Apple Fruit-Rots.

During the season of 1900, the apple growers of Illinois lost at least $1,500,000.00 from the rotting of the fruit on the trees. Illinois was not exceptional, in this. The trouble was wide-spread from the eastern sea-board to the western plains but was usually only severe south of about 39 degrees north latitude, or in Illinois south of Effingham and Jerseyville. Except in the greater than ordinary loss, there was nothing new in the occurrence last year. The same kind of destruction has happened to a greater or less extent throughout great areas of the country every year during at least a quarter of a century, yet there is comparatively little known of the causes, or of a cure. Some excellent studies have been made, the results of which have been published, but there is still great need of more information upon which methods of prevention may be reliably based.

The immediate agents of destruction are certain species of parasitic fungi. Without these the fruit would not decay even though punctured by insects or subject to the most unfavorable climatic conditions. There is something, it is true, in individual trees and in certain varieties which renders their fruit more liable to infection, but the infection itself always comes from the exterior. Spores of the destructive fungi gain entrance only by the penetration of their germinal tubes through the skin of the fruit, with or without mechanical punctures otherwise made. Possibly in some cases the entrance is effected through the tender tissues of the blossoms or through the open "eye" of the fruit, but however this may be, it is never true that the parasites are in the sap of the tree or that they get into the apples from the tree.
BROWN ROT.

Three different species of fungi cause what are commonly known as "brown rot", "black rot" and "bitter rot". The first is common also upon stone fruits, such as peaches, plums, and cherries, the other two are confined to the apple. Brown rot on apples affects more especially the summer varieties and generally near the time of maturity. Though the infection may show first on one side, or at a certain point, the whole fruit is soon involved. There is seldom a definite line bounding the diseased portion; soon the whole surface shows a uniform brown discoloration, then becomes gray with the mass of dusty spores. The flesh is soft and watery and only becomes hard by drying by which the fruit shrivels up. In this condition it may hang upon the tree all winter but it more often falls before the shriveling begins. Spores from the old "mummies" have been germinated the next year. The fungus is called Monilia fructigena, or by some recent writers Sclerotinia fructigena.

BLACK ROT.

What is commonly called the black rot of the apple is sometimes confounded with the bitter rot, or the latter is spoken of as black rot. The two are sufficiently distinct and care should be taken to apply the proper name. The color until quite late of apples affected with black rot is not black, not so dark as is the case with bitter rot; it is brown, though darker than that known as brown rot. There is very often a ringed or zoned appearance of slightly different shades of color due to changes beneath the skin. The affected area is sharply distinct from the healthy portion, in this different from brown rot and from the otherwise somewhat similar mark of sun-scald. The tissues long remain plump and juicy—neither softened as in brown rot nor tough and dry as in bitter rot. Numerous minute pustules, scarcely visible except through a lens, break up through the epidermis in the central area of the affected spot. Sometimes a white, not abundant, and scarcely dusty powder covers the surface studded by the pustules. This is made up of spores, capable of germination at once or of retaining their vitality for some months. Further along these spores become black, and the spot now becoming dry, has a very dark color justifying perhaps the name.

To the taste the discolored flesh is not unpleasant. There is a suggestion of bitterness, neither is there any musty flavor such as is common in apples affected by certain other sorts of rot or decay.

This disease causes great loss at times, but there seems to be every degree of injury. Sometimes it may show abundantly on one tree and not on others. The fungus may develop while the apple still adheres to the twig or it may only show on fruit which has fallen from other causes. No connection has been traced between the development of the fungus and the killing of the tissues by the heat of the sun ("cooking")
or “sun-scald”) though this has been suggested. Often the disease develops only from punctures by insects or other mechanical injuries to the skin of the fruit, or it starts from the eye of the apple. At other times, however, and apparently when most injurious, the start is apparently made without such aid.

Black rot occurs not infrequently in northern regions but its greater ravages are southward. The fungus is known as *Sphaeropsis maliorum*. This same parasite is supposed to cause, in some sections, the disease on limbs called “canker.” Possibly, however, further studies will show specific differences in the parasites.

**Bitter Rot.**

Bitter rot is commonly well characterized by the name, though there seems to be considerable variation in the degree of bitterness developed in the affected tissues. Sometimes, especially as decided by some people, the bitter quality is unrecognizable or present only in a very mild degree, while other samples prove to have an intensely bitter taste. Other species of fungi attacking the apple also produce a very bitter substance, but none of these need be confused with that now under consideration. Bitter rot as herein defined is the result of the fungus *Gloeosporium fructigenum*, which attacks only the apple and this almost exclusively in the country southward of the parallel of 39 degrees, though it has been known to do severe damage much further north. Commonly the fruit is infected while on the tree, and often dry specimens remain all winter firmly adherent to the branches.

In the beginning the disease shows at one to several points, which later become very conspicuous spots from their dark color and sharply defined border. Small as mere specks to start with, they soon enlarge equally in every direction so that the spots are nearly or quite circular in outline whatever the size. These spots are black and so the confusion in the use of the common names is not accountable. The broad border is generally coal-black but with a glossy surface. The affected tissue soon shrinks and this makes the spot concave or somewhat sunken. The flesh is not soft and watery as at first in the brown and black rots. The bitter quality is early developed and long continues. The disease eventually penetrates deeply into the substance of the fruit, but in the course of development there is a very sharply defined limit of infection and destruction of tissue. Deeper down and at the circumference, the flesh is sound and crisp. Not infrequently several originally separate spots run together as they enlarge, so as to make one large area of infection, but it is usually easy to make out the centers of the different spots by the depressions and by the concentric rings to be mentioned below.

Beginning in the central area of each original spot there soon appear numerous minute pustules similar to those of black rot. Here too a lens must be used to see them well, though they are visible to
good unaided eyes. Each pustule opens at its apex and sends out a moist (never dusty), somewhat waxy substance, either as a rounded droplet or as a slender thread which becomes more or less curled like a delicate ringlet or tendril. Soon, however, the material from all the pustules settles down to form a thin stratum of a pinkish-white color, plainly recognizable by the unaided eye. Afterward this becomes whitish from the fading of the original color. As the spot grows larger new pustules appear in irregular rings or circles, like little hoops all having the same center but of ever increasing diameters. This appearance is evident enough to the naked eye.

The black color of the surface with the pinkish substance at length exuding over it, at least in the central portions of the spot, the concave depression caused by the shrinking of the affected tissues, the concentric rows of pustules and the bitterness of the discolored flesh, are characteristic of bitter rot by which anyone may, with much certainty, distinguish this from the other kinds of rots destructive of apples while still upon the trees.

Under the compound microscope the pinkish exudate from the pustules is seen to be made up of myriads of oblong, often somewhat curved spores, very different from those of the black rot. The latter are larger, of greater comparative diameter, and become conspicuously divided into two equal parts by a transverse wall. They are at first uncolored but afterward grow darker until in mass they are black, while the spores of bitter rot never show any color through the microscope.

The life histories of these rot-producing fungi have not been very satisfactorily made out. Spores collected from the mummied fruit have been germinated when one year old and the diseases have been artificially produced by their inoculation into green fruits. In the case of brown rot, another winter-persisting kind of spores has been reported. No such second form, however, has been recognized in connection with the others. The abundant, powdery summer spores of brown rot are carried as dust by the wind and thus they become widely dispersed from each infected fruit. The spores of black rot may be to some extent distributed in the same way, but those of bitter rot can hardly be so carried as they are moist and pasty in the mass. They are fitted to adhere to the bodies of insects and may be dependent upon the latter for distribution. But it is noticeable that bitter rot, at least when it first appears, is much more liable to occur on the fruit borne on the lower branches of the tree. When the limbs reach down to and spread over the ground, this rot may especially be looked for on the fruit. This suggests that the infection comes from the old "mummies" lying under the tree or at least from spores produced in them which have wintered over on the ground inside or outside of the rotten fruits. It is well known that a single fruit affected with brown rot tends to infect
others on the tree when the crop of spores is distributed and that this is much more likely to occur in moist weather, is explained by the fact that moisture is required for the germination of the spores.

It has also been noticed, both with brown and bitter rot, that disease abundantly occurs on fruits hanging beneath one already affected, as though the spores were washed down by rain. In artificial tests it is found that a crop of spores of bitter rot begins to appear within three days after inoculation.

TREATMENT.

Bitter rot and the other diseases above referred to, can be prevented in large measure by cleanliness. By this we mean thorough cultivation of the ground and the absence from the orchard of all rubbish of any kind whatever, where withered or fallen apples may be lodged. By cleanliness we also mean the removal of all dried or withered apples from the trees or ground immediately under the trees.

The spores of these diseases winter over, presumably, in these dried apples or mummies as they are sometimes called, and therefore, such sources of infection should be removed from the orchard and destroyed by fire. Since these diseases usually prevalent during periods of drought, such as is now visiting the fruit sections of the State, cultivation plays an important part in holding up the vitality of the tree to that point where its fruit is much less liable to fall a ready prey to these fungous diseases. However, it is not wise to rely upon these measures alone, since the diseases may gain entrance to the orchard even when the greatest care has been exercised. Spraying therefore, with Bordeaux Mixture or other fungicides is imperative, and by their proper use these diseases can be controlled. Experiments conducted at the Kentucky, Virginia, Missouri and Illinois Experiment Stations, as well as the experience of practical growers throughout the country, demonstrate this fact.

The first sprayings in the spring time (the one before the flower buds expand, one just after the petals fall, and another two weeks later) which are made for the purpose of fighting the apple scab, are sure to lessen the number of spores which would be present to develop bitter rot. Another application of Bordeaux should be made late in June and should be followed by such other sprayings as conditions seem to warrant. If the orchard has been affected with rot in previous years, or if for any other cause, there is reason to expect an attack of the rot, an effort should certainly be made to prevent that attack; and since it is impossible to tell just when the disease will break out, the safest course is to keep the plants and fruit covered with a fungicidal spray so as to prevent the development of the spores. For this purpose applications should be made at least once in three weeks during July and August.

If there is no particular reason for expecting a visitation of the rot and the orchardist does not wish to go to the expense of making the
summer applications of spray, he should watch his trees very closely, and upon the first appearance of the rot, should spray very thoroughly. Although the disease cannot be cured after it has started, it can be prevented from spreading seriously if prompt treatment is given; but a delay of even one day after the rot has commenced may mean the loss of the entire crop, for after the disease has started no amount of spraying will check its spread in those apples already affected. The spray will, however, prevent the spread of the disease from infected fruit to that not already attacked. Some people have sprayed after the disease has made its appearance on all the fruit in the orchard, but this is simply a waste of time and money.

**Material to be Used.**

Bordeaux makes a good solution for these late summer sprays but has the undesirable effect of staining the fruit. For this reason ammoniacal carbonate of copper is recommended. It has nearly as good fungicidal properties as Bordeaux mixture.

**Ammoniacal Solution of Copper Carbonate.**

The formula used in the preparation of this mixture is as follows:

- Copper carbonate ............... 5 ounces,
- Ammonia (26° Beaumé) ............ 3 pints,
- Water .................................. 45 gallons.

First mix the copper carbonate with a small quantity of water until a thin paste is secured, or else place 5 ounces of dry powder in a bottle then fill nearly full with water and shake it vigorously until every particle of dry powder is brought into contact with the water. In other words, see that no lumps are left floating on the water. Dilute 3 pints of ammonia with 3 gallons of water. That is, each volume of the ammonia should be diluted with 7 or 8 volumes of water. To this solution, which should be contained in wooden or earthenware vessels, add the above treated 5 ounces of copper carbonate, pouring in slowly, at the same time stirring the mixture vigorously until the copper carbonate is entirely dissolved. Since ammonia varies in strength, it might require a slight addition to this solution before the copper carbonate is entirely dissolved. Be sure, however, to add no more ammonia than is absolutely required to dissolve the copper carbonate. The amount of ammonia required can be readily determined after making the first batch of the mixture as above described. After the copper carbonate has been thoroughly dissolved, dilute same with 45 gallons additional of water or enough to make a barrel of spraying solution.

This solution possesses some advantages over Bordeaux mixture. It is a clear bluish or purplish liquid, entirely free from sediment and is as readily applied to trees as is water. It can be applied to matured fruit without leaving any undesirable stains such as is the case with
Bordeaux mixture. It ranks next to the Bordeaux mixture in efficiency as a fungicide. It is also cheap. Quotations received August 2, 1901, from Fuller & Fuller Company, wholesale druggists of Chicago, quote copper carbonate at 23 cents per pound and ammonia at 64 cents per pound. Since each pint of ammonia will weigh approximately one pound, we have a cost of approximately 55 cents for material for each 100 gallons of spraying solution or a little more than $\frac{1}{3}$ a cent per gallon. In figuring up the cost, however, one must bear in mind that the carboy which contains the ammonia will cost in the neighborhood of $1.65 and that the express charges on same to most points will be in the neighborhood of $2.00 for each 100 pounds of ammonia. Very often, however, local druggists can give more satisfactory quotations than can the wholesale druggists, and consequently the cost of the spraying material may vary for different localities.

In using copper carbonate solution, one must bear in mind that it is not safe to add Paris Green or other arsenites to this mixture, for these increase its causticness, thereby greatly injuring foliage. This is because the arsenites are dissolved by the ammonia present and not held in suspension as is the case when mixed with water. If it is desirable to add these poisons to the copper carbonate solution, then add two or three times as much lime as poison. We must remember, however, that the addition of lime and Paris Green or other arsenites will increase the staining power of the solution. In the fighting of Bitter Rot we would, therefore, advise that arsenites be not added to this fungicide until it had been definitely determined by examination in the orchard that a brood of Codling-moth is hatching or that other chewing insects are present and which need attention.

Always keep ammonia and copper carbonate mixture in glass stoppered bottles tightly corked when not needed.

If one experiences difficulty in securing copper carbonate and if copper sulfate is readily obtained, the former material can be made from the latter one by dissolving and by the addition of carbonate of soda as follows:

- Dissolve 10 pounds of copper sulfate in 10 gallons of water,
- Dissolve 12 pounds of carbonate of soda in 10 gallons of water.
- Pour one solution into the other slowly, at the same time stirring vigorously and have both solutions cold, if hot water is used for the dissolving. Allow this to stand 12 hours, or until the sediment has settled, after which, pour off the liquid, then add another 20 gallons of water as before, stirring same thoroughly, and then allow to stand for another 12 hours and repeat this operation for a third time; then drain off the liquid and dry the blue powder remaining behind, which is copper carbonate.
BORDEAUX MIXTURE.

Should Bordeaux mixture be used instead of ammoniacal solution of copper carbonate, then use

4 pounds of copper sulfate,
4 pounds of lime,
50 gallons of water.

The commercial fruit grower will find it greatly to his advantage during the spraying season to have stock solutions of copper sulfate and lime constantly on hand. The copper sulfate does not deteriorate when in solution. The lime, however, should not be allowed to stand too long before using nor should it be made up immediately before being applied to the trees. It is best to have lime prepared one day or two days previous to mixing with copper sulfate. Use only the un-slacked or rock lime, slacking it carefully with the necessary amount of water. For convenience in measuring, it is best to add sufficient water to make one gallon or two gallons of solution to each pound of lime used. When 50 gallons of Bordeaux is needed, take four gallons of lime solution (if one gallon of water to each one pound of lime has been previously used) and dilute this with 23 gallons of water, mixing thoroughly. In the same way take 25 gallons of water containing four pounds of dissolved copper sulfate and mix together these two quantities of diluted lime and sulfate solution. This is most conveniently and thoroughly done by allowing the ingredients of the mixture to flow together from two tanks, one containing the copper sulfate solution and the other the lime solution. The two streams may flow together into a third receiving tank or directly into a spraying tank or barrel. This gives a much better and more satisfactory mixture than can otherwise be made. As the mixture passes into the spraying tank it should be strained through a wire strainer containing 20 wires to the inch.

MACHINERY.

While it is highly important that a good mixture of Bordeaux be made, it is also of the greatest importance that the machinery and appliances necessary for the work be in a good state of repair and conveniently operated. On the last page we show a cut of one of the most convenient spraying outfits yet seen operated. The tank is mounted on light and yet substantial running gears with wheels having five inch tires. The front wheels are sufficiently low to permit the making of a short turn which is often desirable in moving about in the orchard. The tank is a 200 gallon tank and when filled is easily handled by one horse of 1450 pounds weight. The hose pass through loops at the rear of the spraying tank and are thereby prevented from being caught in the wheels. Among the best features of this outfit are the tool box and the platform on which the operator stands. The tool box is provided with hammer, pipe wrench, hose couplers, reducers, extra nozzles, extra hose, etc., in short, everything to make necessary repairs on any part of
the apparatus when circumstances demand. This tool box also serves as a seat for the driver in going to and from the orchard. The platform at 1 in the illustration is placed at just the right distance from the lever so that the man who does the pumping can get the greatest purchase on the handle with the least amount of stooping. He is also constantly facing the horse, thus rendering driving convenient.

**Summary.**

Bitter Rot and some other fungous diseases of the apple have made their appearance in many apple orchards in Illinois extending from the extreme southern to the central part of the State and across the State from east to west.

The Illinois Experiment Station has been carefully watching the progress of these diseases and carrying on careful experiments connected with the same in different parts of the State. They have three men devoting their entire time just now to the study of these diseases in the laboratory and in the field.

The crop of apples cannot be saved after the disease has become thoroughly established in the orchard. If treated in time, the apples not already affected can be prevented from rotting.

The fruit should be sprayed with the ammoniacal solution of copper carbonate or with Bordeaux as soon as the presence of the disease is detected.

It would be disastrous so far as the crop is concerned to delay a day or two days after the disease has first appeared.

Be thorough, be persistent, have material properly mixed, and have machinery in perfect working order.

It will pay to spray for Bitter Rot and the other rots of apples if there is at least one-third of a crop of fruit in the orchard and if that fruit has not already been rendered worthless by the attack of apple scab fungus and Codling-moth.

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