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report on
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POWDERY MILDEWS OF ORNAMENTALS

The powdery mildews comprise a large group of fungal diseases that affect woody and herbaceous ornamentals, as well as vegetable, cereal, and fruit crops. The powdery mildew diseases are well named because of the characteristic white to light grayish, powdery appearance of the infected plant parts (Figures 1and 2).

Figure 1. Lilac bush infected with powdery mildew.

Figure 2. Zinnia showing beginning stages of powdery mildew.

Powdery mildews are caused by some 1,100 species of fungi in six, closely related genera: *Erysiphe*, *Microsphaera, Phyllactinia, Podosphaera, Sphaerotheca*, and *Uncinula*. These genera are separated by the type of appendages on and the number of spore sacs (asci) within each sexual fruiting body, called a "cleistothecium" (Figure 3). The genus *Oidium* is the imperfect state of all the fungi. Species of *Oidium* lack the cleistothecia associated with the perfect stage of other powdery mildew fungi. These organism occur throughout the world. Some species of powdery mildew fungi infect only a few closely related host plants. Others attack many genera of plants. The more important powdery mildew fungi that infect ornamentals are listed in Table 1.

The severity of the disease depends on several factors, including the variety or cultivar involved, the age and condition of the plant, when the host is infected, and the weather conditions during the growing season. In general, powdery mildews flourish when the days are warm to hot, the nights are cool, and dew forms on the foliage. Powdery mildews are most severe on crowded plants growing in the shade where air circulation is poor.

Losses from powdery mildew occur from: (1) a reduction in aesthetic value, including the production of fewer flowers of poorer quality; (2) lower photosynthetic efficiency that results in reduced plant growth; (3) greater likelihood of winter injury to perennials because of a weakening of the plants; (4) reduced market value of the cut flowers; and (5) the death of the plant, which is rare.

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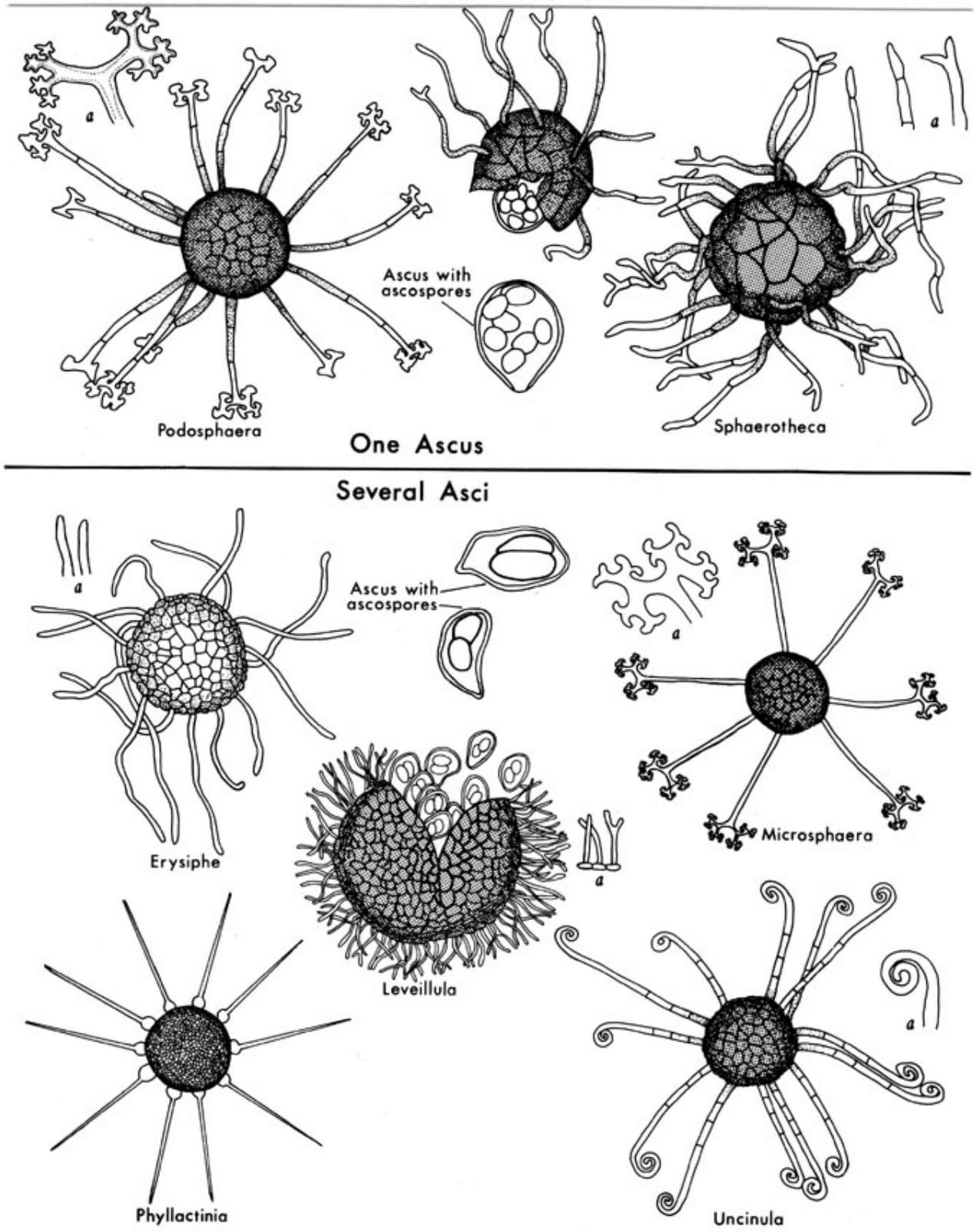

Figure 3. The six genera of powdery mildew fungi. The fungi are classified by the types of appendages on and the number of asci (one or several) within each mature fruiting body (cleistothecium). drawing by Lenore Gray.

Symptoms

Figure 4. Powdery mildew on sweet pea leaves; scattered infections on lower leaf; nearly covered leaf, center; healthy leaf at top (INHS photo).

Powdery mildews first appear as superficial, white, powdery patches on the leaves, young stems, buds, flowers, and even the fruits (Figure 4). These patches may enlarge until they cover the whole leaf on one or both sides. The white powdery growth is composed of mycelium of the fungus and chains of colorless spores (conidia) borne on upright stalks (conidiophores) arising from the white mycelium on the surface of the host plant (Figure 5). Later in the season, these patches may become mealy or felt-like, turn gray to tan in color, and become dotted with minute, dark brown-to-black cleistothecia. A stunting or dwarfing, curling of leaves (Figure 6), chlorosis, premature leaf drop, and deformation of flower buds frequently follow mildew infection. Many powdery mildews, especially those that attack trees and shrubs, are much more unsightly than harmful.

Disease Cycle

The powdery mildew fungi commonly overwinter as mycelial mats in rudimentary leaves within dormant buds, especially on woody plants. Infected buds break open in the spring and may develop into systemically infected shoots. The fungi sporulate on these shoots, producing large numbers of barrel-shaped conidia that are carried by the wind, splashing water, or other means to healthy plant tissue – where they infect the upper and lower leaf surfaces, thus initiating a new disease cycle. Another means of winter survival for powdery mildew fungi in the Midwest is as cleistothecia embedded in the mealy or felt-like mildew growth on plant stems and fallen leaves. The minute cleistothecia are formed within the mycelial mat as the host tissues mature. During warm and humid weather in the spring, a cleistothecium absorbs water and cracks open to discharge one or more asci, depending on the fungus species involved. Each ascus usually contains eight ascospores. The microscopic ascospores are carried by the wind or splashing raindrops to healthy plant tissue where they germinate and may cause infection. A mycelial mat is formed and chains of conidia are evident within a few days, completing the disease cycle.

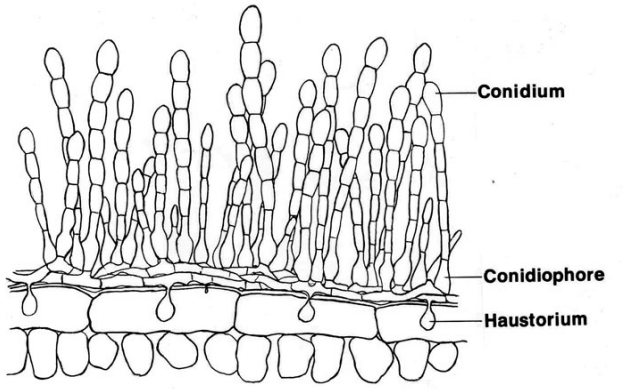

Figure 5. Powdery mildew fungus on the surface of a leaf. Chains of barrel-shaped spores (conidia) are borne on upright stalks (conidiophores). The fungus feeds by means of balloon-shaped sucking organs (haustoria) in the epidermal cells of the host plant.

In greenhouses or in mild climates where the host plants and powdery mildew fungi both grow more or less continuously throughout the year, the cleistothecia are not produced and only the conidia (the *Oidium* stage) are formed. New infection cycles are produced more or less continuously.

Conidia and ascospores that land on the surface of a host plant germinate and form a holdfast structure (appressorium) on the plant surface. A fine penetration tube, or hypha, develops from the bottom of the

appressorium, pierces the cuticle, and enters an epidermal cell where a feeding structure called a haustorium is formed. The fungus develops a dense, branched network of hyphae on the infected plant surface. Additional haustoria form in other epidermal cells. At the same time, short erect branches (conidiophores) develop from the surface hyphae, producing a barrel-shaped conidium at the end of each. Successive conidia are formed, one each day, and commonly remain attached in chains, giving the characteristic powdery white appearance. The conidia eventually break away and are carried by air currents, splashing water, or other means to new infection sites. The conidia are also spread when plants are handled and by the movements of insects, mites, and snails.

Figure 6. Powdery mildew attacking the tip of a young crabapple shoot (courtesy Dr. R.W. Samson).

Epidemiology

When conidia or ascospores fall on a plant surface, they start germinating in 3 hours or less, reaching a maximum at about 25 hours. The optimum temperature for germination is about 71°F (32°C); the minimum about 42°F (5°C); and the maximum, close to 95°F (35°C). Spore germination occurs on the plant surface when the relative humidity is 23 to 99 percent. Free moisture is detrimental to the spore germination of these fungi. Once released, the thin-walled conidia are short lived (from several hours to a day or two). Temperature and relative humidity dictate their life span.

The environment most favorable for conidial production, maturation, release and spread, germination, and infection includes repeated day-night cycles in which the nights are cool (about 60°F, or 16°C) and damp with a relative humidity of 90 to 99 percent and the days are warm (about 80°F, or 27°C) and dry with a relative humidity of 40 to 70 percent. However, if there are no air currents, conidia have recently been reported to form at a relative humidity less than 25 percent. Epidemics of powdery mildew are most common in the spring and fall.

The disease cycle — production of conidia, their release, germination, infection, and the production of a new generation of conidia — may be as short as 72 to 96 hours. Thus, powdery mildew, if left uncontrolled, may quickly become epidemic when cool, damp nights are followed by warm, dry days.

Control

1. **Purchase only top-quality, disease-free plants of resistant cultivars and species from a reputable nursery or greenhouse**. Nursery personnel should be consulted concerning the availability and performance of resistant varieties.

   Seed catalogues frequently list varieties of ornamentals that are resistant to mildew. Because of the presence of physiologic races of the mildew fungi, a cultivar or variety of an ornamental plant may be highly resistant or immune in one locality but very susceptible in another.

2. **Prune out diseased terminals of woody plants, such as rose and crabapple, during the normal pruning period**. All dead wood should be removed and destroyed (preferably by burning). Rake up and destroy all dead leaves that might harbor the fungus.

3. **Maintain plants in a high vigor**.

   a. Plant properly in well-prepared and well-drained soil where the plants will obtain all-day sun (or a minimum of 6 hours of sunlight daily).

   b. Space plants for good air circulation. Do not plant highly susceptible plants — such as phlox, rose, and zinnia — in damp, shady locations.

   c. Do not handle or work among the plants when the foliage is wet.

   d. Water thoroughly at weekly intervals during periods of drought. The soil should be moist 8 to 12 inches deep. Avoid overhead watering and sprinkling the foliage, especially in late afternoon or evening. Use a soil soaker hose or root feeder so the foliage is not wetted.

4. **Use chemical spray programs**. Thoroughly spray all of the above-ground parts of each plant, including both leaf surfaces, with a suggested fungicide.

Carefully follow all directions as printed on the container label. Start when the mildew is first seen or expected. Spraying is more efficient than dusting. Sprays are required at 7- to 14-day intervals to keep young, susceptible growth adequately covered. If possible, the sprays should be applied before a rain to provide maximum protection of the foliage from spores that may be distributed by splashing water or wind-blown rain.

The mycelium and conidia of the powdery fungi are waxy (or oily) and are difficult to set with spray. The addition of a small amount of a household detergent (about ½ teaspoonful per gallon) or a commercial spreader-sticker (surfactant) to the spray mix will make the spray more effective. Follow the directions on the container.

Table 1. Principal Ornamental Hosts of Common Powdery Mildew Fungi

Erysiphe cichoracearum

Acalypha	Calendula	Goldenglow	Phlox
Achillea	Campanula	Golden aster	Prairie coneflower
African violet	China aster	Goldenrod	Romanzoffia
Ageratum	Chrysanthemum	Hebe	Rudbeckia
Anchusa	Cineraria	Helenium	St.-Johns-wort
Arnica	(Florist's)	Hollyhock	Salpiglossis
Artemisia	Clematis	Houndstongue	Salvia
Artilleryplant	Coralbells	Inula	Smoketree
Aspen	Coreopsis	Ivy (English)	Snapdragon
Aster	Cosmos	Joepye weed	Spirea
Bachleor's button	Dahlia	Larkspur	Stachys
Balm	Delphinium	Leopardsbane	Sunflower
Balsam apple	Dusty Miller	Liatris	Sweet William
Balsam pear	Erigeron	Linaria	Tansy
Basketflower	Eucalyptus	Lithospermum	Tidytips
Bedstraw	Eupatorium	Mallow	Transvaal daisy
Begonia	Feverfew	Marguerite	Trumpetvine
Black-eyed Susan	Forget-me-not	Mertensia	Verbena
Boltonia	Gaillardia	Mockcucumber	Veronica
Boneset	Gayfeather	Monkeyflower	Zinnia
Bugleweed	Germander	Nemophila	
Buttercup	Globeflower	Oswego tea	
Butterflyweed	Gloxinia	Penstemon	

Erysiphe lagerstroemiae

Crapemyrtle

Erysiphe polygoni

Acacia	Calendula	Geranium	Sandwort
Aconitum	California poppy	Heath	Scabiosa
Alyssum	Candytuft	Hollyhock	Sedum
Amelanchier	China aster	Honeysuckle	Serviceberry
Amorpha	Cinquefoil	Hydrangea	Sophora
Anemone	Clematis	Kalanchoe	Sweet alyssum
Arenaria	Columbine	Larkspur	Sweetpea
Astilbe	Cuphea	Locust (black)	Teasel
Bean (Sclarlet runner)	Dahlia	Lupine	Tuliptree
	Delphinium	Matrimony vine	Wallflower (Western)
Begonia	Erigeron	Meadowrue	
Bladder senna	Evening primrose	Pansy	
Brassica	Gardenia	PeonyPoppy	
Bundleflower	Genista	Primrose	

Microsphaera alni (M. penicillata) (several varieties)

Alder	Dahoon	Hornbeam	Shallon
Azalea	Dogwood	Laborador-tea	Snowball
Beech	Elder	Lilac	Snowberry
Birch	Elm	Linden	Spindletree
Bittersweet	Euonymus	Lyonia	Spirea
Buckthorn	Forestiera	Magnolia	Sweetpea
Burning bush	Hackberry	Moonseed	Sycamore
Buttonbush	Hazelnut	Mountain holly	Trailing arbutus
Catalpa	Hickory	Mountan laurel	Trumpetvine
Checkerberry	Holly	Oak	Viburnum
Chestnut	Honeylocust	Pecan Planetree	Walnut
Chinquapin	Honesuckle	Privet	
Cranberry bush	Hophornbeam	Rhododendron	

Microsphaera diffusa

Coralberry	Locust (black)	Matrimony vine	Snowberry
Wolfberry			

Podosphaera leucotricha

Crabapple	Photinia	Quince

***Podosphaera oxycanthae* (*P. cladestina* var. *tridactyla*)**

Almond (ornamental)	Crabapple	Peach (ornamental)	Quince
Amelanchier	Hawthorn	Pear (ornamental)	Snowberry
Apricot (ornamental)	Holodiscus	Persimmon	Spirea
Cherry (ornamental)	Mountain ash	Plum (ornamental)	

***Phyllactinia corylea* (*P. guttata*)**

Alder	Chestnut	Hornbeam	Planetree
Amelanchier	Chinaberry	Horse chestnut	Quince
Aralia	Crabapple	Linden	Rose
Ash	Grape myrtle	Locust (black)	Sassafras
Barberry	Dogwood	Magnolia	Silverberry
Beach	Elder	Maple	Sycamore
Birch	Fringetree	Mock orange	Tulip tree
Boxelder	Hazelnut	Mulberry	Walnut Willow
Buckeye	Hickory	Ninebark	Witch hazel
Buttonbush	Holly	Oak	Yellowwood
Calycanthus	Holodiscus	Osoberry	
Catalpa	Hophornbeam	Painted tongue	

Sphaerotheca fuliginea

African violet

Sphaerotheca humuli (S. macularis)

Agastache	Filipendula	Hydrophyllum	Polemonium
Agrimony	Foamflower	Kalanchoe	Rose
Betony	Gaillardia	Larkspur	Saxifrage
Buffalo berry	Geranium	Matricaria	Spirea
Cinquefoil	Geum	Meadowsweet	Sumac
Delphinium	Gilia	Mitella	Tamarisk
Elder	Hawksbeard	Ninebark	Veronica
Epilobium	Hawkweed	Pansy	Violet
Erigeron	Heuchera	Phlox	

Sphaerotheca lanestris
Oak

Sphaerotheca pannosa (several varieties)

Almond (ornamental)	Matrimony	Peach (ornamental)	Rose
Apricot (ornamental)	vine	Photinia	

Uncinula circinata

Maple	Soapberry	Virginia creeper

Uncinula clintonii
Linden

Uncinula flexuosa

Buckeye	Horse chestnut

Uncinula necator

Actindia	Ampelopsis	Ivy (Boston)	Virginia creeper

Uncinula salicis

Aspen	Cottonwood	Poplar	Willow