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TREATMENT OF SOME FUNGOUS DISEASES.

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TREATMENT OF SOME FUNGOUS DISEASES

——BY——

L. M. UNDERWOOD AND F. S. EARLE.

Much has been written in recent years on plant diseases and their treatment. A division of the Department of Agriculture at Washington has been created for the special purpose of studying them, and the entire staff of ten or twelve trained botanists devote their whole time to the work. The various State Experiment Stations are nearly all working in the same field, and publications from these various sources are rapidly accumulating. It is the purpose of the following pages to present in compact and convenient form to the farmers and fruit growers of Alabama a statement of our present knowledge concerning some of the more common and destructive diseases of our more important crops. It is in no sense a contribution to scientific literature, but a compilation intended as a ready reference for practical farmers. Bulletin No. 45 issued from this station, serves a somewhat similar purpose for injurious insects, but so far this station has published no general directions for the treatment of plant diseases caused by fungi. Only the more important diseases, and those likely to prove troublesome in this State will be discussed under the crops which they affect. It is first desirable to give a brief discussion of the nature of fungi, and their relations to other plants, since many hold very erroneous ideas regarding them.

The Nature of Fungi.

Among the lower forms of vegetation none that are relatively so conspicuous and common are popularly so little understood as the fungi. This arises from the fact that the

group contains a vast number of kinds that, so far as form and habit are concerned, are utterly diverse from each other. It is not easy for instance to see any striking resemblance between an ordinary mushroom or toadstool, and the rust that grows on our grain, or the smut that disfigures our corn. There is little outward resemblance between the giant puff-ball, and the leaf spot of cotton or strawberry, yet all these forms come under the same designation as fungi.

A second source of popular confusion has arisen from the more or less one-sided way in which the subject has been treated by popular or even scientific writers. Certain forms of fungi injurious to cultivated plants have been written about, and naturally their ravages have been made prominent. In this way the farmer has often been led to believe that all fungi are enemies to be combatted with Bordeaux mixture, and all sorts of spraying machines. A comprehensive view of the group is rarely presented, and it is desirable in this as in every other subject that we form some definite notion of the subject in its general relations in order that our ideas may not be one-sided or distorted.

The group of plants known collectively as fungi—for fungi are just as truly plants as any other form of vegetation—are associated together and distinguished from other low forms of vegetation by a simple physiological character, which can be easily recognized, notwithstanding the fact that it is a negative one. This characteristic is the inability to live on mineral or inorganic matter. Ordinary green plants, high or low, have the power to take the gaseous constituents of the atmosphere, together with water and certain mineral salts found in the soil, and through the agency of sunlight transform them into starch, sugars, and other more highly organized forms of food stuffs. This they are enabled to do by virtue of the possession of a green substance, that which gives the color to ordinary vegetation. This substance is called *chlorophyll*

(literally leaf-green). It is this function possessed by green plants that serves to distinguish them from all other living things. The fungi having no chlorophyll in their composition, are unable to perform this function, and hence must depend for their food supply on some form of matter already organized. Some live on decaying matter, and are known as saprophytes: such are the toadstools and puff-balls that grow about muck piles, or decaying stumps, or buried roots, and the bracket-fungi on dead or fallen tree trunks; such also are the moulds that grow on bread, preserved fruits, and other forms of food; such also is the microscopic yeast plant that causes alcoholic fermentation, and is used alike in the manufacture of bread and beer; such are many of the still more minute bacteria that are the cause of decay and putrefaction. Other fungi secure their food from the living tissues of plants and animals, and are called parasitic fungi; a few even are parasitic on other fungi.

Fungi are unable to organize inorganic food, because they contain no chlorophyll. Whatever may be their color, they may be characterized as not green.* The more ordinary color of fungi is white, but black, brown, blue, yellow and various shades of red are not uncommon.

Since it happens that not all parasitic plants are fungi, we should limit the definition of the group still further by the statement that fungi reproduce their kind by microscopic spores, and never by seeds.

Spores Different from Seeds.

As the distinction between seed and spore is not well understood, it may be well to contrast them. If we cut open the seed of a squash, apple or bean, we will find that the in-

*Certain apparent exceptions to this rule are familiar in the ordinary green mould, the green fungus of decaying wood which stains fallen timber, and a few others. In all these cases the green color is due to other substances than chlorophyll, and in fact the shade of green presented is different from the familiar green of ordinary vegetation.

terior consists of two halves, connected at one point by a short sprout-like body. Between these two halves, especially in seeds that have commenced to swell, we can see even with the unaided eye, the young shoot that is destined to become the new plant. These two halves of the seed contain a rich supply of nourishment, and as the seed sprouts, they become the first leaves of the young plant, and supply its food until it has developed its roots and is able to obtain nourishment from the soil. This structure which forms the entire contents of the hull in the cases mentioned, is called an embryo, as it is really nothing but a young plant. It is the possession of this embryo that distinguishes a seed as such. In other seeds like the morning glory and the persimmon, the embryo instead of filling the entire hull, lies embedded in a mass of nutritive substance. This embryo can be seen beautifully in the seed of a persimmon that has been split flatwise after a little soaking. A seed then is a reproductive body of sufficient size to be easily seen, possessing a complex structure, and containing an embryo which on sprouting becomes a young seedling.

Now how does a spore differ from a seed? In the first place a spore is so small that it cannot usually be seen singly with the unaided eye. If we press a puff-ball, a small cloud of dust-like particles issues from it. Every particle of this dust-like matter is a spore and the mass of them issuing from the ball becomes visible because of the immense numbers. These spores are so small that it would take about 5,000 of them laid side by side to make a line an inch long, and a puff-ball an inch in diameter would contain many millions of them. And yet each of these spores, consisting of a mere skin containing a minute drop of a glairy fluid, is capable, if placed under suitable conditions of heat and moisture, of germinating into a new fungus like the one that produced the spore in the first place. Another instance of spores that are visible in the mass is seen in the ordinary smut of corn or oats. The black smutted heads of oats are made up when mature of a mass of black dust that easily soils the fingers. Each particle of this black smut is a spore

and each one that reaches a suitable place for sprouting is able to smut a head of grain the following year. Still other spores can be seen in the rusty or black lines that appear on the stems of various small grains. These lines are simply the masses of spores of the parasitic fungus breaking through the surface of their host plant in order to spread the rust to other plants or to hold the fungus over the winter to attack the young grain of the following season.

A spore then is a reproductive body that has the same office as a seed, but differs from it in its microscopic size and simple structure. When the spore germinates it pushes out a minute germ tube which becomes what we call a *hypha*. The spores of fungi have a definite form when viewed through a microscope. Some have characteristic shapes so that the particular group to which they belong can be easily recognized. In others the shape is less characteristic, but the form of spore produced by any one species is as constant for that species as the shape of the seed produced by any of the higher plants.

Definition of a Fungus.

A Fungus then is (1) A plant that has as definite a life history and mode of growth as a cotton plant, an oak or any other form of vegetation. (2) Is devoid of chlorophyll or the ordinary green color of vegetation. (3) Possesses a simple structure, and (4) Reproduces itself by means of spores.

In structure, fungi vary as widely as do the higher forms of vegetation. Some of the simplest, like the yeast-plant, consist of a minute drop of semi-fluid substance (*protoplasm*) surrounded by a delicate covering known as the cell wall, the whole not over one three-thousandth of an inch in diameter. More complex forms like the moulds, form delicate thread-like structures (*hyphæ*) which frequently interlace into a tangled, matted or more or less felty mass (*mycelium*). Some of the larger forms are gelatinous, some are fleshy, some leathery, corky or even firm and woody, but in each case this structure is developed by some modification of the

simple interlacing mycelium. There are none of the highly developed forms of tissues seen in higher plants, the structure of fungi being always simple.

Not all fungi are injurious, many are harmless, some are beneficial and even a necessity to our existence. Of the larger fleshy forms a considerable number are valuable food plants as nutritious as fish, oysters or beef, and there is no reason why they should not form as common an article of food among us as they do in the countries of Europe. The fact that we import large quantities of mushrooms from Europe which could be easily produced in this country and of a much better quality than the imported article is suggestive of one of the undeveloped resources of industry and cultivation that is lying dormant in our midst. It is, however, the parasitic forms of fungi, that at present concern us most.

Classes of Parasitic Fungi.

Parasitic fungi may be conveniently classified in three groups:

(1) Internal free parasites floating or swimming in the cell sap of plants and absorbing their vitality. Such a parasite is the one that produces pear blight and such are the parasites that assist in producing the various rots of different garden vegetables.

(2) External fixed parasites, forming a cobwebby growth of mycelium on the surface of leaves or fruits and drawing nourishment from the plant by means of suckers. Such are the powdery mildew of the grape and those of a similar nature found on many other plants.

(3) Internal fixed parasites, growing entirely within their host-plant, sapping its nourishment, and only appearing at the surface when ready to reproduce by means of spores. This group includes by far the greater number of species of parasitic fungi that infest cultivated plants and include the rusts, smuts, downy mildew of the grape, black rot, the ripe rot of apples and other fruits, etc., etc.

Other Causes of Plant Diseases.

Not all the diseases of plants are produced by parasitic fungi. Some diseases are physiological, due to drainage, the character of the nutrition or the lack of it, and to many other causes not well understood. Other diseases are caused by insects of various kinds or by the ravages of other and often more minute forms of animal life.

In order to treat a disease succesfully we must know its cause and if it is due to a parasitic organism we must know its life-history, its mode of entrance to its host and its method and time of reproducing itself, in order that we may attack it at its weakest point, prevent its entrance to the host, and prevent its spread by its many methods of reproduction.

Not all diseases that are called by the same general name are produced by the same cause. For instance the term "rust" as applied in the State of Alabama to a disease of cotton has nothing in common with the rust that appears on the cereals. In fact the term "cotton rust" is a loose general term that really means about as much as "cotton disease" for it is indiscriminately applied to several distinct diseases, some of which are physiological and some of which are caused by various parasitic fungi. Again the term *blight* has a very loose popular usage and has been the source of much confusion. There is no such thing as a general blight affecting various plants. The blight of the pear and apple is due to a very definite organism, concerning which much is already known. The blights of other plants, notably various garden vegetables, is due to other entirely different organisms whose character is far from being well known.

Root galls, or swellings on the roots of plants, are due to various causes and must be made a separate study before the cause can be determined in any given case. In the grape they may be due to the work of various insects, or produced by minute thread worms (*nematodes*); in many garden vegetables and field crops they may be due entirely to the latter cause; in the cabbage and other members of the mustard family they are due to an internal plant parasite of a low

order that produces the disease known as "club foot," which externally often resembles the deformities produced by the nematodes. In several leguminous plants root galls are produced by an internal parasite, but in this case instead of forming a disease, the parasite is rather beneficial than otherwise as it serves to assist the host in collecting nitrogen. In still other cases the causes of root galls are entirely unknown.

Sufficient has been said to indicate that too careful a study of the conditions and causes of plant diseases can not be made, and that we should be careful in too much hasty generalization. In order to furnish the farmers of Alabama some information of the most common fungous diseases that are likely to be met with in the State, and to furnish simple directions for treating them as approved by practice here and elsewhere, we give, after a few formulas for preparing fungicides, a classified list of fungous diseases, giving symptoms where not well known and method and time of treatment.

FORMULAS FOR FUNGICIDES.

As a rule fungicides are applied as a preventive rather than a cure. Since it has been found that the spores of fungi will not germinaie in the presence of salts of copper, various preparations have been applied which involve the salts of that metal in solution. The following will be found the most efficient for general use, but modifications will be noted for special cases later:

Sulphate of Copper.

Formed by dissolving two pounds of copper sulphate (bluestone) in fifty gallons of water. In dissolving the bluestone it should be placed in a small piece of gunny sack and suspended near the top of the barrel as it will dissolve too slowly otherwise. This can only be used on vines or trees before the buds have commenced to swell.

Bordeaux Mixture.

As commonly applied, it is formed of six pounds of copper sulphate (bluestone) and four to six pounds of quick lime dissolved in fifty gallons of water. The bluestone should be dissolved as in the preceding formula. The mixture must be thoroughly stirred while using.

Ammoniacal Carbonate of Copper.

This is made by dissolving four ounces of carbonate of copper in two quarts of ammonia and adding the solution to fifty gallons of water.

Copper Acetate.

Dissolve four ounces of copper acetate in fifty gallons of water.

Combination of Insecticides and Fungicides.

Four ounces of Paris green or London purple may be added to fifty gallons of Bordeaux mixture when it is desirable to spray for both fungi and insect pests.

Method of Application.

A large number of forms of spraying apparatus are on the market and the amount of work of this kind to be done and the kind of plants to be sprayed will determine the character of the apparatus to be used. A nozzle that produces a fine mist-like spray is always desirable and in some cases a necessity.

DISEASES OF CULTIVATED PLANTS.

CORN.

Fortunately this great staple suffers from comparatively few fungous diseases. The only one to be mentioned here is the smut (*Ustilago maydis*). The appearance of this dis-

ease is too well known to need description. The unsightly pustular masses filled with black powder are only the fruiting portion of the fungus. They usually occur on the ears but are occasionally seen on the tassels or on the leaves. Under the microscope each particle of the black smutty powder is found to be a minute brown ball-like spore covered with little spines. The mycelium or vegetative portion of the fungus grows entirely within the corn plant. It consists of delicate colorless threads which penetrate the tissues of the corn plant and draw its nourishment from it. They cannot be seen without the use of a microscope.

Corn smut is widely distributed. Probably no field can be found entirely free from it. Farmers are so accustomed to seeing it that but little thought is given to the loss it causes. It is true that in individual cases this is not great; it does not sweep through a field destroying an entire crop as is the case with some diseases, but the aggregate loss it occasions is quite large; cattle are sometimes killed by pasturing in badly smutted stalk fields.

The smuts of the small grains can now be quite successfully controlled by treating the seed. So far no treatment has been found that is of the least use for corn smut. It is sometimes recommended to go through the fields and remove the diseased stalks as soon as they can be detected before the spores ripen. If this should be done persistently by all the farmers in a neighborhood, it would doubtless materially reduce the loss from the disease in subsequent crops. At present no other remedy can be suggested.

OATS.

Oat Smut.—Like corn smut this is a widely occurring disease. It is caused by a similar fungus (*Ustilago avenae*). The spore masses are much smaller than in corn smut, and the single spores are slightly smaller and smoother. The smutted heads of course go through the thresher with the rest, so that the dusty smut spores are well mixed with the grain. When such smutty seed is planted the following

spring, the smut spore germinates just as the oats are sprouting, and its delicate germ tube is able to pierce the soft tissue of the young oat sprout. The mycelium of the fungus now grows with the growing oat plant, and it makes no outward sign until the heads are formed, when instead of oats they are found to contain only the worthless smut spores. Fortunately the fungus cannot damage the oat plant after it has had time to harden. Many careful experiments show that infection only takes place through the freshly sprouting seed. For this reason any treatment that will thoroughly disinfect the seed by killing the smut spores adhering to it, will effectually protect the crop. The importance of treatment will be apparent when we know that the average loss in untreated fields is over ten per cent. of the entire crop. Treating the seed with copper sulphate (blue stone), has long been known as a preventitive of smut. It is still often recommended for wheat, but for oats either of the two following treatments are preferred.*

Potassium sulphide treatment.—Dissolve one and one-half pounds of potassium sulphide (liver of sulphur) in 25 gallons of water in a barrel. Add three bushels of seed oats, stir thoroughly at intervals to insure thorough wetting of all the grain, and allow to stand for twenty-four hours. Strain off the liquid and spread the oats to dry. The solution will answer for three lots of seed. Of course a tank should be used for treating large quantities.

Hot water treatment.—Provide two kettles, tubs or barrels holding at least twenty gallons each. Fill one with hot water at 110 to 120 degrees, the other with scalding water at 132 to 133 degrees. Have plenty of boiling water and cold water at hand with which to maintain these temperatures. Put one-half bushel of oats in a coarse loosely woven gunny sack. Plunge it in the vessel of warm water and lift it up and down several times to

*For a full discussion of this subject, see "The grain smuts; their causes and prevention," by W. T. Swingle, in the Yearbook of the Department of Agriculture for 1894.

thoroughly wet and warm the grain. Allow it to drain a moment, and then transfer it to the hot water. Let it remain in the hot water for ten minutes, agitating freely, then remove and spread the grain to dry. The success of the treatment will depend entirely on keeping the hot water as nearly as possible at 133 degrees. If the temperature rises above 135 degrees, it may injure the seed, and if it falls below 130 degrees, some of the smut spores will not be killed. The wet seed should be spread out two or three inches deep, and be shoveled over frequently until quite dry. This is not necessary if it is to be sown immediately by hand.

An important consideration in favor of these two treatments of seed oats, is that the seed germinates quicker, and the yield is considerably increased aside from the gain in preventing smut. The copper sulphate treatment retards germination and does not increase the yield.

Oat Rust.—This disease is produced by *Puccinia coronata*,* quite a different fungus from those causing smut. The mycelium in this case also consists of colorless threads buried within the oat tissues, but instead of extending throughout the plant as with the smut, they are confined to rather small areas beneath the spots covered by the reddish or rust-colored powder from which the disease takes its name. This reddish powder consists of the spores of the fungus. Under the microscope they are seen to be three or four times as large as the smut spores. They are oval in shape, and of a light yellow color. They germinate quickly under proper conditions of heat and moisture, and their germ tubes are able to penetrate the oat leaves, where they soon develop new spots of rust. The disease is thus enabled to spread very rapidly when weather conditions are favorable. This disease does not attack the grain itself, as does the smut. If only a little is present, the injury is slight, but when abundant, it de-

**Puccinia graminis* and *P. rubigo-vera* also occur on oats, but the above remarks will apply equally well to these species.

stroys so much of the leaf surface, and appropriates so much of the nutriment of the plant, that the grain is light and poor in quality, and often greatly deficient in quantity.

A little later in the season a second kind of spore is developed on the rust mycelium. These form short black lines on the leaves and stems. They are called winter spores, because their office is to carry the fungus through the winter. They are long and narrow, and are divided by a cross partition into two cells. They are darker colored, and the cell wall is thicker than in the red or summer spores. This fungus is a good example of the true rusts (*Uredineae*). They form a large group and include some of our most troublesome diseases. As a rule they do not yield readily to treatment. No practical remedy has been found for the oat rust. Some varieties of oats, however, suffer less from the disease than others. In this State it is usually only the resistant or so called "rust proof" varieties that are planted. Something moreover can be done by methods of planting and fertilizing, to help the oat plant to resist the rust. On some soils oats will rust less when plowed in, thus covering the seed more deeply, and producing a deeper rooting habit than when merely brushed and harrowed in after the land is plowed. Excessive applications of nitrogenous fertilizers like stable manure or cottonseed meal that cause a soft, succulent growth, are more apt to favor rust than where the mineral elements, phosphates and potash, predominate in the fertilizer, and the growth is harder and less rapid.

Other serious diseases of oats occur, but they will not be considered here.

COTTON.

The diseases of cotton have been studied by the officers of this station, and have been discussed in Bulletins 21, 27, 36, 41 and 55. In Bulletin 41, Professor Atkinson described all the cotton diseases that had been observed by him, and the reader is referred to that bulletin for a detailed dis-

cussion of them. The diseases enumerated, are briefly as follows:

1. YELLOW LEAF BLIGHT OR MOSAIC DISEASE. A physiological trouble due to poor nutrition. It can often be prevented by applications of kainite.

2. FRENCHING. Caused by a fungus (*Fusisporium vasinfectum*).

3. DAMPING OFF OR SORE-SHIN. Caused by the mycelium of an unknown sterile fungus. This affects the young seedlings.

4. ANTHRACNOSE. Caused by *Colletotrichum Gossypii*, usually affecting the bolls.

5. SHEDDING OF BOLLS. A serious trouble, usually entirely physiological and not due to either insects or fungi.

6. ANGULAR SPOT OF COTTON. An obscure disease of the leaves, probably caused by bacteria.

7. AREOLATE MILDEW OF COTTON. Caused by a fungus (*Ramularia areolata*) which produces a white mildew on the leaves.

8. COTTON LEAF BLIGHT. Caused by the early or Cercospora stage of a fungus (*Sphaerella gossypina*).

9. ROOT GALL OF COTTON. Caused by the nematode (*Heterodera radicicola*). The same nematode affects many other garden and field crops and orchard trees.

Unfortunately no remedies can be suggested at present for most of these diseases. They are doubtless largely induced or at least aggravated by the common practice of cropping the land year after year in cotton. When cotton shall be made to take its place in a carefully considered rotation of crops great benefit will follow in its comparative freedom from disease as well as in the preservation of soil fertility and the avoidance of over production.

POTATOES.

POTATO BLIGHT.—The much dreaded Northern potato rot or blight (*Phytophthora infestans*) probably does not occur in this State. It certainly is not a common disease here.

We have, however, a Southern potato blight that is often very destructive. It manifests itself by the sudden wilting of the tops about the time the young potatoes are forming or perhaps after they are nearly grown. On cutting open the freshly wilted stems a spot will be found near the surface of the ground where the substance of the stalk looks clear and watery much as in the "water core" of certain apples. This watery portion is found to be swarming with bacteria and there is little question but that they are the direct cause of the disease. At first the young potatoes will still be quite sound but the disease soon reaches them through the stem and causes them to rot. When seemingly sound potatoes from a diseased vine are cut open a brown line can often be traced under the skin showing that the disease has already reached them. Such potatoes will not keep but will rot quickly, and if stored with others the rot soon spreads throughout the mass, causing great loss. This disease seems to live in the soil from one crop to the next, so that it is unsafe to plant potatoes the following year on land where the disease has appeared. The same, or at least a very similar disease attacks tomatoes, egg plants and peppers, so that these crops should not follow blighted potatoes.

No remedy is known except to avoid planting on infected land and to practice rotation of crops.

Potato Scab.—The black roughened or sunken patches often seen on potato tubers are caused by an obscure fungus (*Oospora scabies*). The same fungus attacks beets. It seems to be able to live as a saprophyte on the vegetable matter in rich soils, so that when the soil is once infected by planting scabby seed it is unsafe to plant it again in potatoes for some years. No known treatment will prevent the scab on such land. On clean land, treating the seed with corrosive sublimate will entirely prevent the disease even if scabby seed is used. Of course clean seed should always be used when possible. For this treatment dissolve two and one-half ounces of corrosive sublimate in two gallons of hot water in a tub or barrel. After standing until all is dissolved add

thirteen gallons of cold water. Soak the seed potatoes in this solution for an hour and a half, then dry, cut and plant as usual. The treated potatoes should of course all be *planted* and not used for other purposes as they are poisoned by the treatment. When scabby potatoes are fed to stock it is unsafe to use the manure for fertilizing potatoes as the scab fungus propagates in the manure and is thus taken to the field. On this account chemical fertilizers are usually preferred by potato growers.

LEAF-SPOT OF POTATOES OR MACROSPORIUM DISEASE.—Potato foliage is often observed to be covered by rounded brown or arid spots. At first these spots are marked by concentric rings or zones of a darker color, but at length the dried portion of the leaf often breaks out and falls away. This spotting may begin soon after the plants are up. If there is but little of it no great damage is done, but when abundant it destroys so much of the leaf surface that the nutrition of the plant is deranged and the tubers are few and small. In extreme cases the leaves fall and the plant dies prematurely without forming tubers at all. It is a wide spread disease and frequently occasions much damage. Fortunately it can be quite effectually controlled by careful spraying with Bordeaux mixture. The first spraying should be given soon after the plants are up and should be repeated three or four times, at intervals of ten days or two weeks. It must be remembered that this treatment, like most others, is preventive not curative. The Bordeaux mixture serves to protect the foliage from attack; it does not cure the spots already formed, hence the importance of beginning the treatment early. To be successful we must keep ahead of the disease. Fortunately the labor of spraying will not be lost even if the disease does not appear, for in some way, not understood, the Bordeaux mixture seems to slightly increase the yield besides preventing the disease.

If potato beetles appear, Paris green may be mixed with the Bordeaux mixture as indicated elsewhere, and both enemies can be combatted by the one application.

TOMATOES.

SOUTHERN TOMATO BLIGHT.—This is similar to the Southern potato blight if not identical with it and like it is of bacterial origin.* It also attacks egg plants and peppers. It first appears about the time the fruit is beginning to form, and is characterized by the sudden wilting and dying of plants that are apparently vigorous. In some localities its ravages have been so great as to cause the abandonment of the tomato as a market crop. The disease will remain in the soil from one year to the next, and will increase rapidly if tomatoes are planted continously on the same land. Some experiments conducted in Mississippi indicate the probable usefulness of heavy applications of lime and kainite to the soil, as well as the spraying of the stems with Bordeaux mixture, but these experiments are not conclusive, and no treatment can be positively recommended, except to avoid planting on infected land. Even then the disease sometimes appears when tomatoes are planted on entirely new land quite remote from other tomatoes. The source of the contagion has not been accounted for in such cases.

TOMATO LEAF-SPOT OR MACROSPORIUM DISEASE.—This is the same as the potato disease of the same name, and yields to the same treatment. It frequently occasions heavy losses.

TOMATO LEAF BLIGHT.—This is caused by a fungus (*Cladosporium fulvum*) that forms a velvety olive brown coating on the under side of the leaves causing them to fall prematurely. It is a common pest when tomatoes are grown in greenhouses in winter, and is sometimes troublesome in the open air at the South. Spraying for the macrosporium will check this disease also.

TOMATO BLACK-ROT OR BLOSSOM-END ROT.—This widely occurring and destructive disease is not yet well under-

*A blight somewhat similar in its effects occurs in Florida that is caused by the growth of the mycelium of some fungus. It has not so far been detected in this State.

stood. At least two fungi (*Macrosporium Tomato and Fusarium Lycopersici*) are usually associated with it, but in just what connection cannot be positively stated. It is usually first seen as a discolored spot on the blossom end of the tomato fruit, soon after it has formed. This increases rapidly in size, becomes sunken, and is at length covered with the dusty spores of the associated fungi. It is liable to cause very serious damage, not unfrequently destroying over half the crop. The early clusters usually suffer worst, but its attacks are quite erratic, seeming to depend on the weather and on the general condition of the plant. It is invariably bad during seasons of protracted drouth; at such times a good rain will often check its ravages. Again during very wet weather there may be a destructive outbreak. Excessive manuring sometimes seems to favor the disease, while half starved plants growing in some poor spot may also be badly affected. In fact anything that checks or unduly stimulates the normal healthy growth of the plant, seems to favor the disease.

Spraying with Bordeaux mixture is often recommended for this disease, but the results of experiments so far reported are somewhat contradictory, and it cannot be definitely stated how successful such treatment will prove to be. Much will probably depend on the thoroughness and frequency with which the applications are made. Since the Bordeaux is known to be useful in combatting the Macrosporium disease, and is possibly useful in preventing the blight, it should certainly be applied with the hope that it will be of use in preventing the rot also. For one or two applications while the fruits are small, it is advisable to add one-fourth of a pound of Paris green to each barrel of the Bordeaux, with the hope of killing some of the young boll worms that feed on the surface a few hours after they are hatched, and before they bore into the fruit. The ravages of this insect will cause it to contest with the black rot for first place among the enemies of the tomato grower.

Other destructive rots of the green tomato occur, one probably of bacterial origin, but they have been little studied, and no remedies can be suggested.

WATERMELONS.

MELON WILT OR MELON BLIGHT.—This disease is attracting increasing attention throughout the South. In most melon growing districts it is being found impossible to plant the land to melons year after year, without suffering great loss from it. It usually only appears after the vines have run out so as to nearly cover the ground, when they will suddenly wilt and die. The symptons are so much like those of the potato and tomato blights, that some connection between them has been suggested. This, however, is not the case. The melon blight is not bacterial, but is caused by the growth of an internal fungus that plugs up the ducts of the stems and causes the sudden wilting by shutting off the water supplied by the roots. This has been demonstrated by Dr. Erwin F. Smith of the Department of Agriculture, who is making an exhaustive study of this disease. Where the soil becomes infected, it is necessary to abandon the culture of melons for several years. No remedy has been found. A rotation of crops is suggested as a proper preventive measure. In fact the more we study plant diseases, the more important the question of crop rotation becomes.

MELON ANTHRACNOSE OR BLACK-ROT.—This disease occurs abundantly throughout the South, and causes considerable loss to melon growers. It is probably identical with the melon anthracnose caused by *Colletotrichum lagenarium*, discussed in the fifth annual report of the Delaware experiment station. It has been little studied, and no remedy can be suggested.

SWEET POTATOES.

This is an important crop for the South but its diseases have not been studied much here. In Bulletin No. 76 of the

New Jersey Experiment Station, Dr. Halsted describes nine fungous diseases of the sweet potato. It is probable that many of them also occur in this state. Some of them only attack the stored potatoes, others attack the foliage, while still others live on the vine through the summer and cause a destructive rot of the stored potatoes in winter. The Black-rot (*Ceratocystis fimbriata*) is of this class and is perhaps the worst of sweet potato diseases. It first appears on the potatoes as dry sunken dark-colored spots. If any such diseased potatoes are bedded in the spring, the fungus will attack the draws or shoots forming black spots on the stems. Such draws are said to have "black-shank" and if planted will certainly produce diseased potatoes in the fall. This may not show much when dug but it will develop later and the the rot will spread to neighboring sound potatoes in the bin. This shows the necessity for bedding none but perfectly sound potatoes. This disease seems to be able to live over for some time in the soil so when it is detected it is unwise to replant the same land to sweet potatoes for a year or two at least.

Much of the loss in the stored sweet potatoes from the other rots can be avoided by greater care in digging and handling. Cut and bruised sweet potatoes never keep well and when freshly dug they are very easily injured. The common practice of picking them up in sacks after digging always bruises them badly. Smooth shallow boxes holding half a bushel to a bushel should be provided for this purpose and they should be emptied carefully so as to avoid letting the potatoes fall any distance. In fact they should be handled as carefully as eggs in order to keep well. If they are stored in bins or cellars it is important to clean these out thoroughly and disinfect by burning sulphur and whitewashing before storing another crop. Some very favorable results are reported from dusting the potatoes as they are stored with a powder prepared by slaking lime with water in which copper sulphate has been dissolved.

PEACHES AND PLUMS.

These important stone fruits may be considered together since they are mostly subject to the same disesses. Peach yellows so destructive to orchards in many other regions does not occur here; nor has the closely related peach rosette been reported from this state though it occurs abundantly in middle Georgia and may be expected here at any time. Fortunately it has not proved as serious a disease as was feared a few years ago.

PEACH AND PLUM ROT.—This is easily the worst disease of stone fruits. Its appearance on the half grown and ripening fruit is well known but the fungus causing it (*Monilia fructigena*) also attacks the blossoms and very young fruits causing them to blast and fall. At other times it attacks the rapidly growing young wood and causes a destructive twig blight. It lives over winter in such diseased wood and also in the dried or mummied fruits so often seen hanging on the tree in the spring.

Some varieties are more subject to the rot than others but none a are exempt. Its growth is largely influenced by the weather, being greatly aggravated by hot damp or showery days, and in seasons where such weather is frequent, total loss of crops sometimes occurs. As the fruit approaches ripeness the trees should be examined frequently and any rotting specimens should be removed. This is important as the disease spreads very rapidly from the rotting to the sound fruit. Thinning the young fruit so that they hang separately on the limbs is of great use in preventing the spread of the rot as it allows them to dry more quickly. This practice adds so much to the size, quality and market value of the fruit that it should certainly be practiced by all. Another important precaution is to remove all mummied fruits from the orchard before blooming time. Fruit rots worse on rich land or where an excessively luxuriant growth has been caused by heavy applications of nitrogenous manures. Such lands and fertilizers should be avoided for stone fruits. They thrive best on high well

drained, rather thin lands but on such soils will be greatly benefited by moderate applications of the phosphates and potash.

The advisability of spraying with fungicides to combat peach and plum rot is perhaps still an open question. Some experimenters, particularly Professor Chester of the Delaware Experiment Station, report very encouraging results, but the foliage especially of the peach, is very liable to injury from such applications and they must be made with great care. The disease is so important that extensive experiments are justified in attempting to control it, but only the best pumps and Vermorel nozzles giving a fine mist-like spray should be used in making the applications. Professor Chester * recommends the following treatment :—

1st. During the winter gather and burn all mummied fruit.

2nd. In winter or early spring (before the buds start) spray with a solution of copper sulphate using one pound to 25 gallons of water.

3rd. When fruit buds begin to swell spray with Bordeaux mixture made with six pounds of copper sulphate and at least six pounds of quick lime to the barrel.

4th. Spray again with Bordeaux mixture just before the blossoms open.

5th. As soon as the blossoms fall, spray again with the Bordeaux mixture, to which is added three ounces of Paris green per barrel. This is on account of the curculio which attacks the young fruit. The Paris green should be rubbed to a smooth paste with a little water before adding to secure an even mixture.

6th. In ten days repeat the Bordeaux and Paris green

7th. When fruit begins to color, spray with copper acetate (four ounces to the barrel of water). This is recommended instead of the Bordeaux at this stage, since it does not adhere to the fruit nor disfigure it, and it is found to be equally effective.

*Delaware Experiment Station, Bulletin 29.

8th. Repeat the copper acetate after a week or ten days.

The total cost of this treatment is estimated by Professor Chester at twelve cents per tree where everything is done economically, and in the experiments reported about three-fourths of the rot was prevented. He admits some dropping of the leaves as a result of the spraying, but thinks this injury more than balanced by the foliage hanging much later in the fall on the treated than on the untreated trees.

LEAF RUST.—This is caused by a fungus (*Puccinia pruni-spinosae*) closely related to the rusts of grain. It often develops abundantly on peach and plum leaves late in summer, causing them to fall prematurely. This and other leaf destroying fungi will probably be effectively controlled by the spraying suggested for the rot.

GUMMOSIS.—This is an obscure diseased condition that manifests itself by the occurrence of blisters or pockets filled with gum under the bark of the trunk and branches. It is not to be confounded with the copious flow of gum occasioned by injuries from borers or other mechanical causes. It is accompanied by a serious constitutional derangement of the tree, and frequently causes its death, but the nature of the disease is not known, and no remedy can be suggested.

APPLES, PEARS AND QUINCES.

These pomaceous fruits are subject to many of the same diseases, the most important of which is the—

BLIGHT.—This is a bacterial disease caused by the growth of a minute germ or microbe in the young, soft tissues of the tree. The diseased parts soon die, and the blackened persistent leaves can be seen hanging as a signal of distress in most Southern orchards. As the wood growth begins to harden, the disease becomes less active and usually dies out of its own accord. In such cases a distinct ring marks the union of the dead and living bark. In a few cases, however, the disease does not stop, but

continues to grow slowly in the soft inner bark, and it is such spots of still living blight that serve to carry the contagion over winter. This is an important point in the life history of the disease that has been pointed out recently by M. B. Waite of the Department of Agriculture, who has devoted much time to the study of this disease. He has shown that from such spots of "hold over blight," the germs are carried to the flowers in the spring by bees and other insects. Here they multiply rapidly in the nectar secreted by the flowers, and are widely disseminated by the same insect agency, causing the sudden outbreak of "blossom blight," so familiar and so disastrous to Southern pear growers. The disease has attracted most attention on the pear, but it frequently occurs on the apple and the quince. The only known remedy has been to cut out and burn the diseased portions as soon as they can be detected. Mr. Waite's discovery of the way in which the disease passes the winter, indicates that it should be supplemented by a very careful examination of the trees during winter and early spring, to remove all spots of the "hold over blight," thus destroying the contagion as far as possible before it is carried to the open flowers, which are by far the most vulnerable part of the tree.

Another important point in combatting pear blight, is to so control the growth of the tree as to prevent a rank, sappy, over vigorous condition. It is in soft, rapidly growing tissues that the blight thrives best, and when it gains entrance to such trees, it is very hard to check its course. In a tree that is making only a moderate growth that matures and hardens early, the disease frequently dies out of itself without doing such serious injury. For this reason especially, as the trees reach bearing age, nitrogeneous fertilizers and excessive cultivation should be carefully avoided. A little seeming neglect is often the best possible treatment for a pear orchard. On good soil the ideal treatment of a pear orchard of bearing age would be to sow down to some low-growing legume like *Lespedeza* or

white clover, and pasture with hogs, giving occasional top-dressings of kainite and acid phosphate.

APPLE LEAF RUST.—A yellow spotting of apple leaves, caused by the growth of a fungus forming cupshaped receptacles filled with yellow spores, often does considerable damage. Some varieties are much more affected than others. It seldom attacks pears or quinces. Another stage of the growth of the same fungus occurs on the red cedars, causing the large gall-like growths known as cedar apples. The advisability of destroying infested cedars in the neighborhood of apple orchards will at once suggest itself as a remedy against this disease.

PEAR AND QUINCE LEAF BLIGHT.—A very different fungus (*Entomosporium maculatum*) causes the dropping of pear and quince leaves in midsummer. It does not attack apples. Minute brown spots, usually with a reddish border, appear on the leaves, and when there are many of these spots the leaf turns yellow and falls. Some varieties of pears are so badly affected as to be as bare of leaves in June and July as they should be in December. Such trees can, of course, mature no fruit and the falling of the leaves prevents the forming of fruit buds for the next season's crop. The fungus also grows on the fruit, causing it to crack. It is often less severe in trees standing in sod than in cultivated ground. Pear seedlings in the nursery often suffer severely from this trouble and it prevents their becoming large enough to bud.

It is found to yield easily to treatment with Bordeaux mixture, and the spraying of nursery stock is now largely practiced with the best results. In the orchard the treatment to be recommended under the next heading will serve to control this disease also.

APPLE AND PEAR SCAB.—The species of *Fusicladium* causing this well known disease are supposed to be slightly different on apple and pear, but for practical purposes they may be considered as identical. The presence of the fungus prevents the fruit from reaching full size; it injures its keeping qualities, and by its unsightly appearance greatly

reduces its market value. It also develops on the leaves and on the young twigs. An early spring growth of the fungus often causes the blasting of the flowers and the serious dropping of the young fruit.

The following combined treatment is recommended for preventing or materially lessening the amount of scab and leaf blights and of various summer rots, and at the same time to prevent the loss from wormy fruit and leaf eating insects.

1st. In winter or early spring, before the buds swell, spray with solution of copper sulphate.

2d. Just before the blossoms open spray with Bordeaux mixture.

3d. Just after the blossoms fall spray with Bordeaux, to each barrel of which four ounces of Paris green has been added.

4th. In ten days or two weeks repeat the Bordeaux and Paris green. Later sprayings of Bordeaux alone may be useful but are liable to mar the fruit.

The above treatment cannot be too strongly recommended to all apple and pear growers where scab and codling worms are abundant. On the Gulf coast these troubles have not yet appeared so that these sprayings are not required.

GRAPES.

BLACK ROT; DOWNY MILDEW; POWDERY MILDEW; ANTHRACNOSE.—These four well known grape diseases can all be largely prevented by the following treatment, which is earnestly recommended to all grape-growers:

1st. Before the buds swell spray with copper sulphate solution.

2d. When growth starts, and the largest leaves are perhaps an inch across, spray with Bordeaux mixture.

3d. Just before the flowers open spray again with Bordeaux.

4th. As soon as the flowers fall spray with Bordeaux.

5th. In ten days or two weeks, when the berries are the size of small peas, spray again with Bordeaux, taking care to direct the spray so that all the bunches will be fully covered. If the work has been carefully done this will usually serve to protect the crop quite perfectly. In very wet seasons one or two later sprayings may be advisable, but they should be made with the ammoniacal copper carbonate solution, as late spraying with Bordeaux stains the fruit unpleasantly.

The anthracnose is more difficult to fully control than the others and treatment is not always satisfactory. The black rot is also very persistent and in badly affected vineyards the greatest care and thoroughness in making the applications is required to control it. On a small scale pinning paper bags over the clusters as soon as the fruit is set furnishes very complete protection from the rot and such bagged grapes ripen more evenly and are finer in flavor than those unprotected. If the vineyard is infested with the green saw-fly larva or by any of the leaf-eating beetles, four ounces of Paris green may be added to the barrel of Bordeaux at any of the sprayings.

Bitter Rot.—This disease seems to be largely confined to the South. In some localities here it is far more troublesome than the black rot. It attacks the berries just as they are ripening giving them a blistered or sun-scalded appearance. Later they are covered with the fruiting pustules of the fungus (*Melanconium*) which resemble somewhat closely those of the black rot, but the berry remains plump and turgid and does not shrivel and become hard as in the latter disease. The bitter rot also attacks the stems of the fruit clusters and it is here that it does its greatest damage for the diseased stems instead of "curing" and becoming soft and pliant when picked so as to pack nicely and carry well, becomes hard and brittle. The berries fall off easily and such shattered bunches are quite unsaleable in market.

The early spraying with Bordeaux does not prevent this

disease. Something can be done towards controlling it by training the vines so that the fruit will hang in the shade of the leaves, for such sheltered fruit is less often diseased than that hanging exposed to the sun and dew. On this account some form of horizontal trellis is much to be preferred to the ordinary vertical trellis or to training to stakes.

ROOT ROT.—This disease can be detected by the presence of a white mould-like growth under the bark on the roots and crown. It is quite prevalent at the South often doing serious harm. A recent examination of the Station vineyard shows that out of 584 vines all but 83 show evident signs of this disease and many died during the late summer and fall. It seems evident that this is the cause of the death of so many of the vines on the station grounds as reported in previous bulletins. This disease has been little studied in this country and no remedy for it can be proposed at present. It seems to be identical with the disease known as *pourridie* in France. This has been shown to be caused by the growth of any one of three or more different fungi and is usually fatal in from two to three years.

Here some varieties are evidently much more resistant that others and some facts go to show that vines may live many years while more or less affected by it. The character of the soil probably has much to do with the prevalence of the disease.

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Correspondence regarding the appearance and extent of any diseases of plants cultivated in the State of Alabama is requested by this Experiment Station. When writing regarding plant diseases accompany the correspondence with specimens of the affected plants or portions of plants. It is desirable also to give as full data as possible regarding the nature and extent of the disease. Address all correspondence on this head to The Biological Department, Alabama Experiment Station, Auburn, Alabama.