

Powdery Mildew on Vegetables

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Fig. 1. Conidia (spores) that form from hyphae cause infections throughout the growing season. Image courtesy of J. Schlesselman, American Pytopathological



Society.



Fig. 2. *Erysiphe pison* a pea foliage.

Fig. 3. *Golovinomyces cichoracearum* on winter



squash.

Fig. 4. *Leveillula taurica* on pepper. Image courtesy of Dr Parthasarathy Seethapathy, Tamil Nadu Agricultural



University, Bugwood.org.

Fig. 5. *G. cichoracearum* on lettuce. Image courtesy of Gerald Holmes, Strawberry Center, Cal Poly San Luis



Obispo, Bugwood.org. © Tom Trethout

Fig. 6. *Podosphaera xanthii* on melon. Image courtesy of Tom Isakeit, Texas A&M University



Extension.



Fig. 7.L. *taurica* on onion.

Fig. 8. *Erysiphe heraclei* on carrot



foliage.



Fig. 9. *Erysiphe cruciferarum* on kale.

Fig. 10. *L. tauricaon* tomato foliage. Image courtesy of Dollymoon, wikimedia



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Fig. 11. *P.xanthii* on summer squash.

Fig. 12. *Erysiphe polygoni* on bean foliage. Image courtesy of Howard F. Schwartz, Colorado State University,



Bugwood.org.

Fig. 13. *G. cichoracearum* on potato. Image courtesy of Phil Hamm, Pacific Northwest Handbooks.

Quick Facts

- Powdery mildew is widespread in Utah and affects many vegetable, fruit, and landscape plants. There are several species of powdery mildew fungi, and typically they target just a single host, or only hosts in related plant families.
- Powdery mildew is easily identifiable as white, “powdery” patches on the surface of leaves.
- Utah’s environment is favorable to this disease. It thrives in warm temperatures, humid plant canopies, and poor airflow.
- Manage powdery mildew by growing resistant varieties, using cultural pest management practices, and applying organic fungicides such as sulfur or potassium bicarbonate, or conventional fungicides such as chlorothalonil or a strobilurin.

Powdery mildew is one of the most easily recognized fungal plant diseases. It is categorized by spots or patches of white-to-gray powder-like growth on foliage, stems, or fruit. Roughly 700 species exist that infect grasses, ornamentals, weeds, fruit trees, landscape trees, shrubs, and vegetables. The closely-related species of fungi that cause powdery mildew are host-specific (Table 1), meaning they cannot survive without the proper host. Powdery mildew fungi spread in conditions of low rainfall and hot temperatures, making Utah’s climate the perfect environment.

Table 1. Species of powdery mildew and their vegetable hosts in Utah

Powdery Mildew Species	Host Crops
<i>Erysiphe cruciferarum</i>	broccoli, cabbage, cauliflower, kale, and Brussel's sprouts
<i>Erysiphe polygoni</i>	chard, beet, and beans
<i>Erysiphe pisi</i>	pea
<i>Erysiphe heraclei</i>	carrot and celery
<i>Golovinomyces cichoracearum</i>	cucumber, melon, summer squash, and winter squash
<i>Podosphaera xanthii</i>	cucumber, melon, summer squash, and winter squash
<i>Leveillula taurica</i>	onion, pepper, and tomato

Disease Cycle

Powdery mildew fungi are considered “obligate parasites” meaning that they cannot grow without a living host.

Late in the growing season, the powdery mildew fungus initiates sexual reproduction in some plant species. This sexual phase forms resting structures on foliage and other plant parts that are important for overwintering survival. The resting structures are fruiting bodies (chasmothecia) that contain the overwintering spores and are resistant to low temperatures and drought. With warm humid conditions in spring, chasmothecia release wind-blown spores that cause primary infections on susceptible hosts.

Unlike most other fungi, powdery mildew spores can spread and germinate without the presence of moisture. When a spore lands on a suitable host, it germinates and hyphae colonize the leaf surface and specialized hyphal structures (haustoria) penetrate host cells to absorb nutrients. Within 7 to 10 days of this primary infection, the characteristic mix of white mycelium and spores (conidia) is visible. In some powdery mildew species (like those in the *Leveillula* group), the hyphae grow within host tissue.

The massive amount of conidia that form after the primary infection results in multiple secondary infections throughout the growing season. Under conditions of warm and dry weather (75–85° F) with high evening humidity, rapid spread can lead to an epidemic, especially for plants grown closely together. Older foliage is more susceptible to powdery mildew and will likely be the first infected.

Injury

In general, infected plants have white-to-gray patches with powder-like growth on the upper- or under-side of leaves. Less frequently, powdery mildew may also occur on young stems, buds, flowers, and young fruit. The presence of powdery mildew reduces photosynthesis and results in reduced fruit yield and low-quality fruit due to reduced sugar levels. Infections on fruit affect marketability by reducing the product's aesthetics.

Heavily infected vegetable crops may also show symptoms of leaf curling, chlorosis (yellowing), and possible dieback. Fruit yield declines and fruits are smaller and exposed to sunscald from lack of canopy cover. Only melon and cucumber fruits are occasionally directly infected by the pathogen, where the white mycelium is visible on the skin.

Monitoring

Early detection of powdery mildew is critical, so it is important to consistently scout plants for disease. Soon after planting, commercial growers should randomly select 5–10 different locations in the field once a week and check plants for

powdery mildew. Home gardeners may be able to check all plants. Observe the tops and bottoms of older and mature leaves first. Focus on areas of the field that are densely planted, crowded by weeds, vigorously growing, and shaded.

Management

Since powdery mildew can diminish yield, it is important to be proactive with management to reduce disease pressure.

Cultural Control

- Plant resistant varieties. Several varieties of vegetable crops are labeled with some level of resistance against powdery mildew (Table 2). *Podosphaera xanthii* has several races, and varieties labeled as resistant may not be resistant to all races. It is currently unknown what specific races are present in Utah.
- After harvest, remove or plow infected plant material. Powdery mildew overwinters on plant debris and removal can reduce disease occurrence the following season. Remove and destroy all infected parts of the plant (leaves, branches, vines, and infected fruit). Do not place infected plant material in composting piles. Compost pile temperatures are not high enough to kill the pathogen.
- Increase plant spacing. Properly spaced plants will have better air movement, reducing the canopy humidity that can trigger powdery mildew infections.
- Morning irrigation will allow excess moisture to dry from the ground and leaves, reducing evening humidity. Where possible, switch to drip irrigation.

Table 2. Examples of Vegetable Varieties Resistant to Powdery Mildew

Crop	Resistant Varieties
Bean	Contender, Provider, Slenderette
Carrot	Bolero
Beet	Kestrel, Red Acre, Solo
Cucumber	Adam Gherkin, Amiga, Arkansas Little Leaf, Bristol, Bush Pickle, Calypso, Citadel, Cool Breeze II, County Fair, Cross Country, Darlington, Dasher II, Diomede, Diva, Eureka, Fanfare, Fancipak, H-19 Little Leaf, Harmonie, Iznik, Jackson Supreme, Jade, Saladmore, Salt and Pepper, Sassy, Seminis, Slice More, Socrates, Southern Delight, Suyo Long, SV4719CS, Sweet Slice, Talladega, Tasty, Turbo, Tyria, Unagi, Unistars, Vlasstar
Melon	Afterglow, Ambrosia, Aphrodite, Arava, Astound, Athena, Atlantis, Avatar, Camino Europa, Cleopatra, Crescent Moon, Da Vinci, Delicious, Delightful, Divergent, Duchess, El Gordo, Escorial, Full Moon, Hannah's Choice, Infinite Gold, Lilliput, Lilly, Milan, Orange Sherbet, Rockstar, San Juan, Sapomiel, Savor, Shockwave, Sierra Gold, Solstice, Sugar Cube, Torpedo, Sugar Rush, Sun Jewel, Verona
Peas	Avalanche, Dakota, Feisty, Green Arrow, Knight, Maestro, Mr. Big, Oregon Giant, Oregon Sugar Pod II, Penelope, Petite Snap—Greens, PLS 141, PLS 595, Super Sugar Snap
Pumpkins	Benchmark, Big Doris, Blanco, Blaze, Capital, Cargo PMR, Charisma PMR, Cinnamon Girl PMR, Cougar, Denali,

Crop	Resistant Varieties
	Apogee, Dynasty, Early Giant, Early King, Edison, Eureka, Everest, Gemini, Gold Medal, Grizzly Bear, Gumdrop PMR, Jill-Be-Little, Magnum, Mellow Yellow, Mustang, Orion, Pegasus, Pipsqueak PMR, Porcelain Doll, Renegade PMR, Ritz, Rival PMR, Shiver, Spark, Sunlight PMR
Summer Squash	Golden Girl, Sebring Premium, Sligo, Golden Glory, Mabel Dunja, Green Machine, Spineless Perfection, Yellowfin, Golden Glory, Cue Ball, Desert, Gold Star
Winter Squash	Autumn Delight, Autumn Frost, Autumn's Choice, Black Bellota, Bon-Bon, Bugle, Bush Delicata, Butterbaby, Butterscotch PMR, Celebration, Golden Butta Bowl, Honey Bear, JWS 6823 PMR, Metro PRM, Narragansette, Speckled Pup, Starry Night PMR, Sun Spot, Table Treat, Taybelle PM, Tiptop PMR, Unique, Waldo PMR
Tomato	Climstar, Frederik, Geronimo, Granadero, Rebelski
Pepper	Carlomagno, Pizarro
Spinach	Mouflon

Chemical Control

Many fungicides (both organic and synthetic) are available for commercial operations and home gardeners. Consider fungicide treatments when the first sign of powdery mildew is found. Repeated applications should occur every 7–10 days (or according to label recommendations).

Note that some products and product combinations can cause phytotoxicity (plant injury), such as:

- Oils applied at temperatures over 85°
- Sulfur applied at temperatures over 80° F
- Mixing oil and sulfur or applying within 2 weeks of each other

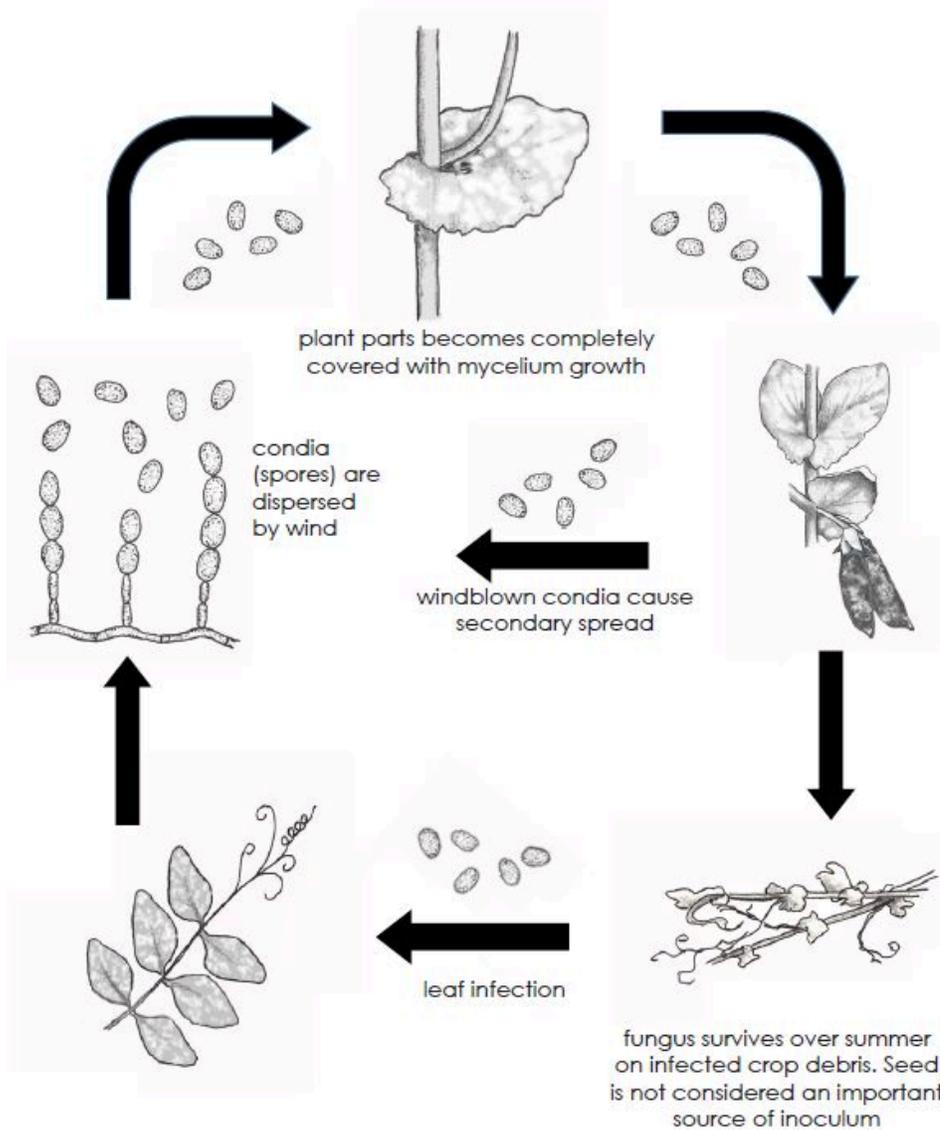


Fig. 14. Simple diagram of the powdery

mildew disease cycle. Image courtesy of Chart referenced from extension.ohio-state.edu (Illustrations by Kylie Fowler).

Table 3. Examples of Fungicides Registered for Commercial Use on Vegetable Powdery Mildew in Utah

Active Ingredient	Brand Name	Cucurbits	Root Crops	Leafy Greens	Solanaceae Crops
Copper sulfate	Cuprofix Ultra	X	X	X	X
Copper hydroxide + mancozeb	Mankocide	X	(see label)	X	X
Sulfur	Cosavet ^o , Microthiol Disperss ^o , Micro Sulf ^o , Thiolux ^o	X	X	X	X

Active Ingredient	Brand Name	Cucurbits	Root Crops	Leafy Greens	Solanaceae Crops
Chlorothalonil	Bravo, Echo, Equus	X	(see label)		X
Benzovindiflupyr + difenoconazole	Aprovia Top	(see label)			
Propiconazole	AmTide Propiconazole 41.8% EC		X		
Cyprodinil + fludioxonil	Switch	X	X	X	X
Azoxystrobin	Quadris	X	X		
<i>Bacillus mycooides</i>	LifeGard ^{OB}	(see label)			
<i>Bacillus subtilis</i>	Serenade ASO ^{OB}	X			
<i>Reynoutrai sachalinensis</i> extract	Regalia CG ^{OB}	X			
Phosphorous acid salts	OxiPhos, Fospite B	X	X	X	X
Hydrogen peroxide + peroxyacetic acid	OxiDate 2.0	X	X	X	X
Neem oil	EcoWorks ^B	X	X	X	X
Mineral oil	PureSpray GREEN ^O , Ultra-Pure Oil Horticultural Insecticide ^O , SuffOil-X ^O , TriTek ^O		X		
Soybean oil	Bionatrol-M ^O	X	X	X	X
Potassium bicarbonate	Kaligreen ^O , MilStop SP ^O	X	(see label)	(see label)	X

Table 4. Examples of Fungicides Registered for Home Use on Vegetable Powdery Mildew in Utah

Active Ingredient	Brand Name	Cucurbits	Root Crops	Leafy Greens	Solanaceae Crops
Copper	Natural Guard Copper Soap, Monterey Lqui-Cop	X	X	X	X
Sulfur + pyrethrins	Natria Insect Disease & Mite ControlB, Bonide Tomato & Vegetable 3-in-1	X	X		X
Chlorothalonil	Fertilome Broad Spectrum Landscape & Garden Fungicide, Hi Yield Vegetable, Flower Fruit & Ornamental Fungicide, Ortho Max Garden Disease Control	X	X		X
Myclobutanil	Spectracide Immunox Multi-Purpose Fungicide	X			X
Potassium salts of fatty acid	Safer Brand Tomato & Vegetable 3-in-1B	(see label)			
Bacillus subtilis strain QST 713	Serenade Garden Disease ControlOB	(see label)			
Oils: mineral-based	Bonide All Seasons Horticultural OilB	X	(see lable)	X	X
Oils: plant-based	Monterey All Natural 3-in-1B, Arborjet Eco-1 Fruit & Vegetable SprayOB	(see label)			

References and Further Reading

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Image Credits

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- 6 Tom Isakeit, Texas A&M University Extension
- 9 alchetron.com
- 10 Dollymoon, wikimedia commons
- 12 Howard F. Schwartz, Colorado State University, Bugwood.org
- 13 Phil Hamm, Pacific Northwest Handbooks
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