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Ghana Veg

Pest Management Guide for Onion




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All photos in this manual were taken by the authors (Dr Ken Okwae Fening and Dr Emmanuel Moses) and the others have been duly acknowledged. Cover photos are also from https://pixabay.com/.

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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

This manual describes using the relevant pictures and illustrations, the pest and disease problems encountered by farmers during onion production, from planning stage, nursery establishment to harvesting.

It also briefly explains with pictures the life cycle of the expected pests and diseases and highlights their destructive stages and how farmers can control the pest at any stage of the life cycle taking advantage of the most vulnerable stage of the pest or early stages of disease manifestation.

A combination of appropriate and compatible pest management strategies (cultural, physical/mechanical, biological, host plant resistance, etc.) is recommended, with the use of pesticides (chemical control), preferably the environmentally-friendly and less toxic pesticides, as the last resort, when other control measures fails to offer effective protection against pests and diseases, a concept known as Integrated Pest Management (IPM).

The IPM approach will allow the farmer to put in place measures that will *prevent*, *monitor* for pests and diseases and their timely *control* to ensure significant damage and yield losses do not occur.

This will improve the yield of onion and promote food and environmental safety.

Only pests and diseases that affect the onion crop in Ghana will be considered.

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.

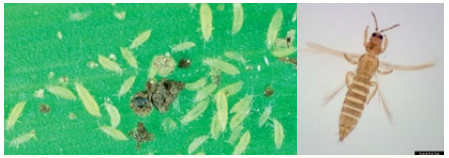
2. Symptoms and descriptions of pests in onion cultivation

2.1 Onion thrips

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

Main damage symptoms:

- Feeding results in stunted growth, reduced bulb weight and predisposes onion plants to various fungal and bacterial pathogens.
- Transmit Iris yellow spot virus (IYSV) which further worsens the damage they cause and ultimately result in complete crop failure.



Larvae and adult of onion thrips, T. tabaci. *(Photograph of larvae by Joseph Ogrodnick, Cornell University and adult by Diane Alston, Utah State University, Bugwood.org).*

Onion thrips, T. tabaci, *damaged onion plant (left) compared with a non-damaged onion plant (right) (Photograph by Brian A. Nault, Cornell University).*

Feeding damage caused by onion thrips, T. tabaci. *(Top and bottom Photograph by Brian A. Nault and Joseph Ogrodnick, Cornell University, respectively).*

IPM measures: prevent, monitor and control

Prevent

- Undertake pre-planting and post-harvest sanitation
  - Remove or destroy volunteer onion plants and debris.
  - Onion plant residues left on the soil surface can harbour thrips to survive and spread the next season.
  - Implement good cultural practices to increase onion plant tolerance and reduce attractiveness to thrips.
  - Effects of mulch on thrips may include increased biological control through enhancement of predator populations, creation of a barrier for pre-pupae and pupae (resting life stages) to access soil, and reduced temperatures, which slow thrips development and population increase.
- Use trap crops and inter-cropping
  - Intercrop onion with trap crops that are highly attractive to onion thrips such as carrots, crucifers, cucurbits, and some flowers.
  - Using a trap crop involves planting small strips or patches of the alternative crop within an onion field to attract thrips.
  - The trap crop is sprayed with an insecticide when thrips populations increase.
  - Inter-cropping, or mixed planting, of carrots and onions has been shown to reduce onion thrips populations on onions by attracting them to the carrots.
  - Thrips injury to carrots is not as economically damaging as injury to onions.
- Apply sprinkler irrigation when possible
  - Use overhead sprinkler irrigation to reduce thrips population on onion plants.
  - The physical action of water washing thrips from plants and water droplets standing on leaf surfaces are inhibitory to thrips.
  - Thrips prefer warm and dry conditions.
  - In addition, water applied through sprinklers may cause a crust to form on the soil surface and reduce the ability of pre-pupae and pupae to seek shelter in the soil.
- Select the right onion variety
  - Some onion varieties can tolerate effects of thrips feeding with only mild yield loss.
  - Varieties with tolerance to thrips require fewer insecticide applications.
  - Reduced insecticide use lowers control costs and slows development of resistance to insecticides in the thrips population and may encourage biological control through preservation of natural enemies.
  - Onion varieties with an open neck growth and dark, glossy leaves are less attractive to thrips than varieties with tight necks and lighter green leaves.

Monitor

- Inspect plants
  - Onion thrips adults and larvae can be visually identified and counted more easily after opening the neck of the onion plants.
  - Inspect the youngest leaves in the lowest centre part of the neck, which is a preferred feeding site for thrips.
  - Older leaves that have been folded over may also be a preferred feeding site for the pest.
  - Thrips sampling is important to optimize management strategies and to inform the grower about thrips population pressure over time.
  - Sampling should begin when plants have at least 4–5 leaves.
  - During sampling, open the neck of onion plants and quickly count thrips adults and larvae before they disperse or hide.
  - The majority of thrips will be at the base of youngest leaves in the lower centre of the neck.
  - It is recommended you sample 5 plants each in about 10 different areas of a field for a total of 50 plants per field.
  - Thrips numbers tend to be higher near field borders where adults infest first.
- Use of blue sticky traps
  - Alternatively, monitor adult thrips population using blue and white sticky traps.

Control

Management of onion thrips involves the combination of cultural, chemical control measures and use of resistant and tolerant varieties (if available) that suppress onion thrips populations and reduce their feeding damage.

- Biopesticides
  - Pyrethrum/Pyrethrins
  - Neem seed extract: 750 g/15 l
  - Neem oil (0.3% Azadirachtin): 60 ml/l
  - Neem oil (1% Azadirachtin): 30 ml/l
  - *Metarhizium anisoplae* (ICIPE 69)
- Synthetic insecticides
  - Spinetoram
  - Etofenprox
  - Spinosad
  - Flubendiamide + Spirotetramat
  - Thiamethoxam + Lambdacyhalothrin
  - Fipronil
  - Chlorfynapyr
  - Acetamiprid + Indoxacarb
  - Pyrethrum + Deltamethrin
  - Acetamiprid + Pyriproxyfen
- Insecticides vary in their toxicity to thrips life stages:
  - Eggs are laid within the leaf so are not accessible except to systemic insecticides that are absorbed through the leaf.
  - Only a few insecticides have ovicidal (egg) activity.
  - Most insecticides are effective in killing the early larval stages (Instars I and II) because the young stages are small and actively feeding.
  - Older larvae (Instars III and IV) are non-feeding and seek protection in the soil or at the base of onion plants, escaping contact by most insecticides.
  - Adults have a thicker cuticle (external covering) than larvae and fly quickly when disturbed, so they are more difficult to kill than larvae.
  - Some insecticides are active against adults.

2.2 Onion fly

Scientific name: *Delia antiqua*
Distribution: Widespread
Stage of crop attacked: Seedling and vegetative stages

Main damage symptoms:

- Larvae attack seedlings, shoots and bulbs.
- Wilting of seedlings, white larvae feed just above the base of the plant.
- Aerial parts of older plants die.
- Oldest leaves turn yellow, wilting and breach.
- Larvae or maggots may be found in developing bulbs.
- The onion fly causes withering in the field and rotting in storage.
- Damage leads to the invasion of *Bacillus carolovorus* which causes soft rot of onion.

Eggs (in circle) and larvae of the onion fly, Delia antiqua *feeding in onion bulb and foliage. (Photo by Rasbak at Dutch Wikipedia, CC BY-SA 3.0.)*

IPM measures: prevent, monitor and control

Prevent

- Regularly practice strict hygiene and good farm sanitation.
- Practice crop rotation with non-host crop (not from onion family).
- Infested plants should be carefully uprooted and burnt or buried deeply (60 cm).
- Destroy crop debris after harvesting.
- Remove and dispose of volunteer onions.
- Grow resistant or tolerant varieties.
- *Allium fistulosum* (spring onion) is more tolerant than *A. cepa* (bulb or common onion).
- Cover seedlings in nursery with fine mesh or net to prevent onion flies from laying eggs on host crop.

Pupae and adult of onion fly, Delia antiqua. *(http://eagri.org/eagri50/ENTO331/lecture27/onion/002.html).*

Monitor

- Inspect plants by examining the symptomatic leaves for the presence of larvae by carefully opening the leaves or look for their damage symptoms in leaves and bulb (wilting of seedlings, death of aerial parts of older plants or longest leaves turn yellow, wilt and breach, holes in bulb, rotten bulbs).
- Monitor fly population with yellow sticky traps.

Control

- Biopesticides
  Neem based insecticides (neem seed extract, neem oil and neem cake).
  - Neem seed extract: 750 g/15 l
  - Neem oil (0.3% Azadirachtin): 60 ml/l
  - Neem oil (1% Azadirachtin): 30 ml/l
  - Neem cake (1 kg per 10 m² or 1 t/ha)
  - Spinosad for drenching
  - Pyrethrum/pyrethrin
- Synthetic insecticides
  Use certified and treated seeds for planting. Spray with:
  - Novaluron
  - Lufenuron Etofenprox
  - Flubendiamide + Spirotetramat
  - Thiamethoxam + Lambdacyhalothrin
  - Profenofos + Lufenuron,
  - Alpha-cypermethrin + Teflubenzuron
  - Chlorfenapyr
  - Acetamiprid + Indoxacarb
  - Imidacloprid + Emamectin benzoate

2.3 Onion leaf miner

Scientific name: *Phytobia cepae*
Distribution: Widespread
Stage of crop attacked: Vegetative stage

Main damage symptoms:

- Larvae carve out white galleries or mines in the leaf.
- The larvae mine the mesenchyma cells of the onion leaves and make white streaks on them.
- Attack leaves but is of higher importance for spring onion production where leaf quality counts.

IPM measures: prevent, monitor and control

Prevent

- Intercrop onion with tomato to reduce the onion leaf miner population, while increasing the population of the natural enemies.
- Onion fields should be kept clean and free of any crop residue that may harbour the pest.
- Ploughing, manuring, irrigation, crop rotation, solarisation and the elimination of symptomatic leaves and destruction of infested onion leaves is useful to control this pest.

Monitor

- Scout onion plants in the field to detect the mines on the onion foliage to initiate management interventions on time.
- Place yellow coloured plastic plates coated with adhesive, placed vertically at a height of 60–70 cm above the ground to monitor the adult fly population.

Control

- Biopesticides
  - Pyrethrum/Pyrethrin
  - Neem seed extract: 750 g/15 l of water
  - Neem oil (0.3% Azadirachtin): 30 ml/15 l of water
  - Neem oil (1% Azadirachtin): 60 ml/15 l of water
  - *Metarhizium anisoplae* (ICIPE 69)
  - *Bacillus thuriengiensis* (Bt)
  - *Beauveria bassiana*

Onion leaf showing galleries or mines of the onion leaf miner

- Synthetic insecticides
  - Etofenprox
  - Spinosad
  - Flubendiamide + Spirotetramat
  - Methoxyfenozide + Spinetoram
  - Emamectin benzoate
  - Imidacloprid + Emamectin benzoate
  - Tebufenozide + Emamectin benzoate
  - Chlorfenapyr
  - Alpha-cypermethrin + Teflubenzuron

2.4 Cutworms

Scientific name: *Agrotis* spp.
Distribution: Widespread
Stage of crop attacked: Seedling stage

Main damage symptoms:

- Cutworm larvae kill plants by girdling (ring-barking) the stem of the plant.
- The girdled plant then falls over and dies.
- Mature larvae hide during day and emerge at night to feed on young stem and foliage.

IPM measures: prevent, monitor and control

Prevent

- Remove weeds in and around the fields to reduce the number of sites where the moths can lay eggs. Do this at least 2–3 weeks before planting. The moths prefer to lay eggs in high grass and weeds.
- At the end of the season, plough and harrow surrounding areas to expose cutworms and destroy their habitat.
- Ploughing and harrowing fields properly before planting destroys eggs and expose caterpillars to birds, ants and other predators.
- Apply neem cake (1 kg/10 m²) or de-oiled castor cake before sowing.
- Encourage the presence of birds with trees and hedges.
- Also promote the activities of natural enemies like spiders, ground beetles and lacewings.
- Sunflowers can be planted as a trap crop.

Monitor

- Cutworms are 2 to 4 cm long larvae, and dark grey-brownish (like the soil colour).
- They are about 0.5 to 1 cm thick and soft.
- The older or bigger larvae can cut and chew young onion stems quickly.
- Under a freshly cut seedling, you can often find a cutworm larva in the soil.
- Action threshold: one larva per 100 plants and the presence of cut plants indicate that control is necessary.
- Known species of cutworms can also be monitored with pheromone traps.

Cutworm inside onion leaf (Photo: The Garden Smallholder publication. https://thegardensmallholder.com/2012/08/13/cutworms/).

- Seven or more adults per trap per week indicate treatment is necessary.

Control

Cutworms rarely cause economic damage. Apply an approved insecticide late in the afternoon for best control.

- Biological control
  - Promote the activities of natural enemies by using biopesticides and less persistent insecticides.
  - Natural enemies of cutworms include the Braconid wasp, *Meteorus communis* and Ichneumonid wasp larvae (*Nepiera* spp.) and green lacewing larvae.
- Biopesticides
  - *Bacillus thuringiensis*
  - *Metarhizium anisopliae*
  - *Azadirachtin*
- Synthetic insecticides
  - Etofenprox
  - Flubendiamide + Spirotetramat
  - Alpha-cypermethrin + Teflubenzuron
  - Lambda cyhalothrin
  - Fipronil
  - Imidacloprid

2.5 Leafworm

Scientific name: *Spodoptera littoralis*
Distribution: Native to Africa and Israel but now widespread
Stage of crop attacked: Seedling stage

Main damage symptoms:

- Larvae occasionally feed on leaves and young shoots, stalks, bolls and buds, often gnawing holes which allow diseases to enter the plant tissue.
- Early larval damage appears as skeletonization and scars on underside of the leaves.
- Larger larvae will do extensive damage and stripping foliage.

IPM measures: prevent, monitor and control

Prevent

- Rotate with non-host crops like cassava, yam and others.
- Employ good farm sanitation and improved cultural practices.

Monitor

- Look for feeding scratches of larvae on leaves.
- Scout leaves for the presence of larvae or egg mass.
- Alternatively, sex pheromone baited delta traps can be used to monitor the incidence of S. *littoralis*.
- Action threshold: 10–20 % infestation of crops calls for implementation of control measures.

Control

- Physical control
  - Handpick and destroy caterpillars and egg masses.
- Biological control
  - Use of parasitoids (braconids, encyrtids, tachinids and ichneumonids) and predators such as ladybird beetles, predatory beetles and spiders.
  - Ladybird beetles have been noted to prey on young larvae and eggs.

Egg mass and larva of Spodoptera littoralis. *(Egg mass photo by Maarten van Merriënboer/PPS, Aalsmeer, Netherland, larva photo by Biologische Bundesanstalt für Land- und Forstwirtschaft, Bugwood.org and photo on damage adapted from Pacific Pests and Pathogens, Australia).*

- Biopesticides
  - *Bacillus thuringiensis* (Bt)
  - Neem oil (Azadirachtin 0.3%): 60 ml/15 l
  - Neem oil (Azadirachtin 1%): 30 ml/15 l
  - Neem seed extract: 750 g/15 l of water
  - Spinosad
  - Pyrethrum/pyrethrin
  - Fresh ripened hot pepper extract in water (300 g/15 l of water)
- Synthetic insecticides
  - Etofenprox
  - Novaluron
  - Flubendiamide + Spirotetramat
  - Tebufenozide + Emamectin benzoate
  - Emamectin benzoate
  - Imidacloprid + Emamectin benzoate
  - Organophosphates
  - Pyrethroids

2.6 Blister beetle

Scientific name: *Epicauta blineata*
Distribution: Nearly cosmopolitan (widespread)
Stage of crop attacked: Seedling stage

Main damage symptoms:

- Adult beetles feed on leaves making irregular shaped holes.
- It damages the leaves and young stems.

IPM measures: prevent, monitor and control

Prevent

- Employ good farm sanitation by clearing weeds that serve as alternative hosts for the beetles.

Monitor

- Look for the presence of adult beetles or their damage symptoms (irregular shaped holes) on the leaves and young stem (shoot).
- Alternatively, monitor the adult population using blue sticky traps.

Control

- The larvae of the beetle are beneficial (predators on the eggs pods of grasshoppers).
- Therefore, no intervention is a good IPM strategy.
- Control may not be necessary if numbers are small.

Photo of adult blister beetle, Epicauta *sp. (Photo from https://en.wikipedia.org/wiki/Epicauta#/media/File:Epicauta_hirticornis_(Haag-Rutenberg,_1880).jpg)*

Table 1. *Summary of biological and synthetic pesticides for onion pests' management*

	Brand name	Group(s)	WHO hazard class*	Caterpillars	Flies	Thrips	Beetles	REI (hrs)	PHI (days)
Azadirachtin	Neem	Botanical	II	++	++	++	++	4	0
Pyrethrum	Pyrethrum 5EW, Agroblaster	Botanical	II	++	++	++	++	0	1
Maltodextrin	Eradicoat T GH	Botanical	III	++	++	++		0	1
Insecticidal soap 'alata samina'	'Alata samina'	Botanical		++	++			12	0
Bacillus thuringiensis (Bt)	NOVA BTK, Agoo, Biopest	Microbial	III	++	++			4	0
PrGV + Bt	Bypel 1	Microbial	III	++				4	0
Metarhizium anisopliae	Campaign	Microbial	III	++				0	0
Novarulon	Rimon 10 EC	IGR	U	++	++	++		12	1
Chlorfenapyr	Klopar 24 SC	Pyrroles	II	++	++	++			
Acetamiprid + Indoxacarb	Viper 46EC, Viper Super 80EC, Zukadoc 46 EC	Neonicotinoid + oxadiazine	II	++	++	++	++	12	7
Imidacloprid + Emamectin benzoate	Dean 62 EC	Neonicotinoid + Avermectin	II	++	++	++	++	24	7
Deltamethrin	Cisthrin	Pyrethroid	II		++	++		12	3
Fipronil	Fipro 50 EC, Fixe 50 SC	Phenylpyrazole	II	++	++	++	++	24	14
Pyrethrum + Deltamethrin	Decis Forte 100 EC, Miricon EC	Botanical + Pyrethroid	II		++	++	++	12	3
Acetamiprid + Pyriproxyfen	Trivor 310 DC	Neonicotinoids + IGR	II	++	++	++	++	24	14
Spirotetramat	Movento 100 SC	Keto-enol	III			++			7
Flubendiamide + Spirotetramat	Tihan 175-ODTEQ	Ryanoid + Keto-enol	III	++		++		24	7
Emamectin benzoate	Chemomectin 50SG, Strike 1.9EC, Attack 1.9 EC, Ataka Super EC	Avermectin	II	++		++		12	7
Etofenprox	Inspire 30 EC, Akate Kaptain	Pyrethroid derivative	U	++	++	++	++	12	0
Tebufenozide + Emamectin benzoate	Evite 340 WP	IGR + Avermectin	II	++				12	7
Thiamethoxam + Lambda cyhalothrin	Colam 247 ZC	Neonicotinoid + pyrethroid	II	++	++	++	++	12	7
Alpha-cypermethrin + Teflubenzuron	Nomax 150SC	Pyrethriod + IGR	II	++	++	++	++	12	3

* WHO hazard Class II = moderately hazardous, Class III = slightly hazardous, Class U = unlikely to pose an acute hazard in normal use.

3. Diseases of onion and their management

3.1 Damping-off

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

Main damage symptoms:

- Seeds can be attacked leading to a watery decay.
- Rotten seeds are often covered with mycelium.
- Roots of infected seedlings may turn dark red or black as they decay.
- Infected seedlings become stunted, yellow, wilt and die eventually.

Nursery affected with damping off

IPM measures: prevent, monitor and control

Prevent

- Change position of nursery every season.
- Avoid keeping un-transplanted seedlings at 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 4 weeks or more. This improves aeration and destruction of pathogens.
- Burn dry grass over the nursery soil before forming the beds.
- Solarization of nursery soil using black polythene (250-gauge type) for a period of two weeks or more in the sunny months before seed sowing is a good practice.
- Certified seeds (disease-free) should be used to raise seedlings of desired varieties.
- Treat seeds with Mancozeb (800 g/kg) (2 g/kg of seeds) before sowing.
- Treat seeds with Copper hydroxide (77%) (2 g/kg of seeds).

Monitor

- Monitor field for symptoms described above and take appropriate actions.

Control options without restriction

- Rogue and destroy infected seedlings by burning immediately they are identified.

Control options with restrictions

- Drench onion beds with 0.1% solution/suspension of Cabendazim (50%). Restrictions: WHO Class III (slightly hazardous). Apply at 5–10 days intervals. REI: 24 hours; PHI: 5 days.

3.2 Fusarium basal rot

Scientific name of causal organism: *Fusarium oxysporum* (fungus)
Distribution: Worldwide
Stage of crop attacked: Bulb development

Main damage symptoms:

- Initial symptoms observed are yellowing of leaves and stunted growth of plants.
- Leaves of infected plants dry from the tip downwards.
- The roots turn pink in the early stages of the disease and rot.
- As the disease progresses, the bulb starts decaying from the lower end until finally the whole plant dies.
- Basal rot disease may occur in storage.

IPM measures: prevent, monitor and control

Prevent

- Avoid planting onions in areas with a history of basal rot.
- Crop rotation with non-allium crops in 3–4 year rotations can reduce incidence of the disease.
- Soil solarisation through the spreading of 250-gauge polythene sheets in the hot sunny months for 30 days or more can destroy some of the infectious propagules (spores, etc.). This practice can reduce incidence and severity of the disease when adopted.
- Plant resistant varieties if available (seek information on resistant varieties from seed suppliers).
- Treat seeds with Mancozeb (800 g/kg) (2 g/kg seeds) before sowing.
- Treat seeds with Copper hydroxide (77%) (2 g/kg).
- Dip seedlings (roots) in 0.1% solution/suspension of Carbendazim (50%) before transplanting.
- Cure bulbs properly before they are stored.
- If possible, store onions at low temperatures and relative humidity not above 70%.

Fusarium basal rot. A.F. Sherf, Cornell University.

Monitor

- Look for the symptoms indicated above and take the recommended actions.

Control options with restrictions

- Drench onion beds with 0.1% solution/suspension of Cabendazim (50%). Restrictions: WHO Class III (slightly hazardous). Apply at 5–10 days intervals. REI: 24 hours; PHI: 5 days.

3.3 Pink root

Scientific name of causal organism: *Phoma terrestris* (fungus)
Distribution: Worldwide
Stage of crop attacked: Growth phase

Main damage symptoms:

- Infected roots first become light pink and may darken to become red and purple.
- With time, the infected roots turn black and die.
- Both old and new roots may be infected.
- The scales of the bulb of infected plants may turn pinkish-red. Infection is restricted to roots and scales of the bulb.
- The centre of the roots (the vascular tissues) may turn dark red.
- Stunted growth may result with undersized shrivelled bulbs produced.
- The disease may kill infected seedlings.

IPM measures: prevent, monitor and control

Prevent

- A well-drained soil with improved soil fertility using organic matter helps to reduce pink root disease incidence.
- Crop rotation with non-*Allium* crops in rotation periods of 3–6 years is recommended. Continuous cropping of onions on the same field for years should be avoided.
- Cereals can be carriers of the pink root pathogen. It is not advisable to grow onions after a cereal crop (e.g. rice, millet).
- There is no clear information on resistant varieties. Many popular varieties are not resistant.
- Tools used on onion fields must be cleaned and disinfected in bleach solution (1:9 dilution) for 5 minutes after use each time.
- Prevent irrigation water from neighbouring onion fields from reaching your plants.
- Pre-planting soil fumigation is the main chemical control practiced against pink root. This is however not recommended for farmers in Ghana.

Pink root of onion. Photo by D. B. Langston, Univ. of Georgia.

Monitor

- Look for the above symptoms to implement control measures.

3.4 Purple blotch

Scientific name of causal organism: *Alternaria porri*
Distribution: Worldwide
Stage of crop attacked: Post seedling phase of growth

Main damage symptoms:

- Early symptoms of purple blotch are small water-soaked lesions with white centres on leaves and flower stalk. Lesions turn purple with dark concentric rings in the centre.
- Lesions enlarge, become necrotic and often kill the leaf tissue.
- Lesions may girdle leaves or flower stalk leading to their drooping.
- Severely infected foliage may die.
- Infected plants may fail to produce bulbs.

IPM measures: prevent, monitor and control

Prevent

- Use resistant varieties if available (check on information on seed containers for information or inquire from seed suppliers).
- Use certified seeds if available.
- Use hot water treatment by soaking of onion seeds (at 50°C for 20 minutes).
- Practice rotations of 3 years or more with non-host crops such as maize or sorghum.
- Care should be taken during weed control to prevent injuries to bulbs.
- Onions should be planted in well drained soils to reduce humidity around plants.
- Irrigate early in the day to ensure that leaf surfaces dry adequately before night.
- Destroy old infected rotten bulbs and plant debris by burning during land preparation.
- Regular weeding must be done. Cut or removed weeds must be burnt.

Purple blotch. Gardeningknowhow.com

Monitor

- Monitor plants regularly (at least once every week) for the symptom above and take recommended actions.

Control options without restriction

- Rogue and destroy few infected plants in early season and destroy them by burning.

Control options with restrictions

- Apply Difenaconazole 25% EC at a concentration of 4 ml in 20 l of water. Restrictions: WHO Class III (slightly hazardous). Apply at 7–10 days intervals. REI: 12 hours; PHI: 7 days.
- Apply Imidacloprid (3%) (insecticide) to control thrips. Restrictions: WHO Class III (slightly hazardous). Apply at intervals of 7 days. REI:12 hours; PHI:14 days.

3.5 Stemphylium leaf blight

Scientific name of causal organism: *Pleospora allii* (formerly *Stemphylium vesicarium*) (fungus)
Distribution: Worldwide
Stage of crop attacked: Post seedling phase of growth

Main damage symptoms:

- First signs of the disease are small, yellow to brown water-soaked lesions on the leaves.
- As lesions develop the centres turn brown to tan (there is no purple colour associated with *Stemphylium* leaf blight disease lesions).
- Several smaller lesions coalesce (join together) to form large diseased areas resulting in loss of photosynthetic surface.
- Bulbs formed are reduced in sizes.
- Infection of the inflorescence stalk causes severe damage to the seed crop.

IPM measures: prevent, monitor and control

Prevent

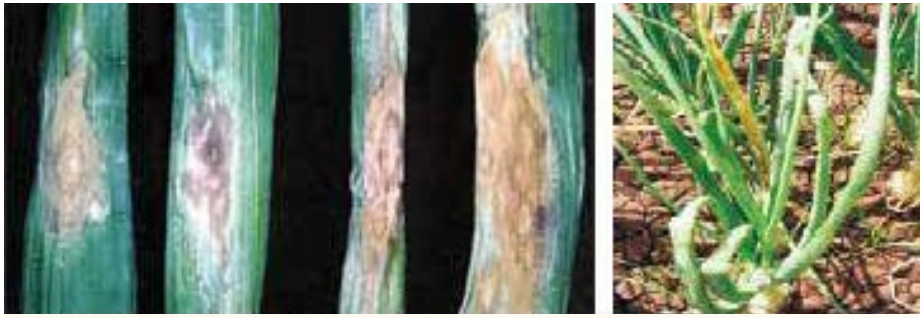
- Old plant debris and volunteer host plants should be removed and burnt.
- Practice crop rotations of 3-4 years duration with plants outside the onion family.
- Good soil fertility and adequate supply of water that ensures healthy growth of plants reduce incidence and severity of *Stemphylium* leaf blight.

Monitor

- Monitor plants regularly and take the recommended actions when the symptoms above are observed.

Control options with restrictions

- Apply Mancozeb (800 g/kg). Restrictions: WHO Class III (slightly hazardous). Apply at 7–10 days intervals. REI: 24 hours; PHI: 5 days.



Stemphylium *leaf blight. Vikaspedia.*

3.6 Anthracnose/Onion twister

Scientific name of causal organism: *Colletotrichum gloeosporioides* (fungus)
Distribution: Worldwide
Stage of crop attacked: Entire crop life

Main damage symptoms:

- Initial symptoms appear on the leaves as water-soaked yellow spots which spreads along the length of the leaf.
- Curling, twisting and chlorosis of the leaves are very prominent.
- Affected leaves shrivel and droop downwards.
- The roots may develop poorly, and the plants become stunted.
- There is often abnormal elongation of the neck of the plant.
- Bulbs produced are slender and decay rapidly in storage.
- In greenhouse transplant production, roots of young seedlings may exhibit a dark rot with spore masses.

IPM measures: prevent, monitor and control

Prevent

- Collect and burn old plant residue during land preparation before seedlings are transplanted.
- Use certified seeds (treated with fungicides such as copper oxychloride).
- Dip roots of seedlings into fungicide solution just before transplanting (0.25% Mancozeb (800 g/kg).
- Avoid overhead irrigation and over-watering especially in transplant production.
- It is important to prevent rain or irrigation water from neighbouring onion fields entering your farm.
- Plant a wind shield of non-allium crops (e. g. few rows of maize) to reduce wind transmission of spores from neighbouring onion fields.
- Control weeds effectively especially that of secondary hosts such as garlic.
- Plant resistant varieties when available.
- Avoid planting onion continuously on the same piece of land.

Onion anthracnose.

Monitor

- Monitor plants regularly (at three days intervals) for the listed symptoms above and take the recommended actions when more than one plant is infected per onion bed.

Control options with restrictions

- Apply Mancozeb (800 g/kg). Spray at a rate of 0.25%. Restrictions: WHO Class III (slightly hazardous). Apply at 7–10 days intervals. REI: 24 hours; PHI: 5 days.
- Spray Carbendazim at a rate of 10–15 g/20 l of water. Restrictions: WHO Class III (slightly hazardous). Apply at 5–10 days intervals. REI: 24 hours; PHI: 5 days.

3.7 White rot

Scientific name of causal organism: *Sclerotium cepivorum* (fungus)
Distribution: Worldwide
Stage of crop attacked: Bulb maturity

Main damage symptoms:

- The first sign of the disease is yellowing of the leaves close to harvest. Farmers often misjudge this sign to indicate plant maturation.
- There is leaf tip dieback.
- Scales and roots start deteriorating with the bulbs becoming soft and water soaked.
- Infected plants pulled out have masses of whitish mycelia around roots and basal parts of bulbs. Masses of black sclerotia are found scattered in these whitish mycelia.

IPM measures: prevent, monitor and control

Prevent

- Use certified disease-free seeds to start your onion production.
- Treat onion seeds with bis-dimethylthiocarbamyl (2 g/kg of seed) before sowing at nursery; or
- Treat seeds with Mancozeb (800 g/kg) (2 g/kg seeds).
- Dip seedling roots into one percent (1%) solution of Carbendazim before transplanting.
- Avoid planting one Allium crop after the other to reduce disease intensity.
- Do not compost infected plants.
- Maintain very good field sanitation and destroy infected bulbs and debris by burning during land preparation.
- Wash any soil off your boots and tools when you work in any part of your field with infected plants.
- Practice crop rotation with non-allium crops with rotations longer than 8 years.
- Sclerotia of the pathogen can survive in the soil for up to 20 years or more.
- There are no resistant varieties to white rot disease.

White rot of onion. Growingproduce.co

Monitor

- Monitor plants closely and regularly especially when the bulbs are developing for the symptoms above and take the recommended action.

Control options with restrictions

- Rogue and destroy few infected plants showing symptoms early in the season and destroy them by burning to reduce spread of the disease.

3.8 Black mould

Scientific name of causal organism: *Aspergillus niger* (fungus)
Distribution: Worldwide
Stage of crop attacked: Developing bulbs

Main damage symptoms:

- The major symptom of the disease is the appearance of black powdery spores on exterior and internal scales of onion bulbs
- Infection often is through the neck of the plant as the foliage dies down at maturity spreading into the central fleshy scales as masses of powdery black spores.
- The masses of black spores are seen as streaks along veins in the outer dry scales.

Black mould of onion

IPM measures: prevent, monitor and control

Prevent

- To achieve effective control of the disease, care should be taken during harvest and post-harvest handling to avoid injuries to bulbs.
- After harvest, bulbs should be left in the field to dry for two days.
- Bulbs should further be dried in a suitable shade for 10 to 15 days before storage.
- Cured onions as described above must be stored in a well-ventilated room with low temperatures and relative humidity.
- Care should be taken when transporting onions to prevent injuries to bulbs.
- Crops should be sprayed with 0.2% solution/ suspension of Carbendazim (50%) 10–15 days before harvest to prevent infection through the neck of plants.

Monitor

- For the symptoms above.

3.9 Bacterial soft rot

Scientific name of causal organism: *Erwinia carotovora* (bacteria)
Distribution: Worldwide
Stage of crop attacked: Matured bulbs

Main damage symptoms:

- Bacterial soft rot symptoms usually appear as a soft watery rot of individual scales of the bulb.
- From the first individual scales infected, the rot spreads to affect entire bulb.
- A viscous foul scented fluid oozes out of the neck of infected bulbs when squeezed.
- In the field, the youngest leaves or entire foliage of infected plants may wilt or appear bleached.

Bacterial soft rot. Ontario CropIPM.

IPM measures: prevent, monitor and control

Prevent

- Avoid overwatering onion plants, especially when it is hot.
- Plant onions in well drained soils and improve aeration through the adoption of good planting distances.
- Avoid re-use of irrigation water and overhead irrigation.
- Practice three-year or longer crop rotations with non-host plants such as maize, soybean, and groundnuts. This practice reduces inoculum levels of the bacteria.
- Avoid bruising or wounding of plants especially bulbs during field operations (e.g. weed control), harvest and post-harvest handling.
- Remove all roots from bulbs during harvest to facilitate rapid drying of foliage and necks before topping.
- Bulbs must be cured in abundant ambient air to ensure that the necks are completely dry before storage.
- Onions are best stored in a cool, dry, dark and well-ventilated room (within a temperature range of 4–10°C and relative humidity less than 70%). These conditions prevent sprouting and rotting in storage. Darkness help onion bulbs stay longer.
- Ensure good ventilation around stored bulbs to prevent moulding and rotting. Storage of bulbs in open baskets, mesh bags and netted bags are recommended.

Monitor

- For the symptoms above.

Control options with restrictions

- Spray Cuprous oxide (86%) just before harvest to control bacterial soft rot. Restrictions: WHO Class III (slightly hazardous). Apply at 7–10 days intervals. REI 24 hours; PHI: 7 days.

3.10 Iris yellow spot

Scientific name of causal organism: Iris Yellow Spot Virus
Distribution: Worldwide
Stage of crop attacked: Vegetative phase

Main damage symptoms:

- Primary symptoms of iris yellow spot disease include the appearance of creamy spots on the leaves. These creamy spots may become elliptical or diamond shaped.
- The spots (lesions) can develop also on flower stalks.
- Late in the infection, leaves or flower stalks may lodge (fall over).

Iris yellow spot. Ipmimages.org

IPM measures: prevent, monitor and control

Prevent

- Do not transplant seedlings with signs or symptoms of IYSV.
- Volunteer plants of onions must not be allowed to exist in any part of an onion field These plants are sources of the viral pathogen and may also harbour the thrip vector Remove volunteer plants and burn them.
- Host plants such as garlic, leek or tobacco should not be intercropped or rotated with onion.
- Ensure maintenance of good soil fertility and supply of adequate water to plants.
- Avoid excessive nitrogen fertilization. Onion thrips are attracted to high nitrogen sources.

Monitor

- Monitor plants closely and regularly looking for the listed symptoms above and presence of thrips that transmit the virus and take the recommended actions.

Control options without restriction

- Rogue and destroy few infected plants showing symptoms (early in the season) and destroy by burning to reduce spread of the disease.

Control options with restrictions

- Apply Imidacloprid (3%) (insecticide) to control thrips. Restrictions: WHO Class III (slightly hazardous). Apply at intervals of 7 days. REI: 12 hours; PHI: 14 days.

3.11 Root-knot nematode

Scientific name of causal organism: *Meloidogyne* spp.
Distribution: Worldwide
Stage of crop attacked: Entire plant life

Main damage symptoms:

- Root-knot infestation in onion is characterized by stunted growth of plants.
- Chlorosis or yellowing of leaves is common.
- Maturity of plants is delayed, and smaller bulbs are produced by infected plants.
- Wilting and death of plants can occur.
- Infested plants develop galls (swellings) on their roots.
- Severely infested seedlings develop few roots and often die rapidly.

Root knot (*Meloidogyne* sp.). Ipmimages.org

IPM measures: prevent, monitor and control

Prevent

- Produce seedlings on solarized soils to prevent early infestation. Solarization can be achieved by covering raised moist beds with clear plastic for 2 to 4 months.
- Expose ploughed land for 3–4 weeks before transplanting of seedlings.
- Avoid siting onion nurseries at the same position season after season.
- Control weeds and volunteer crops effectively to reduce nematode population.
- Destroy old plant debris through burning during land preparation.
- Farm tools such as cutlasses and hoes must be washed of soil particles before being used on a new field or nematode-free zone in an onion field.
- Avoid moving soil whose nematode status is not known from one part of a field to another in areas where nematode is known to be a problem.
- Practice crop rotation with crops such as maize, sorghum, soya beans, etc.
- Fallow lands for periods of 3–4 years after cleaning harvested fields if that is possible.
- In communities where farmers must stay on the same piece of land for a long time, planting Marigold (e.g. *Tagetes patula*) on harvested fields for two months before an onion crop is planted. Marigold plants could trap soil nematodes.
- Application of poultry manure at levels of 5 t/ha in onion fields can increase plant vigour that can reduce nematode infestation.
- Use resistant varieties when available (ask seed suppliers for information on resistance).

Monitor

- Monitor plants regularly for the symptoms above and take the recommended action.

Control options without restriction

- Rogue few plants showing symptoms early in the season and destroy them by burning. Chemical control is not recommended.

Table 2. *Recommended fungicides, active ingredients, examples of trade names in Ghana and their restrictions*

Active ingredient	Trade name (examples)	FRAC Code	WHO Toxicity class*	REI (hrs)	PHI (days)
Copper hydroxide	Champion WP Delco 75 WP	M 01	III	24	3
Copper oxychloride (35%)	Cuprozin 35 WP Curenox	M 01	II	24	4
Difenoconazole 25% EC	Dizole 250 EC	3	III	12	7
Mancozeb (800 g/kg)	Agrithane 80 WP Benco 80 WP Conti-Zeb Ivory 80 WP	M 03	III	24	5
Maneb (80%)	Maneb 80 WP Trimangol 80 WP	M 03	III	24	7
Copper oxide	Nordox 750 WG	M 01	III	24	
Carbendazim (50%)	Callet 50 WP Goldazim 500 SC	1	III	24	5
Cuprous oxide + metalaxyl	Agro Comet 72 WP Ridomil Gold Plus 66 WP	M 01	III	24	7

* WHO Toxicity Class: Class Ia = extremely hazardous; Class Ib = highly hazardous; Class II = moderately hazardous; Class III = slightly hazardous.

4. Other considerations

4.1 How to handle pesticides safely

- Pesticides for the control of pests or diseases are mostly chemicals that are harmful or toxic and must therefore be handled with care.
- Some of them can cause damage to the skin when spilled.
- Some of these chemicals can cause cancer and damage to internal organs and tissues when inhaled or ingested.
- There is the need therefore, for pesticide users to be careful when handling and applying pesticides of all kind. Personal Protective Equipment (PPE) have been designed to ensure that farmers handle and apply these chemicals safely.
- Some of the common PPEs that must be worn at all time when handling or applying pesticides are the following to protect the body:
  - Gloves
  - Goggles
  - Overall dress that will not trap heat to the body
  - Nose Mask
  - Cap or hat
  - Safety boot.

Caution to farmers

- Farmer when handling or applying pesticides should avoid:
  1. Drinking fluids including water
  2. Eating any food
  3. Smoking.

Protective cap: *Prevents head from injury and drift from insecticide*

Safety goggles: *Protects the eyes from water, chemical and particles*

Respiratory mask: *Filters out unwanted particles and limits absorption of insecticide vapour*

Protective gloves: *Protects the hands against insecticide contact and injuries*

Long-sleeved protective clothing *protects the skin from pest, insecticide and injuries*

Safety boots: *Protects the feet from insecticide spills, falling and puncturing objects*

Personal protective equipment for farmers

Advise to farmers

- Farmers must always take time to read and understand the instructions given on the pesticide label.
- For farmers safety and effectiveness of the product, manufacturer's information on recommended dosages or application rates need to be adhered and the necessary PPEs must be worn.
- Knapsack or motorized sprayers must be washed properly before use and after use.
- Observe the re-entry period and pre-harvest intervals for pesticides.
- The re-entry interval (REI) is the minimum amount of time that must pass between the time a pesticide was applied to an area or crop and the time that people can go into that area without protective clothing.
- The pre-harvest interval (PHI) is the minimum amount of time between the last application of a pesticide and when the crop is safe to be harvested.
- The PHI is normally found on the pesticide label. Farmers must check on the label and observe it and must also inform your choice of pesticide.
- Judicious use of insecticides is encouraged based on economic or action thresholds (the no. of pests that necessitates a control action) and regular scouting to ascertain pest population levels as part of an IPM strategy.
- Apply synthetic insecticide during the seedling, early growth stages to the onset of flowering.
- From flowering to fruiting, use the biological pesticides, usually sprayed during late afternoon (4–6 pm), for enhanced action and to ensure food and environmental safety.
- This will prevent pesticide residues in food and preserve beneficial insects – pollinators-, bees and natural enemies (predators and parasites) of the pest.
- Use the right applicator for your pesticide.
- For onion, a knapsack is recommended.

Knapsack sprayers (15 l) for the application of pesticides

- Cone nozzle is suitable for insecticides and fungicides application, and flat fan or deflector nozzle is most suitable for herbicides.
- Herbicides are normally dispensed with a low pressure and insecticides with a high-pressure gauge as indicated by H or L in the CP-15 Knapsack sprayer (H – Insecticides and L – Herbicides).
- Calibrate your knapsack before use.
- Calibrate to determine the flow rate, enhance the applicator's efficiency, and ensure that the correct amounts of insecticides were delivered consistently over the target plots with the correct amount of active ingredient.
- Variables to consider during calibration include sprayer or tank capacity, operator walking speed, the pressure, the type of nozzle being used and the nozzle height from the target which can affect what area a full tank of spray will cover.
- If a sprayer is incorrectly calibrated this can result in under dosing or overdosing areas with chemical.

How to prevent insecticide resistance by pests

- It is important to use the correct or recommended dose of a pesticide to ensure effective pest and disease control.
- Alternate different classes of pesticides to avoid or delay the development of resistance.
- IPM approach involving the use of a combination of different pest and disease management tactics (cultural, biological, host plant resistance and chemical control) will minimise the risk of the pest developing resistance to a pesticide.

4.2 Guidelines on monitoring pests in the field using traps

- Farmers can always scout or monitor pest numbers by inspecting plant parts (root, stem, leaves, flowers) for the presence of the pest.
- In addition to direct scouting for pests on the crop, various traps can be used to monitor the arrival, presence and build-up of pests' population on a crop.
- Mass trapping, involving the placement of more traps than needed for monitoring purposes, can also be undertaken to attract and kill more of the target pests over time to serve as a population suppression tool.
- Some common traps for trapping various pests in the onion cropping system include pheromone traps, sticky traps and water pan traps.
- Common trap colours include yellow, blue and white, depending on the target insect species, e.g. whiteflies are attracted to yellow colour, whiles thrips prefer white and blue colour.
- In addition to direct pests counts on the crop, trap catches can also be used to decide the action threshold for some of the pests to ensure timely implementation of control measures.
- Action thresholds based a combination of trap catches and sampling on the crop will offer a more accurate information on when to initiate control measures.

Blue sticky trap for monitoring thrips population in onion field (Photo: Rosemary Collier, The University of Warwick, UK). Note that there catches of other insect species such as onion flies.

Yellow pan trap for monitoring onion flies and other insect species (Image from https://aphidtrek.org).

Establishing action thresholds for pests

- The aim of using traps for insect monitoring is to predict insect densities that cause crop damage or yield reduction or commodity losses so that timely control actions can be taken.
- Pest densities are monitored indirectly from the crop, using trap catches as an indication of pest density on the plant.

- Therefore, determining the relationship between trap catches of the pest with its numbers in the crop and related yield losses are critical to make correct control decisions.
- Begin monitoring pest population before applying or changing pest control practices.
- First learn what the trap catches reflect in comparison with pest injury and crop quality when using your conventional management practices.
- Then begin modifying pest control actions based on monitoring information.
- Farmers who regularly monitor their crops can develop their own thresholds, such as number of adults caught each week in well-maintained traps.
- Other types of numerical thresholds can be developed for pest monitoring, including visual inspection on plants for pests' presence or damage – e.g. percent number of plants with infestation or number of pests per shaken sample of plants.
- Due to the many variables and the lack of adequate research, growers and farmers can experiment over time to develop thresholds that are appropriate to their situations.
- Establish thresholds by judging the acceptability of the harvested crop in comparison with your records of pest density monitored throughout that production cycle.
- Keep good records and be flexible in adjusting thresholds or adapting monitoring and management methods appropriately.
- E.g. sticky traps alone are generally not a good tool for directly determining the need or timing of treatment application.
- Traps must often be used in combination with visual inspection of plants and other scouting methods to be effective or for informed decision making.
- However, traps are often very efficient and important tool alerting growers of the presence of pests before damage is observed on the crop.

Table 3. *Some suggested thresholds for some common pests from trap catches in tomato cropping system*

Name of pest	Type of trap	No of traps per hectare (monitoring)	No of traps per hectare (mass trapping)	Action threshold	Comments
Thrips – *Thrips tabaci*	Blue or white sticky traps	5	> 5	15 or more per week per 100 m²	Normally used for monitoring
Cutworms – *Agrotis* spp.	Delta pheromone trap with a sticky surface	1	> 5	7 or more adults per trap per week indicate treatment is necessary	
Onion fly – *Delia antiqua*	Yellow sticky traps or water pan trap	5	> 5		
Onion leaf miner – *Phytobia cepae*	Yellow sticky trap	5	> 5		
Blister beetle – *Epicauta blineata*	Blue sticky trap	5	> 5		
Leafworm – *Spodoptera littoralis*	Pheromone-baited Delta sticky trap	1	> 5		

Things to do to make traps effective for pest monitoring and mass trapping

- Traps must be serviced regularly by replacing them when the sticky surface is full of catches or change lure when it expires.
- Traps should be suspended at the same height of crop to make them efficient.
- The correct trap density (number of traps per unit area) is required to achieve the desired purpose, either for monitoring or mass trapping of pests.
- Choose the preferred colour for trap based on the target pests.
- Most insects are attracted to yellow colour, whiles others are also attracted to blue and white colours.

4.3 Overview of commercial or beneficial biocontrol agents for pest management in vegetable (onion) cropping system

Ghana now has the Phytosanitary and regulatory framework in place by the Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture (MoFA), that allows the importation of beneficial or biocontrol agents into the country to control pests or the augmentation of locally available biocontrol agents.

Table 4. *Some commercial/beneficial biocontrol agents for pest management*

Pest	Potential Biocontrol agents
Thrips – *Thrips tabaci*	• Entomopathogenic fungi, *B. bassiana, M. anisopliae, Lecanicillium lecanii* and *Metarhizium flavoviride* var. *minus*
Cotton leafworms – *Spodoptera littoralis*	• Use of parasitoids (braconids, encyrtids, tachinids and ichneumonids) and predators such as ladybird beetles, predatory beetles and spiders • Ladybird beetles have been noted to prey on young larvae and eggs • *Bacillus thuringiensis aizawai* (Bta) • *Beauveria bassiana*
Onion fly – *Delia antiqua*	• Entomopathogenic nematodes • Entomopathogenic fungi • Braconid parasitoids attack the onion fly • Predator *Aleochara bilineata* attack onion maggot eggs, larvae and pupae • Pathogens – *Entomophthora muscae*
Onion leaf miner – *Phytobia cepae*	• *Trichogramma* spp. (effective egg parasitoid) • Beneficial bacteria *Bacillus thuringiensis* • beneficial fungi – *Metarhizium anisopliae* var. *anisopliae, Beauveria bassiana*
Cutworms – *Agrotis* spp.	• The parasitic wasp *Cotesia (Apanteles) ruficrus* has been used in biocontrol programmes • Common predators include ground beetles, lacewings, praying mantis, ants and birds • Hens are useful because they dig out and eat cutworms present near the soil surface. They are very effective when confined on garden beds prior to planting. • A host specific and small braconid wasp, *Snellenius manilae* only parasitizes cutworm larvae • *Cotesia* spp. • Tachinid fly
Blister beetle – *Epicauta blineata*	• Spinosad • *Bacillus thuringiensis gallariae (Btg)* – attacks both larval and adult stages • *Bacillus thuringiensis tenebrionis* – attacks leaf-feeding beetle larvae • Birds
Root knot nematodes	• Free living soil fungi, *Trichoderma spp.* • Three antagonistic microbes' bacterium *Pseudomonas fluorescens*, fungus *Paecilomyces lilacinus* and yeast *Pichia guilliermondii*

5. Conclusion

- In order to effectively manage pests and diseases, a combination of management strategies (cultural, biological, physical, host plant resistance, chemical, etc.) must be used to achieve sustainable control.
- Preventive measures must be put in place to prevent the occurrence and spread of pests and diseases.
- Monitor or scout for pests and diseases regularly before they spread to implement control measures on time.
- Once the action threshold of pests is reached, control measures must be implemented to avoid pests causing serious damage to your crop.
- Pesticides will continue to be an integral part of our pests and diseases management efforts, but careful selection of the right pesticides is required to achieve effective pest control 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.
- It is recommended that the synthetic pesticides are used mostly from the nursery to the vegetative stage.
- Use the biological or biorational pesticides during the bulb formation stage of the onion crop to ensure food safety and to promote the activities of beneficial insects (pollinators and natural enemies of the pests) in the field.

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