AGRICULTURAL EXPERIMENT STATION
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Hop Downy Mildew in Oregon
With Suggestions for 1931

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The object of this circular is to summarize important facts about this disease and to suggest certain control methods.

The Hop Downy Mildew Invasion

This disease was first discovered in Japan in 1905. Then it was reported in Wisconsin in 1909. In 1920 it was found in Kent, England. It swept all over Europe in the next few years. Downy mildew appeared in British Columbia in severe form in 1928 and was noticed for the first time in Oregon and Washington in the spring of 1930. It was widespread and in a few places caused considerable early damage. It has also appeared in the State of New York. Professor E. S. Salmon, who has studied hop downy mildew in England since it was introduced, says: "In every country where this new disease has appeared, it has taken firm root and the outbreaks have increased in extent and severity in each succeeding year."

Scientific Control the Only Hope

Extermination of the disease is not considered possible. Fairly effective control methods, however, have already been worked out by scientific investigation. There is no reason to fear that the industry will be wiped out in the Pacific Northwest. But, since these control methods are expensive and since they have not been fitted to the seasonal conditions prevailing in Washington and Oregon, there is much need for extensive experimental work to determine the most effective and at the same time the most economical program of control which can be devised for the Northwest. Furthermore, scientific plant breeding and selection work should be undertaken with the object of developing one or more commercially desirable hop varieties which will not be seriously affected by the disease.

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Government Investigations

The Congress of the United States has appropriated a fund for the investigation of the hop downy mildew and its control on the Pacific Coast. These investigations will be conducted in

cooperation with the Oregon Agricultural Experiment Station at Corvallis. It may require several years to test thoroughly various methods and materials before the industry can know definitely which are the best and cheapest methods for use with different hop varieties in various localities. The same can be said for the hop selection and breeding work and for the growing of sufficient planting stock of any new resistant sorts which may be developed.

Growers' Cooperation

Success in this work of investigation and experimentation will depend to a large extent upon the cooperation and active assistance of hop growers individually and of the industry as a whole.

The Cause of Downy Mildew

The disease is caused by a microscopic parasite, a fungus with the scientific name Pseudoperonospora humuli (Miy. et Tak.) Wils. Infection may occur on shoots, leaves, burrs, and cones. Microscopic swimming spores enter the hop plant through the breathing pores. The fungus then spreads through the tissues and a few days later appears on the under sides of the leaves as a dark, velvety growth on which innumerable, invisible summer spores are produced. These float readily in the air and scatter the disease. They are probably carried considerable distances by winds. They may alight on the leaves or on any other part of the plant including the burrs or cones, if these are present. If rain or heavy dew keeps these parts wet, or if humidity is high (90% or more), the air-borne spores germinate and each lets out a number of little swimming spores which enter the breathing spores as mentioned above and thus cause new infections.

The fungus as a rule also produces thick-walled resting spores within the infected parts, particularly at the end of the growing season.

These resting spores can remain alive over winter in the old hop trash on the ground. In early spring they can germinate and produce many spores. It is believed that most of the earliest spring infections start from these resting spores.

The Symptoms and Effects

If the tips of the new hop shoots are infected as they come through the ground, the shoot, instead of growing out long and slender, becomes stunted and produces small leaves close together.

This stunted shoot is called a "spike". It is paler than healthy shoots. The fungus generally grows out as a dark, spore-bearing layer on the under sides of the leaves on the spikes, so that as long as these spikes remain alive they provide a constant source of infection in the hop field.

When the buds on the vines become infected, the arms (side branches) or the tips become "spiked" and grow out only a short distance. These spiked arms and tips are therefore constant sources of infection as long as they remain alive. When the tip of a vine becomes spiked, the vine stops lengthening and arms farther down begin to grow out rapidly. Where such infections are abundant early in the season, normal hop growth may be seriously interfered with.

The leaves may become infected at any stage in their growth. If infected when young, large diseased spots or patches develop. When the leaves are full sized at the time of infection the spots are small and angular. The spots are hard to see at first. Then they turn pale and finally die and turn brown. Before this happens, the dark spore-bearing layer of the mildew fungus generally appears on the under side. These infected leaves are consequently a means of further spread.

When the burrs or flowering parts are attacked they turn brown and fail to develop into cones. If cones in various stages of development are attacked, the infected scales turn brown. In severe cases the whole cone becomes brown. In general, only slight damage was reported from attack on the burrs or cones in the Pacific Northwest in 1930. In any year when wet weather develops in July or August, however, serious damage may be expected. Losses in England in 1930 were widespread and severe for this reason.

The Effect of Weather

Damp weather is absolutely necessary for the spread of the downy mildew. The fungus does not produce spores readily, if at all, when the air is dry and the spores cannot cause infection if moisture is not present. Rains, fogs, dews and very humid air conditions favor spore production and infection. In the Pacific Northwest as a rule the greatest amount of damage will generally take place during the spring months.

The hot dry conditions usually prevailing in this section from the middle of June to early September are the greatest protection against the disease. In 1930 nearly all the mildew died out during this period. Spikes that were left on the vines dried up and the leaf spots stopped producing spores. Furthermore, the spores remaining on these parts died. That the disease had not been killed out completely, however, was shown by the fact that the mildew again showed up in commercial yards following September and October rains and resting spores were formed. Therefore, a renewed attack may be expected in the spring of 1931 if wet weather conditions prevail.

Varietal Susceptibility

Of the chief varieties or strains of hops grown commercially in the Pacific Northwest, the Early Clusters appear most susceptible, the Late Clusters somewhat less susceptible and the Fuggles resistant, particularly on the cones. Growers are asked to watch the behavior of the disease on all varieties and strains of hops in their fields.

Control Practices

In continental Europe spraying with Bordeaux mixture has been emphasized as the main means of preventing the disease. In England the plucking off of the spikes as soon as discovered, and the early removal of lower leaves are recommended in addition to spraying with Bordeaux mixture. In British Columbia some lessening of the infection of shoots coming through the ground has been noted where copper-lime dust has been applied to the hills immediately after pruning. In British Columbia Bordeaux mixture has been found effective as a spray and evident benefit has been noted from the use of copper-lime dust applied to the vines with a dusting machine. Because infections take place through the lower leaf surfaces or in the axils of the leaves which are hard to wet with plain Bordeaux spray, spreaders of various sorts have been tried out, some with excellent results.

In Oregon, a number of growers started spraying with Bordeaux mixture with a spreader as soon as mildew was found in the spring of 1930. Copper-lime dust was also employed and many growers kept the spiked shoots cut out early in the season. These practices appeared to result in definite reduction in the spread of the disease.

1931 RECOMMENDATIONS

Until investigators have had a chance to study control practices closely under Oregon conditions, it is necessary to take the experience of workers in Europe and in British Columbia as a guide for American hop growers. There are a good many questions to be settled before we can tell just what the exact value of each step in the program will be in the average season. Until better information is available, the following suggestions are offered:

1. Pruning. In pruning cut off all unnecessary portions of the hill to prevent excessive vine growth. In British Columbia it was found that fewer "basal spikes" developed upon crowns that were high and dry compared with those in low, wet places.

2. Dusting Crowns. Dusting the crowns after pruning with a copper-lime dust (1-6) has reduced the amount of early spring infection in British Columbia tests, particularly when the crowns were left partly exposed. An even, visible layer of dust about

2 feet in diameter should be applied around the crown. Where the crowns are covered with soil after pruning, it is suggested that the dust be applied to the top of the ground.

3. Wild Hops. Wild and volunteer hops about the field, fence rows, buildings and surrounding territory are subject to mildew attack and provide constant sources of infection for commercial plantings. They should be got rid of.

4. Removal of Spikes. The removal of mildew spikes is of benefit in reducing infection but under some conditions, according to British Columbia evidence, the cost may be greater than the value of the practice. The spikes should be removed as soon as they can be detected. Persons removing spikes should avoid touching healthy parts of the vines.

5. Early Training. Early training and early spraying are considered of special importance because as long as the vines are allowed to run out along the moist soil and are unprotected by spray, they are very subject to infection from soil-borne resting spores. The vines should be trained as soon as possible and sprayed immediately since most of the early infection occurs during early growth.

6. Spraying and Dusting for Protection.

(a) Spray the vines thoroughly as soon as they are trained up. Use Bordeaux 4-4-50 with spreader. It is important to cover leaves and shoots thoroughly because the scales along the stalk readily hold spores. Avoid spraying in the hot sun. Try to cover the undersides of the leaves since practically no infections occur on the top.
(b) Repeat the spray when the vines get to the top or dust with copper-lime dust, (one part monohydrated copper sulfate to six parts of fresh hydrated lime). Do not dust unless the air is relatively quiet and moisture is present on the leaves. These conditions are most likely to be met with at night.
(c) Give another application just before the vines come into burr (blossom stage).
(d) If weather conditions especially favorable to mildew spread develop during any part of the growing season, other applications may be advisable.

7. Hill Sanitation. Keeping the hills free from weeds, shoots and runners as well as removing the leaves from the lower parts of the vines is considered a desirable practice from the standpoint of mildew control. Conditions near the ground are the most favorable for the persistence of the mildew through the hot, dry period of the summer and such growth readily harbors the disease.

8. Field Clean-up. Clean up the field and destroy old vines by burning as soon as it is deemed desirable. The more of this material that is raked up and destroyed the smaller is the chance for infection the next spring.

Miscellaneous Considerations

Spraying and Dusting Equipment--Growers are asking what the best types of spraying and dusting equipment, what pressure is necessary, what kind of nozzles to use, etc. These questions can be answered only after careful comparative study. It may be safely assumed that any kind of equipment that does a good job of covering the plants will afford good protection.

Training up extra vines--It has been suggested that where mildew was present last year it may be desirable to train up more vines than usual.

Late vs. Early Working in the Yard--Some growers think that early plowing, pruning and cultivation of the yards lead to earlier growth and therefore more chances of early mildew infection. They plan to do no work until the second week in April. Just how much effect this procedure will have on mildew development remains to be seen.

Confusion of Mildew with Other Troubles--There are a number of troubles affecting hops in the Pacific Northwest and elsewhere which have nothing to do with downy mildew. The grower should study the symptoms described for the mildew and should not confuse other conditions with mildew attack.

How to Prepare Bordeaux Mixture 4-4-50

1. Dissolve 40 pounds of copper-sulfate (bluestone) in 40 gallons of water or at the rate of 1 pound per gallon. If tied in a gunny sack suspended so that the sack just touches the water, the bluestone will dissolve over night. Use a wooden barrel or concrete container as bluestone will corrode metal.

2. Soak 60 pounds of fresh hydrated lime in 40 gallons of water (or at that rate) or slake 40 pounds of quick-lime (fresh stone lime) and fill up with water after slaking, using 40 gallons altogether.

3. Start filling the spray tank with water.

4. Stir up the milk of lime and add 8 gallons of it to the tank for every 100 gallons the spray tank holds. Put the lime in through a strainer.

5. After the tank is about 2/3 full of water and while the agitator is running, stir up the stock solution of dissolved bluestone thoroughly and begin to add this slowly at the rate of 8 gallons for every 100 gallons the tank will hold. By the time the tank is full, the last of the bluestone solution should have been added.

6. Add spreader with agitator still running.

7. Start spraying at once. Bordeaux performs best if applied as soon as mixed. After standing a few hours it loses its best qualities although this deterioration can be checked by

adding to every 100 gallons of freshly prepared Bordeaux one heaping tablespoon (one ounce) of sugar, dissolved in a little water. The stock solutions of lime and of bluestone do not deteriorate as long as they are not mixed.

8. When spraying use a fine mist, and remember that every leaf and tip missed is still open to infection.

9. For other suggestions consult Oregon Experiment Station Bulletin 259 on Sprays and Their Preparation, which will be sent free upon request. Perhaps the worst way to mix the stuff is to throw the bluestone and the lime into a tank and then fill up with water. This will almost always give pump and nozzle trouble too, besides producing a bad mixture.

SPREADERS

In Europe, spreaders are considered unnecessary with Bordeaux mixture. In British Columbia, Dr. William Newton and his assistants found that the use of a resin spreader rendered Bordeaux more effective in mildew control.

In 1930 tests in British Columbia excellent spreading power was given Bordeaux mixture by the:

Needham Spreader

6 gallons of water - bring to a boil and add
10 pounds resin and
1 quart fish oil. When resin dissolves add
2 pounds caustic soda and make up to
18 gallons with water. Then add
10 pounds whale oil soap to the 18 gallons.

About 4 gallons are used for 100 gallons of Bordeaux. If excessive foaming occurs, reduce the amount of spreader.

(This spreader was originated by F. E. Needham, Salem, Oreg.)

An easier spreader to prepare is the one devised by Dr. William Newton in 1930 as a modification of Mr. Needham's spreader. It is called the:

Saanichton Spreader

4 parts resin (rosin)
1 part caustic potash (potassium hydroxide)
1 part fish oil

Heat the whole together. The mixture finally becomes hard like glass. When cool it is pulverized and stored till needed. Two to five pounds are used for every 100 gallons of spray. The powder is first made into a paste with a little hot water and after cooling is put into the tank of Bordeaux.

The Oliver Chemical Company, Ltd. of Penticton, B. C. is manufacturing this spreader for British Columbia.