Dry Weather Fungi

powdery mildews abundant in California where they thrive in the dry summer climate

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Powdery mildews—*Erysiphaceae*—have been found in California, on 176 plant host species.

Of those host species 63 were not recorded as hosts of powdery mildews in any other state at the time of their discovery in California during the past 16 years, and most of these 63 powdery mildews have not yet been recorded elsewhere in the United States.

California's dry summer climate restricts the development of most fungi causing foliage diseases but the powdery mildews comprise a large group of fungi which thrive under these dry conditions.

In the absence of control, powdery mildews could ruin a considerable portion of several California crops each year.

Crops Subject to Attack

Some of the most important crops which are seriously attacked are: grape, apple, peach, cantaloupe, squash, cucumber, pea, bean, barley, wheat, oats and rose. Crops attacked only rarely or mildly are: apricot, plum, prunes, pears, oranges, sugar beets, and walnuts.

These crops are not known to be attacked by powdery mildews in California: almond, potato, tomato, cotton, lemon, avocado, fig, date, grapefruit, hop, lettuce, spinach, celery, and olive.

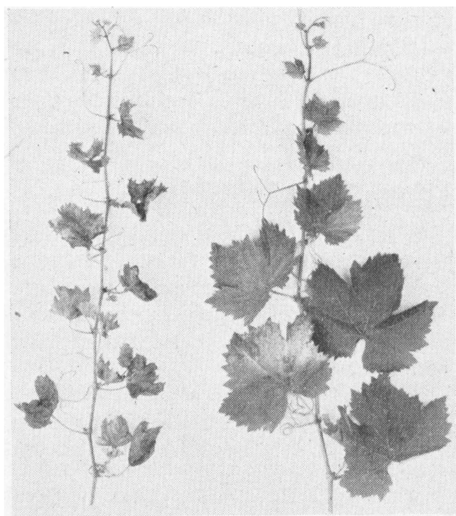
In certain parts of California—where some crops are grown throughout the year—powdery mildews are relatively more abundant in the dry summers than in the rainy winters, and are more abundant in a relatively dry winter than in a relatively wet one.

Effect of Rain

In regions or seasons of moderate rainfall, powdery mildews are more severe on the same crop in greenhouses than outdoors. Even covering plants growing outdoors with frames of glass to protect them from the rain may greatly increase mildew development.

The mycelium—vegetative body—of most powdery mildews is on the surface of the leaf, while the mycelium of most other foliage fungi is within the leaf tissue. A moderate rain can break many of the spore-producing branches of the powdery mildews, and even wash off the mycelium, especially if the fungus is on the upper leaf surface. It takes the fungus about a day to recover from such rain injury.

Because the fungus body is superficial and injured by rain, some powdery mildews have been controlled by syringing the leaves. This has been commercially applied only in the case of rose powdery mildew in greenhouses but has been experimentally demonstrated with the powdery mildews of bean, barley, pea, and evonymus. When spores of bean powdery mildew were immersed in water, they were killed in about two hours.



Grape powdery mildew. *Left,* shoot from untreated vine shows stunting and upcurling of leaves caused by mildew. *Right,* shoot is from vine which was treated twice with sulfur dust. The deposit on the second leaf from below is sulfur dust.

Natural Enemies

Powdery mildews are attacked by smaller fungi—species of *Cicinnobolus*—which grow within and kill the powdery mildew mycelium. *Cicinnobolus* is a wet weather fungus, however, and needs rain for its spread. Therefore, it is rare in California, but moderately abundant in the Eastern States where it plays a part in suppressing the activity of many powdery mildews.

Thrips—small insects which feed on many plants and spread some virus diseases—also feed on powdery mildews to a limited extent. Thrips are favored by dry weather, and are common in California on plants infected with powdery mildews and also on plants without powdery mildews. Unfortunately they cause considerable plant damage, and as they are not highly destructive to powdery mildews they offer no promise as a means of control.

Tolerance to Humidity

The most convincing evidence concerning the tolerance of powdery mildews to low humidity is secured in the laboratory. To obtain a very dry atmosphere, sulphuric acid, calcium chloride, or phosphorus pentoxide is placed in a sealed chamber where the moisture in the air is practically absorbed by the chemical so that relative humidities of between 0% and 1% are produced.

When fresh dry powdery mildew conidia are placed in such a chamber they are thus exposed to a drier air than they are likely ever to encounter in nature. Yet they germinate in the chamber, apparently just as they do on a leaf.

No other fungi known have this property. Most fungus spores will not germinate unless free water is present, though a few are reported to germinate at relative humidities ranging from 60% to 95%.

Unlike other air-borne spores which have a water content of about 10% of their dry weight, powdery mildew spores have a high water content of about 70%. In this regard they are somewhat like carrot roots or potato tubers, which also have a high water content and will germinate without any external source of water.

Slow Drying

Powdery mildew spores are small and thin walled and will dry out slowly when placed in a dry atmosphere. They lose water at only about one thousandth the rate of a free water surface in the same environment. This is so slow that at about 68° F and 50% relative humidity—a typical summer environment—it takes about 24 hours for the spores to dry out. But at this temperature and humidity they will germinate in about two hours and will penetrate the host in about five hours. As soon as they get their haustoria—feeding organs—into the host they are ap-

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parently independent of the drying power of the air, and can get their water supply from the host plant.

Powdery mildews as a group are low-temperature, shade-loving, dryness-tolerating fungi, though they show some differences among themselves with respect to all these characters.

Temperature and Light

Confusing information about the epidermiology of fungi and about the weather has led some people to believe that powdery mildews, like most foliage fungi, are favored by wet weather. In truth, powdery mildew is more abundant on roses and several other plants in the San Francisco Bay area than in the hotter, sunnier, and drier interior valleys of California. This difference in disease is sometimes attributed to the favorable effect on powdery mildews of the higher humidity of the Bay area. A more likely explanation is that it is the higher temperature and higher light intensity of the interior valleys, and not the lower humidity, which limits the development of rose mildew.

Light, temperature, and humidity may interact with each other. Thus an incoming high fog will lower the light intensity, lower the temperature, and increase the relative humidity. In such a case the light intensity may be reduced to about one fourth that of full sunlight, while temperature is changed to a much smaller extent, and humidity to a still less extent.

Factors Studied

The effect of different environmental factors on a disease may be studied under controlled conditions where each factor may be separately and safely analyzed. Such controlled environmental studies have been carried on, in part.

With humidity and light constant and favorable, a rise in temperature above 82° F will suppress most powdery mildews; and the degree of suppression is proportional to the rise in temperature and the time of exposure.

Similarly, with humidity and temperature, constant and favorable, an increase in light intensity may suppress powdery mildew. But with light and temperature constant and favorable, it has never been possible to suppress any powdery mildew by lowering the relative humidity.

While the environmental relations of powdery mildews are by no means adequately understood, the present status of available knowledge is that high light intensity and high temperatures may be limiting factors, but low relative humidity never is.

Another possible source of confusion is the believed similarity between powdery and downy mildews. To many people, mildews are a group of diseases, whether powdery or downy. The downy mildews are definitely favored by wet weather, and have generally received more publicity. This may be why the belief prevails that powdery mildews are also favored by wet weather. Actually downy and powdery mildews are only very distantly related, less closely so than bread mould—*Rhizopus*—and downy mildews. It is possible to separate these two groups of fungi merely by the difference in their moisture relations. When cucumber plants were inoculated simultaneously with spores of both downy and powdery mildew and the plants left on a dry greenhouse bench and with no water on the leaves, only the powdery mildew developed. When similarly inoculated plants were sprayed with water, incubated overnight in a moist chamber and then syringed heavily in the morning, downy mildew developed luxuriantly, but there was only a trace of powdery mildew.

Control

Fortunately most, if not all, powdery mildews are easily controlled with some form of sulfur, and sulfur is also used for the control of other plant diseases.

The importance of powdery mildews in California is further evidenced by the fact that California uses about 40,000,000 pounds of sulfur as a fungicide per year, mostly for the control of grape powdery mildew. This is about one third of the total sulfur used as a fungicide throughout the United States.

Sulfur can not be used on some crops. It is highly injurious to cantaloupes and other cucurbits at high temperatures, and sulfur residues are objectionable on canned products.

For cases where sulfur is undesirable, a number of other less efficient fungicides can be used. Some of these are dinitro capryl phenl crotonate, copper sulphate, and the dicyclohexylamine salt of dinitrocyclohexylphinol. Each of these also has the objectionable character that plant injury will result from overdosage.

Experience of grape growers has shown that if sulfuring of grapes is followed by a heavy rain, mildew may develop quite rapidly if no more sulfur is applied. This is sometimes interpreted to indicate that the rain greatly stimulated the activity of the powdery mildew. A more likely explanation is that the rain washed off the protective coating of sulfur.

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form of a chimney is a characteristic sign of the peach twig borer hibernaculum. On rough prune bark, the hibernaculae are very difficult to see, and it is almost impossible to find them during the winter months.

Larvae emerge during the bloom period and feed on the blossoms and developing fruit. A second generation appears in May and it is this generation that causes the major damage to the prunes.

There may be a third generation which will attack the ripening prunes.

Twig borer larvae characteristically bore a cluster of holes into the flesh of the fruit, usually on the side. They do not penetrate very deep, but occasionally will go as far as the pit. They move from one fruit to another, causing considerable damage. Wherever prunes are in clusters, large numbers of fruits will be attacked.

The damage may be distinguished from that of the orange tortrix by the number of holes in a single fruit, instead of the one large hole characteristic of orange tortrix damage.

The twig borer larvae are similar to the bud moth larvae in appearance but the presence of light intersegmental rings on its body distinguish it.

In the 1950 season, peach twig borer was a pest in Colusa, Glenn, Butte, Sutter and Yolo counties where it was mainly responsible for damage attributed to the bud moth. It was also present—but not damaging—in the coastal prune-growing areas.

Codling Moth

Codling moth—*Carpocapsa pomonella* Linn—is not a primary pest of prunes, but in the 1950 season it did damage in at least two orchards in Sutter County but was not reported from any other prune-growing area.

The codling moth in peaches in Sutter County probably accounts for its presence in prunes in that county.

Codling moth larvae may be distinguished by the white or pinkish body with a black head capsule. Its damage on the fruit is quite distinct as there is a mass of gum, mixed with frass, exuding from a single entrance hole. The larvae penetrate the fruit to the pit and usually feed on the meat of the pit.

Tussock moth, cankerworm, tent caterpillar and red humped caterpillar attack prunes, but occur sporadically and vary from season to season.

These pests are primarily leaf feeders and are easily identified. They are not classed as major pests although infesta-

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