Singapore Food Agency

Guide to Integrated Pest Management (IPM)

for Singapore vegetable farms

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About the Author

Hazel Chew is from the Agri-tech and Food Innovation Department of the Urban Food Solutions Division. With a background in Biology and Environmental Studies, her current interest is in crop protection and climate change.

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Contents

Section 1: Introduction

The integrated pest management (IPM) approach can help reduce and prevent pests and diseases from intruding in the farm and minimize crop loss.

This guide contains the generic components, principles and techniques of IPM which can be applied to vegetable farms in Singapore.

IPM is a crop protection approach that focuses on *long-term prevention* of pests and diseases. Techniques are selected and applied in a manner that *minimizes risks to human health, beneficial and non-target organisms and the environment* (adapted from University of California IPM definition).

Agriculture today uses and is heavily reliant on chemical pesticides. This heavy usage, along with improper use, have led to a decline in effectiveness of chemical pesticides. Research shows that pests are developing resistance to the very pesticides created to manage them.

Other than effectiveness of chemical pesticides, safety is another concern. Prolonged exposure to chemical pesticides through air or liquid contact can lead to serious health implications. If not handled and applied properly, chemical pesticides also pollute the environment.

Crop protection on farms can be improved by incorporating integrated pest management. The IPM approach and techniques tackle the pest issues from multiple angles, ensuring not only the elimination of the pest but also boost the resistance of crops and the abundance of the pest's natural enemies.

Section 2: Integrated Pest Management

Integrated pest management (IPM) is an approach using a combination of techniques to prevent and tackle pests and diseases to ensure healthy growth of crops.

2.1 Components of IPM

2.1.1 Monitoring

Determine threshold levels for pests and diseases on the farm. Threshold levels help inform farmers on management strategies based on level of economic damage to crops. There are three threshold levels:

1. **Economic damage:** pest population or disease incidence where damage on produce is detected. Closely monitor pest situation and continue to practice preventive measures (see Section 3).
2. **Economic threshold:** pest population or disease incidence where control measures should be applied to prevent damage from reaching economic injury level. Apply control measures (see Section 5).
3. **Economic injury level:** pest population or disease incidence where damage to crops cause economic losses.

Identify levels of pests and diseases present on the farm through regular monitoring of the plants, traps etc. Determine plan of action depending on pest or disease type and threshold levels

Select techniques that target the specific pest or disease to control and prevent reoccurrence while ensuring minimal risks to humans, non-target organisms and the environment. See component 2 (control) for more details on this.

2.1.2 Control

Once the target pest or disease has been identified, a range of techniques are implemented to control and prevent them from re-occurring. Control techniques are divided into four categories: cultural, mechanical (also referred to as physical), biological and chemical. See definition and examples in table below:

Control Method	Definition	Examples
Cultural	Practices that reduce and disrupt pest habitat	Crop rotation, Resistant varieties, Sanitization
Mechanical (also referred to as Physical)	Practices that use physical means	Pruning affected plant parts, Nets, Solarization
Biological	Practices that use living organisms	Parasitoids, predators, biopesticides
Chemical	Practices that use synthetic chemicals	Chemical pesticides

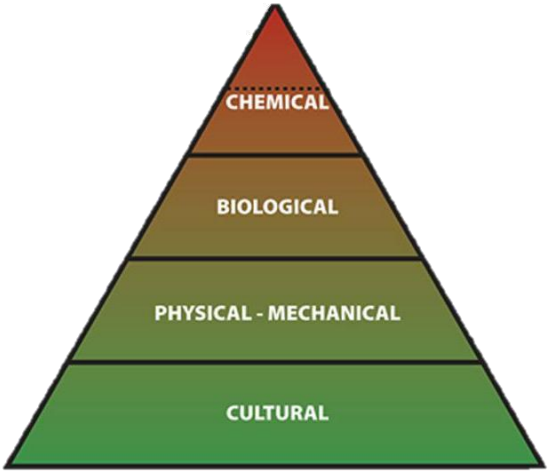

Figure 1: IPM Pyramid from Penn State College of Agricultural Sciences

A combination of the first three techniques (cultural, mechanical and biological) is encouraged. Chemical should only be used as a last resort.

2.2 Crop Protection Programme

A crop protection programme is required on every farm. The programme will cover the following:

- **Risk mitigation:** measures put in place to prevent entry and establishment of pests and diseases. See Section 3 and 4.
- **Emergency plans:** steps on how to manage pests and diseases should they establish on the farm

The programme is to be reviewed annually, and all farm workers are to be briefed on it.

Section 3: Prevention

Techniques can be used to discourage pests and diseases from establishing on the crops and causing significant damage.

3.1 Entry

The first step of prevention is to stop entry. Pests and diseases enter the farm via air through wind and open entrances or on equipment, planting materials and people. Upon entry into the farm, the pest can spread from one plant to another. Therefore, it is important to ensure entrances and exits are closed when not in use, movement of equipment and people are controlled and sanitation is carried out to prevent the critical step of entry by the pests.

3.1.1 Infrastructure

- Install physical barriers such as nets and closed covering (greenhouse structure) to isolate crops from the external environment and stop pests from entering (protected cultivation). Conduct regular checks and maintenance for cracks and tears.
- Ensure adequate and efficient ventilation to prevent moisture build-up that is favoured by fungal and bacterial infections. Air within farm should have a way out and fresh air from outside should have a way in.

3.1.2 Sanitation

- Remove crop waste, including dead and overgrown plants, as they may harbour pests and diseases. Plant waste to be placed in tied bag and removed from vicinity of growing crops and farm equipment.
- Minimize movement of people into growing area as pests and diseases can be transmitted through clothing or shoes.
- Establish biosecurity measures for people entering growing area. Install double doors where only one door is opened at any time. Air curtains and foot baths (disinfectant or sticky tape) are other measures to limit transmission.
- Sanitize on a regular schedule, using cleanser, disinfectant, sanitiser or physical treatment. This includes growing tools, machineries and working surfaces.
- Avoid standing or still water out in the open as they are a breeding ground for mosquitos and algae.

3.2 Growing

- Have fixed watering schedule tailored to crop types to prevent overwatering and moisture accumulation which increases plant and substrate's susceptibility to algae and diseases.
- Have fixed fertilizer application schedule tailored to crop types to prevent accumulation of nitrogen (N) uptake in the plants. High nitrogen reduces plant resistance and makes them more susceptible to pests.
- Purchase certified pest and disease-free substrates. Store away from growing area to avoid cross-contamination.

3.3 Seeds and Seedlings

3.3.1 Purchasing

- Purchase from reputable and established sources.
- Choose varieties suitable to the climate and growing system.
- Choose disease resistant varieties when possible.

3.3.2 Seeding

- Locate seeding area away from growing area to prevent cross contamination.
- Check and remove damaged seeds before sowing.
- Do not overcrowd seedlings.

3.3.3 Transplanting

- Check and remove any infested or infected seedlings before transplanting to growing area.

Section 4: Monitoring

Staying up to date on the situation will allow early decision making of suitable techniques to keep pests and diseases from causing significant damage to crops.

4.1 Crop Monitoring

Regular crop monitoring is essential to a successful crop protection programme. With an established crop monitoring schedule and understanding, pests and diseases will be detected early and curated control measures can be put into action.

Crops should be checked daily for signs and symptoms of pests and diseases. Refer to Section 5: Pests and Diseases for description and photos of frequently seen pests and diseases and their damage symptoms.

4.1.1 Visual Inspection

While on the farm:

- Observe crops for signs and symptoms of pests.
- Scout at border of growing area where there is higher chance of pests and diseases establishment.
- Do not overlook hard-to-see areas, such as underside of leaves and the crown area.

4.1.2 Traps

Traps can be used to monitor, identify and note patterns (e.g. seasonal, preferred crop type) in pest populations and disease incidences. There are several types of traps available:

Yellow sticky trap. Image from SFA

Sticky traps can be placed hanged on poles, ceiling or growing system. Yellow sticky traps are used to trap adult leaf miners, aphids, whiteflies and fungus gnats. Blue sticky traps are used for thrips.

Replace when sticky surface is nearly full or every 30 days, whichever comes first.

Pros: cheap, widely available and appropriate for wide range of pests (non-specific).

Cons: non-specific so may trap a large number of insects, both pests and natural enemies of the pests which may affect their biological control potential in the area. Heavy rainfall could reduce stickiness of trap and will need to be replaced more often.

Pheromone trap. Image from Mehdi

Pheromone traps use synthetic copies of female sex pheromones to attract males. Often used for moths, such as the diamondback moth. Combine pheromones with sticky traps.

Replace pheromones as instructed on manufacturer's packaging and technical data sheet to maintain viability and optimum efficacy of the lure.

Pros: targeted to specific pests (species, genus or family level) to reduce the trapping of beneficial and non-pest organisms. Can help identify mating and breeding times of pests, as it will only trap adult males, which will enable informed decision on control methods to target different life stages (e.g. adult vs larvae).

Cons: Commercially not available for all pest types. Currently available for diamondback moth.

Light trap. Image from Dick

Light traps are suitable for species attracted to light, such as moths. Combine lights with sticky traps.

Replace bulbs every 9-12 months, or when flicking

Pros: require low trap maintenance and human intervention. Can be automated. Insects are easily contained and have minimal damage to aid in identifying.

Cons: high cost of operation, can be reduced in long run if solar powered. Non-specific so may trap a large number of insects.

4.1.3 Identification

Identifying the pest or disease that is causing crop damage is essential to choosing the most effective management methods. If unsure of signs or symptoms and require further assistance for identification, contact National Parks Board (NParks), Animal & Plant Health Centre at *www.nparks.gov.sg/contact-us*.

For more information, please visit *https://www.nparks.gov.sg/services/plant-health-services/plant-science-and-health-laboratory-services*

4.2 Record-keeping

Keeping a record helps monitor past and present situations to guide decision making and provides documentation on what has or has not worked. Records should be checked and verified by farm supervisor and/or manager.

Keep a record of the following, in digital format for easy access and audit purposes:

- Pests and diseases identified (location, date/time, crop type, symptoms found, estimated percentage of damage caused).
- Crop protectants used (pesticides: application, date, location, quantity, pre-harvest interval, operator name).
- Cleaning and maintenance schedule.
- Qualifications and trainings of farm employees (e.g. pesticide operator license). To ensure all qualifications and trainings are up to date.

Section 5: Pests and Diseases

This section provides information on frequently seen pests and diseases found in Singapore farms and suggested IPM measures to both prevent and control them. The list is not exhaustive.

List of frequently seen pests and diseases

Pests	Diseases
Aphid	Bacterial leaf blight
Diamondback moth	Bacterial rot
Flea beetle	Leaf fungal rust
Fungus gnat	Mildew
Grasshopper	Viral leaf curl
Leaf miner	
Mealy bug	
Spider mite	
Thrips	
White fly	

Tip: Click on text above to jump to description

5.1 Pests

Aphid

Aphids are small, pear-shaped insects with long, slender mouth parts that pierce and suck out plant fluids. Aphids may be green, yellow, brown-red or black in colour. They secrete large quantities of sticky exudates known as honeydew, which promotes fungal diseases such as sooty mould. This pest reproduces without fertilization. A single female produces 20-140 nymphs. A life cycle is completed in 8-10 days.

Potential Hosts

Shoots and young leaves of most vegetable crops and herbs, lettuce, spinach, beans, brinjal, chilli, lime, okra, sweet pea, tomato

Symptoms

- Infested foliage and shoots curled downwards and young vegetable fruit become distorted.
- Leaves, stems and fruits appear sticky and blackened with sooty mould.

Preventive and Control Measures

- Monitor and check the undersides of leaves regularly. When the population of aphids is high, distorted and curled leaves are observed. It is often hard to control the aphids as the curled leaves shelter them from insecticide or natural enemies.
- Ants climbing up the plants could be an indication of aphid presence. Control the ants because they feed on the aphids' honeydew and at the same time protect the aphids from natural enemies.
- Before planting, check surrounding plants for aphid infestations and remove them.
- High levels of nitrogen fertilizer favour aphid reproduction. Never use more nitrogen than necessary.
- Prune affected parts of leaves.
- Spray with high pressure water. Ensure plant can withstand pressure.
- Parasitic wasps, ladybird beetles, lacewings and hover/flower flies are natural enemies of aphids.

Aphids – adult. Image from Thomas Shahan

Aphids secrete honeydew that attracts ants. Image from CyclicalCore

Aphids secrete honeydew that can lead to sooty mould. Image from Amnon Shavit

Diamondback moth

A widespread insect pest in hot and dry parts of the year. Several generations may be completed in one field crop. The caterpillars are light brown, about 2 mm long when they hatch, becoming green and growing to about 12 mm. They move rapidly when disturbed and drop from leaves on silk threads which they use later to climb back on the plants. The pupa is a 9 mm long gauze-like silken cocoon that sticks to the underside of a leaf; greenish at first and changes to brown colour as the moth develops. Adults are small, grayish moths, 8-9 mm in length. When the wings are folded, a line of three diamond-shaped markings run along the back that gave them their name.

Potential Hosts

Brassica spp. or cruciferous crops (e.g. baicai, caixin, gailan, xiao bai cai, watercress, cabbage, mustard cabbage)

Symptoms

- Tiny cigar-shaped white eggs laid, singly or in small groups, near the midrib or main leaf vein.
- Holes on leaves.
- First instar sometimes feeds in the spongy plant tissue beneath the leaf surface forming shallow mines that appear as numerous white marks.
- Last stage larva is a voracious feeder; it causes more injury than the first three larval instars.

Preventive and Control Measures

- Maintain netted structure for crops to keep diamondback moth (DBM) out of growing area.
- *Brassica spp.* are especially susceptible. Rotate with non-*Brassica spp.* like bayam or kangkong for 30 days to disrupt DBM cycle.
- Intercrop with plants that have repellent effect, such as tomato.
- Remove all DBM infested materials from farm. Do not use these for composting.
- Remove damaged or diseased crops as these are alternative hosts that harbour pests.
- Use pheromone traps to monitor DBM populations.
- Encourage beneficial insects and natural enemies (e.g. Cotesia plutellae wasps) by spraying less pesticides. These parasites feed on DBM larvae.
- Larvae are heavily susceptible to rainfall or overhead irrigation which causes the larvae to fall from the plant.

Diamondback moth – larvae. Image from Merle Shepard, Gerald R. Carner and P.A.C Ooi

Diamondback moth – pupa. Image from Russ Ottens

Diamondback moth – adult. Image from CSIRO

Diamondback moth larvae bites and creates holes in leaves. Image from Institute of Tropical Agriculture

Flea beetle

The average life cycle of the flea beetle is 17 days. Adults generally are most destructive to young plants. They lay eggs scattered on the soil beneath host plants. Eggs hatch in 2-4 days. The larvae feed on and tunnel into underground stems, roots and tubers for about a week. There are usually three instars. Pupae usually remain in the soil for 3-5 days. The adults live for 20-30 days. There are two common species that are damaging to vegetable crop: the black crucifer flea beetles and the striped flea beetles. When disturbed, they jump like fleas.

Potential Hosts

Leafy vegetables, radish, melons, pumpkins, peas, beans, brinjal

Symptoms

- Fine silvering, stippling or speckling on leaves.
- Scatter small “shot-gun” like holes on leaves.
- Cotyledon leaves eaten at the edges.

Preventive and Control Measures

- Farm sanitation to remove infested crop debris.
- Crop rotation to fruited vegetables and non-Brassica spp.
- Use yellow sticky traps to catch flying adults. Place sticky traps within 0.5 m of the crop canopy as flea beetles do not travel far.
- Grow a trap crop such as radish along the field edge to attract adult flea beetles away from the main crop. The primary vegetable should be planted 7-14 days after the trap crop to encourage flea beetles to stay in the trap crop area.

Striped flea beetle – adult. Image from Katja Schulz

Flea beetle damage - small holes on leaves. Image from ulleo

Fungus gnat

Tiny at about 2.5-3.2mm, fungus gnats are hard to spot and love moist organic matter. They are black with long legs and antennae. Their wings are clear or light grey with a distinctive Y-shaped vein. The larvae are slender, roughly 5.5mm long with legless white to clear bodies and black shiny heads. Larval stage is the most damaging as fungus gnat larvae feed on roots and shoots of plants, causing stunted growth, wilting and even death of seedlings. Larvae may also spread fungal diseases.

Adult females lay 50-300 eggs just under the moist organic material and the larvae emerge 4-7 days later. After pupation, adults will emerge but are generally weak fliers and will remain near plants and organic growing media.

Potential Hosts

No specific hosts, highly dependent on moist organic matter

Symptoms

- Wilting plants.
- Adults are attracted to the light and may be found nearer windows or sunlit areas.
- Larvae leave shiny trails on surface of soil.

Preventive and Control Measures

- Avoid overwatering and allow proper drainage. Let surface of growing media dry to kill off larvae.
- Remove standing water and fix leakages in irrigation or plumbing.
- Remove any moist organic matter as they are breeding ground of fungus gnats.
- Avoid over-fertilizer and excess addition of organic matter.
- Use sticky traps to capture the flying adults.
- Let growing media completely dry or change growing media entirely.

Fungus gnat – larvae. Image from kim fleming

Fungus gnat – adult. Image from Ian Jacobs

Grasshopper

Long hind legs and wings allow grasshoppers to jump and travel quickly, causing widespread damage to crops. Grasshoppers are distinctive from many other pests with a big body and short antennae. Female lay eggs in elongated pods underneath the surface of the growing media; each pod contains 20-100 eggs. Eggs hatch into nymphs which readily feed on nearby plants, moving to new area and plants when food supplies are depleted. Nymphs are wingless. Adults are the most damaging life stage, as they may bite through cloth or plastic. They have a lot of natural enemies and are susceptible to diseases.

Potential Hosts

Leafy vegetables, beans, corn, lettuce, onion

Symptoms

- Adults are easy to spot.
- Large areas of leaves chewed, starting from outer edges of leaves and going inwards.

Preventive and Control Measures

- Have physical barriers to prevent entry of grasshoppers, either metal fences or high bushes.
- Till or turn over growing media to prevent egg laying.
- Remove tall grass in the area so the area is less attractive to grasshoppers and it is easier for birds to prey on grasshoppers.

Grasshopper – adult. Image acquired with CC0 Public Domain

Leaf miner

The tiny white eggs are inserted into plant tissue just beneath the leaf surface and hatch in about three days. Females can produce 600-700 eggs over their life span.
Larvae are about 2.25 mm, nearly colourless, becoming greenish and then yellowish as they mature. The larvae feed on leaf cells below the epidermis, tunnelling mine trails.
The mature larva cuts a semi-circular silt in the upper surface of the mined leaf, emerges from the tunnel, drops from the leaf and burrows a few cm into the soil to form an oval brown puparium to pupate.
The adult emerges in 5-12 days as a small greyish black fly. The entire life cycle varies from 12-26 days depending on temperature and host plants.

Potential Hosts

All leafy vegetables, sweet pea, beans, cabbage, ginger, citrus

Symptoms

- Twisting, serpentine, translucent mine trails on leaves.
- Speckling or puncture hole spotting on leaves.

Preventive and Control Measures

- Farm sanitation to remove infested debris.
- Rotate with fruited crops, such as okra, brinjal etc. These are less susceptible to attack.
- Use yellow sticky traps to trap flying adults.
- Avoid over-fertilizing with nitrogen as it makes plants more attractive to female adults.
- Till or turn over soil regularly after each crop cycle to eliminate the eggs.
- Prune affected leaves and dispose them to prevent adult leaf miner from emerging and adding to the population.

Leaf miner – larvae. Image from Jerry A. Payne

Mine trail made by leaf miner. Image from SFA

Mealybug

They are found in warm weather. Mealybugs are soft, oval-shaped and are covered in wax. They secrete large quantities of sticky exudates known as honeydew, which promotes fungal diseases such as sooty mould. Mealybugs suck on plant sap, and high populations can hinder plant growth and quality. Female adults are 4-5 mm and wingless, while male adults have tiny wings (often not seen). Females lay 100-200 eggs in cotton sacs attached to crowns, leaves, fruits or twigs. Nymphs, when hatched, are yellow to orange-pink and do not have wax. As they feed, wax will develop. Mealybugs do not travel far.

Potential Hosts
Citrus, okra

Symptoms
- Cotton sacs or colonies in protected areas, such as crown of plant or in between stems and touching leaves or fruits.

Preventive and Control Measures
- Farm sanitation to remove infested plants.
- Hand-pick adults or cotton egg sacs where possible.
- Avoid excess nitrogen fertilization as mealybugs are attracted to new growth of plants.
- If mealybugs are exposed, forceful jet of water may be able to dislodge them.

Mealybugs – adult. Image from CSIRO

Mealybugs often found in colonies. Image from CIAT

Spider mite
Mites are transparent, yellow or white, microscopic spiders commonly found near the mid-veins on the underside of leaves in colonies that can contain hundred individuals. Adults have eight legs and oval bodies with two red eyespots near the head. Immature stages may only have six legs. Eggs are spherical and transparent, like tiny droplets. They become cream-coloured before hatching. Spider mites reproduce rapidly and may complete a generation in less than a week. They also disperse rapidly with the aid of wind. Damage is caused by the adults sucking on sap from plant leaves and fruits.

Potential Hosts

Bayam, kangkong, bell pepper, brinjal, chilli, cucumber, melon, okra, sweet potato, tomato

Symptoms

- Tiny red dots (microscopic spider mites) on underside of leaves.
- Stippling on leaves.
- Leaves curl downwards or become malformed with narrow leaf blades.
- Infested plants have faded, yellowish or greyish cast and may have thin layer of webbing if heavily infested.
- Terminal leaves and flower buds become distorted and may drop.
- Corky tissues develop on infested fruit tissues.

Preventive and Control Measures

- Ensure young seedlings are free from mites before transplanting.
- Check plants regularly for early detection of mites, before damaged is noticed.
- Keep plants well-watered during hot dry weather to prevent stress and mist leaves as mites do not like wet conditions.
- Spray down dusty areas like pathways as spider mites favour hot and dry conditions.

Tiny red dots on underside of leaves indicate spider mites. Image from SFA

Spider mites on leaves - close up. Image from Toby Young

Thrips

Thrips are very small and group together along the leaf mid-veins, inside flowers or along the rolled up or curled leaf edges of infested tissues. Their life cycle is highly heat sensitive. In warm weather above 30 °C, thrips' complete life cycle takes only 20 days. Eggs hatch in four days and larvae pupates in another four days. Thereafter, female adults live for 10-30 days, and each lay between 50-100 eggs. Damage is caused by adults sucking sap and scraping on plant leaves and fruits.

Potential Hosts

Leafy vegetables, bell pepper, bitter gourd, chilli, cucumber, melon, onion, squash

Symptoms

- Fine white silvering on young leaves.
- Cause shoots and young leaves to curl upward or malform.
- Brown areas develop between veins of both young and old leaves. Corky tissue developed on infested fruits.
- In severe infestation, plants are stunted and leaves are blighted.
- Cause flower development to fail and drop prematurely leading to yield loss.

Preventive and Control Measures

- Ensure that young transplants or seedlings are free from thrips before transplanting into growing area.
- Use blue sticky traps to monitor pest situation. Traps should be placed just above plants.
- Avoid overwatering or excess nitrogen fertilization.
- Cover plants when young when they are most susceptible to thrips.

Thrips – adult. Image from Ian Jacobs

Thrips cause brown spots on leaves. Image from Institute of Tropical Agriculture

Brown areas develop between leaf veins due to thrips. Image from Swapnil.Karambelkar

White fly

White flies are often found on the underside of the leaf. Each female lays an average of 160 eggs. There are four nymphal stages before the adult emerges in 18-28 days. Adults and nymphs suck the sap from the plant leading to stunting, poor growth, defoliation and reduced yields. Both adults and nymphs excrete honeydew, which promotes fungal diseases such as sooty mould affecting the marketability of the produce and reduce plant photosynthesis. White flies are efficient vectors in spreading plant viruses from infected plants into healthy crops.

Potential Hosts

Bayam, tomato, brinjal, chilli, bell pepper, long bean, French bean, curry leaf

Symptoms

- Infestation produces honeydew that attracts sooty mould fungal growth. Ants are also attracted to the sweet honeydew secretions.
- Severe infestations lead to plant stunting, poor growth and defoliation.
- Leaves yellowed or mottled likely from secondary virus infection vectored by white flies.

Preventive and Control Measures

- Controlling white fly population is very important. If the population of adults is high, it becomes difficult to control the nymph stages.
- Clean up crop residues of heavily infested crops to prevent migration of white flies into adjacent crops.
- Ensure that young seedlings are free from white flies.
- Use yellow sticky traps to monitor pest situation. Traps should be placed just above plants.
- Ladybird beetles, lacewings and spiders are natural enemies of white flies.
- Prune affected leaves.

White fly – adult. Image from Jean and Fred Hort

White fly - adult on tomato plant. Image from laura sorrensen

5.2 Diseases

Bacterial leaf blight

Bacterial leaf blight spreads easily in wet conditions. Bacteria can spread from one plant surface to another by splashes of water by rain or irrigation. Even asymptomatic plants can be a source of inoculum. Symptomatic plants develop once bacterial populations are high and should be destroyed immediately.

Potential Hosts

Wide range including leafy vegetables and fruited crops

Symptoms

- Small, water-soaked lesions (less than 0.6 cm) that darken over time. Multiple lesions combine into one big lesion.
- Older leaves are black and become dry. Lesions rarely affect newly developed leaves.
- Sticky, amber-coloured exudate may appear on leaves or stalks.
- Fruit may produce light-brown ooze from water-soaked markings.

Preventive and Control Measures

- Reduce overhead irrigation where possible to prevent leaf wetness and water splashes.
- Remove crops showing symptoms. Sterilize gardening tools and wash hands after handling infected plants.

Water-soaked lesions caused by bacterial leaf blight. Image from Awkwafaba

Darkened lesions on leaves caused by bacterial leaf blight. Image from Scot Nelson

Bacterial rot

A wide host of plants are susceptible to this bacterial disease. Once infected, the symptoms rapidly appear and decimate the crops. Bacterial rot often starts on leaves, stems and underground parts of the crops, quickly spreading throughout the crop and making the plant tissues soft and mushy. The bacterial pathogen is commonly found in soils and prefers moist conditions. Bacterial rot may take place on farms or during post-harvest.

Potential Hosts

Cabbage, caixin, chilli, gailan, bell pepper, Chinese radish, cucumber, melon, potato, pumpkin, tomato

Symptoms

- Water-soaked, translucent lesions on leaves, stems and underground parts. Start off small but grows in size and depth within 24-48 hours.
- Plant tissue becomes soft, mushy and watery.
- Unpleasant, putrid odour may be detected from decaying tissue.

Preventive and Control Measures

- Allow proper drainage and air circulation in soil to prevent moist conditions.
- Do not overwater.
- Avoid planting crops too close to one another.
- Avoid working with crops when they are wet.
- For post-harvest, avoid leaving harvested plants on soil.
- Remove infected plant parts immediately.

Bacterial rot – kale stem. Image from ***Awkwafaba***

Bacterial rot - napa cabbage. Image from ***Awkwafaba***

Leaf fungal rust

There are many species of leaf fungal rust, each having its own characteristics and host species. Regardless of species, rust prefers wet and mild temperatures. Their spores are windblown and are spread when infected plants are moved from one place to another.

Potential Hosts

Wide range including leafy vegetables and fruited crops

Symptoms

- Powdery masses of yellow, orange, purple, black or brown spores on leaves and stems.
- Leaves may drop prematurely.

Preventive and Control Measures

- Avoid overwatering via overhead irrigation as leaf fungal rust requires water to spread and infect.
- Check seedlings for signs of infection before transplanting.
- Remove infected plant parts, including fallen leaves. Bag properly and do not carry to other growing areas as spores are windblown and may spread.

Leaf rust causes mass of brown spots on leaves. Image from International Maize and Wheat Improvement Center

Leaf rust causes yellow spots on leaves. Image from Evelyn Simak

Mildew

Mildew is a fungal disease that develops during rainy periods when the relative humidity is greater than 95%. Infections spread when the spores are splashed or blown onto other susceptible tissues that remain wet. Spores may also persist in crop residues and soils.

Potential Hosts

Cabbage, caixin, chilli, gailan, leaf mustard, lettuce, spring onion, spinach, sage, bottle gourd, cucumber, melon, okra

Symptoms

- Irregular black or dark specks appear on young leaves, usually on the underside of the leaf first.
- Upper side of leaf will also develop dark spots accompanied by leaf yellowing.
- A white-grey, downy growth can be observed on the underside of the leaf.

Preventive and Control Measures

- Alternate cropping with non-cruciferous crops.

Powdery mildew. Image from Ejdzej

Downy mildew – cucurbit. Image from NY State IPM Program at Cornell University

Viral leaf curl

Tomatoes are particularly susceptible to viral leaf curl known as tomato yellow leaf curl (TYLC). The viral disease is transmitted via insect vectors such as white flies; therefore control of these insect populations are important to managing viral leaf curl. If crops are infected at an early stage, the effects on stunted growth will be more drastic.

Potential Hosts

Wide range including leafy vegetables and fruited crops

Symptoms

- Stunted plant growth and may take on a bushy appearance (‘bonsai’ or ‘broccoli’ like growth).
- Infected leaves are small, curl upwards and show signs of yellowing and crumpling.
- Flower and fruit production is reduced.

Preventive and Control Measures

- Plant resistant varieties.
- Control white fly populations as they can transmit the disease.
- Rotate with non-host crops to break life cycle of insect vectors (e.g. white flies) and disease.
- Quickly remove infected plants or plant parts.

Viral leaf curl – capsicum. Image from LS2018

Section 6: Further Resources

Beyond this guide, there are other resources to gain further understanding of crop protection and the IPM approach. Below are suggested resources and is not an exhaustive list.

6.1 Courses

- Agriculture 101 @ Republic Polytechnic
- Specifications for Good Agriculture Practice in Singapore @ Republic Polytechnic
- CoC in Urban Farming (Pests & Diseases) @ ITE

6.2 Guides and Websites

- Specification for good agriculture practice (GAP) – SS 675
- Specification for clean and green urban farms – Agriculture (SS 661)
- National Parks Board's (NParks) Gardening Resources
- Singapore Food Agency's (SFA) Farming Technologies

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