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Ghana Veg

Pest Management Guide for Cucumber




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All photos in this manual were taken by the authors (Dr. Ken Okwae Fening, Dr. Francis Collison Brentu and Mr. Paul Muteru) and the others have been duly acknowledged.

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Acronyms

AEAs . . . . . .Agricultural Extension Agents

Bt . . . . . .*Bacillus thuringiensis*

Biocontrol. . . . .Biological control

Biopesticide . . .Biological pesticide

CSIR . . . . . .Council for Scientific and Industrial Research

IGRs . . . . . .Insect Growth Regulators

IPM. . . . . .Integrated Pest Management

MoFA . . . . . .Ministry of Food and Agriculture

PPE . . . . . .Personal Protective Equipment

PPRSD. . . . . .Plant Protection and Regulatory Services Directorate

PHI . . . . . .Pre-harvest interval

REI . . . . . .Re-entry interval

1. Introduction

Cucumber (*Cucumis sativus*) is a widely cultivated plant in the gourd family, Cucurbitaceae. It is one of the most important cucurbitaceous crops cultivated throughout the world and in Ghana. According to FAO, the production of fresh cucumber from 2006 to 2020 in Ghana is 132 metric tons (FAO Code 0397).

Despite the economic and nutritional importance of cucumber, its production is challenged by a range of pests and diseases. This guide is put together to describe the arthropod pests (insects and mites), and diseases encountered by farmers during cucumber production, from nursery establishment to harvesting, using relevant pictures and illustrations.

Important Integrated Pest Management (IPM) approaches needed to prevent, monitor, and control the pests and diseases have been included in the document. A combination of appropriate and compatible pest management strategies (cultural, physical/mechanical, biological, host plant resistance, etc.) are recommended, with the use of pesticides (chemical control), preferably the environmentally friendly and less hazardous pesticides, as the last resort, a concept known as IPM. It is advisable to rotate different Mode of Action (MoA) class of pesticides to delay the development of resistance. Also the use of the less hazardous synthetic pesticides should be restricted to the seedling, vegetative and pre-flowering stages of the crop and complemented with the biological pesticides during flowering and fruiting stages of the crop to ensure food and environmental safety, and help promote the activities of beneficial insects (e.g. natural enemies and pollinators).

The guide is structured starting with the main insect pests, followed by the major diseases. The management practices are given in section of prevention, monitoring and control. The guide can be used by advisors as well as farmers. The information will ultimately help farmers better control the pests and diseases they encounter and increase the quantity and quality of cucumber produced in Ghana.

As an appendix to this document (Appendices 3 and 4) are two tracking sheet/scouting guides that can be used by farmers and growers to monitor pests and diseases for timely implementation of control measures. There is the need for regular (bi-weekly) scouting, by inspecting plant parts (leaves, stem, fruits, etc.), depending on the growth stage of crop and the type of pests, for the presence of the pest or its damage to establish their infestation and damage early enough (action threshold), to ensure a decision is made to control to prevent irreversible damage from occuring (economic damage). Scouting can also be done by monitoring catches of pest numbers from traps set in the vicinity of the crop for informed decision making. Taking a decision to control based on the combination of pest thresholds from sampling arthropds from the crop and also estimates from trap catches could offer a more precise information, than when they are utilised independently. This regular scouting will support farmers and growers to document pest and disease incidence on the crop and also record information on the control method employed such as treatment option used, e.g., the type of pesticides applied, the rate and frequency of application, among others. Appendices 1 and 2 also give a summary of registered pesticides for the different pests and other useful information about their use.

Please note that use of pesticides should only be with EPA approved pesticides and follow the label recommendation as can be found on the packaging.

The pesticides listed in this guide are given as active ingredients, not the registered trade names.

Where applicable biocontrol options are given, however, not all are currently available in Ghana. We hope that by mentioning them this will increase the use and application of biological control agents in the future.

2. Pests of cucumber and their management

2.1 Sweet potato whitefly

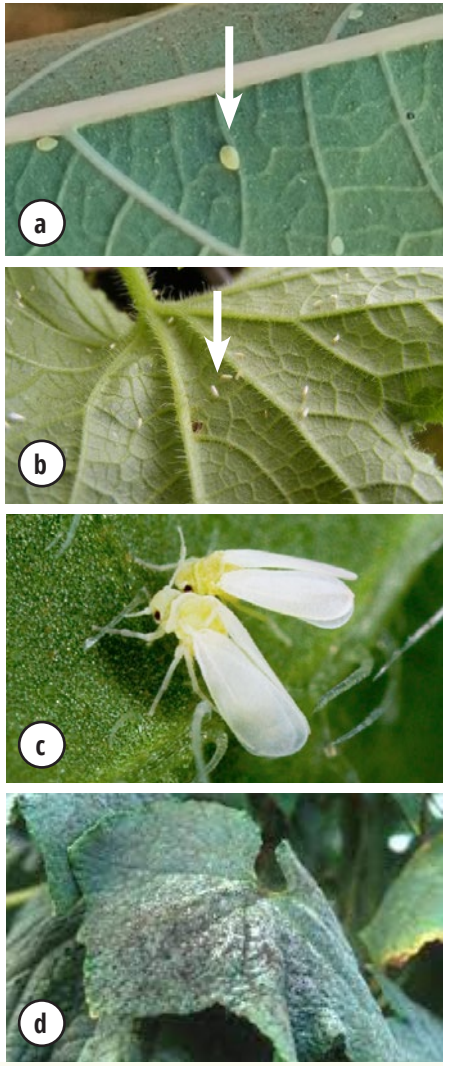
Scientific name: *Bemisia tabaci*
Distribution: Widespread
Stage of crop attacked: Seedling and vegetative stages

Main damage symptoms:

- Feeding activities of nymphs and adult whiteflies result in sooty mould formation on leaves. Transmission of viral diseases.

The adult of the of the sweet potato whitefly (*Bemisia tabaci*) closely resembles the greenhouse whitefly (*Trialeurodes vaporariorum*) but is slightly smaller and yellower. More distinctively, the wings of B. *tabaci* are held vertical and parallel along the body.

Adults and of the greenhouse whitefly, Trialeurodes vaporariorum. *(Unlike, B.* tabaci, *the fourth-instar nymphs have very long waxy filaments and a marginal fringe). (See photo above). Photo ©University of California.*



Nymphs (a) and adults (b and c) of sweet potato whiteflies and sooty mould (d) on cucumber leaves. (b. Photo from Shuterstock.com c) Photo from Public Domain - Released by the USDA-ARS/original image by Stephen Ausmus. d). Image courtesy of Paul De Barro, CSIRO.)

The greenhouse whitefly is known to occur in many continents, including some countries in north, east and southern Africa (CABI 2021). B. *tabaci* and *Trialeurodes* are the vector for several viral diseases. Since viral diseases have no cure, management intervention should focus on early detection of vector and its control.

Prevention

- Implement good farm sanitation practices – regular weeding of bushes or alternative hosts within and around greenhouses to destroy breeding places.

Monitoring

- Use yellow sticky traps to monitor adult whiteflies population within and outside greenhouse.
- The sticky cards are used to detect and monitor whitefly population levels and should be placed uniformly throughout the greenhouse at 1 trap per every 100 m² or one trap per 20 to 50 plants.
- The traps should be hung just above the canopy of the crop as whiteflies are attracted to the young growth of the plants.
- Other locations to consider hanging traps would be near doors, vents and previously known hot spots.
- Thoroughly look at the underside of leaves (aided by a ×10 hand lens) at random for the presence of the nymphs and adult whiteflies early morning (6–7 a.m.), where they are still inactive.
- The action threshold is about 4 adults per leaf in a random 30-leaf sample of healthy leaves or more than 5 adults per trap per week early in production, deployed per 100 m² of production.
- Alternatively, visually inspect crop for signs of whitefly infestation, looking out for suspicious cucumber plants that look stunted or chlorotic.

Control

Physical control using mass trapping – Yellow sticky traps can be used at a rate of one trap per two to five plants in whitefly hotspots to remove excessive numbers of whitefly adults from the tops of plants.

Biological control

- Use or apply commercial predators, parasitoids or beneficial fungi of whiteflies. As cucumbers are a short crop it is essential to release parasitoids early to get the best effect.

  Examples of whitefly predators:
  - Mirid bug (*Nesidiocoris tenuis)*
  - Lacewings
  - Predatory bugs
  - Ladybird beetles
  - Predatory mites

  Examples of whitefly parasitoids:
  - Parasitoid wasps
  - E.g. *Encarsia formosa (Encarsia)* and *Eretmocerus warrae (Eretmocerus)*
  - Green lacewing (*Mallada signata)*

  Example of beneficial fungi:
  - *Metarhizium anisopliae*

- Biological pesticides (for effective control, weekly application is preferable). (Its use is recommended during flowering and fruiting stages of the crop to ensure food safety).
  - Neem oil (Azadirachtin 0.3%): 60 ml/15 l
  - Neem oil (Azadirachtin 1%): 30 ml/15 l
  - Neem seed extract: 750g/15 l
  - Potassic soap solution, *alata samina*: 75g/15 l
  - Pyrethrum at the recommended label application rate
  - Maltodextrin: 150–225 ml/15 l
  - *Beauveria bassiana*
  - Spinosad
  - Oxymatrine

Synthetic insecticides

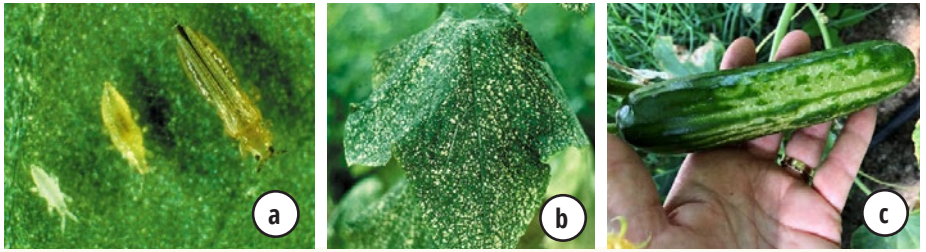
Active ingredient	PHI	Remarks
Imidacloprid or Imidacloprid + Emamectin benzoate	2 weeks	Spray in two weeks intervals to control whiteflies. Rotate this active ingredient with other recommended insecticides to prevent resistance development.
Pymetrozine (500 g/kg)	2 weeks	Spray in rotation with other insecticides to control whiteflies.
Acetamiprid (16 g/l) + Indoxacarb (30 g/l)	2 weeks	Spray in rotation with other insecticides to control whiteflies
Spirotetramat (100 g/l)	1 week	Spray in rotation with other insecticides to control whiteflies
Deltamethrin (12.5 g/l)	3 days	Spray in rotation with other insecticides to control whiteflies
Chlorfenapyr (24%)	2 weeks	Spray in rotation with other insecticides to control whiteflies
Lambda cyhalothrin (25 g/l)	3 days	Spray in rotation with other insecticides to control whiteflies
Novaluron (100 g/l)	1 day	Apply when the majority of the pest population is at egg hatch to early instars
Biological pesticides	0–3 days	Biopesticide used in rotation with other synthetic insecticides. Much preferred during flowering and fluiting stages.

2.2 Thrips

Scientific name: *Thrips* spp.
Distribution: Widespread
Stage of crop attacked: Seedling and reproductive stages

Main damage symptoms:

- Thrips damage leaves and distort the fruit of cucumbers by feeding and laying eggs in leaf and flower tissues and young developing fruit.
- Thrips cause severe damage to the plant characterised by deformation, scars, and silvery patches. Thrips also transmit viral diseases.



Developing stages (1st and 2nd larval instars and adult) (a) of thrips and their characteristic damage on cucumber leaf (b) and fruit (c) (a & b. Photos from OMAF Publication 370, Guide to Greenhouse Floriculture Production/Crop Protection Guide for Greenhouse Vegetables., photo c. Amy Ivy, Vegetable Specialist, Eastern New York Commercial Horticulture).

Prevention

- Farm sanitation - weeds should be removed from around the perimeter of the greenhouse, and ornamentals should not be planted near the greenhouse.
- Cultural control measures also include maintaining a healthy crop and an optimal greenhouse environment (such as 80% relative humidity), creating less favourable conditions for a rapid increase in the density of thrips populations.
- Greenhouse vents can be covered with very fine screening to prevent thrips infiltration from outdoors.

Yellow and blue sticky traps (cards) for monitoring thrips, whiteflies and other arthropods population in greenhouse cucumber production (a. Photo from bugs for bugs sticky trap b. Photo from Garden Guru).

Monitoring

- Commercially available blue or yellow sticky traps can be used to monitor the population densities of adult thrips (see photo on the left).
- Blue traps are more attractive to flower thrips, although yellow traps are more attractive to other pests such as whiteflies and aphids.
- When setting up a monitoring programme, use 1 trap per 100–200 m².
- The exact number will depend on the layout of the greenhouse.
- Early detection provides adequate early warning of thrips.
- Place the sticky cards in a grid pattern throughout the greenhouse.
- Look for characteristic damage symptoms of thrips (their feeding on immature cucumber fruit can result in silvery scarring, or even malformation of the fruit).
- Action threshold is not more than 19 adults per sticky trap per day or 1–2 adults per flower as determined under average greenhouse production conditions (Shipp et al., 2000) and Steiner (1990) suggested a possible action threshold of 1.7 adults or 9.5 larvae per middle leaf of greenhouse cucumber.

Control

Biological control:

Is now the primary strategy for controlling thrips in greenhouse crop production in North America and Europe. In Ghana, there is currently a regulation in place to allow growers to import biocontrol agents to control pests in greenhouse vegetable production. Biological control agents include predatory mites such as:

- *Neoseiulus (= Amblyseius) cucumeris*
- *Amblyseius swirskii*
- *Iphesius (= Amblyseius) degenerans*
- *Stratiolaelaps scimitus (= Hypoaspis miles)*
- *Gaeolaelaps gillespiei*
- *Gaeolaelaps aculeifer (= Hypoaspis aculeifer)*
- minute pirate bugs (*Orius insidiosus*)
- nematodes (*Steinernema feltiae*)

Physical control:

Prevent entry of thrips and other pest by using screens to restrict the movement of insects into the greenhouse.

Biopesticides:

- Spinosad
- Pyrethrum/ Pyrethrins
- Neem seed extract: 750 g/15 l
- Neem oil (0.3% Azadirachtin): 60 ml/l
- Neem oil (1% Azadirachtin): 30 ml/l
- *Beauveria bassiana*
- *Metarhizium anisoplae*

Synthetic insecticides:

Active ingredient	PHI	Remarks
Imidacloprid or Imidacloprid + Emamectin benzoate	2 weeks	Spray in two weeks intervals to control thrips. Rotate this active ingredient with other recommended insecticides to prevent resistance development.
Pymetrozine (500 g/kg)	2 weeks	Spray in rotation with other insecticides to control thrips.
Fipronil (50 g/l)	2 weeks	Spray in rotation with other insecticides to control whiteflies
Thiamethoxam (350g/L) or Thiamethoxam (141 g/l) + Lambdacyhalothrin (106 g/l)	2 weeks	Spray in rotation with other insecticides to control thrips
Acetamiprid (16 g/l) + Indoxacarb (30 g/l)	2 weeks	Spray in rotation with other insecticides to control thrips
Spirotetramat (100 g/l)	1 week	Spray in rotation with other insecticides to control thrips
Deltamethrin (12.5 g/l)	3 days	Spray in rotation with other insecticides to control thrips
Chlorfenapyr (24%)	2 weeks	Spray in rotation with other insecticides to control thrips
Lambda cyhalothrin (25g/l)	3 days	Spray in rotation with other insecticides to control thrips
Novaluron (100 g/l)	1 day	Apply when the majority of the pest population is at egg hatch to early instars
Biological pesticides	0–3 days	Biopesticide used in rotation with other synthetic insecticides. Much preferred during flowering and fluiting stages.

2.3 Cotton or melon aphids

Scientific name: *Aphis gossypii*
Distribution: Widespread
Stage of crop attacked: Seedling and reproductive stages

Main damage symptoms:

- Damage usually becomes obvious on cucurbits after the vines begin to run. Congregating on lower leaf surfaces and terminal buds, aphids pierce plants with their needle-like mouthparts and extract sap.
- When this occurs, leaves curl downward and pucker.
- Wilting and discoloration follow.
- Aphid damage weakens plants and may reduce fruit quality and quantity.
- Honeydew secreted by aphids makes plants sticky and enhances development of black sooty mould on plant foliage, which interferes with photosynthesis.
- Viruses transmitted by melon aphid include cucumber mosaic, watermelon mosaic, and zucchini yellow mosaic.

Prevention

- Cultivars differ in susceptibility to aphid build up and to virus; plant resistant varieties if they are available.
- Use row covers or reflective plastic mulch to prevent early infestation and virus transmission (direct seeding is recommend in reflective mulch for maximum effectiveness).
- Separate early and late plantings.
- Use selective insecticides for other pests to conserve natural enemies.

Monitoring

- Scout for aphids in the greenhouse by searching undersides of leaves on runners.
- Action to control melon aphids must be taken as soon as the first aphid is detected because they reproduce so quickly.
- Action threshold – if 20 percent of runners or more have live aphids' treatment may be needed.

Aphids gossypii on cucumber leaves (a), their damage symptoms (b) and transmission of viruses (c). https://ag.umass.edu, Gardening for beginners (https://burea-uinsurance.com/en/how-to-deal-with-aphids-on-cucumbers-in-a-greenhouse/), Photo: Julius Kühn.

Control

Biological control:

Predators such as lady beetles and their larvae, syrphid fly larvae, and aphid lion larvae reduce melon aphid populations.

- Parasitoid, *Aphidius colemani* is an excellent agent for control of the melon aphids.
- Female *Aphidius* wasps will lay over 100 eggs mostly soon after they emerge as adults.
- Generations occur every 10–14 days depending on temperature so the wasps can get on top of aphid colonies very quickly.
- The key to good control is to release low numbers of wasps regularly in the early crop stages prior to aphid establishment.

Good coverage of undersides of leaves is needed for control.

Biopesticides

- Neem seed extract: 750 g/15 l
- Neem oil (0.3 % Azadirachtin): 60 ml/l
- Neem oil (1% Azadirachtin): 30 ml/l
- Insecticidal soaps – *alata samina* applied at 75 g/15 l
- petroleum-based horticultural oils or
- plant-derived oils, e.g., canola oil
- Oxymatrine

Synthetic insecticides:

Active ingredient	PHI	Remarks
Profenofos (300 g/l) + Lambda-cyhalothrin (15 g/l) or Profenofos (40%) + Cypermethrin (4%)	2 weeks	Spray in rotation with other insecticides to control aphids
Imidacloprid or Imidacloprid + Emamectin benzoate	2 weeks	Spray in two weeks intervals to control aphids. Rotate this active ingredient with other recommended insecticides to prevent resistance development.
Pymetrozine (500 g/kg)	2 weeks	Spray in rotation with other insecticides to control aphids
Fipronil (50 g/l)	2 weeks	Spray in rotation with other insecticides to control aphids
Thiamethoxam (350 g/l) or Thiamethoxam (141 g/l) + Lambdacyhalothrin (106 g/l)	2 weeks	Spray in rotation with other insecticides to control aphids
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Spirotetramat (100 g/l)	1 week	Spray in rotation with other insecticides to control aphids
Deltamethrin (12.5 g/l)	3 days	Spray in rotation with other insecticides to control aphids
Chlorfenapyr (24%)	2 weeks	Spray in rotation with other insecticides to control aphids
Lambda cyhalothrin (25 g/l)	3 days	Spray in rotation with other insecticides to control aphids
Biological pesticides	0–3 days	Biopesticide used in rotation with other synthetic insecticides. Much preferred during flowering and fluiting stages.

2.4 Two-spotted mites

Scientific name: *Tetranychus urticae*
Distribution: Widespread
Stage of crop attacked: Seedling and reproductive stages

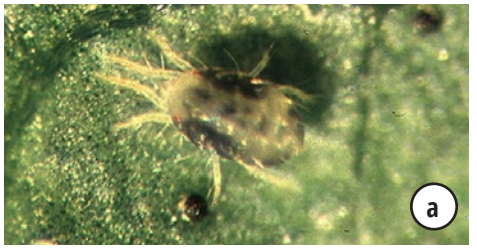
Main damage symptoms:

- Speckling/ fine stippling (small spots) of leaves and fine webbing on the underside of affected leaves. Leaves may turn yellow and dry up, and plants may lose vigour and die when infestations are severe. The pest also causes direct damage on cucumber fruit, resulting in a sandpaper-like texture to the rind.

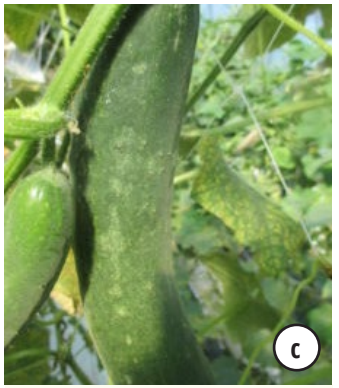
Prevention

Cultural and mechanical practices:

- Use Resistant/tolerant variety: Use resistant or tolerant varieties if available. E.g., Japanese cucumber cultivars such as Taurus was more tolerant to attack by two-spotted spider mite damage (see Photo above).
- Timely irrigation and nutrient management are effective preventive tactics.
- Weeds should be removed from the vicinity of the greenhouse and a 3-m-wide, weed-free zone should be maintained around the perimeter.
- Movement of equipment, people, and plant material from infested to non- infested areas should be restricted.



Susceptibility of two cucumber varieties (Corinto and Taurus) to attack by the two-spotted spider mites in a greenhouse (Photos from Wenjing Guan and Laura Ingwell, Purdue University).



Two-spotted mite adult, damage on cucumber leaves and fruits (a, b, c). (Photos a & b from Wenjing Guan and Laura Ingwell, Perdue University, Photo c. Utah State University Extension).

- Use a strong stream of water from a hose-end nozzle to physically wash mites off infested plants.
- Direct a stiff spray of water to the undersides of leaves and the lower portions of plants.
- Use a slow-release nitrogen fertiliser when possible.
- High nitrogen levels in foliage encourage spider mite reproduction.
- All crop residues should be removed and destroyed after harvesting to prevent reinfestation of the greenhouse.

Monitoring

- Mites are very tiny and difficult to see with the naked eye.
- Observe mites closely or aided by a magnifying hand lens.
- Monitor for early symptoms of infestation in the field (e.g., webbing, yellow discolouration, yellow spot or stippling on leaves, mottled leaves, etc.) or their presence.
- Action threshold is 8–14 spider mites/leaf to implement control measures.

Control

Biological control:

- In screenhouse or greenhouse environments, predatory mites are excellent choices for where spot-treatment may be adequate instead of area-wide release.
- The trick to success is to release them soon after pest detection to suppress the population.
- Potential biocontrol agents include:
  - *Phytoseiulus persimilis* (good against two spotted spider mites in humid environments)
  - *Amblyseius andersoni* (a native predatory species)
  - *Orius insidiosus* (Pirate bug)
  - *Stethorus* (lady beetles that attack spider mites)
  - *Chrysopa* (green lacewings)

Biopesticides

- Neem seed extract: 750 g/15 l
- Neem oil (0.3% Azadirachtin): 60 ml/l
- Neem oil (1% Azadirachtin): 30 ml/l
- horticultural/mineral oils
- paraffinic oils
- other natural oil blends
- Insecticidal soaps – '*alata samina*' (75–120/15 l of water)
- *Metarhizium anisopliae*
- Oxymatrine

Synthetic insecticides:

Active ingredient	PHI	Remarks
Abamectin	2 weeks	Spray in rotation with other insecticides to control spider mites
Sulphur (50%) + Copper (8%)	2 weeks	Spray in rotation with other insecticides to control spider mites
Spirotetramat (100 g/l)	1 week	Spray in rotation with other insecticides to control spider mites
Chlorfenapyr (24%)	2 weeks	Spray in rotation with other insecticides to control spider mites
Biological pesticides	0–3 days	Biopesticide used in rotation with other synthetic insecticides. Much preferred during flowering and fluiting stages.

NB: Control mites using miticides or acaricides

2.5 Fungus gnats

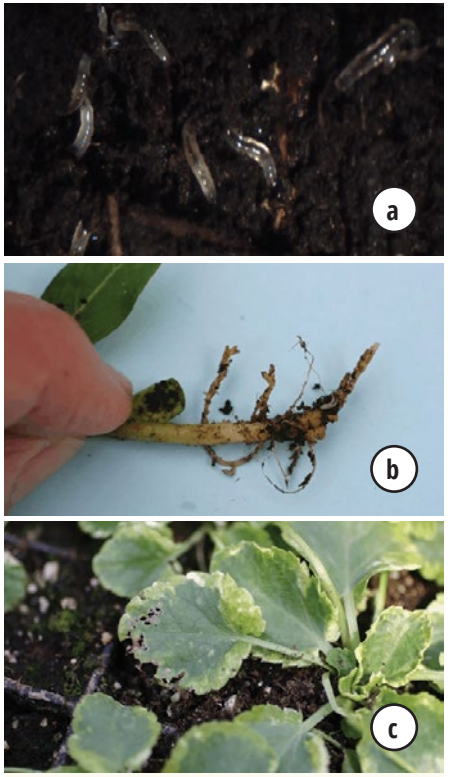
Scientific name: *Bradysia* spp., *Corynoptera* spp.
Distribution: Widespread
Stage of crop attacked: Root and root hairs

Main damage symptoms:

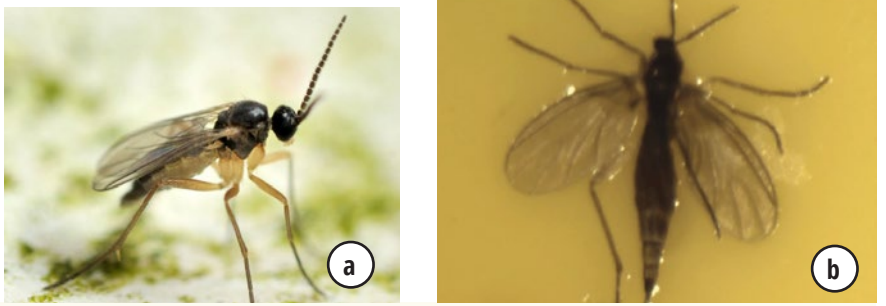
- The larva is the damaging stage, feeding on developing roots, root hairs and young plants.
- Growth reduction may result and feeding opens wounds through which pathogens may invade.
- Fungus gnat larvae and adults may transmit or be involved in the movement of soilborne diseases of greenhouse crops, notably root rots caused by *Pythium* species in cucumber.
- They are a common pest, especially in the moist growing environment in propagation greenhouses and if the growing media contains a high percentage of compost, composted bark or peat moss.
- Larvae can tunnel into plant crowns causing plant death.

Prevention

- Fungus gnats do best in damp soils; be careful not to overwater because wet conditions favour outbreaks.
- When potting, avoid water holding, organic material such as peat moss that may encourage egg laying.
- If pests are present, allow the soil to dry to a depth of one to two inches between waterings. This not only kills larvae and inhibits the development of eggs, it also makes the soil less attractive to egg-laying females.



Fungus gnat larvae and signs of larval damage on root/root hairs and chewing on leaves (a, b, c). (Photo courtesy of Leanne Pundt).



Fungus gnat adult and adult trapped on a yellow sticky card (a. Photo from https://www.planetnatural.com/pest-problem-solver/houseplant-pests/fungus-gnat-control/ .b. Photo by Leanne Pundt).

Monitoring

- Turn up soil carefully near the base of the plant and look for the glossy, clear larvae.
- Use Yellow Sticky Traps placed horizontally at the soil surface to capture large numbers of egg laying adults.
- The gnats are attracted to yellow and are easily removed on the trap before they can lay more eggs.
- Waste plant material should be removed, and good sanitation should be always followed.
- There is no action threshold for fungus gnats.
- If signs of damage are observed in the green-house, such as afternoon wilting, in conjunction with large numbers of fungus gnats around the base of the plants and larvae in the culture medium, then control measures should be initiated immediately.
- If yellow sticky traps become covered with fungus gnat adults within seven days, then treatment is warranted.
- Alternatively, place potato chunks or plugs on the media surface to attract fungus gnat larvae.
- Check potato slices after two days for the larvae.
- Fungus gnat larvae are small, (approximately ¼ of an inch long when mature), translucent to white in colour with a distinctive black head capsule.
- Inspect root systems for overall health and for signs of damage from fungus gnat feeding (i.e., blunt root tips).

Control

Biological control:

- Nematode (*Heterorhabditis* sp.) is effective in controlling fungus gnat larvae, but it does not reproduce in the body of the gnat larva and must be reapplied whenever gnat populations resurge.
- Use of a predatory mite, *Hypoaspis* (syn. *Geolaelaps*) – The mite should be applied at a rate of 50 individuals per plant at planting-out to achieve satisfactory control.

Biopesticides:

- Neem seed extract: 750 g/15 l
- Neem oil (0.3% Azadirachtin): 60 ml/l
- Neem oil (1% Azadirachtin): 30 ml/l
- *Bacillus thuringiensis*

Synthetic insecticides:

- Fungus gnat larvae and adults may be controlled by spray or drench application of insecticides to the surface of the culture medium.

Active ingredient	PHI	Remarks
Thiamethoxam (15%) or Thiamethoxam(141 g/l) + Lambdacyhalothrin(106 g/l)	2 weeks	Spray in rotation with other insecticides to control fungus gnats
Novaluron100 g/l)	1 day	Spray in rotation with other insecticides to control fungus gnats
Chlorfenapyr (24%)	2 weeks	Spray in rotation with other insecticides to control fungus gnats
Biological pesticides	0–3 days	Biopesticide used in rotation with other synthetic insecticides. Much preferred during flowering and fluiting stages.

2.6 Leaf miners

Scientific name: *Liriomyza sativae*, *Liriomyza trifolii*
Distribution: sporadic
Stage of crop attacked: Leaves

Main damage symptoms:

- Larvae creates mines in leaves.
- Larvae are often easily visible within the mine where they remove the mesophyll between the surfaces of the leaf.
- Foliage punctures caused by females during the acts of oviposition or feeding may cause a stippled appearance on foliage, but this damage is slight compared to the leaf mining activity of larvae.
- Their faecal deposits are also evident in the mines.

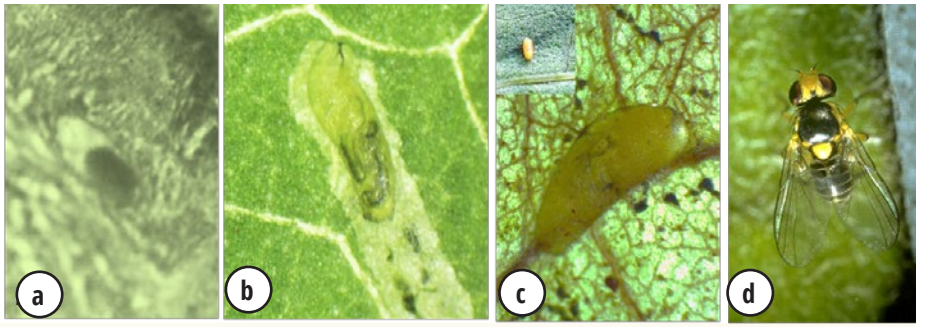
Prevention

- Screen vents into the greenhouse using fine mesh.
- Farm sanitation – Leaf miner can complete its development and emerge from detached leaves that are left on the greenhouse floor, so it is important to keep the greenhouse free of all plant debris and weeds.

Monitoring

- Use of yellow sticky trap for monitoring and mass trapping of adult leaf miners.
- Alternatively carry out visual crop inspection.

Adult of the American serpentine leafminer, Liriomyza trifolii *and mines created in a cucurbit leaf (a, b).*
a. Photograph by Lyle J. Buss, University of Florida.
b. Photograph by J.L. Castner, University of Florida.



The immature developmental stages of Liriomyza trifolii: *(A) egg inside a puncture on the leaf, (B) larvae inside a leaf, behind is a trail of mines, while the dark areas are the waste products, (C) pupa attached to the upper surface of a leaf, and (D) adult dorsal view. Photos: Courtesy of CSL, York (GB)–British Crown.*

Control

- Control measures should be implemented as soon as the first leaf miner is detected in the crop because leaf miner populations can increase rapidly.

Biological control:

- Use of parasitic wasps *Diglyphus* sp. and *Dacnusa* sp.

Biopesticides

- *Bacillus thuringiensis*
- Nematodes (*Steinernema feltiae* and S. *carpocapsae*)
- Neem oil (Azadirachtin 0.3%) : 60 ml/15 l
- Neem seed extract: 750 g/15 l
- Neem oil (0.3% Azadirachtin): 60 ml/l
- Neem oil (1% Azadirachtin): 30ml/l
- *Metarhizium anisopliae*
- *Beauveria bassiana*

Synthetic insecticides:

Active ingredient	PHI	Remarks
Emamectin Benzoate (TL) Emamectin Benzoate (40 g/l) (TL)+ Lufenuron(50 g/l) (TL) Imidacloprid (50 g/l) (S)+ Emamectin benzoate (12 g/l) (TL)	1 week	Spray in two weeks intervals to control leaf miners. Rotate this active ingredient with other recommended insecticides to prevent resistance development.
Acetamiprid (16 g/l) (S)+ Indoxacarb (30 g/l) (S +TL)	2 weeks	Spray in rotation with other insecticides to control leafminers
Spinosad (0.24 g/l)	1 day	Spray in rotation with other insecticides to contro leaf miners
Tebufenozide (TL) (50 g/l) + Emamectin benzoate (10 g/l) (TL)	1 week	Spray in rotation with other insecticides to contro leaf miners
Chlorfenapyr (24%) (TL)	2 weeks	Spray in rotation with other insecticides to contro leaf miners
Novaluron (100 g/l)	1 day	Spray in rotation with other insecticides to contro leaf miners
Biological pesticides	0–3 days	Biopesticide used in rotation with other synthetic insecticides. Much preferred during flowering and fluiting stages.

NB: Most effective control is obtained with systemic (S) or translaminar (TL) products that target the larvae. Thorough coverage of the crop is essential for effective leaf miner control.

2.7 Broad mites

Scientific name: *Polyphagotarsonemus latus*
Distribution:
Stage of crop attacked: Vegetative to reproductive stages

Main damage symptoms:

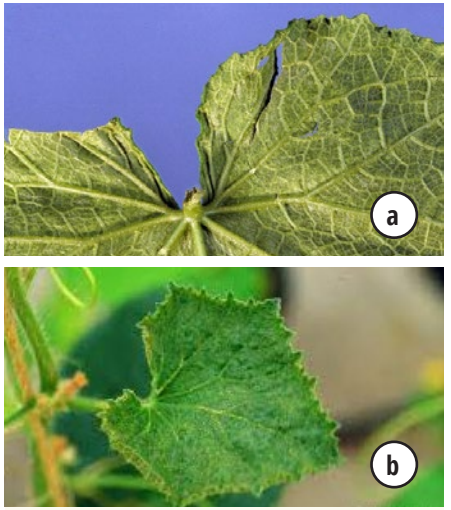
- Broad mites feed in groups, primarily on the underside of young leaves where females lay eggs. They are cell-feeders using their piercing-sucking mouthparts to feed on the epidermis of leaves.
- This causes leaf margins to curl downward, and leaves may become hardened, brittle, puckered, and/or shrivelled (see photo on the right).
- Fruit can be misshapen, with blisters and/or cracked.

Prevention

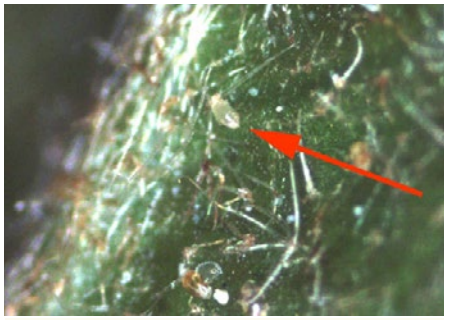
- Weeds within and around greenhouses should be cleared .
- The movement of people or equipment from infested to not infested areas should be avoided.
- Female broad mites have been known to attach to the legs and antennae of adult greenhouse whitefly (*Trialeurodes vaporariorum*) and/or sweet potato whitefly B-biotype (*Bemisia tabaci*); resulting in another means of dispersal.
- Thus, effective control of whiteflies in the greenhouse will minimise the dispersal of broad mites by them.

Monitoring

- Mites attacks young, growing plant parts, and are very tiny and difficult to detect.
- They usually feed on the lower leaf surface and causes leaf edges to become rigid and roll under and causes distortion and/or discoloration of flowers, aborted buds, malformed/blistering of fruits and stunted growth.
- Monitor plants parts regularly, especially the growing points (meristematic region) for the above symptoms/ and presence of broad mites using a magnifying hand lens.
- Although no threshold has been developed.



Underside and top of cucumber leaves showing bronzing caused by the broad mite, Polyphagotarsonemus latus *(a, b). a. Photo by Gerald Holmes, Strawberry Centre, Cal Poly San Luis Obispo, Bugwood.org b. Photo by David Riley, University of Georgia, Bugwood.org*



*Broad mites (*Polyphagotarsonemus latus*) are microscopic in size (0.1–0.3 mm) and can be difficult to see even with a hand lens. For this reason, growers usually only know when they are present by the damage that they cause.*

Control

Biological control:

- Predatory mites and pathogenic fungi are the major natural enemies of broad mites.
- Inoculative releases of the predatory mites *Neoseiulus (Amblyseius) californicus* and *N. barkeri* may be used for biological control, especially in greenhouses.

Biopesticides

- Neem seed extract: 750 g/15 l
- Neem oil (0.3% Azadirachtin): 60 ml/l
- Neem oil (1% Azadirachtin): 30 ml/l
- horticultural/mineral oils
- paraffinic oils
- other natural oil blends
- Insecticidal soaps – *'alata samina'* (75–120/15 l)
- Pathogenic fungus, *Metarhizium anisopliae*
- Oxymatrine

Synthetic insecticides:

Active ingredient	PHI	Remarks
Abamectin	2 weeks	Spray in rotation with other insecticides to control broad mites
Chlorfenapyr (24%)	2 weeks	Spray in rotation with other insecticides to control broad mites
Spirotetramat (100 g/l)	1 week	Spray in rotation with other insecticides to control broad mites
Biological pesticides	0–3 days	Biopesticide used in rotation with other synthetic insecticides. Much preferred during flowering and fluiting stages.

NB: Control mites using miticides or acaricides. However, broad mite populations may be difficult to suppress with contact miticides because the mites are in the meristematic tissues. Those indicate in the above table are okay.

2.8 Mealybugs

Scientific name: *Pseudococcidae* spp.
Distribution: Widespread
Stage of crop attacked: Vegetative to reproductive stages

Main damage symptoms:

- At higher numbers of mealybugs can cause leaf yellowing and curling as the plant weakens.
- Feeding is usually accompanied by honeydew, which makes the plant sticky and encourages the growth of sooty moulds.

Prevention

- Keep farm and its surroundings free from weeds that harbour mealybugs and ants that tender them.
- Inspect any new plants thoroughly for mealybugs before bringing them to your farm or before planting them. If you can't remove all the mealybugs present, discard and destroy the plant.

Monitoring

- Monitor visually observing plant parts (stems, leaves and fruits) for the presence of mealybugs or their damage symptoms (stunted growth, sooty moulds, deformation and yellowing of leaves, sometimes defoliation) to detect early infestation to initiate control measures on time.
- The honeydew produced by mealybugs is often collected by ants which in turn protect the mealybugs against natural enemies.
- Action threshold: Initiate control measures when about 2% of fruits is infested with mealybugs.

Mealybugs on cucumber stem. https://www.planet-natural.com/pest-problem-solver/houseplant-pests/mealybug-control/

Control

Physical control:

- Physically remove mealybugs by handpicking or prune them out.
- In outdoor plants, cultural practices and biological control should be adequate for suppressing mealybugs in most situations.

Biological control:

- Look for parasite pupae within mealybug colonies, or emergence holes in mummified mealybugs.
- Naturally occurring predators of mealybugs include ladybird beetles, green and brown lacewings, spiders, minute pirate bugs, and larvae of predaceous midges.

Biological pesticides:

- Insecticidal soaps, horticultural oil and neem oil insecticides applied directly on mealybugs can provide some suppression, especially against younger nymphs that have less wax accumulation.

Synthetic insecticides

Active ingredient	PHI	Remarks
Profenofos (40%) + Cypermethrin (4%)	2 weeks	Spray in rotation with insecticidal soaps,horticultural oils or neem oil to control mealybugs
Spirotetramat (100 g/l)	1 week	Spray in rotation with insecticidal soaps,horticultural oils or neem oil to control mealybugs
Biological pesticides	0–3 days	Much preferred during flowering and fluiting stages.

NB: Insecticides are generally not very effective for mealybugs The mealybugs' waxy coating repels most contact insecticides, and their habit of aggregating in hidden locations makes them hard to reach.

3. Diseases of cucumber and their management

3.1 Bacterial diseases of cucumber

3.1.1 Angular leaf spot

Scientific name of causal organism: *Pseudomonas syringae pv. lachrymans / Pseudomonas syringae*
Distribution: Worldwide
Stage of crop attacked: Seedling, vegetative and fruiting stages

Description of main symptoms:

- The symptoms of Angular leaf spot can easily be mistaken for Downy Mildew.
- Leaf spots are small, brown-coloured water-soaked lesions that are typically angular/do not cross veins.
- Bacteria ooze in free moisture from leaf spots, which may leave a whitish residue on leaves upon drying.
- Dead tissues in spots occasionally drop, leaving irregular 'shot holes' in the leaves.
- Fruit spots are generally smaller, circular, and slightly depressed.
- Fruit internals turns brown below the skin lesion down to the seed layer zone and may run through the entire length of the fruit.
- Older fruit lesions turn white with noticeable tissue cracking.

Prevention

- Preferably, select cultivars that are resistant to one or more diseases.
- Use certified disease-free seeds or pre-treated seeds.
- Prevent bacterial inoculum by controlling cucumber beetles in the farm, especially during the seed to 5-leaf stage.
- Incorporate crop residues deep into the soil after harvest by ploughing.

Angular leaf spot symptoms on cucumber (Source: University of Minnesota Extension)

- Burn plants residues after harvesting to prevent the pathogen from surviving in crop debris.

Monitoring

- Observe the plant leaves, crown, fruit, and stems for the symptoms described above during plant growth and take appropriate actions.

Cultural control

- Practice farm sanitation to reduce conditions favouring the development and spread of the disease.
- Practice crop rotation with non-host crops for at least one year to break the disease cycle.
- Cull infected plants to prevent inoculum spread.
- Avoid working or harvesting fields while the foliage is wet. Mechanical spread of the bacterial pathogen is likely.

Synthetic fungicides

- Implement a spray program if disease forecasting predicts moderate to high risk or when the disease is first observed in the field.
- Spray Copper-based chemicals on a prophylactic basis to protect the plant surfaces from infection.
- Follow chemical labels direction for use.

Active ingredient	PHI	Remarks
Copper hydroxide (770 g/kg)	2 weeks	Apply as a protectant, 5–7 interval.
Copper oxychloride (35%)	2 weeks	Apply as a protectant, 5–7 interval.

3.1.2 Bacterial wilt of cucumber

Scientific name of causal organism: *Erwinia tracheiphila*
Distribution: Worldwide
Stage of crop attacked: Seedling and vegetative growth stage

Description of main symptoms:

- Infected plants initially show wilted and shrivelled leaf symptoms during the day but recover at night.
- Later, wilting spreads to entire branches, vines, and stems suddenly, leading to rapid drying out and death.
- Wilting occurs in the middle of the day during periods of high water stress.
- In partially resistant plants, symptoms appear as dwarfing, excessive blooms, and branching.
- A diagnostic test for bacterial wilt disease: cut the wilted vine near the base. Touch the knife blade to the cut and draw. White to clear slimy string-like threads of the bacterial ooze from the cut onto the knife blade confirms the disease.
- Beetles spread the inoculum.

Prevention

- Beetles spread the inoculum; hence control-ling beetles offers the most effective control of bacterial wilt.
- Protect plants with netting to prevent cucumber beetles from feeding and infecting plants.
- Grow susceptible crops only on rotation every third year. Since beetles overwinter in the soil and carry the bacterium, the cycle can be disrupted by only planting the host in an area every third year.
- Avoid planting cucurbits next to corn, the alternate host of spotted cucumber beetle larvae.

Monitoring

- Constantly monitor the crops to identify spotted and striped cucumber beetles and other insects or any possible sources of infection and control them.

Wilting in cucumber caused by Bacterial wilt disease. (Source: www.hory.extension.wisc)

Cultural control

- Use insect traps like light, sticky traps, and baits to control insects.
- Remove and destroy plant material when wilting symptoms are first noticed as there is no cure for the disease.
- Practice farm sanitation to reduce conditions favouring the development and spread of the disease.
- Use crop rotation with non-host crops for at least one year to break the disease cycle in severely infected fields.

Synthetic insecticides

- Use Attack 1.9 EC [Emamectin-benzoate (1.9%)] to provide season-long control of spotted and striped cucumber beetles, grasshoppers, and squash bugs. Systemic insecticide or soil-applied insecticide gives moderate control to 5 to 6 weeks.
- Start insecticide applications as soon as the plants crack the soil, before the leaves appear, even if no beetles are evident.
- Frequent insecticide application at 4 to 5 days intervals is necessary, especially in the seedling stage, to keep the foliage free of beetle-feeding wounds. Repeat after rains, especially if beetles are present.
- In flowering plants, apply insecticide treatments in the late afternoon or evening to avoid damage to bees.

3.2 Fungal diseases of cucumber

3.2.1 Anthracnose

Scientific name of causal organism: *Colletotrichum lagenarium*
Distribution: Worldwide
Stage of crop attacked: Seedling, vegetative, fruiting, and post-harvest

Description of main symptoms:

- Symptoms first appear on the foliage as small, yellow, or reddish-brown, water-soaked spots often on veins. These later enlarge and turn brown.
- The dead tissue dries and may crack and fall out. On stems, lesions are elongated and light brown to black.
- Infected fruits are most susceptible during the ripening stage.
- Lesions produced on the fruit are circular, water-soaked, and sunken with varying depth and diameter.
- They expand rapidly to form large ones during fruit transport and storage.
- The disease ultimately reduces the market quality of the fruit.
- Under humid conditions, the centres of the sunken spots turn pinkish due to the production of conidia on acervuli; conidia serve as secondary inoculum, which is spread by splashing water.

Prevention

- Remove and dispose of the previous season's dead and diseased leaves, twigs, and branches before planting.
- Use resistant cultivars if available; this will decrease the rate of disease development and reduce the use of fungicide for disease control.
- Use certified and fungicide-treated seeds for planting.
- Incorporate crop debris into the soil soon after harvest to clean the farm of the previous season's inoculum. Burn the crops residues as an alternative to ploughing.

Anthracnose symptoms on leaf (top)and fruits (bottom) of cucumber. (Source:UMass Extension – UMass Amherst)

Monitoring

- Monitor the plants for the symptoms described above and apply control actions.

Cultural control

- When planting, space the plants far apart to maximise air circulation and increase sunlight, facilitating faster drying of leaf surfaces when fully grown.
- Avoid irrigation systems that wet the plant leaves.
- Prune to increase air circulation in the plant canopy.
- Destroy or bury infected leaves, twigs, and branches during raining season.
- Rogue and destroy infected seedlings by burning them immediately after they are identified.

- Practice farm sanitation to prevent inoculum from surviving on alternate host weeds.
- Plant rows of trap crops along the field borders to reduce the amount of inoculum reaching your field.

Synthetic fungicides

- Fungicides can protect only healthy tissue and don't eradicate existing infections. Complete spray coverage and timing are crucial in preventing disease development and subsequent spread.
- Thoroughly spray all new growth, such as buds, young leaves, and flowers, with protectant fungicides.
- Apply fungicides before rainy periods. If no rains are predicted, delay this application. If moist weather prevails, additional applications may be required to protect new growth areas.
- Follow chemical labels direction for use.

Active ingredient	PHI	Remarks
Mancozeb (800 g/kg)	2 weeks	Apply as a protectant at 5–7 days intervals. A mixture of Mancozeb and Carbendazim offers excellent control.
Azoxystrobin (200 g/l) + Difenoconazole (125 g/l)	3 weeks	No more than two applications per season. It can be tank-mixed with a protectant fungicide.
Copper oxychloride (850 g/kg)	2 weeks	Apply as a protectant at 5–7 days intervals.
Thiophanate-methyl (70%)	3 weeks	Apply as a cure or when the disease has already occurred. A mixture of chlorothalonil and thiophanate-methyl offers an excellent control.

3.2.2 Belly rot

Scientific name of causal organism: *Rhizoctonia solani*
Distribution: Worldwide
Stage of crop attacked: All developing stages of the fruit

Description of main symptoms:

- Infected young fruits exhibit yellow, tan to brown, water-soaked irregular lesions on the underside of the fruits.
- Lesions become sunken and depressed as the disease progresses.
- Mature fruits develop an extensive, water-soaked decay.
- Belly rot symptoms develop rapidly above 27.8°C and in periods of high humidity; a dense, light brown mould growth develops from the fruit lesions.

Belly rot of cucumber fruit. (Source: http//veggiescout.ca.uky.edu)

Prevention

- Start agricultural practices on time and early to escape periods of high humidity.
- Implement a disinfection process on the terrain, including the soil and the structures that form part of the installation.
- Acquire seeds that are free of contaminants.
- Carry out all the agricultural activities while observing the required sanitary measures—disinfection of all tools and labourers' hands before and after handling the plants.
- Provide a support system (trellis or stake) to the crops to elevate them above ground level.
- Use full-bed plastic mulch to lower disease incidence. Plastic mulch prevents fruits from directly contacting the soil, which is the source of inoculum.
- Incorporate the previous crop or weed debris into the soil at least 4–6 weeks before planting.

Monitoring

- Constantly monitor the crops to identify the possible source of infection and apply the control measures.

Cultural control

- Remove and destroy infected fruits.
- Use a three-year rotation program with non-host crops to break the disease cycle and reduce the pathogen inoculum in the field.
- Weed control and farm sanitation are critical for control as the pathogen can attack many weeds.

Synthetic fungicides

- Follow chemical labels direction for use.

Active ingredient	PHI	Remarks
Azoxystrobin (200 g/l) + Difenoconazole (125 g/l)	3 weeks	Make two applications, the first at the 1–3 leaf stage and the second before the vine tip over or 10–14 days after the first, whichever comes first.
Azoxystrobin (500 g/kg)	3 weeks	Make two applications, the first at the 1–3 leaf stage and the second before the vine tip over or 10–14 days after the first, whichever comes first.

3.2.3 Cottony leak

Scientific name of causal organism: *Pythium* spp. (Oomycete)
Distribution: Worldwide
Stage of crop attacked: Fruiting stage and storage

Description of main symptoms:

- The pathogen enters the fruit through the floral parts or directly when the fruit is in contact with contaminated soil.
- Infected fruits produce dark green, water-soaked lesions as the initial symptoms.
- Later, the fruit becomes soft and mushy rapidly and may be covered entirely with a white, cottony mycelium when the weather is warm and wet.
- Huge losses can occur due to fruit rot in transit and fruit storage under moist conditions since the fungus spreads by fruit-to-fruit contact.

Cotton leak signs (white mould) on cucumber fruit

Prevention

- Acquire seeds that are free of contaminants.
- Plant only in well-drained fields. Manage excess soil moisture by providing good drainage and monitoring irrigation practices.
- Use full-bed plastic mulch to prevent fruits from touching the soilborne pathogen.
- Provide a support system (trellis or stake) to elevate the fruits above ground level.

Monitoring

- Constantly monitor the crops for early detection of disease symptoms and control.

Cultural control

- Carefully isolate and place infected fruits in sealed plastic bags.
- Avoid picking fruits from infested areas of the field.
- Infected fruits will contaminate adjacent fruits in buckets, hampers, or other packing containers. So care must be taken to avoid putting infected and healthy fruits together.
- Practice farm sanitation to reduce conditions favouring disease epidemics.

Synthetic fungicides

- Follow chemical labels direction for use.

Active ingredient	PHI	Remarks
Mancozeb + Metalaxyl	3 weeks	Use as a protectant; one application per crop cycle
Copper (I) Oxide (60 g/kg) + Metalaxyl (120 g/kg)	3 weeks	Use as a protectant; one application per crop cycle

3.2.4 Damping-off

Scientific name of causal organism: *Fusarium oxysporum, Rhizoctonia solani, Pythium* sp. (Oomycete)
Distribution: Worldwide
Stage of crop attacked: Seed and seedling stage

Description of main symptoms:

- Seed fails to germinate when infected by soilborne fungi and fungal-like organisms—they colonise and destroy the seed embryo.
- Seeds appear mouldy, rotted, and soft, often with evidence of fungal mycelium.
- Young, newly emerged seedlings often collapse at the crown and topple over.
- The stems of infected seedlings exhibit a prominent discolouration ranging from a reddish-brown to black around the crown region, and maybe dry or mushy to the touch depending on the soil fungus involved.

Damping-off of cucumber seedling. (Source https://www.researchgate.net)

Prevention

- Use fungicide-treated seeds for raising seedlings in the nursery.
- Use sterilised soils in raising seedlings in the nursery.
- Avoid planting seed when soil moisture, temperature, or planting depth do not favour rapid emergence.
- Apply fungicide treatments to protect the plants at the seedling stage.
- Plant in well-tilled soil where old crop and weed residue has been ploughed 30 days previously.

Monitoring

- Constantly monitor the crops for disease symptoms and apply control actions early.

Cultural control

- Rogue infected plants to lower disease spread in the nursery or farm.
- Avoid overcrowding of seeding in the nursery.
- Ensure that the plants receive adequate sunlight and are not exposed to long periods of high humidity.
- Practice farm sanitation and an adequate drainage system.
- Implement a crop rotation system in areas where the disease is a problem.

Physical control

- Practice soil solarisation for 2–3 weeks before transplanting in areas where the disease is endemic. Exposing moist soil covered with a clear plastic sheet to the sun for several days kills the pathogen.
- Use heat sterilisation treatments (steam at 81°C for 30 mins) to kill pathogen inoculum in nursery soil before planting.

Biological control

- Use soil competitor moulds such as *Trichoderma harzianum* to inhibit pathogen growth or reduce inoculum in the field. Apply to the soil immediately after transplanting; repeat once in 20 days.

Synthetic fungicides

- Follow chemical labels directions for use.

Active ingredient	PHI	Remarks
Mancozeb + Metalaxyl	3 weeks	Mix the chemicals and apply by drenching the soil.

3.2.5 Downy mildew

Scientific name of causal organism: *Pseudoperonospora cubensis*
Distribution: Worldwide
Stage of crop attacked: Seedling, vegetative and fruiting stages

Description of main symptoms:

- The initial disease symptoms include angular, yellow spots on the upper leaf surface.
- As these spots enlarge, the chlorosis becomes severe, followed by browning and death of leaf tissues.
- Gray mould growth is visible under the leaf surface under humid and warm weather conditions.
- Usually, the first symptoms are on old leaves, gradually moving outward to young ones.
- Periods of wetness, heavy dews, or fog increase disease occurrence.

Downy mildew symptom on cucumber leaves. (Source: University of Minnesota Extension)

Prevention

- Although recent outbreaks indicate that resistance alone will not prevent this disease, choose downy mildew-resistant varieties.
- Avoid working fields when plant foliage is wet.
- Implement a fungicide control program that prevents disease attacks during wet and humid weather.
- Growing cucurbits in environments where humidity levels can be manipulated can help manage downy mildew. Disease severity can be decreased by taking actions that encourage airflow and reduce leaf wetness.

Monitoring

- Constantly monitor the crops to identify possible sources of infection and apply appropriate control measures.

Cultural control

- Remove and destroy infected plants once spotted on the farm.
- Avoid overcrowding of plant stands.
- Enhance air circulation in and around the plants by pruning excess leaves and branches.
- Ensure that the plants receive adequate sunlight and are not exposed to long periods of high humidity that promotes the development and spread of the disease.
- Practice farm sanitation.

Biological control

- Plant trap crops around the field borders to reduce inoculum reaching the field.

Synthetic fungicides

- Follow chemical labels directions for use.

Active ingredient	PHI	Remarks
Mancozeb (80%)	2 weeks	Use as a protectant; apply 5–7 days interval
Chlorothalonil (400 g/l) + Dimethomorph (80 g/l)	2 weeks	Use as a protectant; apply 5–7 days interval
Azoxystrobin (500 g/kg)	3 weeks	No more than two applications per season. It can be tank-mixed with a protectant fungicide.

3.2.6 *Fusarium* wilt

Scientific name of causal organism: *Fusarium oxysporum* f. sp. *cucumerinum*
Distribution: Worldwide
Stage of crop attacked: All stages of growth

Description of main symptoms:

- Freshly seeded cucumbers show damping-off symptoms below ground or as newly emerged seedlings.
- During mid-day, the entire plant wilts if old plants are infected before vine elongation.
- Plants infected in the vining stage of growth will often wilt with only one or two runners.

Fusarium wilt symptoms in cucumber plants. (Source: www.nexles.com)

Prevention

- Change the position of the nursery every season.
- Certified seeds (disease-free) should be used to raise seedlings of desired varieties.
- Select a variety that is resistant or tolerant.
- Treat seeds with Mancozeb (800 g/kg) (2 g/kg of seeds) and Copper hydroxide (77%) (2 g/kg of seeds) before sowing.
- Avoid keeping un-transplanted seedlings at the nursery to grow.
- Nursery beds should be raised and formed with soils that have good drainage properties.
- Expose loose dug-out nursery soil to sunlight for four or more weeks before planting. This improves soil aeration and the destruction of pathogens.
- Use clean irrigation water free of fungal and bacteria spores.
- Raising the soil pH reduces the development of this disease.

Monitoring

- Monitor the field for symptoms described above during the growing season and apply control actions.

Cultural control

- Remove and place infected plants in sealed plastic bags or burn them.
- Enhance farm sanitation and drainage.
- Rotate cucumber with other crops such as crucifers, legumes, or solanaceous plants for 2–3 years to reduce pathogen inoculum in endemic areas.

Physical control

- Soil treatments.
- Burn dry grass over the nursery soil before forming the beds.
- Practice heat sterilisation of soil (or steam at 81°C for 30 mins) in the sunny months using black polythene cover (250-gauge type) for two or more weeks before planting.
- Solar sterilisation of field beds (clear instead of black polythene sheet) for three weeks can be used to control the soilborne pathogen.

Biological control

- Use competitor moulds such as T. *harzianum* to inhibit the growth of the pathogen in the growing medium. Apply to growing medium soon after transplanting; after that, repeat once in 20 days.

Synthetic fungicides

- In many cases, fungicides will not result in very effective control of the disease.
- Next to the drenching of plant beds, one could consider only a local plant hole drench or apply the chemical using a drip irrigation system.
- Fungicides containing metalaxyl are mostly preferred for controlling soilborne pathogens.
- Follow chemical labels direction for use.

Active ingredient	PHI	Remarks
Copper oxychloride (350 g/kg) + Metalaxyl (150 g/kg)	3 weeks	Use for drenching the soil; drenching is not feasible for large-scale application
Mancozeb (640 g/kg) + Metalaxyl (80 g/kg)	3 weeks	Use for drenching the soil; drenching is not feasible for large-scale application
Metalaxyl-M (37.5 g/kg) + Chlorothalonil (400 g/kg)	3 weeks	Use for drenching the soil; drenching is not feasible for large-scale application
Chlorothalonil (400 g/l) + Dimethomorph (80 g/l)	2 weeks	Use for drenching the soil around the crown region

3.2.7 Gummy stem blight

Scientific name of causal organism: *Didymella bryoniae*
Distribution: Worldwide
Stage of crop attacked: Seedling and vegetative stage

Description of main symptoms:

- Lesions developing on the cotyledons and leaves are round or irregular, brown, with faint zonation.
- The crown and stem lesions are initially brown, turning white with age, with a sap flow.
- The disease will usually begin at the crown and progress outward on the vines.
- The causal fungus is primarily seed-borne but can survive on host crop and weed host debris. The spread of secondary spores is by splashing rainwater.

Gummy stem blight symptoms on cucumber. (Source: https://www.omafra.gov.on.ca)

Prevention

- Plant pathogen-free seeds of resistant varieties.
- Use healthy transplants.
- Use fungicide treated seeds for planting.
- Apply Mancozeb to protect the stem surfaces from infection.
- Burn or plough previous seasons' crop debris deep into the soil before transplanting seedlings to the field.

Monitoring

- Monitor the crops for the symptoms described above and apply control actions.

Cultural control

- Remove and destroy infected plants once spotted on the farm.
- Practice crop rotation with unrelated crops for at least two years.
- Follow good sanitation practices, such as cleaning up crop debris at the end of the growing season.
- Manage irrigation to minimise leaf wetness, avoiding overhead irrigation when possible.

Synthetic fungicides

Active ingredient	PHI	Remarks
Tebuconazole	2 weeks	For suppression only. Apply 10–14 days intervals.
Chlorothalonil (400 g/l) + Dimethomorph (80 g/l)	2 weeks	It can be used as a protectant. Apply 5–7 days intervals.

NB: Follow chemical labels direction for use.

3.2.8 Powdery mildew

Scientific name of causal organism: *Podosphaera xanthii*
Distribution: Worldwide
Stage of crop attacked: Seedling and vegetative stage

Description of main symptoms:

- The fungus infects the leaves and stems, producing round, whitish spots on the underside of older leaves.
- As the spots increase in size, they coalesce and appear on the upper surface as a white powdery growth.
- Severely affected leaves lose their normal dark-green colour and become pale yellow-green, brown, and wither.
- The young stems may also be killed.
- Fruits may sunscald as a result of loss of foliage.
- Spores are readily dispersed by wind over long distances.

Prevention

- Use resistant cultivars when possible.
- Use fungicide treated seeds for planting.
- Avoid the establishment of plants in areas shaded by tall plants or structures.
- Burn previous plant debris to get rid of primary inoculum.

Monitoring

- Daily field inspection for the above symptoms will assist with a step ahead control of the pathogen.

Powdery mildew growth on cucumber leaves. Source: UMass Extension - UMass Amherst.

Cultural control

- Avoid overhead irrigation of the plant.
- Avoid planting too close to each other or avoid dense plant stands.
- Always ensure farm sanitation and drainage.
- Do not work in the field when the leaf surfaces are wet.
- A 2-year rotation out of cucurbits is beneficial.
- Rogue infected plants as soon as they are spotted.
- Plant trap crops along the field borders to reduce the amount of inoculum reaching your field.

Synthetic fungicides

Active ingredient	PHI	Remarks
Sulphur (80%)	1 week	Use as a protectant; apply 5–7 days interval. It should not be used at the flowering stage. It has a negative impact on beneficial organisms.
Azoxystrobin (500g/kg)	3 weeks	No more than two applications per season. It can be tank-mixed with a protectant fungicide for additional control.
Tebuconazole	2 weeks	For suppression only; apply 10–14 days interval

NB: Follow chemical labels direction for use

3.2.9 Scab

Scientific name of causal organism: *Cladosporium cucumerinum*
Distribution: Worldwide
Stage of crop attacked: Vegetative and fruiting stages

Description of main symptoms:

- The fungus produces small brown spots with yellow margins on the leaves. The brown centre may fall out, leaving a ragged hole.
- Young leaves at the vine tips may become distorted.
- The greatest damage caused is on the fruit. Here small sunken dark grey spots appear, and a sticky material oozes from the spots.
- As the spots enlarge, they often run together, forming large scab-like diseased areas.
- Under humid conditions, spores are produced, giving the spots an olive-green colour.
- The fungus is primarily seed-borne but can survive on host crop debris. Spread of the secondary inoculum is carried out by air currents, splashing water, clothing, or tools.

Prevention

- Use certified seeds or mercury-treated seeds to prevent infection.
- Use resistant cultivars whenever available. Scab resistant cultivars include 'Dasher II', 'Raidder', 'Encore', 'Sprint', 'Poinsett 76', 'Turbo', 'Regal', 'Flurry', 'Calypso', 'Quest', 'Gemini', 'Market more', 'Pioneer', 'SMR-58', and 'SMR-18'.
- Plough into the soil the plant debris after harvest.

Monitoring

- Frequent field monitoring for symptoms gives a head start for control.

Scab symptoms on fruit and on leaf of cucumber. (Source: https://www.plantvillage.psu.edu and Aggie Horticulture -Texas A&M University)

Cultural control

- Practice crop rotation using non-cucurbit crops for at least three years in areas where this disease is a problem.
- Remove and destroy infected plants once spotted on the farm.
- Always ensure farm sanitation and drainage.
- Do not work in the field when the leaf surfaces are wet.

Synthetic fungicides

Active ingredient	PHI	Remarks
Mancozeb (80%)	1 week	Use as a protectant; apply 5–7 days intervals
Sulphur (80%)	1 week	Use as a protectant; apply 5–7 days intervals. It should not be used at the flowering stage. It has a negative impact on beneficial organisms.
Chlorothalonil (400 g/l) + Dimethomorph (80 g/l)	2 weeks	Use for suppression only; apply 10–14 days interval

NB: Follow chemical labels direction for use.

3.2.10 Target spot

Scientific name of causal organism: *Corynespora cassiicola*
Distribution: Worldwide
Stage of crop attacked: Vegetative and fruiting stages

Description of main symptoms:

- Symptoms often look the same as downy mildew. Target spot begins on leaves as yellow to white leaf flecks that become angular with a definite outline.
- Later, the spots become circular, with light brown centres surrounded by dark-brown margins.
- The diameter of Individual lesions ranges from 1/8 to 3/8 inch (0.5–1 cm).
- Lesions coalesce to produce larger necrotic areas with drying and shredding of leaves.
- The fungus survives on infected plant material, and its conidia are readily dispersed by air.

Prevention

- Use disease-resistant cultivars if available.
- Burn or plough into the soil the previous year's plant debris before planting.

Monitoring

- Visit the farm regularly to look for disease symptoms and apply control measures as early as possible.

Target spot symptoms on cucumber

Cultural control

- Remove and destroy infected plant parts once spotted on the farm.
- Improve drainage and avoid dense plant stands. This helps to slow the rate of disease spread.
- Avoid working in infected fields when the plant leaves are wet.
- Use a two to three-year crop rotation program with non-host crops to break the pathogens' disease cycle.

Synthetic fungicides

Active ingredient	PHI	Remarks
Mancozeb (80%)	1 week	Use as a protectant; apply 5–7 days intervals.
Copper hydroxide (770 g/kg)	1 week	Apply as a protectant ; apply 5–7 days intervals.
Chlorothalonil (400 g/l) + Dimethomorph (80 g/l)	2 weeks	Use for disease suppression only or when the infection has already occurred. Apply 10–14 days intervals.
Azoxystrobin (500 g/kg)	2 weeks	No more than two applications per season. It can be tank-mixed with a protectant fungicide.

NB: Follow chemical labels direction for use.

3.2.11 Gray mould of cucumber

Scientific name of causal organism: *Botrytis cinerea*
Distribution: Worldwide
Stage of crop attacked: Vegetative and fruiting stages

Description of main symptoms:

- *Botrytis* infection of cucumber fruits is characterised by an invasive grey rot of the fruit. The fungus germinates from small, dark-coloured, over-seasoned structures known as sclerotia.
- The fungus then produces asexual spores (conidia) that spread the disease. These spores are produced throughout the growing season.
- Symptoms develop readily under warm temperatures and moist conditions.

Prevention

- Plant in light, well-drained, well prepared fertile seedbed at the time recommended for your area.
- Avoid heavy soils, heavy seeding and overcrowding, poor air circulation, planting too deep, over-fertilisation, and wet mulches.
- Strive for steady vigorous plant growth, not a soft, luxuriant growth.

Monitoring

- Frequently monitor plants for the symptoms mentioned above and apply control actions.

Gray mould symptoms on cucumber. (Source: ipmimages.org)

Cultural control

- Expose plants to plenty of light in greenhouses and seedbeds for maximum air circulation and drainage.
- Avoid excessive humidity and do not allow water to form on the foliage.
- At night maintain the greenhouse temperature higher than outdoors to prevent water condensation on leaves.
- Remove and destroy infected plants once spotted on the farm.

Physical Control

- If feasible, sterilise the seedbed soil before planting, preferably with heat. Steam treat all soil used for plant beds at 81°C for 30 mins.

Synthetic fungicides

Active ingredient	PHI	Remarks
Azoxystrobin (200 g/l) + Difenoconazole (125 g/l)	2 weeks	Apply the chemical as a cure. No more than two applications per season.

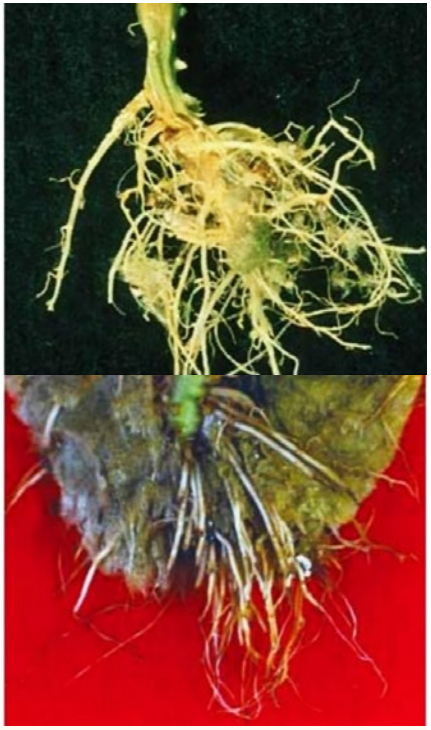
NB: Follow chemical labels direction for use.

3.2.12 Sudden wilt of cucumber

Scientific name of causal organism: *Pythium* spp.
Distribution: Worldwide
Stage of crop attacked: Seedling, vegetative, and fruiting stage

Description of main symptoms:

- *Pythium* causes crown rot and root rot symptoms in mature plants, while sudden wilts occur during warm and sunny weather conditions.
- Sudden wilts usually occur when plants are flowering or have produced their first heavy fruit load.
- Often, the upper leaves of infected plants wilt in the day and recover overnight, but plants eventually die.
- Initial symptoms on roots appear as brown to dark-brown lesions on root tips and feeder roots.
- As the disease progress, symptoms of soft, brown stubby roots, lacking feeder roots, become visible.
- The outer root tissue or cortex peels away in larger roots, leaving the string-like vascular bundles underneath.
- *Pythium* rot also occurs in the crown tissue at the stem base. In cucumber, diseased crown turns orange-brown, often with a soft rot at the base; brownish lesions extending 10 cm up the stem base may be seen.



Crown rot (top) and root rot (bottom) symptoms on cucumber. (Source: greenhousecanada.com)

Prevention

- Use pathogen-free seeds or fungicide coated seeds for planting.
- Follow a strict greenhouse sanitation program throughout the year.
- Clean and disinfect all interior greenhouse surfaces and equipment, including tools, hoses, walkways, carts, totes, troughs, tanks, and water supply lines.
- Use sterile propagating media.
- Avoid low light levels, low pH, high salts, and warm growing conditions (above 28°C) favouring *Pythium* growth.
- In greenhouse cucumbers, the nutrient solution should be delivered at pH 5.0 for approximately five weeks, then adjusted to a 5.8–6.2 regime for one week.
- Ensure rock wool block wetness is about 70–75% between watering.

Monitoring

- Monitor field for the symptoms described above and apply control actions early.

Cultural control

- Avoid overcrowding of seedlings in the nursery.
- Use clean or pathogen-free water for irrigation.
- Remove dying or infected plants and place them directly into plastic bags for disposal away from the greenhouse.
- Have an adequate drainage system and ensure plants receive sufficient sunlight to prevent exposure to long periods of high humidity.
- Practice crop rotation with non-host crops to reduce inoculum build-up in the field areas where the disease is a major problem.

Physical control

- Use soil solarisation for 2–3 weeks before transplanting in areas where the disease is endemic. Exposing moist soil covered with a transparent plastic sheet to the sun for several days kills the pathogen.
- Use heat sterilisation treatments (steam at 81°C for 30 mins) to kill pathogen inoculum in nursery soil before planting.

Biological control

- Use biocontrol agents such as T. *harzianum* to prevent the growth of the pathogen in a growing medium. Apply the agent soon after transplanting, after that repeat once in 20 days.

Synthetic fungicides

Active ingredient	PHI	Remarks
Copper oxychloride (350 g/kg) + Metalaxyl (150 g/kg)	3 weeks	Use for drenching the soil; drenching is not feasible for large-scale application
Mancozeb (640 g/kg) + Metalaxyl (80 g/kg)	3 weeks	Mix the chemicals and apply by drenching the soil
Metalaxyl-M (37.5 g/kg) + Chlorothalonil (400 g/kg)	3 weeks	Use it to prevent infection. One application per crop cycle; apply as drench immediately after transplanting.
Propamocarb (530 g/l) + Fosetyl (310 g/l)	2 weeks	Use it to protect seedlings in the nursery from infection

NB:

- Fungicides containing metalaxyl are mostly preferred for controlling soilborne pathogens.
- Next to the drenching of plant beds, one could consider only a local plant hole drench or apply the chemical using a drip irrigation system.
- Follow chemical labels direction for use.

3.2.13 Phytophthora root rot of cucumber

Scientific name of causal organism: *Phytophthora capsici* (Oomycete)
Distribution: Worldwide
Stage of crop attacked: Seedling and vegetative growth stages

Description of main symptoms:

- The most distinctive symptoms are brown lesions on roots of all sizes.
- The xylem of the roots above the lesions often turns yellowish or brown. In severe cases, nearly all roots may be girdled or rotten.
- Infected plants display aboveground symptoms, including stunting and wilting, and may die in hot weather.
- When fruit in contact with the ground is infected, the disease is called buckeye rot. Symptoms include tan or brown spots with concentric rings.

Prevention

- Plant fungicide-treated seeds.
- Provide good drainage and prevent flooding in the field.
- Avoid planting seed when soil moisture, temperature, or planting depth do not favour rapid emergence.
- Resistant varieties are not yet commercially available.

Monitoring

- Frequent monitoring of symptoms on the field will enhance early control.

Root rot of cucumber. Source: plantpath.ifas.ufl.edu

Cultural control

- Avoid overcrowding of seedlings in the nursery.
- Avoid wide fluctuations in soil moisture, which predisposes plants to infection.
- Keep the tops of the beds dry to avoid buckeye rot of the fruit.
- Ensure plants receive adequate sunlight to encourage vigorous growth.
- Practice farm sanitation and an adequate drainage system.
- Rogue infected plants to lower the rate of disease spread in the nursery or farm.
- Planting cereals as a rotation crop may reduce the level of infestation in the soil.

Physical control

- Soil solarisation for 2–3 weeks before transplanting can help reduce inoculum in infected soils.
- Use heat sterilisation treatments (steam at 81°C for 30 mins) to control pathogens in nursery soil before planting.

Synthetic fungicides

Active ingredient	PHI	Remarks
Copper oxychloride (350 g/kg) + Metalaxyl (150 g/kg)	3 weeks	Use for drenching the nursery soil before planting.
Mancozeb (640 g/kg) + Metalaxyl (80 g/kg)	3 weeks	Mix the chemicals and apply by drenching the soil around the crown. For large-scale applications, drenching is not feasible.
Azoxystrobin (200 g/l) + Difenoconazole (125 g/l)	2 weeks	Apply the chemical as a cure. No more than two applications per season. It can be tank-mixed with a protectant fungicide.
1, 3-Dichloropropene (60.8%) + Chloropicrin (33.3%)		Use as a pre-plant soil disinfectant. Apply to soil 2–4 weeks before planting.

NB:

- Soil fumigation with chemicals containing Chloropicrin can be used to inactivate the pathogen.
- In the nursery, fungicides can be used to drench the soil. This controls the pathogen in the soil before planting.
- Follow chemical labels direction for use.

4. Viral diseases of cucumber

4.1 Aphid-transmitted mosaic viral disease

Scientific name of causal organism: *Papaya ringspot virus Type W, Cucumber mosaic virus, Zucchini yellow mosaic virus, Watermelon mosaic virus 2*
Distribution: Worldwide
Transmission: Aphids
Stage of crop attacked: Any stage of the crop

Description of main symptoms:

- Leaves show varying degrees of mosaic, distortion, and stunting.
- Fruits may also be mottled and deformed. These viruses are aphid-transmitted and can infect cantaloupe, squash, watermelon, and several common weeds.

Prevention

- Use resistant cultivars for planting.
- Maintain weed control in and around cucumber plantings.
- Insecticide control of the aphid vector is recommended because of the rapid transmission of the virus during aphid feeding.
- Establish nursery under Nylon net cover (50 mesh) to protect young plants from aphids.

Monitoring

- Monitor and scout for aphids for immediate control of their population.

Cultural control

- Control/minimise aphid population using reflective plastic mulch and yellow sticky traps.
- Rogue out infected plants from the field. Infected plants serve as the viral repository for insect vectors.
- Eradicate infected plants and weed hosts in the nursery and field early enough to prevent disease spread.

Mosaic virus symptoms on leaves (top) and on fruits (bottom) of cucumber. (Source: https://www.growveg.com and https://www.apsnet.org)

Biological control

- Use biocontrol agents, including lady beetles and their larvae, syrphid fly larvae, and parasitoid (*Aphidius colemani*), to control the aphid population on the field.

Synthetic fungicides

- Spray seedlings with insecticides containing imidacloprid before transplanting.
- Spray insecticides every two weeks after transplant until the flowering stage.
- Insecticide spray followed by neem seed kernel extract (2%) is also effective in the rotation of insecticides.
- Follow chemical labels direction for use.

Active ingredient	PHI	Remarks
Imidacloprid	2 weeks	Spray in two weeks intervals to control aphids. Rotate this active ingredient with other recommended insecticides to prevent resistance development.
Pymetrozine (500 g/kg)	2 weeks	Spray in rotation with other insecticides to control aphids
Profenofos (300 g/l) + Lambda-cyhalothrin (15 g/l)	2 weeks	Spray in rotation with other insecticides to control aphids
Neem Extract 59.80% + Karanja Extract 50.20%	2 weeks	Biopesticide used in rotation with other synthetic insecticides

4.2 Zucchini yellow mosaic viral disease

Scientific name of causal organism: *Zucchini yellow mosaic virus* (ZYMV)
Distribution: Worldwide
Transmission: Aphids
Stage of crop attacked: Any of the growth stages

Description of main symptoms:

- Symptoms resemble those caused by *PRSV-W* depending on the strain involved.
- Leaves of affected plants show yellow mosaic (dark green areas on the leaf contrast to lighter green on the rest of the leaves).
- Malformation, blisters, serration, and extreme reduction in the size of leaf lamina develop in severe cases.

Prevention

- Use resistant cultivars for planting.
- Establish the nursery under Nylon net cover (50 mesh) to screen off aphid vectors.
- Insecticide control of the aphid vector is recommended because of the rapid transmission of the virus during aphid feeding.

Yellow mosaic virus symptoms on leaves (top) and on fruits (bottom) of cucumber. (Source: https://www.wikiwand.com and https://www.sciencedirect.com)

Monitoring

- Monitor the field for symptoms described above and take appropriate actions.
- Scout for aphids for immediate control of their population.

Cultural control

- Control/minimise aphid population by using plastic mulch and yellow sticky traps.
- Two rows of border cropping with baby corn can lower the disease spread rate.
- Rogue out virus-infected plants from the field.
- Eradicate infected plants and weed hosts in the nursery and field early enough to prevent disease spread. Remove weeds that serve as alternate hosts.

Biological control

- Use biocontrol agents, including lady beetles and their larvae, syrphid fly larvae, and parasitoid *(Aphidius colemani)* to control the aphid population on the field.

Insecticides

- Spray seedlings with an insecticide containing imidacloprid before transplanting.
- Spray insecticides every two weeks after transplant until the flowering stage.
- Insecticide spray followed by neem seed kernel extract (2%) is also effective in the rotation of insecticides.
- Follow chemical labels direction for use.

Active ingredient	PHI	Remarks
Imidacloprid	2 weeks	Spray in two weeks intervals to control aphids. Rotate this active ingredient with other recommended insecticides to prevent resistance development.
Pymetrozine (500 g/kg)	2 weeks	Spray in rotation with other insecticides to control aphids
Profenofos (300 g/l) + Lambda-cyhalothrin (15 g/l)	2 weeks	Spray in rotation with other insecticides to control aphids
Neem Extract 59.80% + Karanja Extract 50.20%	2 weeks	Biopesticide used in rotation with other synthetic insecticides

5. Nematode diseases of cucumber

5.1 Root-knot of cucumber

Scientific name of causal organism: *Meloidogyne* spp. (Root-knot nematodes)
Distribution: Worldwide
Stage of crop attacked: Seedling and vegetative growth stage

Description of main symptoms:

- Root-knot nematodes symptoms reflect a malfunctioning root system.
- Characteristic symptoms include the development of galls on roots. Severely galled roots system may appear malformed, shortened, and thickened.
- Aboveground symptoms infestations include patches of leaf chlorosis, stunting, necrosis, or wilting.
- Nematode-infested plants become more susceptible to moisture or temperature stress and exhibit stress symptoms earlier than other plants.
- Root systems damaged by nematodes are often more susceptible to infection by soil-inhabiting fungi like *Fusarium* and *Verticillium*.
- Roots of plants infested with stubby root nematode are likely to have numerous, short and stubby lateral roots.

Galls of root knot nematode on cucumber. (Source: https://www.blogs.ifas.ufl.edu)

5.2 Root Lesion of Cucumber

Scientific name of causal organism: *Pratylenchus* spp.
Distribution: Worldwide
Stage of crop attacked: Seedling and vegetative growth stage

Description of main symptoms:

- The aboveground symptoms induced by *Pratylenchus* spp. on cucumber include root necrotic lesions, stunted growth, reduced plant vigour, leaf chlorosis, defoliation, and low yield.
- The type, colour, and size of lesions vary according to the infestation level, the lesion's age, and the host species.
- Lesions are initially small, but as the nematodes feed, the lesions enlarge, often girdling and later severing the root. Feeder roots thus get destroyed, and the entire root system is reduced.
- The cortex sloughs off like a sleeve when the lesion breaks open, leaving only the vascular cylinder.
- Secondary pathogens often enter these lesions to cause root rot.

Necrotic lesions on roots caused by Pratylenchus *spp. (Source: https://researchgate.net)*

5.3 Control of nematodes

Prevention

- Use nematode-resistant cultivar for planting.
- Plough the field deep enough or turn the soil to expose nematodes to solar radiation for two weeks or more before planting.
- Mulch field with a black plastic sheet. This produces steam to kill the nematodes.

Monitoring

- Initial soil samples should be examined to determine the total nematode population for immediate action before and during planting.

Cultural control

- Intercrop cucumber with trap crops as the main crop for nematode control.
- Ensure adequate drainage system on the field.
- Crop rotation may not be feasible in fields infested with nematodes because of their extensive host range; care is needed to select rotation crops because some may be good alternate hosts.

Physical control

- soil solarisation and heat sterilisation can lower the nematodes population in the topsoil layers to help plants escape an early infestation. However, nematodes in the deeper soil layers may survive the treatment and later become a problem.

Biological control

- Plant repellent plants such as marigold in between rows to control nematode population.
- Apply 2 kg of MULTIPLEX Niyantran (Paecilomyces) in 100 kg FYM and broadcast uniformly on an acre of land.
- Application of 250–400 kg of neem cake/ha is useful in controlling nematode population build-up in the soil.

Synthetic nematicides

Active ingredient	PHI	Remarks
Fluopyram 400 g/l	14 days	Apply on plant foliage using aerial spray equipment. Can also be used for seed treatment.
1, 3-Dichloropropene (60.8%) + Chloropicrin (33.3%)		Use as a pre-plant soil disinfectant (fumigant). Apply to soil 2–4 weeks before planting.
Fosthiazate (5%)	14 days	Soil application. Apply into the soil after planting.
Oxamyl	14 days	Foliar applications are not effective for controlling moderate and high populations of nematodes.

NB: Nematicides containing Chloropicrin can also be used. Follow chemical label directions.

6. Physiological disorders

Physiological disorder is the abnormal growth pattern or abnormal external or internal conditions of fruits due to adverse environmental conditions such as deviation from normal state of temperature, light, moisture, nutrient, harmful gases and inadequate supply of growth regulators. Below are example of physiological disorders that may be encountered.

6.1 Blossom end rot

A serious disorder of tomato, pepper, cucumber and eggplant is blossom end rot. It is an environmental problem (not fungal) most often caused by uneven watering or by calcium deficiency (these can be related; uneven watering can interfere with the uptake of calcium. Affected cucumber develop a dark, almost black, discolouration on the end of the fruit where the flower was located. This area may also crack or become sunken. Fungal growth may also occur on the rotted portion because the cucumber becomes more prone to infection.

Distribution: Worldwide
Stage of crop attacked: fruiting stage

Description of main symptoms:

- Symptoms occur on green and ripe fruits and are identified by water-soaked areas that gradually widen and mature into sunken, brown, leathery spots on the bottom end.
- In many cases, secondary pathogens, which appear as a black, fuzzy-like growth, attack the affected area and cause complete rotting of the fruit.
- Blossom end rot does not spread from plant to plant.

Prevention

- Choose resistant vegetable varieties whenever possible.
- Prevent problems by keeping the soil evenly moist and spray plant leaves with a kelp or calcium solution.
- Adding high levels of calcium bone meal, oyster shell, or gypsum to the soil at planting time usually prevents this problem from developing.
- A layer of mulch (straw, compost, grass) will help conserve soil moisture during hot and dry days.

Blossom end rot of cucumber. Photo from http://www.writeserve.com/beansinabarrel/?p=39

Blossom end rot symptom on cucurbit fruit. Source: plantpath.ifas.ufl.edu

- Foliar applications of liquid Calcium 5% (1–2 Tbsp/gallon of water) can be used to correct or prevent deficiencies of this essential nutrient. For best results, combine with a natural surfactant to increase adhesion and spray leaves to the point of run-off.
- Mulch the soil surface to conserve moisture and provide a more consistent water supply.
- Avoid using high nitrogen fertilisers which accelerate vegetative growth and reduce calcium uptake by plants
- Drip irrigates to supply an even amount of water and apply lime to soils low in calcium. Avoid using ammonium sources of fertiliser or excess magnesium.
- Fertilise with calcium nitrate in areas where blossom end rot is known to occur.

Monitoring

- Timely monitoring of the above symptoms is key to controlling the disorder.

No control options are available at present

6.2 Growth cracks

Fruit cracking is usually associated with fluctuations in humidity condition. If the vegetables grow in drought and then high humidity start to be (e.g. heavy rain, intensive watering) - plant body fails to cope with immediate excess water and therefore its fruits crack. These cracks in the fruit is a gateway to various infections. Various microorganisms can attack such plant body very quickly.

6.3 Sunscald

This condition is not a disease, but it still decreases the appeal of the fruit. Maintaining a healthy plant will help to protect fruit from the harmful rays of the sun.

Fruit crack in cucumber. Photo from https://www.researchgate.net/post/Cucumber_plants_have_short_internodes_and_curly_leaves_cracked_fruits_what_is_the_reason

Sun scald on cucumber fruit. Photo from https://www.pinterest.com/pin/343118065336864089/

6.4 Physiological leaf roll

Curled or rolled leaves is a physiological disorder that is often associated with hot dry weather or wind, however it can also occur in response to other stresses like high moisture and nitrogen, fast growth, heavy production, pruning and root damage.

Physiological leaf roll in cucumber. Photo from https://ask2.extension.org/kb/faq.php?id=470828

7. Insecticide resistance management

- Insecticide resistance is the ability of an insect to survive even repeated application of the recommended dose of an insecticide.
- Pesticides will continue to be an integral part of our pests and diseases management efforts, but careful selection of the right pesticides and their combinations is required to achieve effective pest control, minimise the development of insecticide resistance by pests, and with minimal negative impact on humans and the environment.
- Pesticides must always be used in a lawful manner, consistent with the product's label and observe all safety protocols.
- Always carefully select and rotate different Mode of Action (MoA) classes of pesticides to help manage insecticide resistance.
- Similarly, biopesticide such as neem (azadirachtin) which exhibits multiple modes of action (e.g., anti-feedant, causes abnormal and delayed moults, growth regulator, mortality, sterility effect, etc.) could be used alongside other insecticides to manage insecticide resistance.
- It is recommended that the synthetic pesticides are used mostly from the nursery to the onset of flowering and alternated with the biological or biorational pesticides during flowering and fruiting stages of the crop to ensure food safety and to promote the activities of beneficial insects (pollinators and natural enemies of the pests) in the field.

8. Options for biocontrol importation in Ghana

The Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture (MoFA), Ghana has now developed the procedures for importation of Biological Control Agents (BCAs) (MoFA/PPRSD 2000a). BCAs such as *Amblyseius swirskii*, and *Orius laevigatus* have been imported into the country as biocontrol agents for greenhouse vegetable production. Hitherto, this wasn't the case. You can visit the head office of PPRSD at Pokuase in Accra or any of their regional offices for a copy of the guidelines to offer more information about the procedures involved and the requirements for their importation.

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Appendix 1 – Summary of biological pesticides for the management of pests of cucumber

	Group(s)	Mode of action class	WHO hazard class*	White-flies	Aphids	Caterpil-lars	Spider mites	Mealy-bugs	Thrips	REI (hrs)	PHI (days)
Azadirachtin	Botanical	Unknown or uncertain MoA	II	++	++	++	++	++	++	4	0
Pyrethrum/Pyrethrins	Botanical	Nerve & muscle targets	II	++	++	++			++	12	0
Maltodextrin	Botanical	Mechanical disruptor	III	++	++	++	++	++	++	0	1
Spinosad	Microbial	Nerve & muscle targets	U			++				0	0
Insecticidal soap 'alata samina'	Botanical			++	++	++	++	++		12	0
Bacillus thuringiensis (Btk)	Microbial	Midgut targets	III			++				4	0
PrGV + Bt	Microbial	Midgut targets	II			++				4	0
Metarhizium anisopliae	Microbial	Unknown or uncertain MoA	U			++			++	0	0
Oxymatrine	Botanical	Unknown or uncertain MoA	III	++	++		++			1	0

* WHO hazard Class II = moderately hazardous, Class III = slightly hazardous, Class U = unlikely to pose an acute hazard in normal use.
REI = Re-entry interval, PHI = Pre-harvest interval. The reader is advised to check the latest EPA list of registered pesticides.

Appendix 2 – Summary of synthetic pesticides for the management of pests of cucumber

	Group(s)	Mode of action class	WHO hazard class*	White-flies	Aphids	Cater-pillars	Mites	Mealy-bugs	Thrips	REI (hrs)	PHI (days)
Novarulon	IGR	Growth & development targets	U	++		++			++	12	1
Chlorfenapyr	Pyrroles	Respiration targets	II	++		++	++		++		
Acetamiprid + Indoxacarb	Neonicotinoid + oxadiazine	Nerve & muscle targets	II	++	++	++			++	12	7
Imidacloprid + Emamectin benzoate	Neonicotinoid + Avermectin	Nerve & muscle targets	II	++	++	++			++	24	7
Deltamethrin	Pyrethroid	Nerve & muscle targets	II	++					++	12	3
Fipronil	Phenylpyrazole	Nerve & muscle targets	II			++			++	24	14
Pyrethrum + Deltamethrin	Botanical + Pyrethroid	Nerve & muscle targets	II	++					++	12	3
Acetamiprid + Pyriproxyfen	Neonicotinoids + IGR	Growth & development targets	II	++		++	++	++	++	24	14
Spirotetramat	Keto-enol	Growth & development targets	III	++	++			++	++	12	7
Flubendiamide + Spirotetramat	Ryanoid + Keto-enol	Growth & development targets	III	++	++	++		++	++	24	7
Emamectin benzoate	Avermectin	Nerve & muscle targets	II			++	++		++	12	7
Pymetrozine	Pyridine azomethines	Nerve & muscle targets	III	++	++					12	0
Etofenprox	Pyrethroid derivative	Nerve & muscle targets	U	++	++	++		++	++	12	3
Tebufenozide +Emamectin benzoate	IGR + Avermectin	Nerve & muscle targets	II			++				12	7
Methoxyfenozide +Spinetoram	Diacylhydrazine + Spinosyn	Nerve & muscle targets	III	++		++			++	4	1
Profenofos	Organophosphate	Nerve & muscle targets	II	++	++	++	++		++	12	14
Thiamethoxam + Lambda cyhalothrin	Neonicotinoid + pyrethroid	Nerve & muscle targets	II	++	++	++		++	++	12	7
Alpha-cypermethrin + Teflubenzuron	Pyrethriod + IGR	Nerve & muscle targets	II	++	++	++			++	12	3
Abamectin	Avermectins & milbemycins	Nerve & muscle targets			++		++			12	

* WHO hazard Class II = moderately hazardous, Class III = slightly hazardous, Class U = unlikely to pose an acute hazard in normal use.
REI = Re-entry interval, PHI = Pre-harvest interval. The reader is advised to check the latest EPA list of registered pesticides.

Appendix 3 and 4 – Tracking and scouting sheets I and II

See attached sheet I (Appendix 3) and sheet II (Appendix 4). Growers in the greenhouse could use either sheet I or II to undertake the scouting, preferably twice a week for timely decision making.

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