

# Crop Protection FACTSHEET

## Management of Powdery Mildew, *Leveillula taurica*, in Greenhouse Peppers

### 1. Introduction

Powdery mildew, *Leveillula taurica*, became a new and serious threat to British Columbia's greenhouse bell pepper industry early February, 2003. The disease was found simultaneously in two separate locations near Langley in southern British Columbia. Trace amounts of mildew developed on the foliage of cultivar Zamboni in one operation and 10-80% of the foliage of cultivar Triple Four in an organic operation. Reported pepper fruit yield losses have been 2 to 4 kg/m<sup>2</sup>. By summer, pepper powdery mildew was reported throughout British Columbia's pepper greenhouses.

Dutch research has shown a direct relationship between per cent mildew infection of the leaves and yield loss. One per cent mildew infection on the leaves results in a one percent yield loss. Studies show that the higher the level of powdery mildew infection the higher the loss of production. An early, heavy infection with mildew had about 30% loss of production compared to a later, lighter infection. Powdery mildew generally has caused 10-15% yield loss in NA greenhouse pepper crops. Greenhouse pepper growers need to follow an intensive disease prevention plan because it is very important that powdery mildew never gets out of hand. Once pepper leaves are infected with powdery mildew it is difficult to control; if left unchecked the crop can be entirely destroyed. Monitor the crop right from the start. Apply preventive fungicide sprays once the disease is detected. Carry out strict hygiene throughout the year and practice a thorough year-end clean up. There are no powdery mildew resistant pepper varieties currently available.

Pepper powdery mildew is different in several ways from the mildews that infect tomato (*Erysiphe*, *Oidium lycopersicum*), or cucumber, (*Erysiphe cichoracearum*, *Sphaerotheca fuliginea*). Pepper powdery mildew grows unseen, within the leaf tissue for a latency period of up to 21 days. Unlike tomato and cucumber powdery mildew which is easily seen on the top side of the leaves, pepper powdery mildew grows on the under side of leaves (Figure 1).



Figure 1. Unlike other powdery mildew diseases, greenhouse pepper powdery mildew, *Leveillula taurica*, forms on the under side of leaves not on the upper leaf surface.

Disease monitoring, early detection and prevention of pepper powdery mildew is critical. By the time pepper powdery mildew is detected in a greenhouse many more leaves are already infected but do not show any disease symptoms or signs. In addition, pepper plants can become defoliated and do not recover as quickly as other greenhouse crops when infected with powdery mildew. Pepper powdery mildew does not infect the fruit or stems but can quickly destroy unprotected leaves and eventually the entire pepper crop.

### 2. Distribution

*Leveillula taurica* is a tropical to subtropical fungus which first appeared in North America in Florida in 1971. Since the early 1990's it has been a recurring problem in California on chili and bell peppers, tomato, cotton, globe artichoke, onion and can also infect weed species. By the late 1990's it had spread to Arizona, Idaho, New York, Oklahoma, Utah, Mexico and Ontario. It was first detected in British Columbia in February, 2003 on greenhouse pepper crops and has since spread throughout the greenhouse pepper industry.

### 3. Susceptible Greenhouse Crops and Environment

Over 1000 plant species in numerous plant families are susceptible to the pepper powdery mildew fungus. *Leveillula taurica* has been reported on greenhouse bell peppers but not on any other greenhouse vegetable crop in British Columbia. The disease can also infect tomato and eggplant while cucumbers are not as readily infected.

Pepper powdery mildew infection can occur over a wide temperature range (19-33 °C) with high or low humidity.

### 4. Symptoms

In general, pepper crops become more susceptible to this powdery mildew as they mature. Older plants and lower leaves are the first to show evidence of powdery mildew infection. Pepper powdery mildew needs living host plant tissue to grow and survive. The fungus only infects the leaves not the fruit or stems of pepper plants. Check for pepper powdery mildew by closely inspecting the underside of older leaves for the first signs of the disease. Look for fluffy, white patches of powdery mildew on the underside of leaves (Figure 1). These patches may turn brown rather than remaining white. The top surface of the leaf may appear normal or have diffuse, yellow patches which correspond to the mildew colonies on the lower surface (Figure 2). Early powdery mildew infections can be seen more easily by holding the leaf up to the light and looking for developing mildew colonies. Severely infected leaves wither and drop off causing plants to die. Dutch research showed that the amount of leaf drop depended not only on the severity of powdery mildew but also on the pepper variety. Outbreaks of pepper powdery mildew can devastate a pepper crop. Ontario greenhouse pepper growers have also experienced severe leaf drop resulting in sun burned fruit.



Figure 2. Light yellow spots may also form on the top side of the leaf corresponding to the powdery mildew colonies on the under surface of infected pepper leaves.

### 5. The Disease Cycle

The powdery mildew disease cycle (life cycle) starts when spores (known as conidia) land on a pepper leaf (Figure 3). Spores germinate much like a seed and begin to grow into the leaf. Pepper powdery mildew parasitizes the plant using it as a food source. The fungus initially grows unseen within the leaf for a latency period of 18-21 days. Then the fungus grows out of the breathing pores (stomates) on the under surface of the leaf, producing spores which are borne singly on numerous, fine strands or stalks (conidiophores) (Figure 4). These fungal strands become visible as white patches or mildew colonies on the under side of the leaf. Air currents within the greenhouse carry these microscopic, infectious spores to more plants. Spores are dispersed further through the greenhouse vents. In addition to dispersal by air currents or wind, powdery mildew can spread on ornamental plants and weeds, and by workers on their clothing. Repeated cycles of powdery mildew can lead to severe outbreaks of powdery mildew that economically damage the crop.



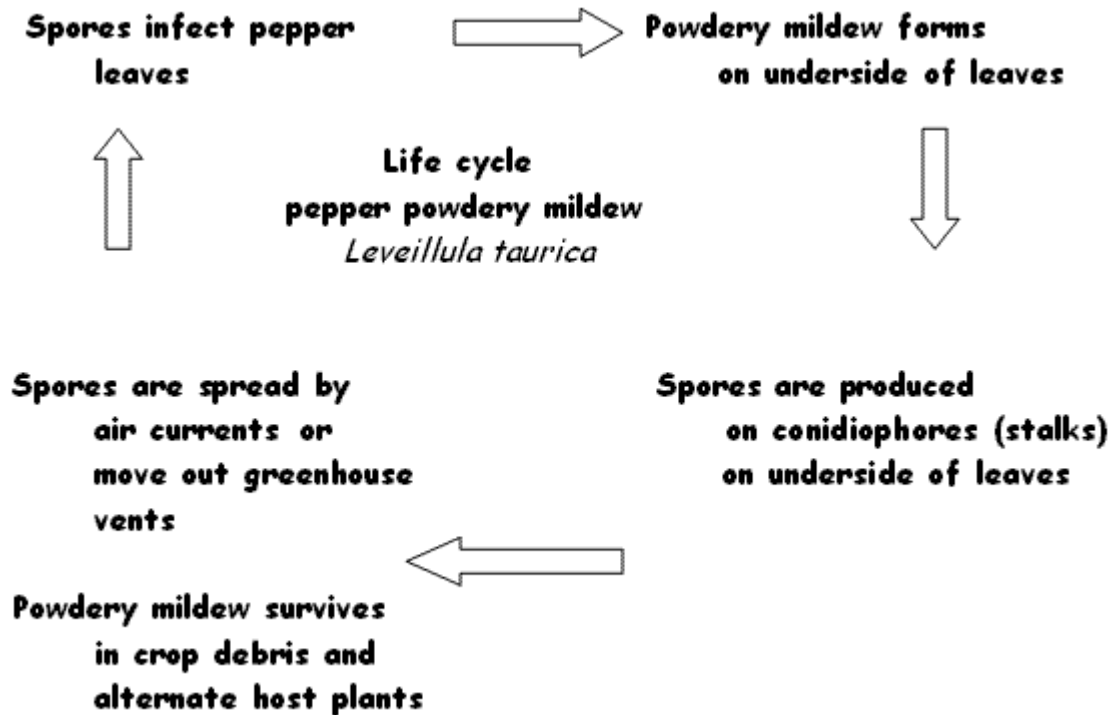
Figure 4. Powdery mildew, *Leveillula taurica*, grows through the stomates and produces white colonies of abundant spores (conidia) borne singly on stalks (conidiophores) on the underside of pepper leaves.

### 6. Lab Diagnosis

Send samples of pepper powdery mildew for lab confirmation to the BC Ministry of Agriculture and Lands provincial Plant Diagnostic Lab. Send a representative sample of infected leaves showing mild to severe symptoms and include some healthy appearing leaves.

Provincial Plant Diagnostic Lab  
BC Ministry of Agriculture and Lands  
Abbotsford Agriculture Centre  
1767 Angus Campbell Road  
Abbotsford BC V3G 2M3  
Tel: 604.556.3126 (directly) or 1.800.661.9903  
Fax: 604.556.3154  
Website: [www.al.gov.bc.ca/cropprot/lab.htm](http://www.al.gov.bc.ca/cropprot/lab.htm)

Figure 3. Life cycle of greenhouse pepper powdery mildew (*Leveillula taurica*)



## 7. Disease Management Plan

### Cultural controls

Take these steps to prevent introducing pepper powdery mildew into your greenhouse:

- Restrict visitor access to the greenhouse
- Follow strict greenhouse hygiene throughout the growing season
- Conduct a through year-end clean up and dispose of all crop debris off-site or by burning or burying in a landfill. For more information consult the BCMAL fact sheet ‘Greenhouse Vegetable Crop Clean-Up’.
- Control outdoor weeds surrounding the greenhouse
- Keep ornamentals and imported tropical plants out of the greenhouse and immediate area
- Improve greenhouse climate to reduce relative humidity and increase air circulation

### Monitoring

**Training workers:** Train workers and integrated pest management (IPM) scouts to recognize early symptoms and signs of powdery mildew. Early disease detection is important for successful powdery mildew control. Follow season-long monitoring for powdery mildew starting as soon as new plants are placed in the greenhouse. Target

areas in the greenhouse for closer inspection where diseases have sprung up in the past or where powdery mildew first started the previous year. Hot spots for powdery mildew are areas where the climate fluctuates, air circulation is poor and relative humidity is high. Powdery mildew is likely to start on older, lower leaves. Remember to check the lower leaf surface for signs of pepper powdery mildew. Also check leaves with oedema spots (water blisters) which indicate relative humidity fluctuations and possibly powdery mildew sites. Use a hand lens or dissecting microscope (15-30 x magnification) to examine the under side of suspect leaves and compare them to healthy leaves.

**Moist chamber:** Enhance early disease detection by placing suspect leaves in a moist chamber made by placing a suspect leaf in a zip lock bag with some moist paper toweling. After a day or two in a warm spot you can use a hand lens (15-30 x) to check the under surface of leaves for white mildew colonies. Be sure to have the disease confirmed by sending a sample to the plant diagnostic lab.

### Resistance

Greenhouse bell pepper cultivars will react differently to powdery mildew infection. Currently there are no powdery mildew resistant bell pepper varieties. Consult your seed supplier for the latest information concerning new developments in resistant pepper varieties.

## Chemical

The disease can be prevented by early application of fungicides. Apply a protectant fungicide when powdery mildew is first detected. Repeat the treatment by alternating with a different fungicide. Continue treatments if your greenhouse has had powdery mildew the previous season or if disease pressure warrants control. If practical, remove and dispose of the first infected leaves or entire plants to help stop the disease build up. Strict hygiene is necessary as powdery mildew can survive in plant debris.

Inactive powdery mildew colonies should be flattened, discolored and not actively expanding once fungicide treatment has been applied. The following fungicides are registered in Canada for pepper powdery mildew control. Always follow label directions and rates. For more information refer to Health Canada's Pest Management Regulatory Agency website: [www.eddenet.pmra-arla.gc.ca](http://www.eddenet.pmra-arla.gc.ca) for fungicide label information.

### Fungicides registered in Canada for pepper powdery mildew control:

Nova 40W (myclobutanil), PCP 22399 (triazole - sterol inhibitor fungicide)

- Nova is used as a systemic protectant and curative fungicide, and has good activity against powdery mildew fungi.
- Apply as soon as possible after initial infection and again 12 days later when disease pressure warrants control.
- Use Nova 40 W at a rate of 340 g/ha
- Apply in 1500- 3000 L/ha for thorough crop coverage.
- Alternate fungicides to avoid fungicide resistance.
- Use no more than a maximum of 3 applications of Nova 40W per crop cycle.
- Do not apply Nova 40W within 3 days of harvest.
- Do not re-enter treated areas within 12 hours of application.

Microscopic Sulphur 92%, PCP 00873 (elemental, inorganic fungicide)

- Microscopic Sulphur is used as a protectant fungicide applied prior to infection.
- Apply uniformly and evenly according to specified interval throughout the cropping season.
- Consider applications in late evening when it is cooler.
- Apply Microscopic Sulphur 92% at 500-700g ai/ha (ai = active ingredient) (= 543-761 g product/ha)
- Use no more than 10 applications per crop cycle
- Apply on a minimum of 14 day interval
- There are no specified days to harvest.

## 8. Research

**Biological control:** There are no biological controls currently registered for pepper powdery mildew. Sporodex (*Pseudozyma flocculosa*) is registered in Canada for powdery mildew control on cucumber and rose but has not been evaluated and is not registered for pepper powdery mildew. Biological control agents are pest control products that also require registration through the federal Pest Management Regulatory Agency (PMRA) system.

Further research is also needed on these potential powdery mildew controls:

- Silica amendment of nutrient solutions
- Bicarbonates (sodium, potassium) as foliar sprays
- Fertilizer salts (calcium, potassium and sulphur) as foliar sprays
- Ionized water as foliar sprays
- Sulphur vaporizers
- Alternative fungicides

## 9. Additional Sources of Information

- BCMAL Infobasket: <http://infobasket.gov.bc.ca/> under Greenhouse Vegetable section A1.4.2.3 'Diseases of Pepper'
- First report of powdery mildew of greenhouse pepper caused by *Leveillula taurica* in British Columbia, Canada. Cerkauskas, R.F. and A. Buonassisi. Plant Disease 87: 1151. 2003.
- First report of powdery mildew of greenhouse pepper caused by *Leveillula taurica* in Canada. Cerkauskas, R.F. and J. Brown. Plant Disease 83:781. 1999.
- Suppression of powdery mildew on greenhouse-grown cucumber by addition of silicon to hydroponic nutrient solution is inhibited at high temperature. Schuenger, Andrew and W. Hammer. Plant Disease 87:177-185. 2003.
- Evaluation of fungicides for control of powdery mildew of greenhouse peppers. Olsen, M.W. et. al. <http://cals.arizona.edu/pubs/crops/az1252/az1252-3c.pdf>
- Cornell University Vegetable MD: <http://vegetablemdonline.ppath.cornell.edu/NewsArticles/PepperyPowdery.htm>
- Pest Management Fact Sheet: Powdery mildew (*Leveillula taurica*) on greenhouse pepper. Isaacson, Peter, 2001. Available upon request from the BC Greenhouse Growers Association: [www.bcgreenhouse.ca](http://www.bcgreenhouse.ca)

- PMRA label search, for fungicide label information: <http://www.eddenet.pmra-arla.gc.ca>
- *Leveillula taurica* - HYPP Pathology home, INRA:  
<http://www.inra.fr/hyp3/pathogene/6levtau.htm>
- Bicarbonate solutions control powdery mildew (*Leveillula taurica*) on sweet red pepper and reduce the development of postharvest fruit rotting. Fallik, E. et. al.  
<http://phytoparasitica.org/phyto/pdfs/1997/issue1/NOTE.pdf>

## 10. Acknowledgements

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