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DEPARTMENT OF HORTICULTURE HIMACHAL PRADESH

ASCI
Agriculture Skill Council of India

# Integrated Disease and Insect-Pest Management (IPM) in Apple Orchards Of Himachal Pradesh

## A Manual for Trainers

## in Shimla and Kullu Districts in Himachal Pradesh

As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

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# Integrated Disease and Insect-Pest Management (IPM) in Apple Orchards Of Himachal Pradesh

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# Foreword from GIZ

The global programme “Green Innovation Centres for the Agriculture and Food Sector (GIC)”, commissioned by the German Federal Ministry of Economic Development and Cooperation (BMZ), is being implemented in India by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, in cooperation with the Ministry of Agriculture & Farmers Welfare (MoA&FW).

The project has been working on the integrated development of the tomato, potato and apple value chains, focusing on identifying and scaling innovations that enhance the productivity and income of smallholder farmers and small-scale farming enterprises, promoting good agricultural practices and supporting FPO development. In this way the project lays the groundwork that allows farmers to adopt agroecological practices and contribute to the transformation towards sustainable and climate-resilient food systems.

Apple farmers are confronted with multi-dimensional problems, such as climate change and a decrease in chilling hours, post-harvest losses, lack of alternatives to chemical inputs, and decline in pollinator populations. These challenges keep productivity low which negatively influences the farmers’ income. To address this, the project has introduced many innovations such as manuals on good agricultural practices with scientific backstopping, pollination as an ecosystem service, solar-powered cold storage and solar dryers, trainings in food processing, and efficient irrigation techniques. Overall, the project has adopted sustainable agriculture practices to protect the soil and environment.

In Himachal Pradesh, the GIC project has been working in the apple value chain in Shimla and Kullu districts. The project is being implemented in close cooperation with the Department of Horticulture (DoH) Himachal Pradesh, Dr. Y S Parmar University of Horticulture and Forestry, (UHF) Nauni, and the Krishi Vigyana Kendra, and other implementing and private partners. The project has successfully demonstrated several innovations to achieve the key objectives.

GIC India promotes ‘innovation bundles’, which combine individual interventions to tackle multi-dimensional eco¬nomic, social, and environmental challenges. Innovation bundles build evidence and promote proven solutions for upscaling through regional and national strategies and policies.

The project has worked towards disseminating the promoted good agricultural practices by training master trainers. These technical manuals on various aspects of apple production are useful tools for expanding the project’s efforts. This document is prepared with the involvement of UHF and the DoH Shimla. I sincerely thank these organisations for contributing their learnings and hope that this technical manual will help to scale up sustainable agricultural practices in apple cultivation in Himachal Pradesh.

**Ms. Regina Sanchez Sosa**
Project Director
Green Innovation Centres for the Agriculture and Food Sector – India

# Message from Department of Horticulture, Himachal Pradesh

Since 2016, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) India, under the project Green Innovation Centres for the Agriculture and Food Sector (GIC) India has been focusing on the apple value chain in the Kullu and Shimla districts of Himachal Pradesh. With an ever-growing demand for sustainable agricultural practices and the need to enhance the livelihoods of farmers, this project stands as a beacon of innovation and collaboration.

The Memorandum of Understanding signed between our department and GIZ underscores our commitment to fostering agriculture innovation and promoting holistic development in the horticulture sector. Through this partnership, we aim to leverage climate -smart technologies and best practices, and knowledge exchange to empower apple farmers and uplift the entire apple value chain.

The joint goal of the Himachal Pradesh State Department of Horticulture (DoH) and GIZ is to create scalable models, processes, technologies, and knowledge management systems that can be effectively implemented by the DoH. Our aim is to enhance the income and productivity of smallholder farmers while ensuring the sustainability of the apple industry. Through innovative approaches and scalable solutions, we seek to address the challenges posed by climate change and foster resilience. By collaborating closely with stakeholders, leveraging expertise, and embracing a spirit of innovation, we are committed to realizing these goals and making a meaningful impact on the livelihoods of apple farmers in Shimla and Kullu districts.

The manuals, which compiles sustainable farming practices for apple crop, will undoubtedly help all extension functionaries and farmers as a practical knowledge source. It is the result of combined efforts by GIZ India, the Department of Horticulture, and scientists from the Dr. Y S Parmar University of Horticulture and Forestry, Solan and will help make apple farming more sustainable and profitable.

As we embark on this journey, I extend my heartfelt gratitude to all the partners, stakeholders, and collaborators who have contributed their expertise, resources, and unwavering support to make this project a reality. Together, we can cultivate a greener, more prosperous future for the apple growers of the state of Himachal Pradesh, while ensuring environmental sustainability and socio-economic progress.

**Mr C. Paulrasu, IAS**
Principal Secretary, Horticulture
Government of Himachal Pradesh

# Message from Dr. YS Parmar University of Horticulture & Forestry

Apple fruit is the oldest, commercially the most important, and high value temperate horticultural crop of Himachal Pradesh. With its unique climatic conditions, the state has been blessed with some of the finest varieties of apples in India. However, to ensure the sustainability and profitability of apple farming in face of multiple challenges including climate change, it is imperative to adopt climate-smart practices and technologies.

Through the Green Innovation Centers for the Agriculture and Food Sector (GIC) project implemented by GIZ India, we aim to empower apple farmers with the necessary skills and knowledge to enhance their productivity, quality, and marketability. We want to create a conducive environment for the growth of the apple industry, benefiting not only the farmers but also the entire community.

It is with great pleasure that I introduce the collaborative efforts of the GIC project and Dr. Y.S. Parmar University of Horticulture and Forestry (UHF), which aim to promote Good Agricultural Practices (GAP) in the region and provide essential knowledge through these manuals.

In this context, the research accomplishments and Good Agricultural Practices of apple cultivation practices have been compiled in the form of manuals. They serve as a comprehensive guide, covering various aspects of apple cultivation, from orchard management to post-harvest handling. These manuals are designed to be accessible and practical, catering to the needs of all kinds of farmers. I am sure this manual will help different stakeholders of the farming community to improve their knowledge, resulting in better income and sustainable horticulture development.

These manuals aim to enhance the skills of farmers, officials, and members of Farmers Producer Organizations (FPOs), creating a cadre of trainers equipped to disseminate knowledge and best practices within their communities. These barefoot trainers will sustain the capacity building process by providing farmers with the necessary skills in apple cultivation practices and creating a multiplier effect.

I am confident that through these collaborative efforts, we will foster a culture of continuous learning and improvement within the apple farming community. Together, we can create a sustainable and prosperous future for apple farming in Himachal Pradesh.

My best wishes and congratulations to whole team.

**Dr. Rajeshwar Chandel**
Vice-Chancellor,
Dr. Y S Parmar University of Horticulture and Forestry,
Solan, Himachal Pradesh

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# Introduction

## Apple Production in Himachal Pradesh

Apple (Malus domestica) belongs to the genus Malus in the Rose (Rosaceae) family. Apple trees are generally small when cultivated, with a height between 2 and 4.5 meters. If left untrimmed, a tree grown with standard rootstock can reach a height of 9 meters (30 feet) with an equally large crown diameter. The bark is usually brown and scaly. The simple leaves are roughly oval in shape and usually have serrated margins. Apple flowers are showy with five white petals, often tinged with pink, and numerous stamens. Bees and other insects pollinate the flowers, and most varieties require cross-pollination for fertilisation.

The apple fruit is a pome (fleshy) fruit in which the ripened ovary and surrounding tissue become fleshy and edible. When harvested, apples are usually roundish, 5–10 cm (2–4 inches) in diameter, and some shade of red, green, or yellow in colour; they vary in size, shape, and acidity depending on the variety of which there are thousands.

In India, the total area under apple cultivation in 2020-21 was 3,12,620 Ha, with a total production of 22,75,840 MT. The average productivity was 7.28 MT/Ha. Jammu and Kashmir is the most important apple-producing state, followed by Himachal Pradesh and Uttarakhand. Both the area under cultivation and the total production are on an increasing trend. India ranks fifth in terms of production amongst apple-producing countries in the world. In 2020-21, India exported 30,680 MT of apples worth Rs. 106.65 Crores, which has more than doubled in 4 years between 2017 and 2021.

While the apple is a temperate fruit crop, the apple-growing areas in India do not fall in the temperate zone. However, the prevailing temperate climate of these apple-growing regions is due to the Himalayan ranges and high altitudes. The average summer temperature for apples should be around 21-24°C during active growth. Apple succeeds best in areas where the trees experience uninterrupted rest in winter and abundant sunshine for good colour development. It can be grown at an altitude of 1500- 2700 m above sea level. Well-distributed rainfall of 1000-1250 mm throughout the growing season is most favourable for optimum growth and fruitfulness of apple trees.

Himachal Pradesh is called India’s fruit basket, with a total area of 2,34,780 Ha under fruit cultivation, and a production of 6,24,490 MT in the year 2020-21. Apple accounts for 1,14,650 Ha

area with a total production of 4,81,060 MT in 2020-21. Apple contributes about Rs. 5000-6000 crores to the state economy, contributing more than 80% of the total fruit production in Himachal Pradesh. Shimla and Kullu districts together constitute approximately 65% of the total area under cultivation in apples and rank the highest and second highest among all districts in the state in production, respectively.

Apple production is susceptible to climate change, which will cause an increase in temperature and variability in precipitation. The excessive use of chemical fertilisers and pesticides has decimated the populations of most pollinators (bees, butterflies, and insects); poor pollination has, in turn, compromised apple production. Any negative impact on apple production due to climate change will impact the horticultural economy which provides livelihoods and income for hundreds of thousands of families and other value chain actors from production to consumption.

## About Green Innovation Centres for the Agriculture and Food Sector - India

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is a public-benefit federal enterprise of the German Government. In its projects, GIZ works with partners in national governments as well as actors from the private sector, civil society and research institutions. GIZ's main commissioning party is Germany's Federal Ministry for Economic Cooperation and Development (BMZ). Other commissioners include the European Union, the UN, the private sector, and governments of third countries.

The global programme "Green Innovation Centres for the Agriculture and Food Sector (GIC)" is funded through the Special Initiative "Transformation of Agricultural and Food Systems" of the BMZ. Since 2016, the project is implemented in India by GIZ in cooperation with the Ministry of Agriculture & Farmers Welfare (MoA&FW). In Himachal Pradesh, the project works in collaboration with the Department of Horticulture, Himachal Pradesh.

Working in the Rohru and Chirgaon regions of Shimla district and the Naggar and Kullu regions of Kullu district, the GIC project identified, tested, and introduced various innovations in a participatory manner involving the farmers.

## Why we developed this Training of Trainers Module

GIC India, in partnership with the Department of Horticulture, Himachal Pradesh (DoH) and Dr. YS Parmar University of Horticulture and Forestry, Nauni (UHF), is creating a pool of Master Trainers in Good Agriculture Practices in apple cultivation in Himachal Pradesh. These Good Agriculture Practices cover canopy management, pollination management, nutrition management, and integrated pest management. This pool of master trainers is being created through Training of Trainers (ToT).

This Training of Trainers (ToT) manual provides technical information on canopy management and follows the flow of the field training.

This manual is meant as a tool during the ToTs for Master Trainers and horticulture extension officers to enable them to train farmers and transfer agronomic knowledge on integrated disease and insect-pest management. This will enhance the farmers' skills and knowledge. This manual addresses principles of learning and training design for adults, provides technical information on integrated disease and insect-pest management, and provides references for further reading.

The manual seeks to convey an interactive, well-designed and facilitative approach to learning for the target group of farmers. The inclusion of women trainers is essential in the ToTs. Women with suitable profiles and interest who can become master trainers should be included in the trainings.

This manual aims to provide insights into the integrated disease and insect-pest management practices in apple farms. It provides an overview of the main concepts of integrated disease and insect-pest management and its importance in apple orchards. It also includes information on various methods and practices to ensure adequate pollination, as well as the importance of conservation of bees and wild insect pollinators, along with chemicals to avoid that are harmful to the pollinators, to make a balance between improving productivity and ecological biodiversity and health. Its objective is to provide extension officers, members of Farmer Producer Organisations (FPO), and progressive youth with the necessary information and skills to become trainers and deliver technical capacity sessions on this topic.

# Acknowledgements

Various institutions and individuals have contributed to the technical content of these manuals, which are acknowledged below.

- Scientists from Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan
- Agriculture experts of the GIC India Project, GIZ
- Experts from the Kompetenzzentrum Obstbau Bodensee
- Senior consultants - Dr. Joginder Singh Chandel, Retired Head of Fruit Science, Dr. YS Parmar UHF Nauni and Dr. Shamshar Singh Rana, Retired Associate Director, RHRTS Nurpur UHF Nauni.
- Training design by The Training Shift

# Overview of apple production in India

Apple (Malus domestica) cultivation in India has emerged as a promising horticulture crop, offering significant growth and economic development potential. With a diverse range of agro-climatic conditions and suitable regions, the country has steadily expanded its apple production over the years. The cultivation primarily thrives in the northern states such as Himachal Pradesh, Jammu and Kashmir, and Uttarakhand due to their favourable climatic conditions.

**Agro-climatic diversity:** India's diverse topography and climate provide a spectrum of conditions suitable for different apple varieties. The temperate climate in higher altitudes mirrors the conditions conducive to apple cultivation, allowing for a range of cultivars to be successfully grown.

**Varieties of Apples:** Several apple varieties have been introduced and adapted to Indian conditions. These include both traditional varieties and spur varieties, each with unique characteristics and suitability for specific regions. The most common standard varieties include Red Delicious, Royal Delicious, Golden Delicious, and Fuji.


**Cultural practices and management:** Successful apple cultivation involves various cultural practices such as proper site selection, suitable irrigation techniques, nutrient management, training and pruning, and pest control. These practices are essential for maintaining orchard health and ensuring a fruitful yield.

**Economic impact:** The apple production industry significantly contributes to the socio-economic development of the regions. It generates employment opportunities for local communities, supports agri-tourism, and contributes to the overall agricultural economy.

**Market dynamics:** The demand for high-quality apples in both domestic and international markets is on the rise. India not only caters to its domestic demand but also exports apples to countries in the Middle East, Southeast Asia, and beyond. For successful commercial apple production, understanding market demands and consumer preferences is crucial.

**Technological integration:** The integration of modern technologies and innovation, such as precision farming, advanced irrigation systems, and data-driven agricultural practices, is increasingly becoming a part of apple cultivation, optimising yield and quality.

**Sustainability and environmental concerns:** The industry is shifting towards sustainable practices, considering environmental impact, conservation of resources, and biodiversity preservation. Compliance with environmental regulations and certification standards is gaining significance in the sector.

# ToT Manual
# INTEGRATED PEST MANAGEMENT (IPM)

## 1 Day Field Training

# Topic 1 | Integrated Pest Management (IPM) as an Opportunity

## Objectives and key messages

| | |
|---|---|
| Topic objectives | • Define IPM<br>• Understand the aim and benefits of IPM |
| Key messages to bring out | Integrated pest management, or IPM, is a process to solve pest problems while minimising risks to people and the environment.<br><br>IPM can be used to manage all kinds of pests anywhere–in urban, agricultural, wildland, or natural areas. |

# What is IPM?

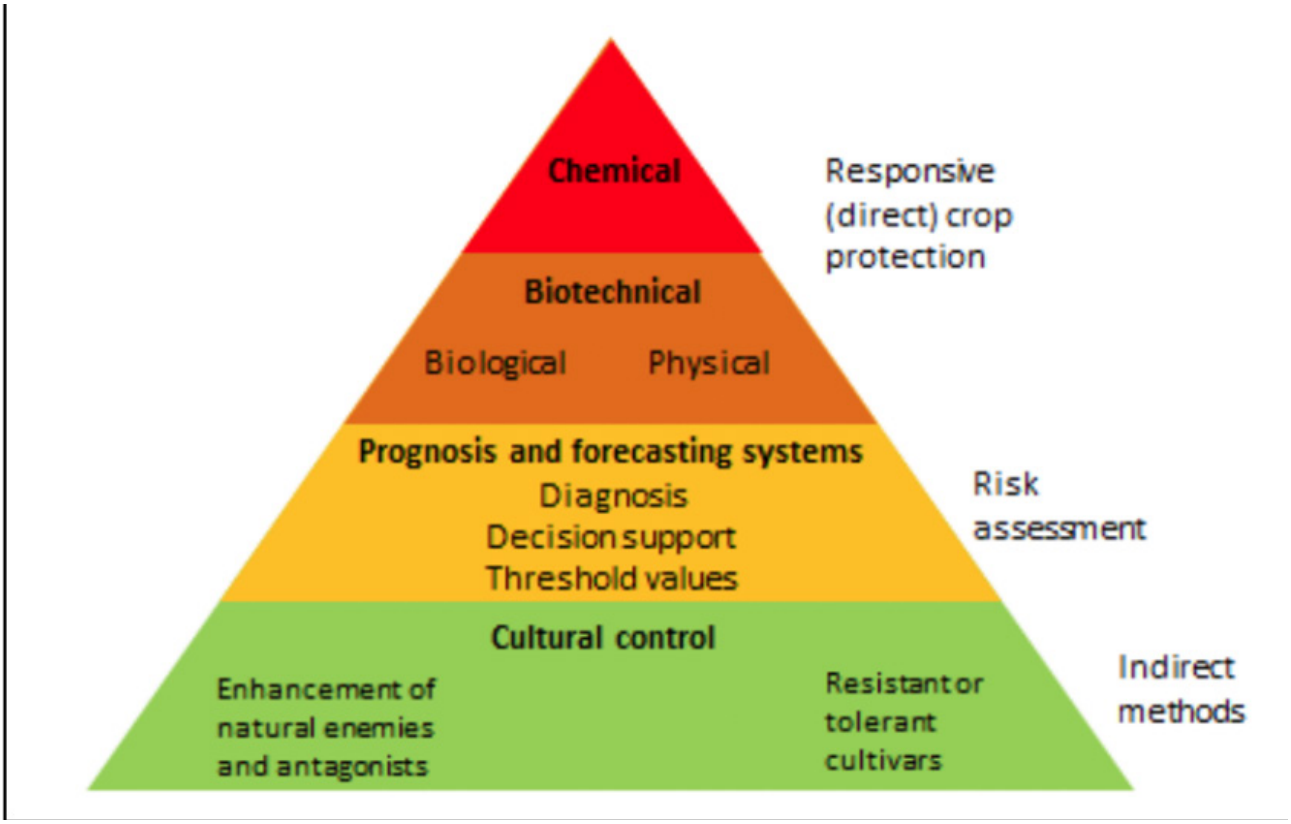



*Fig. 1: Integrated pest management.*

Integrated pest management, or IPM, is a process to solve pest problems while minimising risks to people and the environment. IPM can be used to manage all kinds of pests anywhere–in urban, agricultural, wildland, or natural areas.

Integrated pest management means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations, keep pesticides and other interventions to levels that are economically justified and reduce or minimise risks to human health and the environment. IPM emphasises the growth of a healthy crop with the least possible disruption to agroecosystems and encourages natural pest control mechanisms.

# Aim of IPM

- Reduce the use of synthetic pesticides.
- Adopt environment-friendly strategies for pest control.
- Use of pesticides in a way that causes minimal risk to human health.
- Provide consumable safe food.
- Lower chances of development of pesticide resistant strains

*Fig. 2: Apple trees must be checked regularly for pest infestation.*

## Principles of IPM

- Identification of key pests and beneficial organisms.
- Establishment of economic thresholds limit.
- Development of assessment techniques.
- Evolving description of predictive pest models.
- The prevention and/or suppression of harmful organisms should be achieved or supported among other options, especially by
    - Crop rotation,
    - Use of adequate cultivation techniques (e.g. sowing densities),
    - Use, where appropriate, of resistant/tolerant cultivars and standard/certified seed and planting material,
    - Use of balanced fertilisation, liming and irrigation/drainage practices,
    - Preventing the spread of harmful organisms by hygiene measures (e.g. by regular cleansing of machinery and equipment),
    - Protection and enhancement of important beneficial organisms, e.g. by adequate plant protection measures or the utilisation of ecological infrastructures inside and outside production sites.
- Harmful organisms must be monitored by adequate methods and tools.
- Such adequate tools should include observations in the field as well as scientifically sound warning, forecasting, and early diagnosis systems, where feasible, as well as the use of advice from professionally qualified advisors.

## Key Benefits of Using IPM

- Promotes healthy plants.
- Promotes bio-based pest management, i.e., control by useful insects.
- Reduces air and groundwater contamination.
- Maintains soil fertility.
- Prevent soil depletion and reduce soil erosion.
- Lower risks to human health and the environment (e.g., water resources, pollinating insects)
- Delayed development of pesticide resistance
- Cost effective as the pesticides are costly.
- Improved public image of agricultural products.

# Topic 2 | Spectrum of Harmful Organisms in Orchards

## Objectives and key messages

| | |
|---|---|
| Topic objectives | • Identify the four most harmful organisms on orchards |
| Key messages to bring out | Orchards contain a wide variety of diseases and pests. Farmers need to understand how viral and phytoplasma diseases, bacterial infections, fungal diseases, and insect pests impact their apple trees. |

Fruit crops are food sources for harmful organisms in the form of leaves, shoots, woody parts and fruits and provide them with shelter and opportunities to spread over the years. In orchards, there is an extraordinarily wide variety of diseases and pests. The spectrum includes viral and phytoplasma diseases, bacterial diseases, fungal diseases, and insect pests. These can be specialised in certain plant types of fruit or occur in various types.

## Viruses and phytoplasmas

Viruses do not have their own metabolism and are made up of proteins and nucleic acids. They multiply in living cells and disrupt their metabolism. They spread in orchards through the planting material or seeds. The transmission from plant to plant is carried out by animal vectors (carriers), such as leaf suckers, aphids, cicadas, gall mites and nematodes. Transmission through pollen is also possible. Symptoms of infestation in fruit plants are characteristic discolourations and deformities on leaves, shoots and fruit, stunted growth and dieback symptoms shortly after infection or even later. It is not possible to cure diseased plants in the orchard. Phytoplasmas are bacteria without a true cell wall that grow obligatory in the plant phloem. These phytoplasmosis pathogens belong to the class of mollicutes and were formerly known as mycoplasma-like organisms (MLOs). Examples of phytoplasmoses are apple proliferation (Candidatus phytoplasma mali) and pear blight (Candidatus phytoplasma pyri). Typical symptoms of phytoplasmosis are leaf yellowing, red foliage and greening and malformation of flowers or fruit deformation.

## Bacteria

Bacterial plant diseases are caused by unicellular rod-shaped organisms, which reproduce exclusively by division. The pathogens, which are only a few thousandths of a millimetre, are spread in particular by rain splashes, insects and the planting material.

## Fungal Diseases

The most important pathogens on fruit plants are fungi. Some live exclusively on living plant parts, while others also live on dead matter (saprophytic). The fungi are spread by spores. These are mainly spread by rain and wind. Of the various types of spores, ascospores and conidia are the most important. Ascospores develop in a sac-shaped structure (ascus), mostly within spherical (perithecia, pseudothecia, etc.) or cup-shaped fruiting bodies (apothecia). They are often responsible for the initial infections in spring and long-distance spread. Conidia develop vegetatively on conidiophores or in more or less closed containers (pycnidia, acervuli). They perform the same tasks as ascospores. In addition, they also ensure the rapid local spread of the fungi in summer.

## Pests

Most pests in orchards are insects and mites. Harmful vertebrates occur in small numbers.
**Insects:** Among the insects, species with imperfections and those with complete metamorphosis are distinguished. Aphids, scale insects, leaf suckers, cicadas and bugs are insects with imperfect metamorphosis. Thenymph that hatch from the eggs are already more or less resemble the adult animals. The nymphs develop from moult to moult to the mostly winged full insect (adult, imago). Insects with complete metamorphosis include butterflies, beetles, hymenoptera and diptera. Their larvae look completely different than the respective full insect: The larvae grow over the course of several moults and then rest as a pupa. Then, the adult insect hatches from the pupa.
**Mites:** The mites that are harmful to plants include spider mites and gall mites. Their development is similar to insects with imperfect development. This is why the protonymph and deutonymph look very similar to the adults.
**Vertebrates:** These are mainly birds. A dangerous root pest is the vole or shearer mouse. Field mice cause damage mainly by gnawing the bark just above the ground.

# Topic 3 | Pest Scouting

## Objectives and key messages

| | |
|---|---|
| Topic objectives | • Understand the difference between direct and indirect techniques of pest scouting<br>• Use standard format and formula to calculate and record the severity of damages on apple trees. |
| Key messages to bring out | The goal of pest scouting is to detect pests early and determine whether their populations have reached a level where control measures are necessary.<br><br>The most efficient method to estimate the population density of insects/incidence of disease is through "sampling", which are direct and indirect scouting techniques.<br><br>Get farmers familiar with how to record the severity of damages caused by insects and pests on their farms. |

Pest scouting, also known as pest monitoring, is a systematic approach to identifying and assessing pest populations in agricultural or horticultural settings. It involves regularly inspecting crops or plants for signs of pests, diseases, or other damage. The goal is to detect pests early and determine whether their populations have reached a level where control measures are necessary.

The scouting can be carried out for an entire growing season or at certain critical periods in the life cycle of insect pests and diseases. It is classified as qualitative (dealing with pest detection – a type of species) or quantitative (dealing with pest abundance), where the count of insects or a measure of their presence is obtained. The latter are more common in relation to IPM/ IDM. The most efficient method to estimate the population density of insects/incidence of disease is through "sampling". Two types of sampling techniques are employed.

# Direct and indirect scouting techniques

**Direct techniques**

- Such techniques take a direct count of insects/ diseased leaves /fruit/ plants. Data obtained are expressed as a number of insects or a number of fruit/ leaves/ plants infected. Insect counts can be further divided into
- In situ count
- **Knockdown** (Berlese funnel, chemical, jarring),
- **Netting** (Sweep net, vacuum net, rotary net),
- **Trapping:** Attractive traps (Visual trap, bait trap, pheromone trap), passive traps (Suction trap, water pan trap, window trap, sticky trap. pitfall trap).

**Indirect techniques**

In these techniques population estimates are made on effects or products of insect pests and disease and called population indices.

- Effects of the insect feeding and pathogen infection: Per cent defoliation, per cent incidence/ severity, number of plants cut by cutworm/ infected by the disease, dead hearts caused by borers.
- Products of insects: Measures of larvae and pupal skins, frass (dropping including insect excrement), webs/ tents.

# Record severity of damages

**Scouting technique for recording the severity of diseases and insect pest damage**

- Select five random apple trees per reference orchard.
- Mark the selected trees and number them in black colour from 1 to 5 in a white rectangle. background on the middle of the tree trunk.
- Examine four random branches/trees for insect pests & diseases at every ten days interval. Select branches from 4 different directions per tree for scouting.
- Examine leaves, buds, flowers, fruits & twigs of each branch with a 10-x lens and rate for insect pests & diseases as per a 0-5 rating scale.
- Record the observations for the disease or insect pest as per the rating scale.

*Fig. 3: Observing and recording severity of diseases and pest damage.*

| Disease or Insect Pest Rating (0 - 5 Scale) | |
|---|---|
| 0 | No relevant disease or insect pest attack was observed on leaf fruit or plant parts. |
| 1 | Up to 10 % attack of disease or insect on the relevant plant part |
| 2 | 11 to 25 % attack of disease or insect on relevant plant part. |
| 3 | 26 to 50 % attack of disease or insect on relevant plant part. |
| 4 | 51 to 75 % attack of disease or insect on relevant plant part. |
| 5 | 76 to 100 % attack of disease or insect on relevant plant part. |

Per cent disease or insect damage index indicative of severity is calculated by following the formula.

$$\text{PDI/ PIDI} = \frac{\text{Sum of all disease/ insect damage ratings}}{\text{No. of sample observed x maximum grade of rating}} \times 100$$

*Fig. 4: Rating scale for diseases and insect along with formula to calculate severity of damage.*

# Topic 4 | Bee Protection

## Objectives and key messages

| | |
|---|---|
| Topic objectives | • Recognize the western honeybee's importance as a pollinator in fruit growing and its impact on biodiversity.<br>• Identify protective measures to protect honeybees from harmful pesticides |
| Key messages to bring out | The western honeybee is one of the most important pollinator insects in fruit growing.<br><br>Pollination by bees enhances fruit yield, improves crop quality, and supports biodiversity.<br><br>Honeybees must be protected due to their crucial role in pollination.<br><br>Pesticides can endanger honeybees, but understanding bee behaviour can help reduce harm. |

The western honeybee is one of the most important pollinator insects in fruit growing. Pollination of flowers occurs when the bee collects pollen and nectar as food from the flowers. Pollen remains on the bee's coat and is transferred to the stigma of the next flower when it is visited. The pollination service provided by bees not only secures fruit yields and increases the quality of crops but also ensures biodiversity. The honeybees must, therefore, be protected. The application of pesticides can pose a danger to honeybees. However, if farmers are aware of the behavioural patterns, there are a few ways to significantly improve their protection when applying pesticides.

**Protective measures**

- Do not apply plant protection products that are hazardous to bees during flowering.
- The spray mist from bee-hazardous products must never be allowed to reach flowering plants. Particular attention must be paid to whether there are flowering herbs under the trees. If these flowering herbs are there, no bee-hazardous products may be sprayed.
- Insecticides that are not harmful to bees should also be applied outside the bee flight. The evening hours after the daily bee flight are suitable.

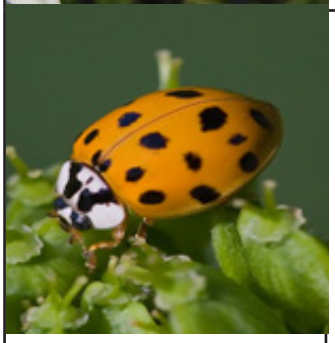
# Topic 5 | Beneficial Insects

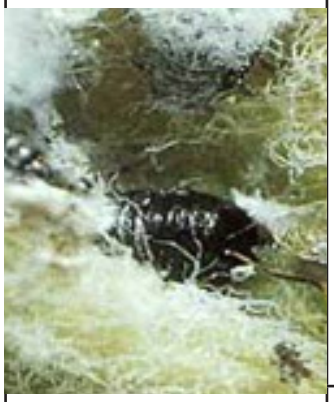
## Objectives and key messages

| | |
|---|---|
| Topic objectives | • Identify beneficial insects in your orchard<br>• Create measures to promote beneficial insects |
| Key messages to bring out | A high level of biodiversity is without doubt a prerequisite for well-functioning integrated pest management. Natural antagonists of various pests help to minimize the need for direct plant protection measures.<br><br>There are 8 ways to create measures to promote these beneficial insects on orchards:<br>Measure # 1 Promotion of a Species-Rich Undergrowth<br>Measure # 2 Hedges, Shrubs and Individual Trees<br>Measure # 3 Cairns/Dry Stone Walls and Wetlands<br>Measure # 4 Nesting and Breeding Aids<br>Measure # 5 Seeding<br>Measure # 6 Suitable Plant Species<br>Measure # 7 Creating the Flower Strips<br>Measure # 8 Maintenance of the Flower Strips |

# Identify beneficial insects

A high level of biodiversity is without doubt a prerequisite for well-functioning integrated pest management. Natural antagonists of various pests help to minimize the need for direct plant protection measures.

| | Description | Beneficial insect performance | Prey/ Host |
|---|---|---|---|
|  Phytoseiulus persimilis | Predatory mites are drop-shaped, very agile and have long legs. They are most easily found on the leaf veins on the underside of the leaf and in the leaf axils. There are various species in our apple orchards. | 30 to 50 spider mites | Spider Mites, Rust Mites |
|  Orius insidosus | Predatory bugs include flower bugs, soft bugs, and sickle bugs. These beneficial insects are characterised by their flat bodies, short, three-limbed, strong proboscis and large neck shields. | 200 spider mites | Spider Mites, Aphids, Pear Sucker |
|  | Seven-spot ladybugs have, as the name suggests, seven black dots on their orange-coloured, strongly curved wing covers. The egg clutches are yellow and upright. Ladybugs are already active before the apple blossom. | 400 aphids | Aphids, Spider Mites |
|  Asian Ladybug | The Asian ladybug is variably coloured. It can have black, red or orange elytra. These can have up to twenty red or black spots. This ladybug sometimes displaces other species. | >aphids<br><br>The number may be added. | Aphids, Woolly Aphids |

| | | | |
|---|---|---|---|
|  | The black spherical ladybug, better known as the spherical ladybug, is approx. 1.5 mm in size and black. Its body is densely hairy, and its antennae and legs are yellowish. | 240 spider mites, 600 mites | Spider Mites |
|  | Green lacewings are characterised by the filigree structure of their transparent wings, which are folded like a roof. The eggs of the 6 to 10-mm long lacewings sit on long stalks. | 200 to 500 spider mites | Aphids, Spider Mites |
|  | Lacewing wasps belong to the family of parasitic wasps, which are very host-specific parasites. The females lay their eggs directly in the host. The hatching larvae feed on their host animal. The intensive parasitisation phase begins in June. | One wholly aphid per larva | Wolly Aphids |
|  | Several ichneumon wasp species of the genera Trissolcus, Anastatus and Telenomus can lay their eggs in the egg clutches of bugs and thus render them harmless. The picture on the left shows a clutch of the marmorated stink bug with the characteristic dark discolouration of the parasitised eggs. | Varies depending on the species | Stink bugs |
|  | The earwigs, which are mainly nocturnal, have been shown to decimate aphid colonies. In recent years, the omnivores have also occasionally caused damage through leaf feeding. Healthy apples are not usually eaten, but existing skin damage, for example, in the stem pit, can be enlarged. | Several aphids per day | Aphids, Woolly Aphids, Mites |

In addition to arthropods, there are also numerous other beneficial animals such as various mammals (hedgehogs, weasels, bats), reptiles (lizards and snakes) and birds (birds of prey, insectivores). They can play an important role in pest control and should be encouraged in integrated farming systems.

## Create measures to promote beneficial insects

**Measure # 1 Promotion of a Species-Rich Undergrowth**

In spring and summer, shoots with a high predatory mite population can be introduced from other apple orchards. Many insect species are dependent on the supply of pollen and nectar. The herbaceous layer also serves as an important refuge for a wide variety of beneficial insects.

- Alternating mulching of the areas (only every second row is mulched in one pass) ensures that there are always flowering herbs and retreat areas for insects in the plantation. Alternatively, a narrow strip in the middle of the row can be left for a longer time.
- Sown flowering strips between the lanes or at the edge of a plantation are a valuable measure to improve the supply of flowering herbs and grasses.
- In dry locations, care should be taken to ensure that the undergrowth does not dry out completely in summer.
- When implementing these measures, it should be noted that the flowering undergrowth must be mulched before treatment with products that are harmful to bees. The mulching process should take place outside the bee flight.

**Measure #2 Hedges, Shrubs and Individual Trees**

Hedges and individual trees form important landscape elements and are among the most species-rich habitats, they provide a refuge for a large number of beneficial insects The availability of flowering shrubs over as long a period as possible is only achieved by a wide range of different species.

- Caution: Hedge plants can be hosting plants for unwanted pests such as flies or bugs. Bear this in mind when selecting plants. As an alternative to planting hedges, the edges of orchards can also provide refuge areas for beneficial organisms. These include roadsides, embankments, or fringe strips.

**Measure #3 Cairns/Dry Stone Walls and Wetlands**

- Stone piles are not only suitable as shelters and burrows for beneficial small mammals such as weasels and hedgehogs. Insectivorous and molluscivorous reptiles and amphibians also depend on cavities to survive.
- Many animal and plant species are specially adapted to live in and around bodies of water. Near-natural bodies of water are now very rare and, with their typical riparian vegetation, are important ecological compensation areas.

**Measure #4 Nesting and Breeding Aids**

- Many useful songbirds are cavity nesters. It is particularly useful to install nesting boxes where natural nesting opportunities are lacking.
- For weasels to settle and reproduce, they need a selection of suitable hiding places. Three to four weasel nesting boxes per hectare can help here.
- Bats colonise the walls of houses and quiet, spacious attics. As these habitats are becoming increasingly rare, bat caves could make up for this.
- Insect nesting sites, also known as insect hotels, can be used to attract various Hymenoptera, such as wild bees or hornets, to the orchard. These nesting places can be bought or made.
- Boxes filled with wood wool and painted red or red-brown with entrance and exit slats on one side and on the bottom are suitable as an overwintering aid for lacewings.
- The colonisation of earwigs can be encouraged by providing suitable hiding places. For example, flowerpots filled with wood wool and hung upside down near the trunk are suitable for this purpose.
- Conversely, in young plants in which leaf damage occurs due to an overgrowth of the earwig population, it is important to reduce hiding places, for example, by not using bamboo poles in the support structure.

**Measure #5 Seeding**

- A targeted increase in plant diversity in orchards improves the living conditions of beneficial insects and helps to optimise their ecosystem services.
- Flower strips are a habitat and food source for numerous species of predators, parasitoids and pollinators.
- In contrast to short-cut grass, the higher activity of a flowering strip enables improved biological pest control through natural antagonists.
- In plants where sowing was carried out last year, an increased occurrence of bugs has been observed.
- Caution: Plant protection products that are hazardous to bees must not be applied to flowering plants (see chapter on bee protection).

**Measure #6 Suitable Plant Species**

The selection of plants should be tailored to the needs of beneficial insects. Early and easily accessible flowers, suitable for the mostly short mouthparts, offer easy access to nectar and pollen. Continuous flowering of the seed mixture during the entire vegetation period is advantageous. The choice of plants should also be adapted to the site in terms of precipitation patterns, soil type and shade.
Biennial and perennial species do not need to be reseeded annually.

**Measure # 7 Creating the Flower Strips**

- Flower strips planted in the tramline should not exceed the width of the tractor track so that they are not in direct competition with the apple trees for nutrients and water. This is particularly important for new plantings.
- The sowing date depends primarily on the composition of the seed. Seed mixtures in

productive orchards should, if possible, be sown in the pre-flowering period, while hardy seedings should be sown within September.
- The seed requirement depends on the width of the flowering strip and is approximately between 5 and 10 g per square meter.
- A well-prepared seedbed using a rotary harrow or cultivator promotes the germination and development of the sown plant species and makes subsequent maintenance of the flowering strip much easier.
- If the soil is heavy and compacted, it is advisable to prepare the soil using a spading machine or cultivator.
- The seed can be supplemented with sand or soybean meal to make sowing by hand easier and to prevent segregation of the sowing mixture.
- Rolling the seed after sowing ensures good contact between the seed and the soil and reduces the germination of weeds. In the event of prolonged drought, the seed should be watered if possible.

**Measure #8 Maintenance of the Flower Strips**
- Without regular maintenance, weeds can be established in the soil from their natural seeds despite sowing. Appropriate care measures and sufficient soil moisture promote the establishment of the seed mixture.
- Not too frequent mulching allows the sown plants to spread and seed out.
- The mulching dates should be chosen depending on the stage of development of the flower strip mixture.
- As a rule, flower strips can be mulched three to a maximum of four times a year.
- The first maintenance cut at a growth height of 30 to 40 centimetres improves the light conditions for seedlings. Ideally, the clippings should not lie on top of the seed, as a thick layer of mulch prevents further seeds from germinating.
- A second cut six to eight weeks later encourages seedlings to germinate. If necessary and if there is strong growth, a further mulching process can take place before harvesting.
- Further mulching after harvesting helps to regulate mice.
- The cut should be made at least 8 to 10 cm above the ground to protect the vegetation, especially rosette-forming species.
- In the case of perennial flowering mixtures, care in the first year forms the basis for a permanent spread of the sown plants.

# Additional information about beneficial insects

### Predatory mites *(Typhlodromus pyri, Amblyseius andersoni, Zetzella mali, Neoseiulus longispinosus)*

Predatory mites are among the most important beneficial insects in fruit cultivation. As antagonists of harmful mites, they contribute significantly to the natural reduction of spider and rust mites. Just 1/3 of the leaves covered with predatory mites can sufficiently regulate the number of spider mites. As “protective predators”, they are always present in the plants. Of course, this only applies if certain plant protection rules are observed.

Predatory mites react very sensitively to some plant protection products. The use of preparations that are gentle on predatory mites should, therefore, be a priority when choosing products. In times of need, when no animal prey is available, they switch to plant food. Around 30 different species of predatory mites can be found on fruit trees. T. pyri is the most important in apple cultivation. Amblyseius andersoni is often found on hedges and older trees.

**Family Phytoseiidae:** In terms of size, they are very similar to spider mites. The 0.25 mm males are slightly smaller than their female counterparts (0.34 mm). Their oval body has a smooth, shiny surface. Depending on the type of food, it is white and yellowish in colour. Red colouration is rather rare. The adults are extremely agile. The four pairs of legs enable them to move quickly in warm weather. The front pair of legs is also very elongated, which is the characteristic distinguishing feature. The roundish eggs are translucent white. They are laid on the underside of the leaf, protected in the groove of the main leaf vein.

**Family Stigmaeidae:** Zetzella mali has a clearly reddish-yellow coloured, oval body. The legs are relatively short compared to the species described above. It moves slowly. Its main food is rust mites and the eggs of the fruit tree spider mite. This species is difficult to distinguish from the other indifferent species.

**Way of Life:** The females survive the cold season under bark scales, on corked cuts and in other protected places on the apple tree. They become active in spring. First, they colonise the leaves before they begin to lay their eggs during flowering. During the year, 3-5 generations, sometimes overlapping, are formed; predatory mites are, therefore, present on the leaves throughout the entire vegetation period. They are mainly found on the underside of the leaves. They spread rapidly through the crop. In some cases, the predatory mites are carried by the wind into the neighbouring rows.

**Significance:** The diet of predatory mites is varied. They are considered voracious predators of spider mites, other mites and their eggs. They even eat small insects. With their pointed jaws and long mouthparts, they pierce their prey and suck it dry. A population density of just 0.5-1 predatory mite per leaf can keep the spider mite, for example, below the economic damage threshold. In the absence of animal prey, they switch to plant food sources such as pollen, fungal spores, honeydew and plant sap. Predatory mites are considered “protective predators”. Predatory mites are always present in older trees with sufficient hiding places.

**Protection and Control:** Predatory mites react very sensitively to insecticides and fungicides, especially preparations containing sulphur. Therefore, only pesticides that are gentle on predatory mites should be used. Natural colonisation of predatory mites is possible. This is particularly recommended in young plants. In summer, shoots from plants that are well colonised with predatory mites are hung in the young trees. Another option is to insert already colonised coir ropes and felt bands in the winter months. These were wrapped around branches and trunks of older trees with expectedly high predatory mite populations over the summer. The predatory mites readily accept these materials as hiding places and retreat into them for hibernation before leaf fall. Inspection: Checking branch samples in winter provides an initial indication of the subsequent emergence in spring and summer. Popular hiding places are old pruning wounds and frayed bark injuries. The underside of the leaves can be visually inspected for predatory mites in early summer.

**Observations from Practice:** New plantings are colonized very quickly by predatory mites if there are orchards with predatory mites in their immediate vicinity.
In spring, there are still a few predatory mites around. After the 1st generation, they are easy to find, usually on the main leaf vein on the underside of older leaves inside the tree.
Shields of dead large fruit tree scale insects are very popular as hiding places, especially the shields of parasitized scale insects with loopholes.

### Lacewing *(Chrysoperla carnea, Chrysoperla zastrowi sillemi)*

Over 30 different lacewing species are known. The most common species in orchards, and therefore the most economically important, is the common green lacewing (Chrysoperla carnea).I The larvae, some of which are cannibalistic, are predators of aphids, leaf fleas and other harmful insects and mites. The large, shiny golden eyes of the adults are striking. In India, particularly in Himachal Pradesh, it is Chrysoperla zastrowi sillemi which is more common.

**Biology:** The adults have a green to greenish-yellow coloured body, about 6-10 mm long. The four filigree, transparent, and green-veined wings are longer than the body and reach a wingspan of up to 30 mm. The hind wings are somewhat smaller than the forewings. The large, gold-coloured eyes and the thread-like antennae are striking. The pale green, elliptically-shaped eggs are 1 mm long. They are laid on long, flexible stalks to protect them from predators, which are often their own siblings. The body of the larvae is spindle-shaped and 7-8 mm long. Two reddish-brown bands run along the back on a light cream-coloured background. Laterally, there are small, hairy tubercles. A pair of well-developed suction hooks is attached to the head for sucking out prey. There are three pairs of sterna. Pupation takes place in sheltered places in a white, almost round (3-5 mm) cocoon.

**Way of Life:** In contrast to other lacewing species, the females and males of Chrysoperla carnea overwinter in the adult stage in suitable hiding places (high trunks, wood crevices, hedges, greenhouse walls). They often survive the cold season in houses. They become active again in spring. Eggs are laid from May to July and in August. The eggs are laid almost randomly, individually or in groups, on the underside of leaves, on branches or on wooden poles. A female lays several hundred eggs over the course of the growing season. Depending on the temperature, the first larvae hatch after 3 to 15 days. These are extremely active and consume a large amount of prey during their 8 to 10-day development phase. The fully-grown larvae spin themselves into a white

cocoon shortly before pupation. The lacewings hatch after a few weeks. Depending on the location, 2-3 generations occur per year.

**Significance:** In contrast to other predatory species, the adults of the common lacewing feed mainly on honeydew and pollen. As aggressive predators of aphids, and spider mites, the larvae are particularly important in regulating pest populations. Due to their wide range of prey and their high mobility, their effect on individual pests cannot be reliably predicted. Nevertheless, they make a major contribution to the containment of a wide range of pests.

**Protection and Control:** Both larvae and adults react very sensitively to pesticides. The use of insecticides leads to a significant population reduction. It is not easy to make reliable statements about the population density of lacewings. Their vagabond lifestyle and random egg-laying make visual monitoring difficult. Larvae can possibly be detected by tapping.

### Ladybug (different ladybug species)

There are more than 70 species of ladybugs in Central Europe and more than 55 species of ladybugs have been recorded in Himachal Pradesh. The majority of them feed on aphids, some on-scale insects, while the remaining species specialise in eating spider mites and mildew fungi. Both beetles and larvae are predatory and very voracious. The individual species can be distinguished by the very varied colouration of the wing covers. Ladybugs have a regulating effect in controlling pest populations in orchards, but their importance in biological control should not be overestimated. Like many other beneficial insect species, they are usually only effective when large numbers of feeding animals (pests) are present. The damage is often already done by then.

**Biology:** Ladybugs are known for their hemispherical shape and strikingly coloured wings. Individual species can be distinguished by characteristic dots, spots and patterns on the elytra. Even within a species, the design and colouration of the elytra vary greatly. Ladybugs have two pairs of wings. The forewings (elytra) are hardened and cover the entire hind body. Underneath are the membranous hind wings, which act as propulsion when flying. The underside of the body is flat. The eggs are usually yellowish and oval and are laid standing individually or in groups, preferably in the vicinity of pest colonies. The extremely lively larvae have a spindle-shaped, strongly segmented body and three well-developed pairs of legs. The warts with bristles or wax excretions on the upper side are striking. As voracious predators, the larvae and beetles have well-developed mouthparts. The hemispherical pupae are attached to a leaf with their abdomen.

**Way of Life and Significance:** They hibernate as beetles in dry, sheltered places. The beetles become active in spring. The females lay hundreds of eggs over several weeks, usually on the underside of the leaves. Some of the hatched larvae have a very limited ability to find a host. For this reason, the females prefer to lay their eggs in the vicinity of pest colonies. Four larval stages and a pupal stage, during which the wings develop, are passed through until the adult animal emerges. The number of generations per year depends on the species, food supply and weather conditions.

**Protection and Promotion:** Ladybugs are typical “clean-up predators”. They are attracted by a pest infestation and travel long distances for this purpose. In order to keep the beneficial insects in the orchard, pest levels below the damage threshold should, therefore, be tolerated. When the prey supply is high, feeding performance and egg-laying increase, but mass reproduction of the pests cannot always be prevented. Near-natural biotopes, such as hedges, stone walls and woodpiles, serve the beetles as a hiding place for hibernation on the one hand and as a starting point for recolonisation of the plant on the other. A high species diversity of ladybugs can only be achieved if different species of aphids are present at the same time, as each species has its own specific range of prey. Various species of shrubs and perennials, such as elderberry and snowball, are readily infested by aphids. Their presence, therefore, indirectly increases the number of ladybug species. The ladybug population can be estimated using the tapping test and visual inspection. All stages of ladybugs are very sensitive to certain insecticides. Many of the products approved for use in integrated production are gentle on ladybugs. Others may be applied no more than once per season.

**The most important species in orchards:**
With a length of 6-8 mm, the **seven-spot ladybug** *(**Coccinella septempunctata)*** is a relatively large species among ladybugs. The seven black dots on the otherwise orange-red coloured wing covers are striking (3 dots per wing, one dot at the wing base). The head, thorax, legs and underside are black. There is a white spot on each of the front corners of the thorax. The seven-spot ladybug flies before and during the apple blossom. However, the population peak is only in summer when there are sufficient aphids, especially the green apple aphid. It prefers to occur in the herb layer, e.g. on white goosefoot. This is often colonised by aphids in midsummer, which suits the voracious animals.

**The two-spot ladybug *(Adalia bipunctata)*** is also considered an important aphid predator. The elytra are usually red with a black dot in the middle, hence the name. However, there are many other red and black colour variants with different numbers of dots. Females and males are sometimes coloured differently. The most important distinguishing feature is the always black underside of the body. Adult beetles are 3.5-5.5 mm in size. The beetles hibernate in groups. The yellow eggs are laid in clutches near aphid colonies. A female lays between 100 and 300 eggs. Population peaks in spring at the time of the first generation of grass aphids and green apple aphids. All stages can be found in the summer months. The beetles prefer to live on bushes and trees. One generation is formed per year.

**The four-spot ladybug** *(Exochomus quadripustulatu)* specialises in scale insects, with the exception of the comma scale insect. It is also an important predator of aphids and is most active in spring. The strongly curved (hemispherical) 3-5 mm long beetle is shiny black with two red spots on each wing cover. The eggs are white and are laid in small clutches.

The smallest representative among the ladybugs is the **spherical ladybug *(Stethorus punctillum),*** with a size of only 1-1.5 mm. It is considered a natural enemy of the fruit tree spider mite and is an important regulatory factor in cases of high spider mite incidence. The beetles are hemispherical and black. Legs and antennae are yellowish. The densely hairy elytra are striking. The whitish eggs are laid individually in the vicinity of mite colonies. There are two generations per year.

### Common earwig *(Forficula auricularia)*

Fig. 5: Common earwig

Earwigs are found all over the world, especially in tropical regions. As a crepuscular predator of aphids, butterfly caterpillars and scale insects, it is a welcome beneficial insect in orchards. Flower pots filled with wood wool are placed upside down on the trees to encourage them. In years of mass reproduction, the feeding activity can also cause damage to leaves and fruit. However, soft fruits such as cherries, apricots and peaches are more at risk. Further feeding damage is only possible on previously damaged apples and pears.

**Biology:** The earwigs have an elongated, dark brown body with a slightly lightened thoracic shield and three yellowish pairs of legs. Large, strongly folded and membranous hind wings are found under the short cover wings. Although adults can fly, they hardly ever use this ability. There is a pair of antennae on the head. The mouthparts are biting and chewing. At 12-14 mm in length, the females are somewhat smaller than their male counterparts (13-17 mm). The chitinous pincers on the abdomen are characteristic. They are mainly used to catch prey and defend against enemies. In males, they are an auxiliary instrument for mating. Males and females can be distinguished from each other by the shape of the pincers. The eggs are pale yellow and oval (1.3 x 0.8 mm). The nymph is lighter brown.

Fig. 6: Earwig larvae.

**Way of Life:** The earwigs overwinter as adults in the soil. They develop from eggs through nymph stages to adults. In spring, the females lay several eggs in previously dug cavities in the soil. Until the larvae hatch, and for some time afterwards, the brood is guarded by the female (“brood care”). After moulting four to five times (“nymph stages”), the larvae are fully grown in early summer. The females can lay eggs a second time. Their larvae develop from the beginning of July to September. The animals are mainly active at dusk and night. During the day, they hide under stones, cracks or foliage. Sometimes, they can also be found in leaves rolled up by aphid colonies or in the stem cavity of short-stemmed apples hanging in pairs. They overwinter in sheltered places behind the bark.

**Significance and Occasional Damage:** Earwigs are omnivores. They feed mainly on animal food such as aphids, spider mites and other fruit pests. They are therefore of great importance in biological pest control. Sometimes fruit, flowers and leaves are also found eaten, which is why the earwig is sometimes classified as a pest. Soft-skinned cherries and plums and cracked, pre-damaged or russet apples also show feeding damage. Healthy fruit is very rarely damaged. Droppings can also be found in the stem pit.

**Encouragement:** To encourage the earwigs, flowerpots filled with wood wool ("earwig pots") or bamboo tubes are hung in the fruit trees. These serve as shelters for the animals, from which they start their "raids" at night. However, it only makes sense to place them in young orchards; compared to older orchards with large treetops and undergrowth, these offer few natural hiding places. They should already be inhabited before they are distributed throughout the orchard. In spring, they are therefore placed near typical hibernation hiding places, e.g. hedge edges, brushwood piles, leaf litter on the ground, etc. Once the brood has been cared for, the burrows are colonised by earwigs and other insects in summer (from June). They are then "hung" on the fruit trees in contact with the trunk or branches. In this way, the animals can easily reach their shelter "on foot".

### Hoverfly (Syrphidae)

There are many different species of hoverflies, which differ greatly in size, colour and shape. The adult flies are often confused with bees and wasps due to their yellow-black markings on the abdomen. In contrast to wasps, hoverflies have only one pair of wings and no constricted waist. Their early appearance in spring and their enormous reproductive and feeding potential (up to 80 aphids per day) make them important. Predator of aphids in fruit cultivation. Only the larvae are predatory; the adult hoverflies feed on flower pollen and nectar. The name "hoverfly" comes from the characteristic flight behaviour of the animals: they can suddenly interrupt their flight and hover in the same spot in the air for a long time, similar to a hummingbird.

**Biology:** The white eggs are 1 mm long and have a reticulated surface. They are laid individually or in small groups directly in the aphid colonies. The 10-20 mm long larvae are pointed at the front. They have no head capsule and are blind. This is a simple distinguishing feature from the butterfly caterpillars with head capsules. Due to their lack of legs, hoverfly larvae are not very mobile. Their coloration varies. Depending on the species, they have a greenish, brownish, black or translucent body. The drop-shaped, brown pupae are 8-10 mm long. They are found on leaves and shoots. The flies are yellow-black striped and about 10-14 mm long. Their heads have diamond-shaped eyes and short antennae.

**Way of Life and Significance:** The development cycle differs from species to species. They overwinter as larvae, pupae or fertilised females. One to several generations appear each year.

The adult flies are pure flower visitors. They feed on pollen, nectar and honeydew. Umbellifers such as hogweed, meadow chervil and wild carrot are particularly popular. The females have a very pronounced search behaviour when laying eggs in aphid colonies. Their high mobility enables them to recolonise infested trees relatively quickly. One female lays 50-100 eggs. The predatory larvae develop from these eggs. These feed mainly on aphids. Until they pupate, they suck out several

hundred aphids. Hoverflies are one of the first predatory insects in spring. They can, therefore, take early action against aphids and build up their population. Later in the year, they help regulate the more economically important aphid species (mealy apple aphid in rolled leaves, wrinkle aphids).

**Protection and Promotion:** Hoverflies react sensitively to the use of certain insecticides. In addition to direct control, there is indirect damage because of reduced food supply. Therefore, avoid unnecessary spraying. As flower visitors, hoverflies are dependent on a wide and constant supply of flowers. Marginal strips should, therefore, not be mulched so frequently. Shrubs and hedges serve as hibernation sites for the animals and as a reserve when food is scarce.

**Inspection:** Visually check for eggs and larvae from the appearance of the grass louse (end of March/beginning of April). Larvae can also be found in the tapping sample. As a general rule, animals are only found if there is also an infestation of aphids.

**Observations from practices in Europe:** If spraying against insects is carried out in spring, the grass aphids, which are basically not very harmful, are inevitably decimated. At the beginning of April, there are, therefore, no or only a few aphid colonies in which the hoverflies can lay their eggs. The aphids not detected during the control of the mealy apple aphid at the end of April can then reproduce undisturbed, as no or only a few hoverfly larvae are on the move.

A weak infestation of the grass aphid in spring or a weak infestation of the green apple aphid in summer can be sufficiently regulated by the interaction of hoverflies and predatory apple leaf gall midges. However, the flying aphids are also carriers of various diseases. The risk of fire blight should, therefore, be considered in summer. If there is an infestation in the immediate vicinity, an aphid spray should be carried out as a precaution.

Hoverfly larvae could also decimate a heavy aphid infestation, but the damage to the leaves, shoots, and fruit is usually already too high, especially in the case of infestation by the mealy apple aphid or the apple aphid.

# Topic 6 | Disease management practices

## Objectives and key messages

| | |
|---|---|
| Topic objectives | • Identify the 9 common diseases that affect apple trees<br>• Describe the symptoms, biology, risk factors, cultural measures, and control measures for each of the 9 common diseases that affect apple trees<br>• Recognize the control measures to use against each disease |
| Key messages to bring out | There are 9 common diseases that affect apple trees:<br>1. Apple scab<br>2. Powdery Mildew<br>3. Marssonina blotch<br>4. Alternaria Leaf Spot<br>5. Sooty blotch and Flyspeck<br>6. Canker Diseases<br>7. Collar Rot<br>8. White Root Rot<br>9. Moldy Core and Core Rot<br><br>It's important to be able to identify each disease based on these features:<br>1. Symptoms<br>2. Biology<br>3. Risk factors<br>4. Cultural measures<br>5. Control measures |

# Apple scab *(Venturia inaequalis)*

**Symptoms**

- Apple scab predominantly appears on leaves and fruits.
- On leaves, it first appears on the lower side as velvety brown to olive green or mousy black spots.
- It becomes more definite in outline, turns dark brown to black with age and develop on both sides of the leaves.
- Affected leaves finally turn yellowish brown and drop (midsummer) prematurely.
- Sometimes, the entire leaf surface is covered with velvety black coloured scab lessions, called as “sheet scab”.
- It develops on fruit in early spring as (dark olive green spots) usually at calyx end; later, it becomes almost circular brown to black and corky.
- Severely infected fruit become disfigured, knotty and develop cracks

**Biology (Disease cycle & favourable environment)**

- Pathogen overwinters as pinhead-sized mature pseudothecia in dead fallen leaves on the orchard floor.
- In March - April, numerous spores (ascospores) are released from these pseudothecia, reach the young leaves and fruit and cause primary infection.
- Numerous spores called ‘conidia’ emerge from these primary infection spots and produce new spots by infecting again and again until fruit harvest. This is called a secondary infection, and as a result, the disease leads to the development of an epidemic.
- Cool temperatures ranging between 18.2 - 23.8oC and minimum leaf wetness of 9 and 5.9 hours favour primary and secondary infection of the disease.

**Risk Factors**

- A high infestation from the previous year (over 10 % of shoots with scab infestation in autumn).
- All factors that prolong leaf wetness and increase air humidity (e.g. dense trees).
- Strong-growing trees with late or no shoot termination.
- Locations with humidity
- A rainy winter and/or a rainy spring
- Snow cover in apple orchards over a longer period
- Leaf wet periods around flowering

**Cultural Measures**

- In order not to disrupt leaf decomposition, copper should not be used after the harvest.
- If scab-infected leaves are found on more than 10% of the shoots in the fall, 5 kg/ha of urea should be applied shortly before leaf fall. The amount of nitrogen thus applied must be considered in the annual nitrogen balance.
- If possible, the fallen leaves should be raked into the lane in late fall or swathed and shredded with a flail mower. This will speed up the decomposition of the fallen leaves. If this measure is not carried out until spring, the expected effect is less.
- Due to a loose tree structure and calm growth, the trees are less susceptible to scab infections.

- Promote early shoot closure.
- Use drip irrigation or when watering with overhead sprinklers, make sure that the trees do not remain wet for longer than eight hours.

Control Measures: Key Points

- All scab-susceptible varieties must be preventively covered with an effective scab fungicide before each rainy period from budding until the end of the primary scab season. The scab-resistant varieties, on the other hand, should be covered with a scab fungicide if heavy periods and/or heavy sporulation are expected.
- The result of the primary scab defence must be checked at the beginning of June. To do this, the leaves of 100 shoots are scanned for scab spots. If scab spots are found on two shoots, this indicates a scab infestation of 2 %.
- During periods of leaf wetness in summer that last longer than two days, there is a risk of fruit scab infections in the sensitive varieties even with a low initial infestation (0 to 2 % shoots with scab infestation). These varieties should, therefore, be treated preventively with a contact fungicide if longer periods of leaf wetness are expected. In the case of higher leaf scab infestation, care must also be taken after the primary scab period to ensure that the infection potential does not build up further. In this case, the fungicide coating should be renewed approximately every ten days in May and every 14 days from June onwards.
- For varieties that are less susceptible to secondary scab, no more than one fungicide spray per month against scab is necessary in summer if the infestation is below 5%. If the primary scab infestation is above 5% and in the case of longer periods of leaf wetness (more than two days), the plants should be covered with effective fungicide.
- Scab-resistant varieties do not need to be treated against scab in summer. However, these varieties should still be treated with fungicides against other fungal pathogens about once a month before longer periods of leaf wetness (see the chapter on white mould, sooty mould and rain spot, Marssonina leaf drop, etc.).
- In order to better assess the supply of ascospores in the spring, we recommend determining the leaf scab infestation on the long shoots in the fall by counting. If scab-infested leaves are found on more than 10 % of the shoots in the fall, a high supply of Ascospores can be expected

# Additional information about apple scab

**Primary Scab Defense with Scab-Resistant Varieties**

- The so-called “vf resistance” of the varieties (e.g. Co-op 12, Co-op 13, Priscilla, Macfree, Florina or RedPop, Giga, Topaz, Bonita and Modi) is based on a single gene. In many cultivation areas, this monogenic resistance has already been overcome by the scab fungus. In order to maintain the effect of the VF gene for as long as possible, treating all VF-resistant varieties with a scab fungicide is recommended if heavy periods and/or heavy sporulation are expected.

**Plant Protection Measures**

I) Preventive

- Covering all infections as  near to the start of the rainy season as possible. The preventive effect in spring depends primarily on leaf growth, dosage of fungicides and rainfall.

II) During the Germination Phase of the Ascospores or After the Start of the Rain

- The germination phase of the ascospores lasts about 160-degree hours (e.g. 16 hours at 10°C or 20 hours at 8°C). If the preventive spraying is missed, a treatment in the germination phase should be carried out. Spraying in the germination phase is more effective than curative spraying.
- If an infection is only treated at curative stage (post-symptom), an efficiency of 80 % to 90 % can be expected. This level of efficiency is too low for successful scab control. It is, therefore, not recommended as a strategy. Only a few active substances are available for curative treatment (e.g. anilinopyrimidines and azoles).

**Alternative Products Against Apple Scab**

Alternative products with a lower environmental impact are already being used successfully around the world to regulate apple scabs. They are listed below and should be used in the summer months. The effectiveness is partly comparable with chemical products (e.g. carbonates).

| Active ingredient | Use | Dosage for 200 l of water | Rainfall in mm | Addi-tionally effective | Environ-mental impacts/ Hazardous-ness | Tree Stage |
|---|---|---|---|---|---|---|
| Bacillus subtilis | | 200 gm | | | harmless | Orchard floor after harvest |
| Cladosporium cladossporioides | Preven-tive/ cura-tive | 250 gm | | | harmless | Secondary Season |
| Cu-hydroxide | preventive | 10 g Cu met. | 60 | | harmless | Secondary Season |
| K-hydrogen Car-bonates | curative | 250 gm | 20 | Powdery mildew | harmless | Secondary Season |
| Na-hydrogen Car-bonates | curative | 250 gm | 20 | Powdery mildew | harmless | Secondary Season |
| Lime Sulphur | curative | 750 ml | 20 | Alternaria leaf spot/ Core rot | harmless | Primary / Secondary Season |
| Microsphaeropsis ochracea | | 200 gm | | | harmless | Orchard floor after harvest |
| Sulphur | preventive | 100 gm | 10 | | harmless | Secondary Season |
| Urea | | 10 kg | | | harmless | pre-leaf fall |

Fig. 7: Alternative products with a lower environmental impact.

- In winter, collect and destroy fallen leaves.
- In summer, products based on Cladosporium cladosporioides H39, Carbonates, Copper, Lime Sulphur or sulphur can be sprayed if the infection pressure is lower. They are good alternatives.
- Spray of urea 5 % (10 kg / 200 litres water) at pre-leaf fall stage in the month of October – November destroys the overwintering inoculum in leaf litter and “pseudothecia” seed pitchers are not formed on them and the disease cycle is interrupted.
- Spray of Bacillus subtilis strain BIMV 262 or Microsphaeropsis ochracea on the orchard floor. This results in accelerated decomposition of fallen leaves, which limits the formation of pseudothecia and breaks the disease cycle.
- Adopt proper pruning of trees for adequate air circulation and sunlight penetration in the plant canopy.

**Chemical products against apple scab**

| Active Ingredient | Uses | Dosage for 200 l of water | Rainfall in mm | Additionally effective | Environ-mental impacts/ Hazardous-ness | Tree Stage |
|---|---|---|---|---|---|---|
| Boscalid | preventive | | 60 | | D | Petal fall |
| Difeno-conazole | curative | 30 ml | 40 | Powdery mildew | C | Primary season |
| Dodine | preventive/ short cura-tive | 200 gm | 40 | Alternaria leaf spot | C | Primary / Secondary season |
| Fluopyram | preventive | | 40 | Alternaria leaf spot | D | Secondary season |
| Fluxapyroxad | preventive | 60 ml | 60 | | D | Primary season |
| Hexaconazole | curative | 500 gm | 40 | Powdery mildew/ Core rot | B | Primary season/ Pre-harvest |
| Metiram | preventive | | 40 | Alternaria leaf spot | B | Secondary season |
| Metrafenone | preventive | | 40 | | D | Petal fall |
| Myclobutanil | preventive | 80 gm | 40 | Powdery mildew | C | Primary season |
| Pyraclostrobin | preventive | | 50 | Alternaria leaf spot | D | Primary season/ Pre-harvest |
| Tebuconazole | preventive | 500 ml | 40 | Alternaria leaf spot | D | Secondary season |
| Trifloxystrobin | preventive | 80 gm | 50 | Powdery mildew | D | Secondary season |

Fig. 8: Chemical products that can be used against apple scab.

- Give protective spray with ziram (600 ml/ 200 litres water), mancozeb (600 gm/ 200 litres water), dodine (150 gm/ 200 litres water), propineb (600 gm / 200 litres water) and sterol-inhibitor fungicides at 15 - 20 days interval up to fruit harvest.
- Adopt monitored disease control practices by spraying effective fungicides at pre-symptom (curative) and post-infection (eradicative) stages with systemic fungicides viz., difenoconazole (30 ml/ 200 litres water), hexaconazole (100 ml / 200 litres water), tebuconazole +

Trifloxystrobin (80 gm/ 200 litres water), dodine (150 gm/ 200 litres water), fluxapyroxad+ difenoconazole (60 ml/ 200 litres water), myclobutanil (80 gm/ 200 litres water), to curtail the secondary spread of disease.

Not allowed are Carbendazim and Flusilazole. As previously mentioned, we have sufficient alternatives available. Follow the spray schedule for the control of apples diseases every year, as recommended by the State Department of Horticulture, Shimla.

**Banned chemical products against apple scab**

The following pesticides are proposed to be banned: Captan, Ziram, Mancozeb, Carbendazim, Thiophanatemethyl because of the risk to environment and health. These products should therefore no longer be used.

| Active ingredient | Use | Dosage for 200 l of water | Rainfall in mm | Additionally effective | Environmental impacts | Tree Stage |
|---|---|---|---|---|---|---|
| Captan | preventive | 600 gm | 50 | Bitter rot | banned | Primary Season/ Pre-harvest |
| Ziram | preventive | 600 ml/gm | 40 | | banned | Primary Season / Pre-harvest |
| Mancozeb | preventive | 600 gm | 40 | Marsonina Leaf Blotch | banned | Primary season |
| Propineb | preventive | 600 gm | 35 | Marsonina Leaf Blotch | banned | Primary season |
| Carbendazim | preventive | 100 gm | 40 | Alternaria leaf spot Marsonina Leaf blotch | banned | Primary season |
| Thiophanate Methyl | preventive | 100 gm | 40 | Marsonina Leaf Blotch | banned | Petal fall |
| Zineb | preventive | 600 gm | 35 | | banned | Primary / Secondary season |

Fig. 9: Chemical products that can be used against apple scab.

# Marssonina blotch *(Marssonina coronaria / Diplocarpon mali)*

*Fig. 10: Symptoms of marssonina blotch.*

**Symptoms**

- Disease symptoms first appear on mature leaves as dark green irregular spots become brownish during summer.
- These spots later turn dark brown to black and coalesce to form a big blotch.
- Small black pin-head-like structures called “acervuli” are visible in the leaf spots.
- Surrounding areas around the blotch turn yellow followed by severe defoliation during rainy season and only the fruits are seen hanging on the leafless shoots of the trees.
- As a result, the size of the fruit remains small. They also do not get full colour, and sometimes they also fall off.
- The development of spurs is also affected, and the yield for the next year is reduced. About one-third of the flowers of such plants bloom in November-December.
- Clear brown spots develop on the fruit surface near harvest, become oval, depressed, and dark brown with age and almost black at harvest. small black acervuli are visible in the lesions.

**Biology (Disease Cycle & Favourable Environment)**

- Apple blotch, caused by Marssonina coronaria, is a serious and widely distributed fungal disease that causes huge losses to apple production especially in South and East Asia. The pathogen causes black spots on apple fruit and leaves and leads to premature defoliation, resulting in weakened physiological balance of the host, reduced tree vigour and decreased yield.
- The pathogenic fungus survives in winter by forming seed pitchers called ‘Apothecia’ and often ‘Acervuli’ on fallen leaves on the ground. In the spring, initial infection occurs by ‘ascospore’ released from pitcher apothecia and ‘conidia’ spores from acervuli. In the rainy season, conidia spores emerge from the spots of these primary infections and lead to repeated secondary infections. Thus, disease takes the form of epidemics after repeated infections.
- The optimum temperature for infection and spread of the disease is 20-25 °C. Infection requires the leaf to remain wet for at least 4 hours. Symptoms appear 8 - 12 days after infection.
- After about two weeks, the diseased leaves turn yellow and fall off. If the leaves remain wet for more than 40 hours, symptoms of blight may appear because of severe infection .

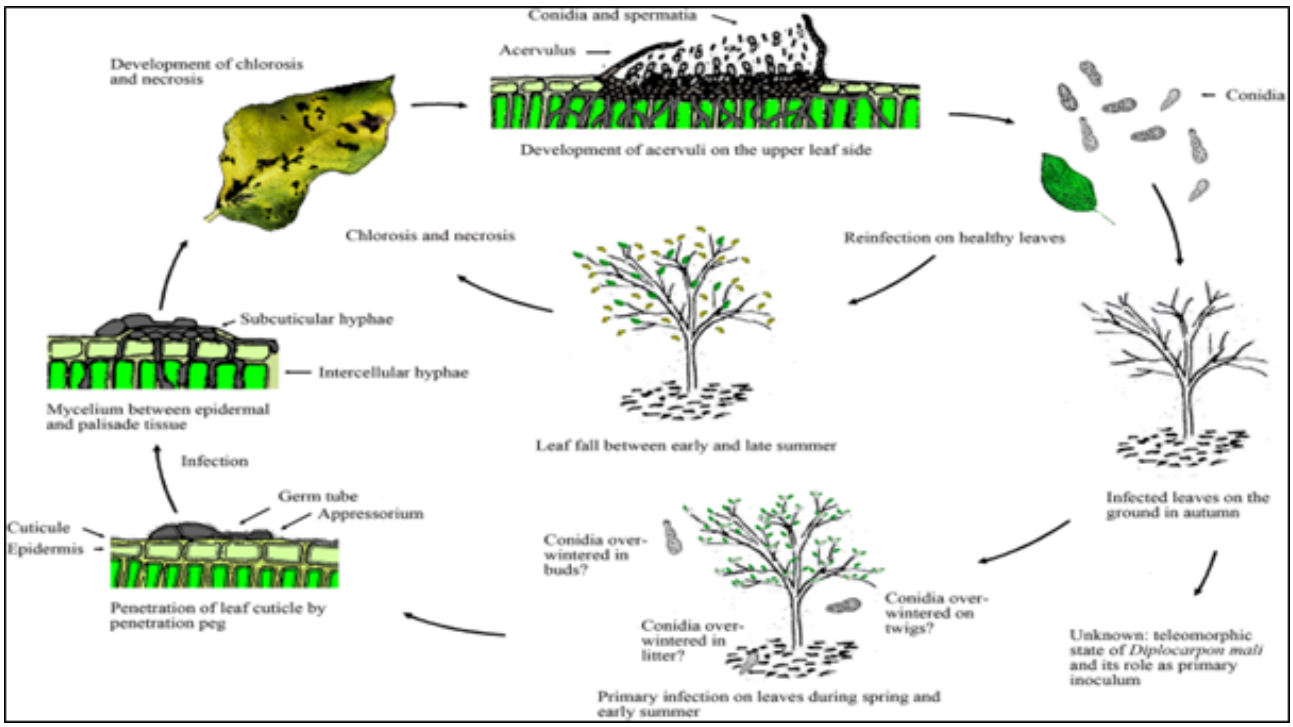



*Fig. 11: Lifecycle of Marssonina coronaria.*

**Risk Factors**

- Previous year's infestation
- Damp dew layers
- Reduced plant protection
- In integrated cultivation, Red Delicious has been the most severely infested variety. All varieties grown in Northern India are infested by Marssonina coronaria.

**Cultural Measures**

- Ensure calm growth and a loose tree structure.
- All measures that promote rapid drying of the trees.

**Control Measures**

I. Non-Chemical

- Orchard sanitation by removing the fallen leaf litter and infected fruit helps in lowering the primary source of inoculum.
- Adopt proper pruning of trees for adequate penetration of sunlight and air circulation.
- Effective weed management in the rainy season prevents the development of disease to a greater extent.

II. Chemical Products

- Spray of urea 5% (10 kg/ 200 litres water) before general leaf fall in the month of October – November helps in the rapid decomposition of the fallen leaves on the orchard floor and devoid the formation of primary inoculum, thus intrupt the disease cycle.
- protective spays of dodine (150 gm/ 200 litres water), mancozeb (600 gm in 200 litres water),

and ziram (600 ml in 200 litres water) starting from the walnut stage till fruit harvest at an interval of 15 - 20 days are recommended.

- Strobilurins based combi-products fungicides viz., tebuconazole + trifloxystrobin (80 gm in 200 litres water), metiram + pyraclostrobin (200 gm in 200 litres of water), fluxapyroxad + pyraclostrobin (20 ml in 200 litres water), is recommended for spray after the appearance of disease during the rainy season at an interval of 15 - 20 days as eradicate.

Follow the spray schedule recommended by the State Department of Horticulture, Shimla, for the control of apple diseases every year.

## Alternaria Leaf Spot *(Alternaria alternata)*

*Fig. 12: Symptoms of alternaria leaf spot.*

**Symptoms**

- In late summer and during the rainy season, it appears often in the leaves as circular, dark-brown spots with dark purple edges. Sometimes, when the environment is favourable for the disease, irregularly shaped spots, which are dark brown to black in colour, develop.
- Infection on petiole appears as brown to dark brown elongated lesions.
- Heavily infected leaves become yellow and fall prematurely.
- On fruits sunken slightly circular brown spots appear about 6-8 weeks before harvest significantly reducing the quality and the shelf or storage life of affected fruit.
- A minimum of 10 - 12 hours of leaf wetness is required at temperatures around 20-25 °C for infection to take place.

**Biology (Disease Cycle & Favourable Environment)**

- The genus Alternaria consists of a diverse group of pathogens, saprophytes, and endophytes. These have a global distribution and can be found on and in a large variety of crop plants, ornamentals, fruit trees, and other hosts. Saprophytic species cause putrefaction and sometimes produce mycotoxins in foods and other biomaterials. Plant-pathogenic Alternaria spp. can reduce crop yield and pose serious threats to agricultural production, causing a wide variety of symptoms, including leaf spot, blossom rot, and fruit rot and blight.
- Alternaria overwinters in dead leaves on the ground, in mechanical injuries on twigs, and in dormant buds, with spores formed in leaf lesions and swollen lenticels.
- Primary infection occurs in late spring, and the number of infections increases rapidly in the rainy season. The occurrence of warm weather in the following period contributes to increased infection

- The optimal temperature for infection, symptom and spore production is 25-30 °C.
- Successful infection occurs in a few hours under laboratory conditions and within 24 - 48 hours under optimal conditions in the field.

**Risk Factors**

- Damp locations where the surface moisture of the trees dries out slowly.
- Heavy infestation from the previous year
- The fruit mummies remaining on the tree, as well as dead branches and leaves, are breeding for the Alternaria fungus.
- If it stays wet for more than six hours in summer and the temperature rises above 20 °C, leaf and fruit infections can occur.
- Use of overhead sprinkling in summer
- Stress factors such as periods of heat in summer

**Cultural Measures**

The Alternaria fungus develops on dead plant substrate. The decomposition of the organic matter (fallen leaves, pruning wood) should therefore be encouraged. Treatment with urea (5 kg/ha) in the fall accelerates leaf decomposition. The shredding of the fallen leaves with a flail mulcher promotes decomposition. All maintenance measures should be aimed at preventing leaf spots.

**Control Measures**

I. Non-Chemical

- Do proper pruning of trees for adequate air circulation and sunlight penetration in the plant canopy.
- Follow orchard sanitation by removing fallen leaves, fruits, weeds and bushes, which helps in better management of the disease.

Ii. Chemical Products

- Spray of urea 5% (10 kg/ 200 litres water) at pre-leaf fall in the month of October – November destroys the overwintering inoculum in leaf litter. It lowers the availability of inoculum during the following year.
- Give protective sprays with propineb (600 gm per 200 litres water), mancozeb (600 gm per 200 litres water), ziram (600 ml per 200 litres water), zineb (600gm per 200 litres water), dodine (150 gm per 200 litres water) from pea stage till harvest at an interval of 15 - 20 days.
- Spray fungicides, namely dodine (150 gm per 200 litres water), tebuconazole + trifloxystrobin (80 gm per 200 litres water), metiram + pyraclostrobin (200 gm per 200 litres water), fluxapyroxad +pyraclostrobin (20 ml per 200 litres water), difenoconazole (30 ml per 200 litres water), hexaconazole (100 ml per 200 litres water) with the first appearance of disease as eradicate.
- Give 2 - 3 sprays at 15 - 21 days.Follow the spray schedule for the control of apple diseases every year as recommended by the State Department of Horticulture, Shimla.

# Moldy Core and Core Rot *(Alternaria alternata, Alternaria mali, Trichothecium roseum, Fusarium spp.)*

*Fig. 13: Symptoms of moldy core and core rot.*

Various pathogens can infect the fruit and cause rot. The various fungal pathogens can cause similar symptoms. Differentiation of the pathogens is usually only possible in the laboratory. However, their control is very similar, which is why they are described together below.

**Symptoms**

- Symptoms of the disease usually appear on the fruit from the month of June till harvesting.
- Affected fruit remain small, become disfigured and develop early colour.
- Drop prematurely, starting from fruit development to the pre-harvest stage.
- Longitudinal cut show growth of different coloured molds (black, pink, white)
- These affected fruits rot at harvest or during storage.
- Biology (Disease Cycle & Favourable Environment)
- Infection usually takes place by conidia of the pathogen at the pink bud to the walnut stage, and pathogens infect the fruit cavity and develop rots.
- Occurness of normal temperature of 18-20 degrees Celsius along with intermittent rain help in infection till walnut size.

**Risk Factors**

- Varieties susceptible to pit rot are Gala, Red Delicious and Fuji.
- Leaf wetness from full flowering until after flowering
- previous year's infestation
- Fruit mummies on the tree
- Petals that remain in the calyx cavity after flowering and are not shed; they are a breeding ground for fungi.

**Cultural Measures**

- Removal of infested fruit and fruit mummies.

**Control Measures**

I. Non-Chemical

- Collect the fallen leaves and affected fruits and destroy them.

II. Chemical Products

- A Direct defence against these fungi does not exist. Commonly used fungicides; Cyprodinil, Carboxamide, Fluazinam or Pyrimethanil applied between full bloom and post flowering, have a side-effect against the various pathogens when they are sprayed against apple scabs.
- A spray schedule consisting of three sprays starting with Propineb/ Mancozeb (600 gm/ 200 litres water) at the pink bud stage, followed by another two sprays at petal fall to pea stage and walnut stage with Hexaconazole (100 ml/ 200 litres water) or Difenoconazole (30 ml/ 200 litres water) and Dodine (150 gm/ 200 litres water) respectively is quite effective.

## Powdery Mildew *(Podosphaera leucotricha)*

*Fig. 14: Symptoms of powdery mildew.*

**Symptoms**

- Initial infections appear as a white powdery mass on the lower side of young leaves, causing chlorotic patches on the upper surface. Later, the fungus appears on both the leaf surfaces, and the infected leaf tends to crinkle, curl, or roll upward along the edges. Giving a narrow appearance. Severe infection results in dropping of affected leaves during summer months.
- Infected new shoots become stunted with shortened internodes and covered with silver-grey fungal growth show die-back
- Flower buds and petals are also affected by this disease. Such an infected bud is covered with a solid layer of white powder. There buds either do not bear fruit or the fruit remain small in size.
- Polliniser varieties are more affected by this disease.

**Biology (Disease Cycle & Favourable Environment)**

- In winter, the pathogenic fungus usually survives as dormant mycelium on the anterior part of small twigs (up to 4 -5 buds). In some areas, the pathogenic fungus survives in winter by making seed pitchers 'Cleistothecia'.
- In the spring (March-April), the initial infection is caused by the release of spores (conidia) from the fungus or 'ascospores' from the Cleistothecia.
- Later, conidia continue to infect young leaves, flowers and fruit until the leaves fall.
- The fungus conidia germinate readily at temperatures ranging from 10 – 25 °C and relative humidity ranging from 70 to 100 per cent.
- The disease progresses more rapidly in April -May, with the prevalence of normal temperature (18-22°C) accompanied by intermittent rainfall.

**Risk Factors**

- Previous year's infestation
- Dry, warm climate
- Shoot growth in summer
- Hill and mountain locations

**Cultural Measures**

- Cutting or tearing off mildew-infested shoots during winter pruning and in the growing season significantly reduces the infection pressure. This measure is particularly necessary in heavily infested plants, as chemical control alone is not sufficient.
- In summer, shoot closure/clipping should be encouraged. The mildew fungus primarily attacks young leaves.
- Orchard sanitation and planting resistant varieties Before selecting the varieties, the varieties are tested for suitability in the respective region.

**Control Measures:**

Chemical Products against Powdery Mildew

- A four-spray schedule starting with wettable sulphur (600 gm/ 200 litres water) after pruning at late dormancy followed by another three sprays at green tip, petal fall and after 2 weeks of petal fall with above effective systemic fungicides has been recommended.
- Use only products that are environmentally friendly: Spray effective mildew fungicides such as difenoconazole (30 ml/ 200 litres water), fluxapyroxad +difenoconazole (60 ml/ 200 litres water), boscalid + pyraclostrobin (50 gm / 200 litres water) or metagenome (20 ml/ 200 litres water). Starting with the first appearance of disease/ bud swell stage followed by another 2-3 sprays at an interval of 15-20 days.
- Carry out the first mildew spraying in yielding plants from the beginning of the bud swell stage. The highest infection pressure occurs from flowering to shoot closure. During this period, treatment intervals should not be long.
- Follow the spray schedule for the control of diseases of apple every year as recommended by the State Department of Horticulture, Shimla.

# Sooty blotch *(Gloeodes pomigena) and Flyspeck (Schizothyrium pomi)*


*Fig. 15: Symptoms of sooty blotch.*

**Symptoms**

- Both sooty blotch and flyspeck appear on the surface of the fruits during the rainy season
- Sooty blotch appears as an irregular olive green to a sooty blemish on the large portion of the fruit surface.
- The fungal crust can be removed by gentle rubbing. These diseases are more common in late-maturing varieties.
- Flyspeck disease causes clusters of microscopic black spots on the surface of the fruit, which are often seen as a fly excretion. These clusters are usually round to irregular in shape.
- These diseases lower the market acceptability of the fruit and its price as well.

**Risk Factors**

- Previous year's infestation
- Use of nitrogenous foliar fertilisers, rock powders (e.g. Zeolite) and rust-promoting agents after flowering until harvesting
- All factors that prolong leaf wetness and increase humidity (e.g. overhead sprinkling, dense systems, poor weed control, multi-row systems and hail nets)
- Late ripening varieties
- Reduced use of fungicides
- Infestation by woolly aphids or aphids (honeydew)

**Cultural Measures**

- All measures that promote rapid drying of the fruit.
- In infested areas, give preference to drip irrigation.
- Avoid using nitrogenous foliar fertilisers after flowering.

Control Measures

Non-Chemical

- Follow orchard sanitation by removing fallen leaves and fruit, weeds and bushes.

Chemical Products

- Pre-harvest spray of ziram (600 ml per 200 litres water) is recommended.
- A spray of dodine at preharvest is risky and not recommended, as temperatures above 30°C sometimes cause russeting on the fruit surface.

# Canker Diseases

Cankers appear as lesions on the stem, branch or twig, which are often black, brown or pink in colour and are completely clear and defined. These lesions are confined to the inner part of the wood or restricted up to the bark. Due to infection of the twigs, they dry up starting from the top, exhibiting dieback symptoms. As a result, the flow of water, minerals, and carbohydrates stops, and the infected plant dies in a few years. Out of the 14 canker diseases reported in H.P., the following six are the most common and devastating:

- Smoky blight *(Botryosphaeria obtusea)*
- Pink canker (Corticium salmonicolor)
- Stem brown *(Botryosphaeria dothidea)*
- Stem black *(Coniothecium chomatosporum)*
- Perennial canker *(Neofabraea perennans)*
- European canker *(Nectria galligena)*

**Symptoms of Smoky blight**

- On the leaf, lesions appear after the petal fall as circular with a purplish margin and tan to brown centre, giving a “Frog Eye” appearance.
- Heavily infected leaves become yellow and fall prematurely.
- Canker develops as reddish brown, sunken lesions on the upper side of branches, which turns smoky with a series of alternate rings. These later became elliptical and completely girdled the affected limb.
- Affected fruits develop a series of concentric rings of black and brown colour, ripen early, become mummified, and may remain attached to trees

*Fig. 16: Symptoms of smoky blight.*

**Symptoms of Pink canker**

- This canker develops on the trunk, stems and twigs, as pinkish incrustation during the rainy season results in death or blight of terminal parts.

*Fig. 17: Symptoms of pink canker.*

**Symptoms of Stem Brown Canker**

- Canker appears on stem, limb and twigs as depressed reddish-brown lesions and form blisters.
- Affected bark becomes slimy and peels off, expressing papery bark symptoms. Large limbs are girdled by the fusion of cankers.
- Infected mature fruit become tan to light brown, soft and watery and usually drop. Some shrivel and remain attached to trees. It is called “white rot”.
- Lesion in affected fruits extends in a cylindrical manner in cross-section.

*Fig. 18: Symptoms of stem brown canker.*

**Symptoms of Stem Black Canker**

- Raised blisters appear on affected branches, developing long vertical cracks containing black powders.
- Cracking and die-back of branches start from the pruned/cut end.
- Infected fruit develop brown spots. Such fruit later rot.

*Fig. 19: Symptoms of stem black canker.*

**Symptoms of Perennial Canker**

- Initially oozing of cell sap on the surface of branches is seen.
- Canker appears as reddish brown spots on moist bark, and oozing of cell sap on the surface of branches is seen.
- The affected area becomes dark brown in colour, forming circular lesions, mostly around the lenticels.
- Leaves on heavily infected branches become yellow and fall prematurely, causing the affected branches to dry up.
- Cause the bark to crack around the infected area later form the “Fiddle string stage”. In which the diseased bark turns into thick threads.
- On fruit, symptoms develop as brown, circular spots, slightly sunken with a light brown centre, often in concentric rings, giving the appearance of a “bull’s eye”. Such fruits rot during harvest or storage.

*Fig. 20: Symptoms of perennial canker.*

**Symptoms of European Canker**

- Canker lesions appear as elliptical, sunken areas, dark reddish-brown areas mostly on year-old twigs around leaf scars (bud).
- Later girdle the affected portion, leading to drying of distal parts.
- On fruits, depressed brown necrotic areas develop near the blossom end with a pale brown centre and later, such fruits rot

*Fig. 21: Symptoms of European canker.*

**Biology (Disease Cycle & Favourable Environment)**

- On the dead bark tissue, the spores of the pathogen develop reproductive organs (perithecia and Acervuli or pycnidia) containing macroconidia, microconidia and ascospores.
- In spring and summer, ascospores and conidia are mainly released from their fungal-containing structures.
- These spores are washed away by precipitation and penetrate into the bark tissue through wounds or injuries. The ascospores can move several hundred metres. The spread in the tree takes place mainly through conidia.
- Many wounds that occur during harvesting and leaf fall favour the penetration of spores into the tissue.
- Heavy hail storms also create entry points.

**Control Measures**

I. Non-Chemical

- The management of crop activities in the gardens should be proper. In which balanced use of fertilisers, regular irrigation, proper pruning, weed control, etc. are important.
- Prune and destroy infected plant parts and dead and dry branches.
- Do proper orchard sanitation, collect infected fruits fallen on the ground floor as well as the mummified fruits remain on tree after harvest and destroy them.

II. Chemical Products

- At post-harvest stage with copper oxychloride (600 gm/ 200 litres of water) or Bordeaux mixture (Copper sulphate [2 kg] + quick lime [2 kg/ 200 litres of water])
- If there is a severe incidence of disease, spray them again on bud swelling in February - March.
- During winter season after pruning, cover the pruned cuts as well as other wounds on the branches with Bordeaux paste (Copper sulphate [800 gm] + Lime [1000 gm] in 10 litres water) or Bordeaux paint (Copper sulphate [1 kg] + lime [2 kg] + Linseed oil [3 litres]), or Chaubatia paint (Copper carbonate [800 gm] + Red lead [800 gm] + Linseed oil [1 litre]) or Copper oxychloride paint (Copper oxychloride and linseed oil in 4: 6)
- Application of cow dung paste (fresh cow dung [1kg] + clay soil 1 [kg] + water 1 litre) is also recommended.
- Treat the canker lesions during the winter season by removing the diseased area with a sharp knife up to the green portion and applying the above-mentioned paints. The addition of 10 mg of the hormone kinetin per litre of paste or paint is advised for quick recovery of canker lesions.

# Collar Rot *(Phytophthora cactorum)*

*Fig. 22: Symptoms of collar rot.*

**Symptoms**

- The infection of the disease starts from the ground part of the plant at the soil level and spreads down to the crown part.
- Bark of the stem at soil level becomes slimy, brown and rot, girdles the entire stem leading to untimely death of plants.
- The leaves of diseased plants turn yellow, and their veins and edges become red.
- Under field conditions attacked trees can be easily recognized during late rainy season by chlorotic foliage with purplish red colouration of veins and margins of leaves giving a reddish yellow/ violet appearance of the affected tree.
- Sometimes, the severely affected plants wilt at the pink bud to fruit setting stage.
- Generally, infected plants die in 2 - 3 years.
- Sometimes, fruits at the lower portion are infected at the calyx end, showing light brown discolouration and rot later.

**Biology (Disease Cycle & Favourable Environment)**

- Pathogen survives in the soil as oospore or doormat mycelium in plant debris, germinate to form mycelium-producing zoospores, which swim for some to cause infection at the collar region during the month of March-April or August-September.
- The microclimate also influences the outbreak of the disease: plant growth around the base of the stem provides the conditions favourable to the pathogen. (require more clarification)
- Waterlogged soil with a temperature of 18 to 22°C and pH 5-6 has been found to be the best for disease development and subsequent spread.
- Humus-poor soils provide optimal propagation conditions.

**Risk Factors**

- Highly susceptible rootstock: MM 106
- Susceptible rootstocks: M 7, M 26
- Damp locations and waterlogging
- Heavy, clay-rich soils
- Soil temperatures above 15 °C and persistent, heavy rainfall
- Excessive irrigation
- Damage to the trunk.

- Fallen fruit not removed.

**Cultural Measures**

- Keep the trunk dry.
- Lay drainage in case of waterlogging.
- Avoid bark injuries.
- Apply tree balm to wounds.
- Remove fallen fruit from the orchard.
- Do not allow the water to stagnate in the plant basin; improve the water drainage system in the orchard.
- Replace the soil around the collar portion with sand or small pebbles so water may not stagnate.
- While planting, the graft union should be kept 20-25 cm above the soil line.
- Add mustard cake or mulch the plant basin with mustard plants.
- Use biocontrol agents like Trichoderma harzianum, T viride, Bacillus subtilis, B. megaterium for long term control.
- Bridge/approach grafting helps rejuvenate the affected plants.

*Fig. 23: Affected plants rejuvenated through bridge/approach grafting.*

- Use resistant rootstocks M4, M9, MM116, MM115 for grafting improved varieties.
- Avoid flood irrigation in the orchard and from plant to plant,
- Use plastic pipes for irrigation and irrigate the plants separately.
- Change the acidic nature of pH soil from neutral to alkaline 6.5-7.0 by adding lime during winter or rainy season.
- Drenching cow urine decoction containing Eucalyptus, Melia and Vitex leaves (10 litres/200 litres water) per plant during spring, rainy and post rainy season is also quite effective.

Control Measures

- Expose the infected part of plants to sunlight during winter by removing the soil, remove the infected portion and apply Chaubatia paint.
- Drench the soil around the stem up to 1ft area with either of fungicides viz., metalaxyl MZ 0,3 % (3 gm per 1 liter water), copper oxychloride 0,5 % (5 gm per 1 literr water), metiram +

pyraclostrobin 0,2 % (2 gm per 1 liter water), cymoxanil 8 % during spring, rainy and post rainy season.

- Every year, in the months of change in weather like March and November, whitewash the stem of the plant by adding lime into copper sulfate. Also add DDL or linseed oil as adhesive agent to ensure their better sticking on the stem.

## White Root Rot *(Dematophora necatrix)*

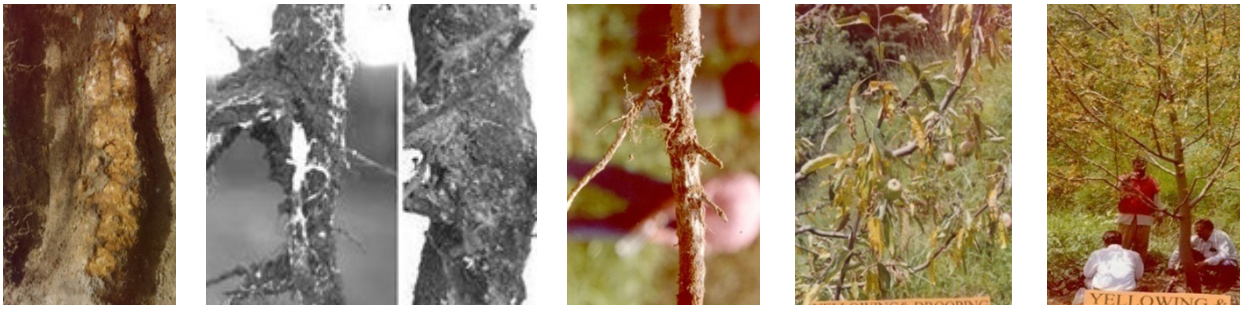


*Fig. 24: Symptoms of white root rot.*

**Symptoms**

- Above-ground symptoms are expressed as diminution in the leaf size, chlorotic to bronzed, scattered, and drooped leaves, leading to stunted tree growth.
- In infected plants, heavy blossoms and fruiting are seen in the following year, and much of the fruit fails to reach maturity.
- Below ground symptoms, lateral roots turn dark brown. They are covered with a greenish grey or white mycelial mat having a flocculent web of whitish strands or ribbons more evident during monsoon season.
- Later, the fibrous root system and white flocculent web disappear, leaving the root surface dotted with small, round, black sclerotia.
- In the succeeding years, few leaves emerge, and the dying back of branches is quite evident. Infected trees become shaky and succumb to death within 2 - 3 years.
- Biology (Disease Cycle & Favourable Environment)
- The fungus of this disease usually survives in the soil in the form of dormant mycelium and sometimes sclerotium on infected root residues.
- During the rainy season, the thin mycelium of the pathogenic fungus is produced and spreads in the soil, which infects by reaching new roots. After that, the fungus reaches the big roots by destroying the tissues under the bark and thaws the roots by producing toxic substances.
- Trees often die suddenly, usually within two years after the aboveground parts first show symptoms of the disease. Trees of all ages may be killed by white root rot, although the disease occurs more commonly in older trees.

**Risk Factors**

- The disease is most serious in water-logged, clay loam and acidic soils at pH 5.5 to 6.0.
- Maximum disease spread during July-August under moderate temperatures (15-25°C) and high moisture.

**Cultural Measures**

- Control of white root rot depends primarily on avoiding the pathogen by not planting trees in soil that harbours it. As with Armillaria root rot, replanting is often not successful. Remove all old roots from a site for two consecutive years before attempting any replanting, and allow a year or two for any remaining tree roots to completely decompose before planting new fruit trees. No apple rootstocks are resistant to the white root rot pathogen.
- Improve the water drainage system in the orchard and do not allow the water to stagnate in the plant basin.
- Follow soil amendments with neem leaves/ cake, Lantana leaves, cabbage leaves and deodar needles.

**Control Measures**

I. Non-Chemical

- Use of biological control agents like Trichoderma viride, Trichoderma harzianum, Bacillus subtilis and Pseudomonas fluorescens. The products have a long-term effect and support plant growth.
- Add lime or dolomite to the basin when the pH in the garden is acidic (5.5-6.5).
- Bridge/approach grafting helps rejuvenate and extend the life of the affected plants.

II. Chemical Products

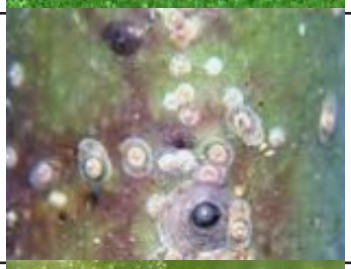
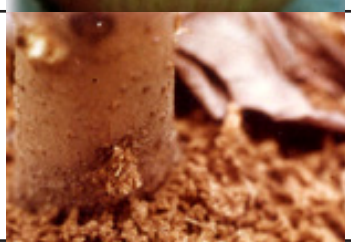
- Expose the roots of diseased plants to sunlight during the winter season, remove the diseased roots, and apply Chaubatia paint at the cut ends.
- Application of effective fungicides as aureofungin plus copper sulphate (40 gm + 40 gm / 200 litres water), metiram + pyroclostrobin (400 gm/200 litres of water) through deep holes (15-20 cm) in tree basins at a distance of 30 cm apart with the onset of the rainy season, followed by another 2-3 soil drenching at an interval of 15-20 days.

# Topic 7 | Insect-pest management practices

## Objectives and key messages

| | |
|---|---|
| Topic objectives | • Identify the 7 common insect-pests that cause diseases that affect apple trees<br>• Describe the damage symptoms, biology, cultural measures, and control measures for each of the 7 common insect-pests that cause diseases that affect apple trees<br>• Recognize the control measures to use against each disease |
| Key messages to bring out | There are 7 common insect-pest diseases that affect apple trees:<br>1. Woolly Apple Aphid<br>2. Blossom Thrips<br>3. Sanjose Scale<br>4. Mites<br>5. Apple Root Borer<br>6. Apple Leaf Folder<br>7. Apple Stem Borer and Shoot Borer<br><br>It's important to be able to identify each disease based on these features:<br>1. Damage symptoms<br>2. Biology<br>3. Cultural measures<br>4. Control measures |

# Recognize insect-pest diseases

| | | |
|---|---|---|
| |  | Woolly Apple Aphid (Eriosoma lanigerum) |
| |  | Blossom Thrips (Frankliniella dampfi / Taeniothrips spp./ Thrips flavus/ Thrips florum/ Thrips carthami / Aeolothrips collaris/ Haplothrip stenuipennish) |
| |  | 3 Sanjose Scale (Quadraspidiotus perniciosus) |
| |  | Mites (Panonycus ulmi and Tetranychus urticae) |
| |  | Apple Root Borer (Dorysthenes hugelii) |
| |  | Apple Leaf Folder (Archips termias) |
| |  | Apple Stem Borer (Apriona cinerea) and Shoot Borer (Zeuzera multistrigata) |

# Common insect-pest diseases

## 1. Woolly Apple Aphid *(Eriosoma lanigerum)*

*Fig. 25: Symptoms of woolly apple aphid.*

**Damage Symptoms**

- It is a small purple-coloured (1.5–3.0 mm) sap-sucking insect bearing slit like cornicles and short rounded cauda. They live in colonies, and their body is covered with a white woolly waxy substance, which is visible from a distance in the form of wool.
- Adult and nymph suck sap from twigs and underground parts.
- Feeding on aerial parts and root systems roughens the bark, resulting in the formation of galls, which interfere with nutrient uptake and movement, thus reduces the vitality and fruit yield. Heavily infested trees often develop a short fibrous root system, yellowish foliage, become shaky and can be easily uprooted.
- Wooly aphids secrete sticky material called honeydew which can cause russet spots as well as sooty growth on the fruits. Its waxy flocculant when covers the fruits result in fading its colour.
- It also attacks the roots of young plants in the nursery and hinders their growth.

**Biology (Life Cycle & Favourable Environment)**

- The attack in the upper parts of the plants occurs from April-May to October-November. In winter, it moves inside the ground and attacks on the roots.
- The pests survive in the winter in the cracks and holes made on the bark of the twigs and the roots inside the ground. After the spring season, as the environment starts to warm up, then pests breed in large numbers and keep attacking aerial parts till the onset of the cold season.

**Risk Factors**

- Strong shoot growth
- Delayed shoot termination
- Dense vegetation
- Winter pruning with lots of cuts

**Cultural Measures**

- Calm building growth, moderate fertilisation
- Avoid excessive pruning cuts during winter pruning.
- Prioritize a few large cuts over many small ones.
- Encourage early shoot termination.

- Encourage beneficial insects such as earwigs, aphid wasps, lacewings and hoverflies.

**Control Measures**

I. Non-Chemical

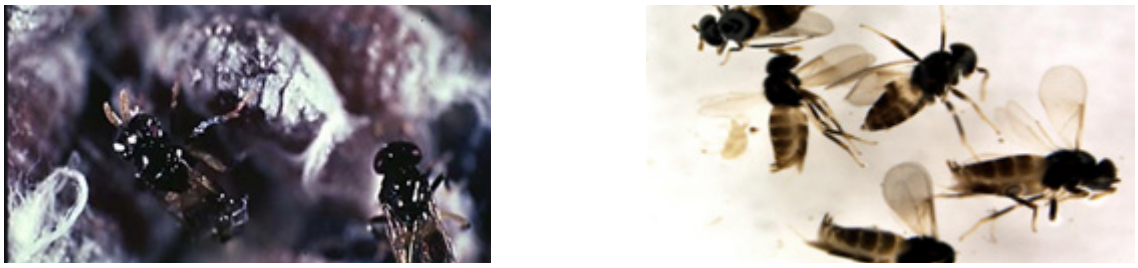


*Fig. 26: Aphelinus mali (woolly aphid).*

- Raise a new apple orchard by planting healthy aphid-free plants.
- Remove the water sprouts and cover the pruning cuts, cracks, crevices and wounds with the recommended paints.
- Pruning and burning of infested plant parts.
- Woolly aphids can be managed by the release of nymphal parasitoid *Aphelinus mali*. Syrphids - Episyrphus balteatus and Eupeodes corollae can target superficial woolly apple aphid root colonies,
- Conserve endo parasitoid Aphelinus mali and other predators like coocinellids, syrphids and chrysophids of this pest for natural control.
- Coccinellids- *Coccinella transversoguttata, Hippodamia* convergens etc. and chrysopids- are known to suppress the population of aphids.
- European earwig, *Forficula auricularia L. (Dermaptera: Forficulidae)*, is another localised, omnivorous predator feeding on woolly apple aphids.
- Flowering plants in or on the borders of the orchards provide nectar and pollens, which helps to converse and attract natural enemies.
- Plant new plants raised on resistant rootstocks viz., MM 111, M793, MM778, MM789, MM106, M21 and M25.
- Use sticky bands around the stem for mechanical control during April –May and October.
- Keep plant basin weed-free.
- Fungal pathogen *Verticillium lecanii* is the known fungal pathogen of E. lanigerum

II. Chemical Products

- Treat the infested plants with Thiamethoxam (100 ml per 200 litres of water) to reduce the aphid population before plantation.
- In non-bearing young plants, place Phorate granules (10 - 30 gm) or Carbofuran (30 - 50 gm) at 5 cm deep in the soil by making a furrow around the stem during April –May and October month. However, in fruit-bearing trees, the dose can be increased to 2 times.
- Mark the infested plants and spray with Spirotetramat (150 ml/ 200 liters of water), or Thiamethoxam (100 ml/ 200 liters of water) during June to October or after fruit harvest.

- Drenching of the root system with thiamethoxam (0.05%) or Imidacloprid (0.05%) helps in reducing the root population of the aphid.

### 2. Blossom Thrips *(Frankliniella dampfi / Taeniothrips spp./ Thrips flavus/ Thrips florum/ Thrips carthami / Aeolothrips collaris/ Haplothrip stenuipennish)*

*Fig. 27: Symptoms of blossom thrips.*

**Damage Symptoms**

- As soon as the bud bursts, the female enters the bud and lays eggs. Thrips start increasing after flowering.
- Both nymphs and adults feed by rasping flower and floral buds and leaves.
- Infested blossom become distorted, dull and open only on one side.
- Growth of thrips causes poor fruit set and quality.
- Adult thrips are narrow, having fringed wings with reduced venation and long marginal setae.
- Nymphs are elongated white, yellow or pale brown and have three larval instars. Full-grown nymphs fall on the ground and pupate in the soil.

**Biology (Life Cycle & Favourable Environment)**

- Consists of an egg, two active feeding larval instars, two relatively quiescent pupal instars and the adult.
- Adults and larvae aggregate in flowers or other concealed areas on plants, such as developing foliage and flower buds.
- Females have a saw-like ovipositor, which they use to deposit eggs into leaves, petioles, flower bracts and petals.
- The prepupa and pupa dropped to the ground to pupate. Eggs are kidney-shaped and hatch in 1 to 2 days.
- First instar larvae moult to second instar larvae in 2 to 3 days, which is much bigger and has more colour, and second instar moults into pre-pupa in 5 to 6 days and pre-pupa into a pupa in 3 to 4 days.
- The adults survive for 2 to 3 days in the case of males and 3 to 4 days in the case of females and fully develop a pair of fringed wings. The thrip thus completes its life cycle in 13 to 18 days (males) and 14 to 19 days (females) on apple. The thrip survives for three successive generations on Apple from mid-March up to the end of April.
- After completing all three generations on apple, the thrip then moves over to alternate hosts like Matricaria chamomilla (Chamomile), Ranunculus acris (Buttercup) and Ageratum

conyzoides (Chickweed). It feeds on these flowering weeds till the onset of November and goes for hibernation in crevices, under the weed's debris and in the soil. The thrip emerges again from the hibernation process in the form of an adult and resumes its life cycle again.

*Fig. 28: Blossom thrip.*

**Risk Factors**

- Very dry, warm weather in full bloom
- Lack of herbaceous undergrowth
- Herbicide treatment shortly before apple blossom

**Cultural Measures**

- Do not mulch during the flowering period.
- Do not use herbicides during the flowering period.

*Fig. 29: Blossom thrip larvae.*

**Control Measures**

I. Non-Chemical

- Clean cultivation and digging of beds in winter expose the insects to natural enemies.
- Conserve predators such as the minute pirate bug, Orius tricolour, and green lacewing larvae.

Chemical Products

- Spray Thiamethoxam (100 ml/ 200 liters) water at pink stage.
- Spray of thiacloprid 100ml/200 l water at pink bud stage.

### 3. Sanjose Scale *(Quadraspidiotus perniciosus)*

*Fig. 30: Symptoms of sanjose scale.*

**Damage Symptoms**

- It is a small sap-sucking insect whose body is covered with a greyish-coloured shell.
- If the shell is removed, a yellow lemon-coloured insect appears.
- Initially, small needle-tip-like brown spots are formed on the affected twigs, and in case of severe infection, the entire part is covered with a layer of dark grey coloured coating.
- Sucking of plant sap results in the formation of a halo-like red colouration/ distinct measles spots around the feeding point, more pronounced on twigs and fruits.
- Due to the sucking of sap by this insect, the trees become weak with decreased production. In case of excessive attack, the affected plants dry up and die.
- The insect usually survives in winter by covering the twigs with a black layer called “black cap” and is active in spring.

**Biology (Life Cycle & Favorable Environment)**

- In summer, active females, which are usually covered with a grey colour layer, give birth to above 100 ‘crawlers’. From this stage, the outbreak of scale increases.
- There are four overlapping generations from April – November, with the fifth overwintering in the nymphal stage.
- The peak infestation takes place from March to May and June, lowering the plant vigour and affecting fruit quality and yield.

**Risk Factors**

- Previous year’s infestation
- Dense trees
- Cracks in the bark prevent optimal wetting/coverage with plant protection products.

**Cultural Measures**

- Heavily infested branches and twigs should be removed and burned.
- Ensure an appropriately developed tree structure so that plant protection products can reach on its entire surface.

**Control Measures**

Non-Chemical

- Raise a new apple orchard from pest-free nursery stock.
- Heavily infested branches and twigs should be pruned and burnt.
- Two parasitoids, namely Aphytis sp. and Encarsia perniciosi, attack scale population. A coccinellid predator, Chilocorus inferrnalis (10 - 20 beetles/tree), is quite effective.
- Reduce the amount of pesticides in summer. Only spray insecticides if a pest is present in the orchard and the damage is likely, for protection of the parasitoides.
- Reduce the use of pesticides for the protection of the parasitoids.

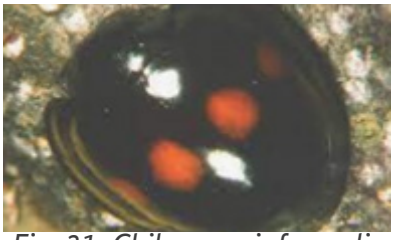


*Fig. 31: Chilocorus inferrnalis as a predator.*

*Fig. 32: Aphytis sp. and Encarsia perniciosi are parasites.*

Chemical Products

- Make a solution of oil (horticultural mineral oil) such as Orchex 796/DC Tron Plus / Arbofine / Orchol-13 / Servo / Mac Illusion / Hindustan Petroleum HMO / Rilso 999 / Atso Supreme Oil / Petro Star HMO / Balmirol Hair Spray HMO (4 litres per 200 litres of water) between half-inch green and tight cluster stage. Due to the environmental impact, Horticultural Mineral Oil should be prohibited. Only use the product in exceptional cases if the infestation is particularly high.
- If the above spraying has not been done due to some reason, then in the month of May, take 2 liters of summer oil per 200 liters of water and spray it.
- Mark the affected plants in the orchard and spray approved insecticides at the time of crawler emergence from mid-May till three weeks before harvesting.
- For monitoring the emergence of male scale insects and crawlers, use pheromone traps starting from the pink bud stage till harvest. These traps also catch male insects and thus prevent the mating of females, thus lowering the crawler population and subsequent population build–up.
- Follow the spray schedule for the control of pests of apple every year as recommended by the State Department of Horticulture, Shimla.

### 4. Mites *(Panonycus ulmi and Tetranychus urticae)*

It is a microscopic very small organism belonging to the eight-legged spider species. Two mites, the 'European red mite' and the 'two-spotted spider mite, 'attack apples mainly.

- European red mites (Panonychus ulmi)
- Two-spotted spider mites (Tetranychus urticae)

**Damage Symptoms Of European Red Mite**

- The female mite is red to chocolate brown with fine white spots on the body, about 0.4 mm in size and visible to the naked eye.
- The male is yellow-tinged with red colour and more slender than the female.
- The overwintering eggs are seen on spurs, twigs, and branches from October - November to March. They are spherical, pinkish to red, with hair rising from the centre.

*Fig. 33: Symptoms of European red mite.*

**Biology (Life Cycle & Favorable Environment) Of European Red Mites**

- Eggs hatch from mid-April to the end of June, and the life cycle is completed in 11 - 26 days, depending on weather conditions.
- On hatching, juvenile mites move to the underside of the leaves and begin feeding and attain maturity in about three weeks, undergoing three moults.
- Number of generations per year varies between 5-7 and more depending upon the weather conditions and geographical situation of the orchard.
- Dry and hot weather is highly favourable for their multiplication. They do not spin webs.

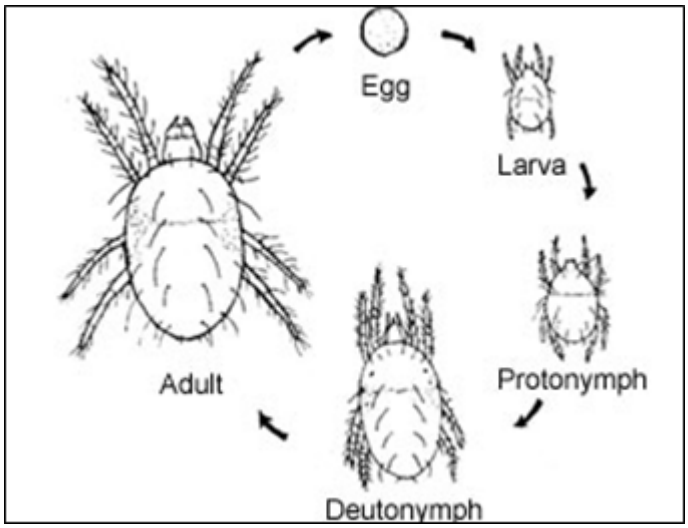


*Fig. 34: Lifecycle of European red mites.*

- The adult and the nymphs of mites suck the sap from the leaves and tender plant parts, causing yellowing and bronzing of leaves and sometimes the formation of white minute specks on infested plant parts followed by weakening of buds.
- Continuous feeding by European red mites makes undersized and poorly coloured fruit prone to early dropping.

**Damage Symptoms of Two-Spotted Spider Mites**

- The two-spotted spider mites are generally pale yellow, pale green, or straw-coloured. The adult has two dark green or black patches on the anterior part of the body.
- Unlike the summer forms, the hibernating mites produced during autumn are uniformly pink without spots on their body.
- Two-spotted spider mites produce dense webbing to coat the surface of leaves. Overwintering females usually turn reddish-orange and are often found near the calyx and stem of fruit near harvest. Two-spotted spider mites cause bronzing on the leaves.
- The young and adult suck the sap on the lower surface of the leaves. As a result, sometimes numerous yellow spots appear on the upper surface.
- In excessive attack, the leaves turn from light green to copper in color and turn inwards.This mite forms a web.
- Fruit quality (size and color) and yield of affected plants are reduced. This also adversely affects the yield potential of the next year.


*Fig. 35: Two spotted spider mites.mites.*


*Fig. 36: Two spotted spider mites with dense webbing.*


*Fig. 37: Apple with yellow spots.*

*Fig. 38: Leaves turn copper in colour and turn inwards.*

**Biology (Life Cycle & Favourable Environment) Two Spotted Spider Mites**

- The two-spotted spider mites overwinter as female adults in the debris of fallen leaves and loose bark in cracks and dead leaves of other plants to resume activity in spring.
- Eggs hatch in 2-6 days depending on weather conditions. After hatching the mite passes through the larva, protonymph and deutonymph stages before becoming adults.
- It spins a fine silken web near the feeding site and later extend it to cover the adjoining leaves and branches
- This mite completes its life cycle in 9 - 19 days during the crop period or depending on the temperature, humidity and geographical location of the orchards.
- The life cycle of this mite is temperature-dependent. The lifecycle is completed in 9 days at 35°C, 12 days at 20°C, 55 days at 10°C.
- Generally, 6 - 7 or more generations of this mite are formed.

**Risk Factors of Mites**

- Previous year's infestation
- Proximity to roads (dust development, higher temperatures)
- Dry, hot weather
- Spray sequence damaging to predatory mites.
- Indescriminate use of broad-sprectrum highly toxic insecticides.

**Cultural Measures of Mites**

- In the event of localised occurrence, shoots with a high predatory mite population can be carried over from other apple trees.
- Use plant protection products that are gentle on predatory mites.

**Control Measures of Mites**

I. Non-Chemical

- Avoid indiscriminate spray of insecticides during the growing period.
- During peak period of activity (July - August), predators, namely Stethorus punctrum, Chrysoprela zastrowi sillemi, Orius sp., Predatory mites (Amblyseius longispinosus, A. fallacis, Zitzellia mali, Neoseiululus longispinosus ) and some thrips feed on different mite stages and control the mite population. Conserve these predators for biological control of mite pests.
- Three releases of the predatory mites, Neoseiulus long spinous, at the predator-prey ratio of 1:30, have proved helpful in controlling the infestation.

II. Chemical Products

- Spray dormant oil at half-inch green to tight cluster stage as against the San Jose scale. It also kills overwintering eggs of European red mites and adults of two-spotted spider mites.
- At petal fall stage, foliar application Spiromesifen (60 ml/ 200 liters of water) or Hexythiazox (200 ml / 200 liters of water) has been recommended.
- At walnut stage foliar application of HMO in a concentration of 1% (2 liters/200 liters) or Fenzaquin (50ml/ 200 liters water) is recommended.
- When the population becomes high in June – August (> 5mites per leaf), the application of acaricides, namely Fenzaquin (50 ml/ 200 litres of water) or Hexythiazox (200 ml/ 200 litres of water) or Spiromesifen (60 ml/ 200 litres of water) have been proved effective.
- Follow spray schedule for the control of pests of apple every year as recommended by the State Department of Horticulture, Shimla.

### 5. Apple Root Borer *(Dorysthenes hugelii)*

*Fig. 39: Symptoms of apple root borer.*

**Damage Symptoms**

- The leaves on infested plants become small, scattered with reduced green color.
- Infested plant show typical deep cuts on limbs and braches.
- Affected branches wither, tree become weak, shaky and die
- The grubs bore into or girdle around internal tissues of root.. As a result the main roots are severely damaged from the base and the trees, if young, die away while the older ones become weak and fall with strong winds.
- It is a polyphagous pest, and it damages the roots of crops.

**Biology (Life Cycle & Favorable Environment)**

- The adults of this borer are chestnut red beetles with head and thorax darker than elytra. These beetles are also known as longicorn beetles due to the presence of long serrated antennae.
- Adults start emerging with the onset of pre-monsoon rains during the second fortnight of June, and the majority of the beetles (75 - 80%) emerge by the first week of July, but the emergence continues up to the second week of August. They get attracted to light, mate, and a female lays 250 -3 00 eggs about 1 cm deep in the soil.
- Egg hatch in 3-7 weeks; young larvae feed on the organic matter and bore into the root for about 3.5 years. The full-grown larva is creamy white, having well-developed mandibles and measures 7.5 – 10 cm in length. Larva mostly survives within a 90 cm radius of tree basin and up to 30 cm depth of the soil.
- These grubs become full fed in about 3.5 years. Then it leaves the roots, contract, and makes an earthern cell and remains inside till May, when the pupation begins. The adult emerges in about one month from the pupa
- Thus, It completes its life cycle in 4 years.

**Risk Factors**

- Problem is more severe in loamy and sandy-loam soils. Orchards near the deodar forest are more prone.

**Cultural Measures**

- Keep the orchard healthy, following good agricultural practices.
- Manually catch and kill adults.
- Use cultural practices such as sanitation felling (destruction of damaged and infected plants or

pruning).
- New plantations should be. Avoided in sandy soil and areas having previous history of borer infestation

**Control Measures**

I. Non-Chemical
- After cutting the wild plants from the garden, cut off the remaining stem up to the roots. These are ideal place for survival and multiplication of this pest.
- Open the tree basins during dormancy for collection and killing of the grubs.
- Install light trap in the orchard during June –July to attract the beetles, collect them and kill them by putting in kerosinised water.
- Alternatively, Install pheromones trap with the onset of rainy season to trap the male beetles. It will cause shortage of .male beetle available for mating, thus consequently lowers the population build-up.
- Improve plant health through bridge/approach graft.
- Use parasitic nematodes such as Steinernema pravassos and Heterorhabditis spp., and natural enemies such as Neoplectana nematodes and Elatrid beetle.
- Use insect pathogenic fungus Metarhizium anisopliae in the infested soil and it infects the damaging stage, larvae, of the borer.

Chemical Products

There are currently no effective chemical products to control very high infestation. In these exceptional situations, the active ingredient Chlorpyriphos can help.
- Apply chlorpyriphos dust (300 gm/ tree) in the plant basin from June to July to kill the eggs laid in the plant basin.
- Drench the plant basins with Chlorpyriphos (1000 ml in 200 litres of water) from August – September to kill the neonate larvae.
- Irrigate the basin of affected plants with Chlorpyriphos (1000 ml/200 litre of water) in the 1.0-meter circle of the main stem from mid-November to March.

## 6. Apple Leaf Folder *(Archips termias)*

*Fig. 40: Symptoms of apple leaf folder.*

**Damage Symptoms**

- It overwinters as larvae in the fallen leaves, cracks, and crevices of trees as well as in wrappers/ trays of stored fruits. Overwintering larvae become active in spring, and moths emerge in May and lay eggs in clusters.
- Black-headed green larvae feed on young leaves folded by silken threads and fruits by scraping the fruit skin.
- Maximum damage occurs from June to October, and about 40 per cent of losses are estimated during storage.

**Biology (Life Cycle & Favorable Environment)**

- Disc like flattened eggs are laid in clusters of 35 - 180 on the upper surface of the leaf or on the depressed fruit surface. Egg duration is 1 - 2 weeks.
- The pest hibernates as a larva for about seven to eight months. .Larval is green with black head, which hangs in air with the help of silken thread. Larval duration is 3 - 5 weeks.
- Pupal duration is 1 - 3 weeks.
- Adults are small buff coloured tortricid moths.
- Two generations are completed by September and third generation larvae hibernates in the fallen leaves or in cracks/ crevices for seven to eight months after September till April.
- The overwintering larvae become active in spring and moth emerges in May

**Cultural Measures**

- Avoid late-maturing varieties.

**Control Measures**

I. Non-Chemical

- Collection and destruction of fallen leaves,
- Covering the cracks and crevices with recommended paste/ paint helps in lowering the pest population.
- Spray Bacillus thruingiensis (Bt) in the initial stage of infestation effective. Bacillus thuringiensis is effective against small caterpillars.

II. Chemical Products

In exception, spraying Malathion (200 ml/ 200 lts of water) in mid-June and before harvest gives satisfactory control. It should only be carried out in case of very high infestation.

### 7. Apple Stem Borer *(Apriona cinerea)* and Shoot Borer *(Zeuzera multistrigata)*

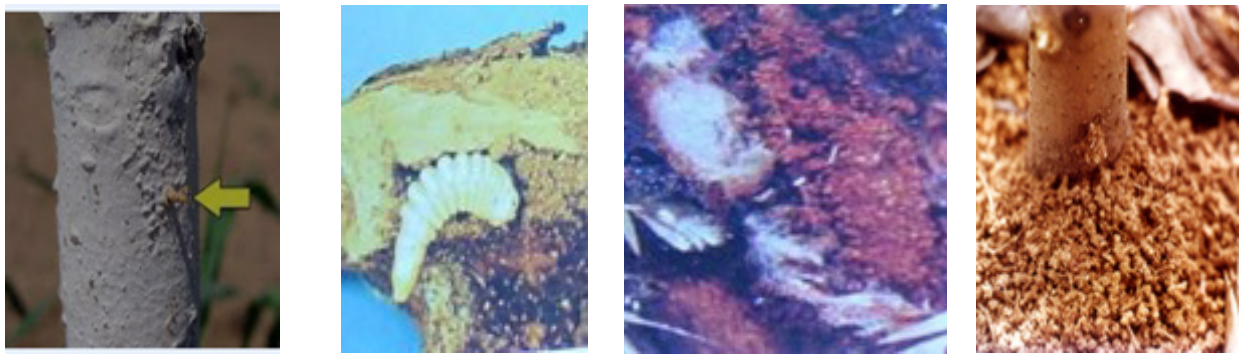


*Fig. 41: Symptoms of apple stem borer.*

**Damage Symptoms**

- In stem borer, the larvae feed below the bark, tunnel down the branches and finally reach the truck.
- Its attack can be easily identified on the basis of faecal pellets and wood shreds pushed by grub from the circular holes.
- Similarly, in the case of shoot borer, young larvae bore into the shoot and feed on the internal tissue. Later, instars bore into the heartwood and kept tunnelling the collar region. Pinkish-round excretal pellets can be seen around the hole.
- Affected tree becomes weak, and the yield is reduced significantly.
- In case of third Shoot hole borer makes gun-shot like holes on the stems and twigs and the plant becomes sick, weakens, and dries up.

**Biology (Life Cycle & Favorable Environment)**

Stem Borer:

- Ashy-grey long horned beetle (2,5-5cm in length) lay eggs singly in thick branches, which hatch in a week.
- Larva keep on feeding below bark and tunnel down to finally reach the trunk.
- It become full fed in second winter, makes a pupal chamber and overwinters. And young adults are formed in May-June and their emergence continues till September.
- The attack of stem borer can be easily be identified on the basis of fecal pellets and wood shreds pushed by the grub from circular hole on stem/ thick branches.

Shoot borer:

- White moths with blue black markings appear in May-July and lay about 600 eggs singly or in group in cracks or crevices of the tree,
- Hatch in 7-9 days and youg larva initially scraps bark, then cut small hole, bore into shoot and feed on internal tissue.
- Later instar bore into hard wood and keep on tunneling down upto collar region. Larval stage lasts for 20-22 months. And life cycle is completed in 20-26 months.

**Cultural Measures**

- Removal of alternative/other hosts.
- Destruction of infested plants and plant parts.
- Prune and destroy the affected branches.
- Follow all agricultural practices to keep the orchard healthy.
- Natural enemies like Neoplectana, Alaus sp., Aprostocetus fukutai, Beauveriana bassiana and Dastarcus helophoroides are known to suppress the pest.

**Control Measures**

I. Non-Chemical

- Manual picking and killing of adults.
- Injection of Beauvaria bassiana into larval holes.
- Parasitic nematodes, Steinernema pravassos and Heterorhabditis spp. are effective.
- Kill the larvae by inserting and pushing a flexible wire into the borer's tunnel.
- Location of live holes, injection of petrol, and sealing them with mud to kill the pest.

II. Chemical Products

- Insert solid fumigant (0,2 gm Aluminium phosphate) or cotton wick soaked in liquid fumigant (petroleum) or insecticide emulsion (0,1% Dichlorvos) in cleaned larval gallery and plug it with mud plaster to kill the grubs.
- Spray Quinalphos or Malathion (200 ml/200 litres) of water on the new growth in exceptional situations when you know that this region has a high infestation level.

# Topic 8 | Hazardous chemicals to avoid

## Objectives and key messages

| | |
|---|---|
| Topic objectives | • Identify chemical names that are hazardous to use on orchards<br>• Determine the active ingredients, effects on beneficial insects, and environmental impacts of commonly used trade names.<br>• Recognize banned products to avoid using on orchards |
| Key messages to bring out | There are certain hazardous ingredients that farmers should never use, which are sold under different trade names:<br>• Carbendazim<br>• Mancozeb + Carbendazim<br>• Flusilazole + Carbendazim<br>• Flusilazole<br>• Oxy-demeton Methyl<br>• Propargite<br>• Thiacloprid |

# Recognize hazardous chemicals

| Environmental impacts/ Hazardousness | Effect on beneficial insects. | Active Ingredient | Trade name(s) |
|---|---|---|---|
| A |  | Carbendazim | Dhanustin/ Bavistin/ Mavistin/ Derosal/ Benfil/ Gilzim/ Carbestin/ Goldstin |
| D |  | Captan | Captaf/ Dhanutan/ Kohicap/ Masstan/ Captax/ Capgold |
| C |  | Copper oxychloride | Blitox/ Fytolan/ Masstox/ Copter/ Trucop/ Riva |
| C |  | Difenoconazole | Score/ Scale/ Dizole/ Rubigon/ Dkarara |
| C |  | Dodine | Superstar/ Syllit/ Himdin/ Tihfa/ Noor |
| B + D |  | Metiram+Pyraclostrobin | Cabrio Top |
| B |  | Hexaconazole | Contaf/ Hexzol/ Sitara/ Titan/ Glow/ Envil/ Hexcon/ Krozole |
| B |  | Mancozeb | Indofil M-45/ Dithane M-45/ Abic M-45/ Emthane M-45/ Uthane M-45/ Dhanuka M-45/ Mass M-45/ Kohinoor M-/45/ Uthane M-45/ Hindustan M-45/ Gold M-45 /Marlett M-45 |
| C |  | Myclobutanil | Systhane/ Boon/ Index/ Grapple |
| B |  | Propineb | Antracol/ Aaroosh |
| B |  | Thiophanate methyl | Roko/ Topsin M/ Alert/ Stop/ Trust/ Key |
| B |  | Zineb | Indofil Z-78/ Kanji |
| B |  | Ziram 27 % | Cuman L |
| (C) |  | Ziran 80% | IPL Ziram |

| | | | |
|---|---|---|---|
| C +(C) |  | Tebuconazole +Trofloxystrobin | Nativo |
| C + D |  | Tebuconazole + Captan | Shamir |
| D + C |  | Fluxapyroxad + Difenoconazole | Sercadis Plus |
| A + B |  | Carbendazim + Mancozeb | SAAF |
| D + D |  | Boscalid + Pyra-clostrobin | Signum |
| D |  | Metrafenone | Acisio |
| D + D |  | Fluxapyroxad + pyraclostrobin | Merivon |
| A |  | Flusilazole | Cursor |
| A + A |  | Carbendazim+ Flusilazole | Lustre |

*Fig. 42: Hazardous chemicals to avoid.*

| Colour/ Symbol | Side Effects on Beneficial Organisms |
|---|---|
|  | No known side effects on beneficial organisms |
|  | Slightly harmful side effects on beneficial organisms |
|  | Harmful side effects on beneficial organisms |

*Fig. 43: Colour codes for side effects on beneficial organisms .*

| Colour/ Symbol | Explanation |
|---|---|
| D | Appropriate precaution |
| C | Only by authorised staff |
| B | For use only as an exception |
| A | Not allowed |

*Fig. 44: Explanation of colour codes.*

# Topic 9 | Pesticides Handling and Application

## Objectives and key messages

| | |
|---|---|
| Topic objectives | • Determine the sequence of steps to be followed when spraying pesticides<br>• Understand how to read labels and data safety sheets to safely prepare spray mixture<br>• Recognize the importance of personal protection equipment (PPE) and how to maintain it for regular use |
| Key messages to bring out | The correct steps to follow when preparing and applying pesticides are:<br>Step 1: Read the Safety Data Sheet<br>Step 2: Observe the label<br>Step 3: Put on personal protection equipment (PPE)<br>Step 4: Prepare spray mixture.<br>Step 5: Clean the Protective Clothing<br>Step 6: Observe the re-entry time<br>Understand what needs to happen in each step before, during, and after spraying pesticides in their orchard. |

# Procedure to safely spray pesticides

**Preparation of the Spraying Mixture**

Weighing, dosing, and preparing the spraying mixture pose the most significant health risks to the user as it directly works with the undiluted plant protection product. It is, therefore, important to use personal protective equipment. When preparing the spray mixture, the mask, gloves and protective suit must be used to combat the chemical risks. To prevent damage to people and the environment, plant protection products must never be handled at the border areas. Care must also be taken to ensure that the stock tank does not overflow.

The following personal protection equipment is required:

- **Half mask to protect the respiratory tract:** The mask should cover the mouth, nose and chin. A mask with a combination filter against gases and vaporous organic compounds with low absorption capacity should be used. The filters must be changed if the inhalation resistance increases unpleasantly or when the expiry date is reached.
- **Protective gloves against chemicals:** Protective gloves for chemical risks must be made of synthetic latex such as nitrile rubber or neoprene.
- **Protective suit for chemical risks:** Protective clothing against liquid chemicals (spray-tight) is sufficient for handling most plant protection products. The full-body protective suit should ensure spray-tight connections between the different parts of the clothing (e.g., boots, gloves).
- **Safety goggles:** The safety goggles can be safety spectacles with side protection or safety goggles with a basket. If the goggles are more like safety glasses, make sure that they fit well, especially in the nose area, and at least completely cover the eye area.

**Observe the Label**

The label is particularly important. The label must be read before use, as it also contains important information on handling the plant protection product and the health risks for the user.

**Read the Safety Data Sheet**

There is a separate safety data sheet for each plant protection product. This contains information that enables the user to take all necessary measures to protect their own health and safety. Safety data sheets for plant protection products can be obtained from traders or online.

**Protection During the Application of Crop Protection Products**

The application of the spray liquid also poses health risks for the user, as they can come into contact with it via the respiratory tract or skin. Personal protective equipment must be adapted accordingly.

**Cleaning the Protective Clothing**

All soiled parts of the protective clothing should be cleaned after spraying work has been

completed. The manufacturer's cleaning instructions should be followed for protective clothing. Do not wash together with other items of clothing. Disposal instructions must be followed for disposable protective suits. Protective gloves, rubber boots and goggles should be cleaned with soap and water. All parts of the protective clothing should be stored outside the crop protection agent store in a dry and clean place, preferably in a cupboard.

**Observe the Re-Entry Time**

For all plant protection products, no work should be carried out in the plant before the spray mixture has dried. The first 24 hours after treatment, the plant should only be entered wearing personal protective equipment. Even if a shorter re-entry time is specified on the label, this should be observed for safety reasons. However, if the legislator stipulates a longer re-entry time than 24 hours on the label, this must be followed.
For some products, there are additional regulations regarding the wearing of protective clothing when working after the re-entry time has expired. This information is also printed on the label or safety data sheet.