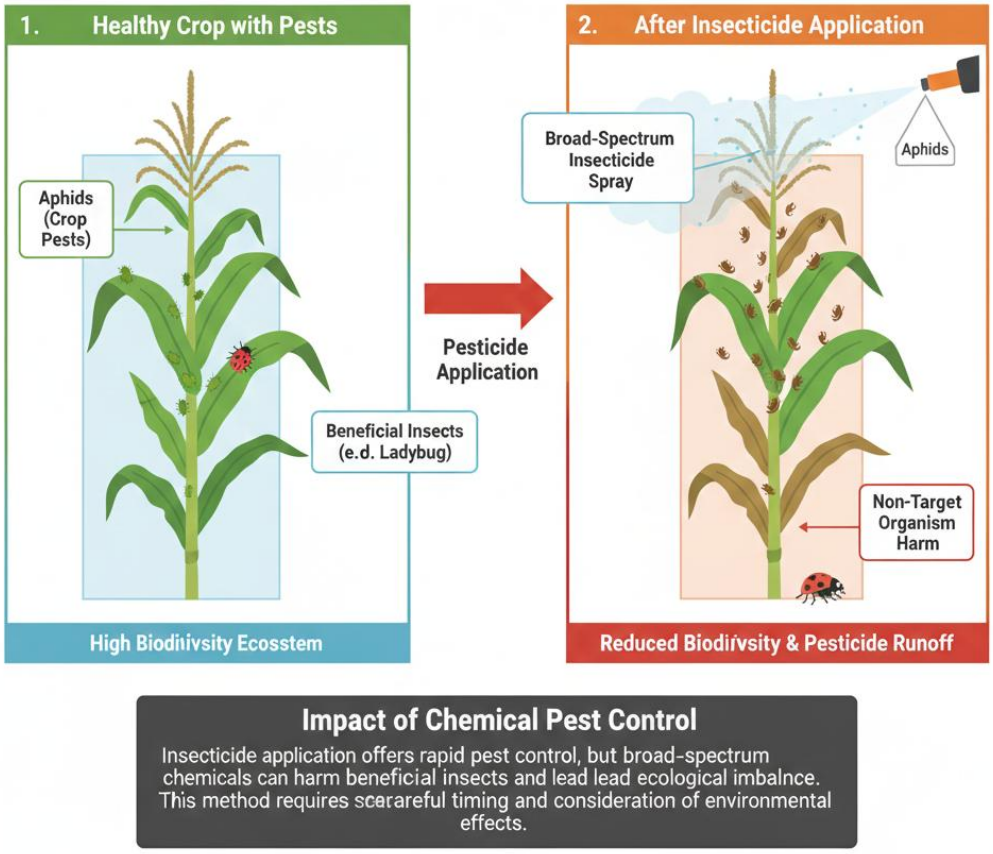


Figure 5.3 Insecticide application in crop protection

Figure 5.3 Insecticide application in crop protection

5.3.2 Fungicides

Fungicides are chemicals used to control fungal diseases such as leaf spots and blights. They may be protective (preventing infection) or curative (stopping disease spread).

Fungicides are chemicals used to control _____ diseases in crops.

Plate 5.3 Fungicide application in crop protection

5.3.3 Herbicides and nematicides

Herbicides control weeds that compete with crops for nutrients, while **nematicides** control nematodes that damage roots. Both improve crop growth but must be applied responsibly.

Herbicides control weeds, while nematicides control _____ that damage crop roots.

Box 5.3 Chemical control methods

Category	Target Organism	How it Works	Practical Examples
Insecticides	Insects (larvae or adults)	Disrupts the nervous system, growth, or energy production of pests.	**Neonicotinoids** for aphids; **Pyrethroids** for beetles and caterpillars.
Fungicides	Fungi and Oomycetes	Prevents spore germination or stops the growth of fungal hyphae within plant tissue.	**Copper-based sprays** for late blight; **Triazoles** for cereal rusts.
Herbicides	Weeds	Inhibits photosynthesis, protein synthesis, or root development in competing plants.	**Glyphosate** for non-selective weed control; **Atrazine** for selective control in maize.
Bactericides	Bacteria	Kills or inhibits the growth of bacteria that cause blights, wilts, and galls.	**Antibiotics** (like Streptomycin) or **Copper compounds** used for Citrus Canker.
Nematicides	Nematodes	Chemicals applied to soil to kill parasitic roundworms that attack roots.	**Fumigants** applied to soil before planting high-value vegetable crops.

Pilot questions 5.3

Define insecticides and state one type.

What is the role of fungicides in crop protection?

Mention one example of a herbicide.

State one advantage of nematicides.

Distinguish between insecticides and fungicides.

5.4 Integrated Pest and Disease Management (IPM)

5.4.1 Principles of IPM

Integrated pest and disease management (IPM) combines cultural, biological, and chemical methods to control pests sustainably. Its principles include prevention, monitoring, and using multiple strategies to reduce reliance on chemicals.

IPM combines cultural, biological, and chemical methods to control pests _____.

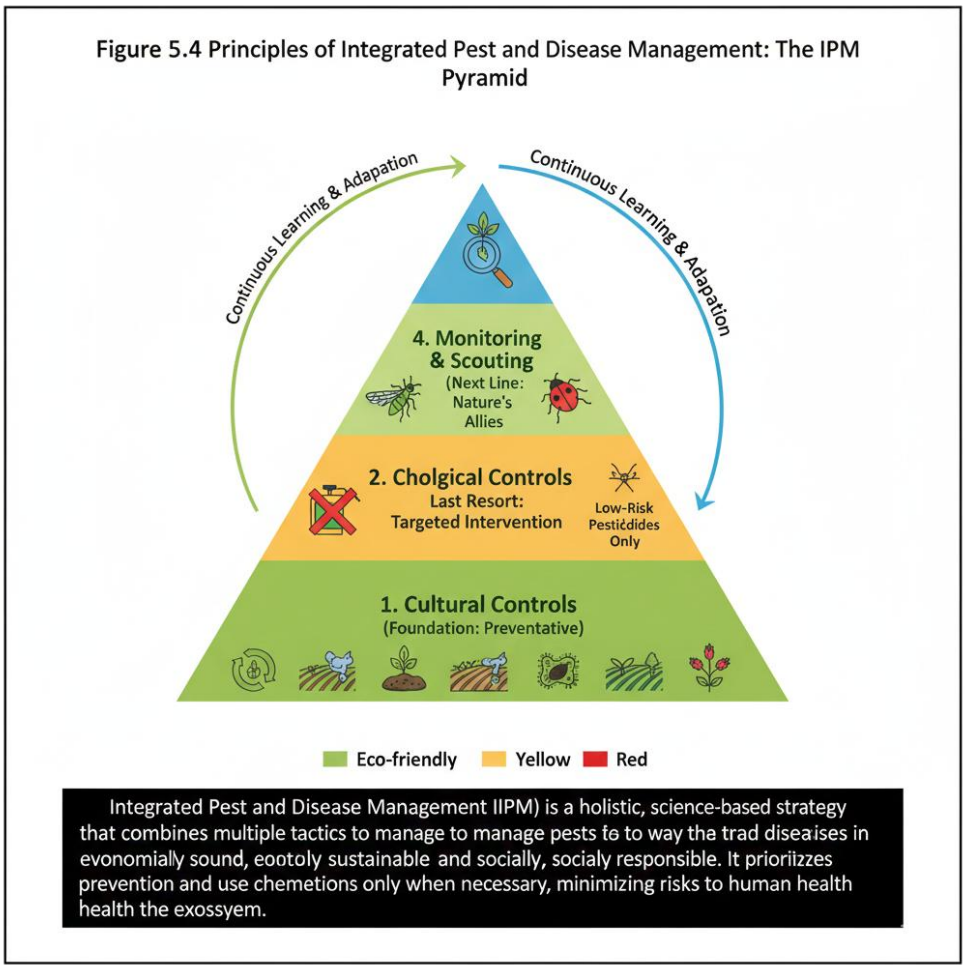


Figure 5.4 Principles of integrated pest and disease management

5.4.2 Combining control strategies

IPM emphasises combining strategies to achieve effective control. For example, crop rotation (cultural), ladybird beetles (biological), and limited insecticide use (chemical) can be applied together.

IPM emphasises combining strategies such as crop rotation, biological agents, and limited use of _____.

Plate 5.4 Combining control strategies in IPM

5.4.3 Sustainable crop protection

IPM promotes sustainability by reducing chemical use, conserving biodiversity, and protecting the environment. It ensures long-term productivity and food security.

IPM promotes sustainability by reducing chemical use and conserving _____.

Box 5.4 Integrated pest and disease management

Principle	Strategy & Description	Practical Examples
Prevention	Focuses on keeping pest populations from becoming a problem in the first place.	Using **certified disease-free seeds** and implementing strict **field sanitation** to remove host debris.
Monitoring & Identification	Regular scouting to identify pests and beneficial insects. Not all "bugs" are enemies.	Using **pheromone traps** to count moth populations or visual inspections for early fungal spots.
Action Thresholds	Deciding the point at which pest populations or environmental conditions indicate that action must be taken.	Only spraying if **more than 10%** of a leaf area is affected, ensuring the cost of control is less than the potential loss.
Integration of Tactics	Using a "toolbox" approach where multiple methods are layered for maximum effectiveness.	Combining **crop rotation** (cultural), **ladybird release** (biological), and **targeted spraying** (chemical).
Sustainability & Safety	Prioritizing methods with the least risk to human health, non-target organisms, and the environment.	Choosing a **narrow-spectrum bio-pesticide** over a broad-spectrum synthetic chemical to protect bees.

Pilot questions 5.4

Define IPM and state its principles.

What is the role of monitoring in IPM?

Mention one example of combining control strategies.

State one-way IPM promotes sustainability.

Distinguish between cultural control and IPM.

Series summary

This Series has explored the major methods of pest and disease control and how they can be integrated for sustainable crop protection. We began with cultural methods such as crop rotation, sanitation, and resistant varieties. Then we examined biological methods, including natural enemies, microbial agents, and conservation of beneficial organisms. Following that, we considered chemical methods such as insecticides, fungicides, herbicides, and nematicides. Finally, we discussed integrated pest and disease management (IPM), highlighting its principles, strategies, and role in sustainable agriculture.

By completing this Series, you should now be able to describe cultural methods, identify biological approaches, explain chemical control, and apply the principles of IPM to design sustainable crop protection strategies. These abilities directly align with the Series Learning Outcomes and prepare you to make informed decisions about pest and disease management in tropical agriculture.

Glossary of terms

Biological control: The use of natural enemies or microbial agents to manage pests.

Cultural control: Farming practices such as crop rotation and sanitation that reduce pest and disease incidence.

Fungicides: Chemicals used to control fungal diseases in crops.

Herbicides: Chemicals used to control weeds that compete with crops.

Insecticides: Chemicals used to kill insect pests.

Integrated pest management (IPM): A sustainable approach combining cultural, biological, and chemical methods to control pests.

Microbial control agents: Microorganisms such as fungi, bacteria, or viruses used to kill pests.

Natural enemies: Predators, parasitoids, or pathogens that attack and reduce pest populations.

Nematicides: Chemicals used to control nematodes that damage crop roots.

Resistant varieties: Crop types bred to withstand specific pests or diseases.

Sanitation: Practices such as removing diseased residues and cleaning tools to reduce infection sources.

Concept check questions [Series 5]

Objective questions

Define crop rotation and state its purpose. (Linked to SLO 5.1)

Which biological control agent produces toxins that kill caterpillars? (Linked to SLO 5.2)

State one example of a chemical used to control fungal diseases. (Linked to SLO 5.3)

What does IPM stand for? (Linked to SLO 5.4)

Which cultural method involves removing diseased residues from fields? (Linked to SLO 5.1)

Short-answer questions

Explain the difference between natural enemies and microbial agents. (Linked to SLO 5.2)

Mention two examples of resistant crop varieties. (Linked to SLO 5.1)

Describe one limitation of chemical control methods. (Linked to SLO 5.3)

State one principle of IPM. (Linked to SLO 5.4)

Identify one example of combining control strategies in IPM. (Linked to SLO 5.4)

Long-answer questions

Analyse the role of cultural control methods in sustainable crop protection. (Linked to SLO 5.1)

Evaluate the effectiveness of biological control methods compared to chemical methods. (Linked to SLO 5.2 & SLO 5.3)

Discuss the importance of integrated pest and disease management in tropical agriculture. (Linked to SLO 5.4)

Answers to concept check questions [Series 5]

Objective answers

Crop rotation is growing different crops in succession to break pest cycles.

Bacillus thuringiensis (Bt).

Fungicides.

Integrated pest management.

Sanitation.

Short-answer answers

Natural enemies are predators or parasitoids, microbial agents are microorganisms that infect pests.

Cassava resistant to mosaic disease, maize resistant to stem borers.

Chemicals may cause resistance or environmental harm.

Prevention.

Crop rotation + biological agents + limited chemical use.

Long-answer answers

Basic response: Cultural methods reduce pest incidence through crop rotation, sanitation, and resistant varieties. *Value-added response*: They also promote sustainability by reducing chemical use and improving soil health.

Basic response: Biological methods use natural enemies and microbes, while chemical methods rely on pesticides. *Value-added response*: Biological methods are environmentally friendly, while chemicals provide quick results but risk resistance.

Basic response: IPM combines multiple methods for effective and sustainable pest control. *Value-added response*: It ensures long-term productivity, protects biodiversity, and reduces reliance on chemicals.

Answers to pilot questions [Series 5]

Pilot questions 5.1

Crop rotation is growing different crops in succession; maize rotated with legumes is an example.

Sanitation reduces infection sources.

Resistant varieties withstand pests or diseases.

Crop rotation breaks pest life cycles.

Sanitation removes residues, resistant varieties prevent infection.

Pilot questions 5.2

Natural enemies are predators or parasitoids; ladybird beetles are an example.

Bt produces toxins that kill caterpillars.

Planting flowering strips conserves beneficial organisms.

Biological control is environmentally friendly.

Natural enemies attack pests directly; microbial agents infect them.

Pilot questions 5.3

Insecticides are chemicals used to kill insect pests; contact type is one example.

Fungicides control fungal diseases.

Glyphosate is a herbicide.

Nematicides protect roots from nematodes.

Insecticides kill insects, fungicides control fungi.

Pilot questions 5.4

IPM combines cultural, biological, and chemical methods; principles include prevention and monitoring.

Monitoring involves regular field checks.

Crop rotation + ladybird beetles + limited insecticide use.

IPM reduces chemical use and conserves biodiversity.

Cultural control is one method, IPM integrates multiple strategies.

References and attributions [Series 5]

Figure 5.1 Crop rotation as a cultural control method: Suggested AI prompt "Generate a labelled diagram showing crop rotation sequence between maize and legumes."

Plate 5.1 Sanitation and field hygiene in crop protection: Suggested AI prompt "Generate an image showing farmers removing diseased crop residues from a field."

Box 5.1 Examples of cultural control methods: Suggested AI prompt "Generate a box summarising cultural control methods with examples."

Figure 5.2 Natural enemies in biological control: Suggested AI prompt "Generate a labelled diagram showing ladybird beetles feeding on aphids."

Plate 5.2 Microbial control agents in pest management: Suggested AI prompt "Generate an image showing Bt microbial control applied to crops."

Box 5.2 Biological control methods: Suggested AI prompt "Generate a box summarising biological control methods with examples."

Figure 5.3 Insecticide application in crop protection: Suggested AI prompt "Generate a labelled diagram showing insecticide application on crops."

Plate 5.3 Fungicide application in crop protection: Suggested AI prompt "Generate an image showing fungicide spraying on tomato plants."

Box 5.3 Chemical control methods: Suggested AI prompt "Generate a box summarising chemical control methods with examples."

Figure 5.4 Principles of integrated pest and disease management: Suggested AI prompt "Generate a labelled diagram showing integration of cultural, biological, and chemical methods in IPM."

Plate 5.4 Combining control strategies in IPM: Suggested AI prompt "Generate an image showing farmers applying combined IPM strategies in crop fields."

Box 5.4 Integrated pest and disease management: Suggested AI prompt "Generate a box summarising principles and strategies of IPM with examples."

All illustrations are placeholders intended for AI generation or sourcing from open educational resources (OER).

Image showing modern storage facilities for arable crops.

Caption: Plate 5.3 Modern storage facilities for arable crops

AI prompt suggestion: "Generate an image showing silos, cold storage units, and warehouses for crop storage."

Search string: "modern storage facilities arable crops Nigeria OER image"