Module 4: Diseases of Cruficers & it's Management

OBJECTIVES

The main objectives of this chapter are to acquaint the students about the:

i) symptoms of different crucifer diseases;
ii) epidemiology and management of different crucifer diseases.

SUMMARY

Cruciferous vegetable (cabbage, cauliflower, broccolis, brussels sprouts, knolkhol, radish, turnip and rutabaga etc.) group constitutes low volume and high value seed crops. These cool-season crops are well-adapted for spring and fall production. While most of the production is for processing, both processing and fresh markets demand high-quality produce free of blemishes. Diseases are important factors limiting the production of leafy greens. Diseases mainly cause damage by reducing crop quality. Severe disease development can reduce quality to the point where the crop is unmarketable. Cruciferous plants can be protected against diseases by physical, chemical and biological means or by its own internal barrier known as disease resistance. The use of resistant variety is one of the best way to control certain diseases.

Introduction

Cruciferous vegetable group constitutes low volume and high value seed crops. The amount of vegetables produced in the country at present serves per capita per day intake of vegetables only around 145grams against the requirement of 285 grams. Unfortunately, diseases are the important limiting factors which restrict the fast expansion of cultivation and productivity of vegetable crops. The important diseases of crucifers, symptoms and management practices are discussed here.

1. Damping-Off & Wire stem

Causal Agent: *Pythium* spp., *Fusarium* spp., *Rhizoctonia solani*

Symptoms

Pre-emergence damping-off is generally caused by the invasion of the host by the fungus prior to plant emergence from soil. This is due to conditions that inhibit or slow seed germination, while allowing pathogen to grow. Post-emergence damping-off occurs on young seedlings at or near the soil line. The host tissue appears water-soaked and constricted, eventually leading to seedling collapse. Infection on hypocotyl or stem of older plants by *Rhizoctonia solani* may produce canker. Infected stems may be somewhat smaller in diameter than normal, but tough and wiry; hence, the name "wirestem".

Epidemiology

The disease is promoted by high humidity and high temperature. Temperature between 24 to 30^{o}C is congenial for the development of the disease. Oospores survive in the soil act as the primary source of inoculum.

Management

A. Cultural practices

1. Fresh seed should be purchased each year.
2. Seed should be planted in the recommended depth.
3. Seed should always be planted in raised seed bed.
4. Use sterilized soil when planting seeds in pots.
5. Disinfest tools and potting containers used in seeding/ transplanting operations.

Seed Treatments

i) Metalaxyl or Cymoxanil or Thiram or Captan @ 2.5g/kg seed or mixture of Carboxin and Thiram @3g/kg seed.

ii) Seed treatments also can be done with bio-control agents such as *Trichoderma* @10g/kg seed or *Psuedomonas fluorescence* @5g/kg seed.

B. Soil drenching

Soil drenching can be done with the chemicals such as Metalaxyl + Mancozeb (Metalaxyl 8% + Mancozeb 64%) or Copper oxychloride @2g/l of water. Drench the soil 5-6 days before sowing and repeat 3-4 times at 10 days interval.

2. Black leg

The disease was first described in France in 1849.

Causal Agent: *Leptosphaeria maculans* (anamorph: *Phoma lingam*)

Symptoms

Symptoms manifest as oval, sunken, light-brown cankers with purple-to-black margins near the base of stems. Lesions may also develop on cotyledons and hypocotyls of young seedlings and appear on leaves as pale, irregular spots. Leaf spots gradually enlarge, becoming circular with gray centers.

Epidemiology

The fungus can survive in crop debris and cruciferous weeds. Infected seed, however may also be a source of primary inoculum. The disease may also be spread by splashing rain, workers and equipment.

Management

i) Destruction of the crop residues by rapid plowing in the field.

ii) Fumigation, solarization or flooding of infested fields helps in reducing field inoculum levels.

iii) Crop rotation with non-host plant for at least 3 years.

iv) Hot water treatment of seed at 50^{0}C for 30minutes can be effective for lightly infected seeds.

iv) Benzimidazole fungicides are the most effective slurry treatment.

3. Club rot

Causal organism: *Plasmodiophora brassicae*

Symptoms

The most important characteristic symptoms of the disease consists of small or large, spindle like spherical, club shaped swelling on the roots and rootles. Affected plants show decline in vigour first and partly recover by forming adventitious roots. The infected roots may rot and perish as a result of secondary infection.

Epidemiology

Infected roots serve as the major source of inoculum and release zoospores, which infect root tissue. Acidic soils and temperatures ranging from 12-27°C allow for rapid disease development.

Management

i)Eradicate cruciferous weeds and volunteers.

ii) Implement five-to-seven years crop rotations with non-hosts,

iii)Lime soil to a pH of 7.3 or more.

v) Seed bed areas can be kept free from the pathogen by treating the soil with chloropicrin or formalin approximately 2 weeks before planting.

4. Alternaria leaf spot / Alternaria blight

Causal organism: *Alternaria brassicae, Alternaria brassicola A. raphani*

Symptoms

These *Alternaria* species cause leaf spots that appear on older tissue and often begin as small, circular lesions. These lesions expand and develop concentric rings with chlorotic haloes. They may also infect seedlings with symptoms appearing as black streaks on cotyledons and hypocotyls, which may result in damping-off. Infected pods produce small, discolored and shriveled seeds.

Epidemiology

The pathogen survives through spores (conidia) or mycelium in diseases plant debris and weed host like *Anagalis arvensis* L., *Convovulus arvensis* L., *Chenopodium*, radish and other cultivated crucifers. Moist (above 70% RH) and warm weather (12-25^{0}C) with intermittent rains play vital role for disease development.

Management

i) Crop rotation

ii) Burn debris

iii) Deep plowing

iv) Application of balanced dose of fertilizers.

v) Use healthy seed or pathogen free seed.

vii) Timely showing of the crop.

viii) Removal of weeds.

ix) Spray with fungicides like Mancozeb or Iprodione @0.2% at fifteen days interval soon after disease appearance.

5. White rust

This is also known as white blister disease. This is a common disease of cruciferous plants.

Causal organism: *Albugo candida*

Symptoms

White rust affects every known cruciferous crop. Symptoms manifest as chlorotic or necrotic spots on upper leaf surfaces. Later pustules form on abaxial leaf surfaces, small stems and floral parts. Pustules rupture the host epidermis and expose a white, chalky dust of sporangia in small, zonate areas. Occasionally affected portions of leaves are swollen and distorted. On flower stalks, distorted stems and flowers result in a staghead appearance.

Epidemiology

Overwintering of white rust by means of oospores in plant debris and weed host serves as primary source of inoculum. Moist (above 75% RH) and cool weather (5-12^{0}C) with short days i.e cloudy days (2-6 hrs sunshine) favours the disease development.

Management

i) Crop rotation
ii) Burn debris
iii) Deep plowing
iv) Application of balanced dose of fertilizers.
v)Use healthy seed or pathogen free seed.
vi) Seed treatment with Metalaxyl @6g/kg.
ix) Spray with fungicides like Ridomil MZ 72 WP@ 0.2% at 15 days interval soon after appearance of the disease.

6. Bacterial Soft Rot

Causal Agent: *Pectobacterium* spp. (synonym: *Erwinia* spp.), *Pseudomonas marginalis* pv. *marginalis*

Symptoms

Symptoms first appear on leaves as small, water-soaked lesions that quickly enlarge. Affected tissue turns brown and becomes soft and mushy with an accompanying foul odor. Eventually, leaves, stems and roots may decay entirely. This disease may be found in the field on cabbage, Chinese cabbage, rutabaga and turnips, but post-harvest soft rot during shipping or storage accounts for the majority of
losses from this pathogen.

Epidemiology

Soft rot bacteria survive in soil and decaying plant material and infect plants through wounds, stomata or hydathodes. The pathogen is generally spread by irrigation water, rain, several species of maggot flies and other insects. Disease development is usually favoured by warm temperature of 25-30°C.

Management

To minimize soft rot losses, control insects, try to avoid mechanical injury during harvest, packing and shipping, and do not pack the produce when wet. Additionally, store and ship produce at temperatures near 4°C.

7. Black Rot

Causal Agent: *Xanthomonas campestris* pv. *campestris*

Symptoms

Symptoms manifest as localized wilting at leaf margins. Wilted tissue becomes chlorotic and progresses to form the characteristic V-shaped lesion associated with this disease. Within chlorotic tissue, leaf veins turn black, giving the disease its name – black rot. At advanced stages, affected tissue becomes brown and necrotic.

Epidemiology

The black rot organism can survive in crop residue for upto two years. The bacterium can also infect cruciferous weeds, such as pepper grass, wild radish, black mustard, wild turnip and others. Though hydathode infection is most common, stomatal entry may occur when plants are subjected to heavy rains or irrigation. With warm temperatures of 27-30°C, symptoms may appear in 10 to 12 days. Spread of the disease in the field generally occurs by wind-blown rain, irrigation water, cultivation, insects or animals. The bacterium can be seedborne, which may result in seedling infection.

Management

i) Use high-quality seed free of *X. campestris* pv. *campestris.*
ii) Implement a three-year rotation to non-cruciferous crops.
iii) Seed beds should be geographically isolated from commercial crucifer crops.
iv) Do not clip transplants.
v) Plant crops in well-drained soils and use irrigation practices that minimize leaf wetness.
vi) Keep fields free of cruciferous weeds.
vii) Disinfect seed beds and equipment with steam or germicidal sprays before use.
viii) Control insects to minimize spread of the pathogen.

8. Yellows

Causal Agent: *Fusarium oxysporum* f. sp. *conglutinans* and *F. oxysporum* f. sp. *raphani*

Symptoms:

Affected foliage turns dull and chlorotic. Some leaves appear distorted due to uneven growth. Leaves may die prematurely and senesce, starting at the base of the plant. This pathogen invades the vascular system of host plants, turning the vascular tissue brown or yellow. Plants which do not die are often stunted and have one-sided yellowing of the leaves or stem.

Epidemiology

This fungus survives in the soil and produces spores which can persist in the soil for many years. The fungus enters the plant through the roots and moves into the vascular system. The disease is generally favored by warm temperature. At temperatures below 20°C, disease development is greatly reduced.

Management

Resistant varieties help provide the most effective control of this disease.

9. Cauliflower Mosaic

Causal organism: Cauliflower mosaic virus (CaMV)

Symptoms

Only members of the crucifer family are susceptible to CaMV. Systemic symptoms consist of

a clearing or chlorosis along leaf veins (vein clearing). Later, symptoms appear as dark green areas along veins (vein banding) and necrotic spotting of the leaf. Chinese cabbage is particularly susceptible to CaMV. In addition to vein clearing, a striking mosaic may develop with light and dark green areas on leaves. Internal necrotic spotting in stored cabbage has been attributed to CaMV infection.

Epidemiology

The primary inoculum source of CaMV is infected brassica crops or cruciferous weeds. The virus is transmitted to the crop by many species of aphids, such as the cabbage aphid, the false cabbage aphid and the green peach aphid. Aphids can acquire and transmit CaMV within one minute of feeding on an infected plant. Temperatures between 16-20°C favour symptom expression in plants. CaMV is often found as a mixed infection with Turnip mosaic virus, resulting in more severe symptoms than when either virus is present alone.

Management

i) Eradicate cruciferous weeds and volunteers, and incorporate crop debris immediately after harvest.
ii) Isolate transplant beds from commercial crucifer crops.
iii) Use of insecticides for controlling of insects.

Other minor diseases

Downy Mildew, Phytophthora Root Rot, Powdery Mildew, Ring Spot, Sclerotinia Stem Rot and Watery Soft Rot, Verticillium Wilt, White Leaf Spot, Xanthomonas Leaf Spot, Black Root, Scab, Cercospora Leaf Spot, Radish Mosaic, Turnip Mosaic, Turnip Yellow Mosaic, Cabbage Cyst and root knot.

Conclusion

Cruciferous plants can be protected against diseases by physical, chemical and biological means or by its own internal barrier known as disease resistance. Important diseases of crucifers are damping off, black leg, club rot, alternaria leaf blight, white rust, black leg, yellows and cauliflower mosaic. The present topic discussed on symptomatology, epidemiology and probable management of some important disease strategies with reference to pertaining original research work. The use of resistant variety is one of the best way to control certain diseases.

TRANSCRIPT

Introduction

Cruciferous vegetable group constitutes low volume and high value seed crops. The amount of vegetables produced in the country at present serves per capita per day intake of vegetables only around 145grams against the requirement of 285 grams. Unfortunately, diseases are the important limiting factors which restrict the fast expansion of cultivation and productivity of vegetable crops. The important diseases of crucifers, symptoms and management practices are discussed here.

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Pre-emergence damping-off is generally caused by the invasion of the host by the fungus prior to plant emergence from soil. This is due to conditions that inhibit or slow seed germination, while allowing pathogen to grow. Post-emergence damping-off occurs on young seedlings or near the soil line. The host tissue appears water-soaked and constricted, eventually leading to seedling collapse. Infection on hypocotyl or stem of older plants by *Rhizoctonia solani* may produce canker. Infected stems may be somewhat smaller in diameter than normal, but tough and wiry; hence the name "wirestem".

Epidemiology

The disease is promoted by high humidity and high temperature. Temperature between 24 to 30^{o}C is congenial for the development of the disease. Oospores survive in the soil, act as the primary source of inoculum.

Disease Management

C. Cultural practices

6. Fresh seed should be purchased each year.
7. Seed should be planted in the recommended depth.
8. Seed should always be planted in raised seed bed.
9. Use sterilized-soil when planting seeds in pots.
10. Disinfest tools and potting containers used in seeding/transplanting operations.

Seed Treatments

i) Metalaxyl or Cymoxanil or Thiram or Captan @ 2.5g/kg seed or mixture of Carboxin and Thiram @3g/kg seed,

ii) Seed treatments also can be done with bio-control agents such as *Trichoderma* @10g/kg seed or *Psuedomonas fluorescence* @5g/kg seed.

D. Soil drenching

Soil drenching can be done with the chemicals such as Metalaxyl + Mancozeb (Metalaxyl 8% + Mancozeb 64%) or Copper oxychloride @2g/l of water. Drench the soil 5-6 days before sowing and repeat 3-4 times at 10 days interval.

2. Black leg

Causal Agent: *Leptosphaeria maculans* (anamorph: *Phoma lingam*)

Symptoms

Symptoms manifest as oval, sunken, light-brown cankers with purple-to-black margins near the base of stems. Lesions may also develop on cotyledons and hypocotyls of young seedlings and appear on leaves as pale, irregular spots. Leaf spots gradually enlarge, becoming circular with grey centers.

Epidemiology

The fungus can survive in crop debris and cruciferous weeds. Infected seed, however may also be a source of primary inoculum. The disease may also be spread by splashing rain, workers and equipment.

Disease Management

i) Destruction of the crop residues by rapid ploughing in the field.

ii) Fumigation, solarisation or flooding of infested fields help in reducing field inoculum levels.

iii) Crop rotation with non-host plant for at least 3 years.
iv) Hot water treatment of seed at 50^0C for 30minutes can be effective for lightly infected seeds.
11. Benzimidazole fungicides are most effective as slurry treatment.

3. Club rot
Causal organism: *Plasmodiophora brassicae*
Symptoms
The most characteristic symptoms of the disease consists of small or large, spindle like spherical, club- shaped swelling on the roots and rootles. Affected plants show decline in vigour first and partially recover by forming adventitious roots. The infected roots may rot and perish as a result of secondary infection.
Epidemiology
Infected roots serve as the major source of inoculum and release zoospores, which infect root tissue. Acidic soils and temperatures ranging from 12-27°C allow for rapid disease development.
Disease Management
i) Eradicate cruciferous weeds and volunteers.
ii) Implement 5 to7 years crop rotations with non-hosts.
iii)Lime soil to a pH of 7.3 or more.
iv)Seed-bed areas can be kept free from the pathogen by treating the soil with Chloropicrin or Formalin approximately 2 weeks before planting.

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Causal organism: *Alternaria brassicae, Alternaria brassicola A. raphani*
Symptoms
These *Alternaria* species cause leaf spots that appear on older tissue and often begin as small, circular lesions. These lesions expand and develop concentric rings with chlorotic haloes. They may also infect seedlings with symptoms appearing as black streaks on cotyledons and hypocotyls, which may result in damping-off. Infected pods produce small, discolored and shriveled seeds.

Epidemiology
The pathogen survives through spores (conidia) or mycelium in diseases plant debris and weed host like *Anagalis arvensis* L., *Convovulus arvensis* L., *Chenopodium*, radish and other cultivated crucifers. Moist (above 70% RH) and warm weather (12-25^0C) with intermittent rains play vital role for disease development.

Disease Management
i) Crop rotation
ii)Burn debris
iii)Deep ploughing
iv) Application of balanced dose of fertilisers.
v) Use healthy seed or pathogen-free seed.
vii) Timely showing-off the crop.
viii) Removal of weeds.
ix) Spray with fungicides like Mancozeb or Iprodione @0.2% at 15 days interval soon after disease appearance.

5. White rust

Causal organism: *Albugo candida*

Symptoms

White rust affects every known cruciferous crop. Symptoms manifest as chlorotic or necrotic spots on the upper leaf surfaces. Later pustules form on abaxial leaf surfaces, small stems and floral parts. Pustules rupture the host epidermis and expose a white, chalky dust of sporangia in small, zonate areas. Occasionally affected portions of leaves are swollen and distorted. On flower stalks, distorted stems and flowers results in a stag-head appearance.

Epidemiology

Overwintering of white rust by means of oospores in plant debris and weed host serves as primary source of inoculum. Moist (above 75% RH) and cool weather (5-12^{0}C) with short-days i.e cloudy days (2-6 hours sunshine) favours the disease development.

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6. Bacterial Soft Rot

Causal Agent: *Pectobacterium* spp. (synonym: *Erwinia* spp.), *Pseudomonas marginalis* pv. *marginalis*

Symptoms

Symptoms first appear on leaves as small, water-soaked lesions that quickly enlarge. Affected tissue turns brown and becomes soft and mushy with an accompanying foul odour. Eventually, leaves, stems and roots may decay entirely. This disease may be found in the field on cabbage, chinese cabbage, rutabaga and turnips, but post-harvest soft rot during shipping or storage accounts for the majority of
losses from this pathogen.

Epidemiology

Soft rot bacteria survive in soil and decaying plant material and infect plants through wounds, stomata or hydathodes. The pathogen is generally spread by irrigation water, rain, several species of maggot flies and other insects. Disease development is usually favoured by warm temperature of 25-30°C.

Disease Management

To minimise soft rot losses, control insects, try to avoid mechanical injury during harvest, packing and shipping and do not pack the produce when wet. Additionally, store and ship produce at temperatures near 4°C.

7. Black Rot

Causal Agent: *Xanthomonas campestris* pv. *campestris*

Symptoms

Symptoms manifest as localised wilting at leaf margins. Wilted tissue becomes chlorotic and progresses to form the characteristic V-shaped lesion associated with this disease. Within

chlorotic tissue, leaf veins turn black, giving the disease its name – black rot. At advanced stages, affected tissue becomes brown and necrotic.

Epidemiology

The black rot organism can survive in crop residue for upto two years. The bacterium can also infect cruciferous weeds, such as pepper grass, wild radish, black mustard, wild turnip and others. Though hydathode infection is most common, stomatal entry may occur when plants are subjected to heavy rains or irrigation. With warm temperatures of 27-30°C, symptoms may appear in 10 to 12 days. Spread of the disease in the field generally occurs by wind-blown rain, irrigation water, cultivation, insects or animals. The bacterium can be seed-borne, which may result in seedling infection.

Disease Management

i) Use high-quality seed free of *X. campestris* pv. *campestris.*
ii) Implement a 3-year rotation to non-cruciferous crops.
iii) Seed-beds should be geographically isolated from commercial crucifer crops.
iv) Do not clip transplants.
v) Plant crops in well-drained soils and use irrigation practices that minimise leaf wetness.
vi) Keep fields free of cruciferous weeds.
12. Disinfect seed beds and equipment with steam or germicidal sprays before use.
13. Control insects to minimise spread of the pathogen.

8. Yellows

Causal Agent: *Fusarium oxysporum* f. sp. *conglutinans* and *F. oxysporum* f. sp. *raphani*

Symptoms

Affected foliage turns dull and chlorotic. Some leaves appear distorted due to uneven growth. Leaves may die prematurely and senesce, starting at the base of the plant. This pathogen invades the vascular system of host plants, turning the vascular tissue brown or yellow. Plants which do not die are often stunted and have one-sided yellowing of the leaves or stem.

Epidemiology

This fungus survives in the soil and produces spores which can persist in the soil for many years. The fungus enters the plant through the roots and moves into the vascular system. The disease is generally favoured by warm temperature. At temperatures below 20°C, disease development is greatly reduced.

Disease Management

Resistant varieties help provide the most effective control of this disease.

9. Cauliflower Mosaic

Causal organism: *Cauliflower mosaic virus* (CaMV)

Symptoms

Only members of the crucifer family are susceptible to CaMV. Systemic symptoms consist of a clearing or chlorosis along leaf veins (vein clearing). Later, symptoms appear as dark green areas along veins (vein banding) and necrotic spotting of the leaf. Chinese cabbage is particularly susceptible to CaMV. In addition to vein clearing, a striking mosaic may develop with light and dark green areas on leaves. Internal necrotic spotting in stored cabbage has been attributed to CaMV infection.

Epidemiology

The primary inoculum source of CaMV is infected brassica crops or cruciferous weeds. The virus is transmitted to the crop by many species of aphids, such as the cabbage aphid, the false cabbage aphid and the green peach aphid. Aphids can acquire and transmit CaMV

within one minute of feeding on an infected plant. Temperatures between 16-20°C favour symptom expression in plants. CaMV is often found as a mixed infection with turnip mosaic virus, resulting in more severe symptoms than when either virus is present alone.

Disease Management

i)Eradicate cruciferous weeds and volunteers, and incorporate crop debris immediately after harvest.
ii)Isolate transplant beds from commercial crucifer crops.
iii)Use of insecticides for controlling of insects.

Conclusion

Cruciferous plants can be protected against diseases by physical, chemical and biological means or by its own internal barrier known as disease resistance. Important diseases of crucifers are damping-off, black leg, club rot, alternaria leaf blight, white rust, black leg, yellows and cauliflower mosaic. The present topic discusses on symptomatology, epidemiology and probable management of some important disease strategies with reference to pertaining original research work. The use of resistant variety is one of the best way to control certain diseases.

FREQUENTLY ASKED QUESTIONS (FAQS)

Q1. Write the symptoms of white rust of curcifers.

Ans: White rust affects every known cruciferous crop. Symptoms manifest as chlorotic or necrotic spots on upper leaf surfaces. Later pustules form on abaxial leaf surfaces, small stems and floral parts. Pustules rupture the host epidermis and expose a white, chalky dust of sporangia in small, zonate areas. Occasionally affected portions of leaves are swollen and distorted. On flower stalks, distorted stems and flowers result in a staghead appearance.

Q2. Write the symptoms of damping-off and wire stem of crucifers.

Ans: Pre-emergence damping-off is generally caused by the invasion of the host by the fungus prior to plant emergence from soil. This is due to conditions that inhibit or slow seed germination, while allowing pathogen to grow. Post-emergence damping-off occurs on young seedlings at or near the soil line. The host tissue appears water-soaked and constricted, eventually leading to seedling collapse. Infection on hypocotyl or stem of older plants by *Rhizoctonia solani* may produce canker. Infected stems may be somewhat smaller in diameter than normal, but tough and wiry; hence, the name “wirestem”.

Q3. Name two bacterial diseases of curcifers .

Ans. Two bacterial diseases of curcifers are:

- Bacterial Soft Rot**:** *Pectobacterium* spp., *Pseudomonas marginalis* pv. *marginalis*
- Black Rot**:** *Xanthomonas campestris* pv. *campestris*

Q4. Write the management of Black rot disease of crucifer.

Ans: The management of Black rot disease are:

- Use high-quality seed free of *X. campestris* pv. *Campestris*
- Implement a three-year rotation to non-cruciferous crops.
- Seed beds should be geographically isolated from commercial crucifer crops.
- Do not clip transplants.
- Plant crops in well-drained soils and use irrigation practices that minimize leaf wetness.
- Keep fields free of cruciferous weeds.
- Disinfect seed beds and equipment with steam or germicidal sprays before use.
- Control insects to minimize spread of the pathogen.

Q5. Write the symptoms of Cauliflower Mosaic**:** Cauliflower mosaic virus (CaMV).

Ans: Only members of the crucifer family are susceptible to CaMV. Systemic symptoms consist of a clearing or chlorosis along leaf veins (vein clearing). Later, symptoms appear as dark green areas along veins (vein banding) and necrotic spotting of the leaf. Chinese cabbage is particularly susceptible to CaMV. In addition to vein clearing, a striking mosaic may develop with light and dark green areas on leaves. Internal necrotic spotting in stored cabbage has been attributed to CaMV infection.

GLOSSARY

1. **Virus:** A sub-microscopic obligate disease causing agent.
2. **Volunteer:** A cultivated plant growing from self-sown or accidentally dropped seed or vegetative matter.
3. **Zoospore:** An asexually produced fungal spore bearing flagella and capable of active movement in water.
4. **Sporangium(pl. sporangia)**: A spore case of fungi; commonly a sac-like or flask-like fungus structure of which the contents are converted by cleavage into an indefinite number of endogenous asexual spores.
5. **Seedborne pathogen:** Infectious agent associated with seed and having the potential of causing a disease of a seedling or a plant.
6. **Mycelium (pl. Mycelia):** The mass of thin, microscopic, hair-like structures that forms the vegetative part of a fungus.
7. **Necrosis (adj. necrotic):** The death of plant cells or tissues, usually accompanied by black or brown darkening.
8. **Nematode:** Tiny worms that can live in plants, animals, soil or water.
9. **Oospore:** A sexual spore produced by the union of two morphologically different gametangia (oogonium and antheridium).

10. **Hydathode:** A leaf structure that eliminates unused salts, sugars and water from a plant through a pore at the leaf margin.
11. **Hypocotyl :**The lower stem of a plant between the cotyledons and the roots.
12. **Chlorosis (adj. chlorotic):** The failure of chlorophyll development caused by disease or a nutritional disorder; the fading of green plant color to light green, yellow or white.
13. **Damping-off:** A rotting of seedlings at or below soil level.