crucifers package

Cruciferous vegetables are economically the most important vegetable crops throughout the world. They are normally considered temperate crops, but are also important in the tropics. They are valuable sources of nutrition, including vitamins A, C, Niacin, Folic acid, and dietary fiber. In recent years, crucifer production has been seriously affected by a steady increase in pests and diseases that reduce yield and quality of produce. This increase could be due to the indiscriminate use of pesticides and the development of pesticide resistance. This brochure describes successful IPM Innovation Lab (IPM IL) approaches that have been tested by scientists, extension agents, and farmers to manage crucifer pests, diseases, and viruses. Pictures, descriptions of key pests, and recommendations for management are provided.

WHAT IS IPM?
Integrated pest management (IPM), an environmentally-sound and economical approach to pest control, was developed in response to pesticide misuse in the 1960s. Pesticide misuse has led to pesticide resistance among prevailing pests, a resurgence of non-target pests, loss of biodiversity, and environmental and human health hazards.

WHAT ARE IPM PACKAGES?
The IPM Innovation Lab has developed and tested robust IPM packages, holistic suites of IPM recommendations and practices for the production of vegetables and other crops. Farmers who use IPM packages in planting, production, and throughout the supply chain see enhanced profitability in their crops. The recommended practices in IPM packages cover economically significant pest species over a wide range of cropping systems across the tropical world, resulting in benefits to human health and the environment.

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**DISEASES**

**Black Rot**

*Xanthomonas campestris pv. campestris*

Considered the most important disease of crucifer crops worldwide. All crucifer crops are susceptible to black rot. Plants can be infected during any growth stage. Initial symptoms are seen as 1-3 cm irregular yellow areas along the leaf margins. These lesions expand toward the midrib giving the affected areas a wedge or V-shape. These lesions coalesce as the disease progresses, giving leaf margins a scorched appearance and severely affected leaves may drop off. V-shaped marginal lesions occur when bacteria enter the leaves through hydathodes (natural openings at the vein ends on leaf margins). Bacteria can also enter leaves through wounds due to insect damage or root injury. Soft rotting follows invasion of petioles and head leaves of brassicas.

**Bacterial Soft Rot**

*Pectobacterium carotovorum*
syn *Erwinia carotovora* subsp. carotovora, *Erwinia carotovora* subsp. atroseptica and *Pseudomonas marginalis*

It is another significant disease of crucifers. It occurs on all crucifer crops but is more prevalent on Chinese cabbage and common cabbage. The disease can occur in the field, or produce in transit or in storage. Early symptoms appear as water-soaked lesions, which expand rapidly, and the affected areas turn soft, mushy and rotten. Soft rot-infected plants give off an unpleasant sour odor.

*Xanthomonas Leaf Spot*

*Xanthomonas campestris pv. campestris*

Occurs on all cultivated crucifers. Symptoms appear as depressed, translucent water-soaked spots on leaves, but lesions can also occur on cotyledons, flowers and fruits. The leaf spots develop into brown-to-black-colored circular lesions surrounded by chlorotic margins. Dry tissue falling from the center of lesions give a shot hole appearance to the leaves. Symptoms are generally confined to tissues between veins but necrotic streaks may be present along the sides of the veins. Under severe infestation, the entire leaf may collapse.

**Clubroot**

*Plasmodiaphora brassicae*

Most crucifer crops are susceptible to clubroot. It develops extensively on roots before any above ground symptoms are observed. Swelling of fine roots, secondary roots and taproots results in the formation of large spindle-shaped club roots. It impairs the ability of plants to efficiently absorb water and nutrients and the plants become stunted and wilted. The roots also become more susceptible to invasion by soft rot pathogens.

**Downy Mildew**

*Hyaloperonospora parasitica*

Widespread throughout the world. Extent and severity of infection is more pronounced in younger plants than older plants. All aerial plant parts can become infected; however, symptoms appear primarily on leaves and inflorescences. Symptoms appear as dark-colored specks on leaves, usually first on the underside of the leaf. A distinctive characteristic is the presence of fluffy whitish-grey mass of conidiophores and conidia on the underside of leaves. A yellow irregular-shaped area appears on the upper side of the leaf corresponding to the sporulation growth on the underside. On the cabbage heads or cauliflower curds, symptoms appear as dark, sunken spots and dark brown internal streaks can develop on heads.

**Powdery Mildew**

*Erysiphe cruciferarum*

Symptoms occur as white lesions on upper surface of foliage and later appear as a powdery sugar-like growth. It could also occur on shoots and sometimes on flowers. Leaves turn yellow, die and fall off. The disease reduces crop yield and quality.

**Yellows, (Fusarium Wilt)**

*Fusarium oxysporum f. sp. conglutinans*

Cabbage is the most susceptible host crop, but Fusarium Yellows can also affect other brassica crops. It could affect any growth stage, from seedlings to mature plants. Initial symptoms appear as a dull yellowish green discoloration of leaves and plant stunting. Discoloration of leaves is more intense on one side of the plant and results in twisting of leaves and stems. The disease is more pronounced on lower leaves and progresses upwards. Lower leaves turn brown and brittle and drop off prematurely. Under severe infestations, young seedlings and plants are quickly killed. Vascular system develops a distinctive brown discoloration.
cruciferous diseases and viruses

Photos
(From left):
• Cauliflower mosaic virus
• Turnip mosaic virus
• Black soft rot

Damping off and Wirestem
Pythium spp. and Rhizoctonia solani
All plant growth stages are susceptible. When young seedlings are attacked, before or after emergence, it is referred to as damping off. When older seedlings are attacked, the cortical tissue is damaged. The lower stem becomes constricted and becomes dark-brown near the soil surface. This symptom is called wire-stem. Such plants may die when stressed or produce a stunted, unmarketable crop. When lower leaves near the soil line develop large water-soaked lesions, it is called bottom rot. If the infection from lower leaves progresses into cabbage heads, causing decay, it is called head rot.

White mold
Sclerotinia sclerotiorum
The pathogen has a wide host range and affects all crucifers and other vegetables. Appearance of symptoms vary with host plant and weather conditions. Symptoms appear as water-soaked lesions on the stem, leaves or head. These lesions enlarge and are covered by cottony white mycelial growth. The mycelial growth may spread to other plant tissues. Infected plants may wilt, topple or even die. Later on, small black-colored hard sclerotia develop on the mycelial growth. The disease can occur in the field or during transportation.

White leaf spot
Pseudocercospora capsellae; sexual stage: Mycosphaerella capsellae
It can occur on leaves, stem and pods. White-to-tan-colored, round or irregular spots develop on leaves, which later become ash-gray-to-white with a brownish margin. As the leaves age, the center of the lesions may fall out giving a shot hole appearance. Under severe infestations defoliations may occur.

Ring Spot
Mycosphaerella brassicicola
Symptoms appear as water-soaked lesions on leaves and stems and expand to form concentric yellow rings, giving a tattered appearance to leaves and stems.

Cyst Nematode
Heterodera cruciferae
(Nematoda: Heteroderidae)
As the infection begins, plants appear to have a nutrient deficiency followed by wilting, especially in hot weather. The nematode produces lemon-shaped, tan, white-hard cysts on the root surface. Infected plants eventually die.

Root Knot Nematode
Meloidogyne spp.
(Nematoda: Meloidogynidae)
The root knot nematodes have a wide host range and are most severe in warm areas with long growing seasons. Plants infected by root-knot nematodes are generally less vigorous and healthy. Symptoms of nutrient deficiency and diurnal wilting are visible on leaves due to reduced efficiency of the root system. The presence of bead-like galls on roots is characteristic of nematode presence.

VIRUS DISEASES

Turnip Mosaic
Turnip mosaic virus
Also known as rutabaga virus, it is the most prevalent and widespread virus infecting crucifers, especially brassicas, and is transmitted by aphids. Symptoms appear as a distinct mosaic pattern on leaves, necrotic flecks and streak or ringspots, depending on the host and virus strain. Following infection, systemic mosaic symptoms develop rapidly on young plants. Infected plants may be stunted, produce reduced yields and are vulnerable to secondary infections.

Cauliflower Mosaic
Cauliflower mosaic virus
It is transmitted by aphids; Brevicoryne brassicaceae, Myzus persicae. Symptoms include chlorosis along leaf veins, dark green bands, necrosis and stunting of plants.

Radish Mosaic
Radish mosaic virus
Symptoms include mosaic, ring spot, leaf distortion, vein necrosis and leaf etiations. In cauliflower and cabbage, chlorotic and necrotic lesions are also seen. It is transmitted by the chrysomelid beetles e.g. crucifer flea beetles, spotted cucumber beetles and tobacco flea beetles.

Turnip Yellows
Turnip yellows virus
Aphids transmit TuYV aphids and symptoms appear as chlorotic spots followed by yellowing and thickening of leaves.
**cruciferous insect pests**

**Aphids**

*Brevicoryne brassicae, Myzus persicae, Hyadaphis erysimi* (Hemiptera: Aphididae)

Aphids suck the sap from plants, which results in yellowing, curling, and deformation of leaves. Continuous feeding by aphids leads to yellowing, wilting and stunting of plants. Honeydew secretion leads to development of sooty mold. Aphids also vector several important viruses on crucifers including *Cauliflower mosaic virus, Turnip yellow virus, Turnip mosaic virus* etc.

**Whitefly**

*Bemisia tabaci* (Hemiptera: Aleyrodidae)

Whiteflies cause damage by sucking and secreting sticky honeydew. Black sooty mold grows over the honeydew. Extensive feeding may result in stunting, poor growth, defoliation, and reduced yields.

**Cutworm (Common armyworm, Cotton leafworm)**

*Spodoptera litura, S. littoralis* (Lepidoptera: Noctuidae)

Seedlings of young plants are cut very near or below the soil line. It is common to see several plants in a row cut off or wilting due to cutworm damage. Damage is more severe in fields where cutworms are present before planting.

**Cotton bollworm**

*Helicoverpa armigera* (Lepidoptera: Noctuidae)

Young larvae prefer to feed on leaves and flowers but larger larvae feed on flowers, and heads. Feeding holes filled with excreta are characteristic of larval damage. Severe damage leads to yield losses.

**Cabbage head caterpillar**

*Crocidolomia pavonana* (Lepidoptera: Crambidae)

The larvae generally feed on the leaf surface but as they grow older, they also feed inside cabbage heads. The larvae feed upon the leaf surface, leaving major veins intact, but young leaves may be completely eaten.

**Cabbage Looper**

*Trichoplusia ni* (Lepidoptera: Noctuidae)

The larvae feed by chewing holes in leaves and also bore into the head. The larval feeding and frass left behind makes the produce unmarketable. Larval feeding on seedlings causes stunting and death of seedlings.

**Cabbage Webworm**

*Hellula undalis* (Lepidoptera: Crambidae)

The young larvae mine the leaves and feed on the underside of the leaves, chewing small holes. Webbing on the surface of inner leaves is seen and these webs are covered with insect remains and frass. Larger larvae can burrow into buds, stems, and leaves. Larval feeding on growing point of seedlings causes severe damage.

**Diamondback moth**

*Plutella xylostella* (Lepidoptera: Plutellidae)

Plants at all growth stages are susceptible to damage. Larvae feed by chewing holes in leaves and damage is confined to areas between veins. Young larvae feed on underside of the leaves leaving the epidermis intact and giving a windowpane appearance. On young plants, the growing tips are eaten and plants are stunted. The larvae also attack developing cabbage heads, making them prone to attack by pathogens.

**Cabbage butterflies**

*Pieris brassicae and P. rapae* (Lepidoptera: Pieridae)

Young larvae cause damage by scraping the leaves and later by chewing irregular holes in leaves. The larvae cause skeletonization of leaves. The larvae also bore into heads of cabbage and cauliflower.

**Cabbage shield bug**

*Eurydema pulchrum* (Hemiptera: Pentatomidae)

Feeding by nymphs and adults cause necrotic spots on leaves. Damage is confined to older, outer leaves and is localized.

**Painted Bug**

*Bagrada cruciferarum* (Hemiptera: Pentatomidae)

Nymphs and adults feed by sucking sap from tender plant parts, causing yellowing and drying of leaves and premature leaf fall. Heavy infestations reduce growth and yield. Infested plants are also more susceptible to fungal and bacterial infections.

**Striped flea beetle**

*Phyllotreta striolata* (Coleoptera: Chrysomelidae)

Young leaves have small, round holes, which can coalesce to form large holes as leaves mature giving a “shot hole appearance.” Under severe infestation, seedlings may be killed.
**Soil preparation**

A light, well-drained, well-prepared fertile soil results in healthy plants with minimal pest problems. Soil solarization and fertilization combined with compost inoculated with *Trichoderma* spp., neem cake, and *Vesicular Arbucular Mycorrhiza* (VAM) fungus improve the nutrients available to the crop, priming the plant’s own defenses and reducing the incidence of nematodes and other plant diseases.

**Seed selection**

Select a high-yielding, locally preferred crucifer variety that is resistant or moderately resistant to diseases such as *Turnip mosaic virus*, clubroot and *Fusarium yellows*. Grow transplants in mesh-covered seedbeds to prevent aphids, whiteflies, diamondback moth and flea beetles. Discard diseased seedlings or infected plants. Always use pathogen free seed.

**Seed treatment**

Treating seeds with the *Trichoderma viride* or *T. harzianum* fungi, and *Pseudomonas fluorescens* and *Bacillus subtilis* bacteria protects seedlings from fungal and bacterial diseases, increases seedling vigor, and induces plant defense against pests. Hot water seed treatment is effective against bacterial pathogens like *Xanthomonas*.

**Seedling nursery**

Good seedbed preparation is fundamental to the production of healthy plants. The use of seedling trays and coconut pith medium reduces contamination. Irrigation should be monitored to prevent excess moisture, which increases the incidence of diseases like black rot, *Xanthomonas* leaf spot, and others.

**Sanitation**

Before planting, remove and destroy plant debris or infested plant material from the field to avoid fungal diseases. Remove weeds, which may serve as reservoir for diseases and insect pests.

**Crop rotation**

Crop rotation with non-host or less susceptible crops helps in reducing incidence of soil-borne diseases.

**Fertilization**

Neem cake or mustard cake alone, or in combination with compost inoculated with *Trichoderma* spp., is effective against soil borne diseases. Using neem and mustard cakes reduces the incidence of nematodes. Additionally, they contribute to the build-up of beneficial soil microbes that assist in nutrient absorption by the plants.

**Traps**

Setting up large, yellow sticky sheets in fields helps to reduce pest populations such as aphids and whiteflies. Pheromone traps can be used for the diamondback moth, *Spodoptera* spp. and *Helicoverpa armigera*.

**Biological control**

Inundative release of ladybird beetles helps to reduce aphid populations. Use of neem-based biopesticides helps in managing aphids, whiteflies and other pests. Egg parasitoids *Trichogrammaidea bactrae*, *Diaegma*, *Diadromus*, and *Cotesia* are also effective against diamondback moth. The parasitoids, *Voria ruralis*, *Eucelatoria armigera*, *Microplitis brassicae* and *Chelonus texanus* are natural enemies against the cabbage looper. To a certain extent, eggs of the cabbage head caterpillar are parasitized by *Aphanogmus* spp. Inundative release of parasitoids such as *Trichogramma* spp. and *Bracon* spp. controls caterpillar pests such as *H. armigera* and *Spodoptera* spp.

**Microbial biological control agents**

Beneficial nematodes such as *Steinernema feltiae* and *S. carpocapsae* may be used for the control of the striped flea beetle. Using *Bacillus thuringiensis* is also effective against lepidopteran pests. *S. litura* nuclear polyhedrosis virus (SINPV) is commercially available and used against *S. litura*. *H. armigera* nuclear polyhedrosis virus (HaNPV) can also be used against *H. armigera*. Microbial control agents have little or no impact on parasitoids and predators of pests. For this reason, natural enemies will continue to serve as effective regulators of a variety of pests. By using these biopesticides, one may reduce/eliminate the use of synthetic pesticides.