DISEASES OF ECONOMIC PLANTS

STEVENS AND HALL

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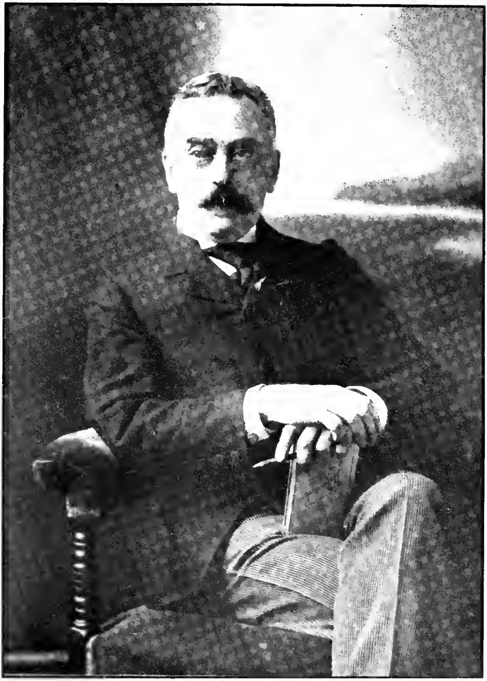

Yours truly
M. G. Farlow

DISEASES

OF

ECONOMIC PLANTS

BY

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PREFACE

Students of Plant Disease are naturally divided into two categories. First: those who wish to recognize and treat diseases, without the burden of long study as to their causes; second: those who desire to study the etiology of diseases, and to become familiar with the parasites which are often their cause.

The present book is designed to meet the needs of the first of these two classes of readers. It indicates the chief prominent characters of the most destructive plant diseases of the United States, caused by bacteria or fungi, in such a way that in most cases reliable diagnoses may be made, though it must be recognized that in some cases certainty cannot be had without recourse to microscopic details. Information is given regarding the best methods of prevention or cure for these diseases.

In this volume only such characters are used as appear to the naked eye or through the aid of a hand lens, and all technical discussion is avoided in so far as is possible. No consideration is given to the causal organism except as it is conspicuous enough to be of service in diagnosis, or exhibits peculiarities, knowledge of which may be of use in prophylaxis.

While, in the main, nonparasitic diseases are not discussed, a few of the most conspicuous of this class are briefly mentioned, as are also diseases caused by the most common parasitic flowering plants.

In selecting common names for diseases the authors have chosen those that are most widely used or generally known. In default of any generally accepted name or in cases where the name now in use is ambiguous, as when the same name is applied to more than one distinct disease, they have followed the plan of giving to the disease a name made by joining to the name of the genus of the causal fungus, with or without elision of the last syllable, as euphony may dictate, the termination "ose," signifying "full of." They have also employed this more accurate mode of designation in the text in all cases where it seemed desirable to do so.

F. L. STEVENS.
J. G. HALL.

RALEIGH, N.C.,
July, 1910.

ACKNOWLEDGMENT

WHILE the authors drew their information to a large extent from personal experience with the diseases discussed, the descriptions are necessarily largely compiled and the authors wish to acknowledge their great indebtedness to the publications of the various State Agricultural Experiment Stations and of the United States Department of Agriculture. In many instances the words of the original description are used, almost as quotations except for slight modification for brevity or to secure a change of sequence. In such cases the authors could not always indicate the quoted words. They desire here to record their special indebtedness to the writings of the following investigators: Ralph E. Smith; G. P. Clinton; Mel. T. Cook; H. S. Fawcett; J. C. Arthur; F. D. Kern; C. W. Edgerton; Ernst A. Bessey; J. B. S. Norton; E. M. Freeman; F. M. Rolfs; Chas. E. Bessey; E. Meade Wilcox; Chas. Brooks; B. D. Halsted; F. C. Stewart; H. A. Harding; J. G. Grossenbacher; H. H. Whetzel; B. M. Duggar; H. L. Bolley; A. D. Selby; Thomas F. Manns; H. R. Fulton; E. W. Olive; S. M. Bain; L. R. Jones; N. J. Giddings; H. S. Reed; W. H. Lawrence; J. L. Sheldon; D. Reddick; Roland Thaxter; W. G. Farlow; M. A. Carlton; W. W. Gilbert; G. G. Hedgcock; Haven Metcalf; W. A. Orton; Mrs. Flora W. Patterson; W. M. Scott; Erwin F. Smith;

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The authors are also deeply indebted for valuable suggestions and for helpful criticism of the manuscript to G. P. Clinton who read the portion pertaining to smuts, L. R. Jones potato diseases, J. C. Arthur and F. D. Kern the rusts, Erwin F. Smith the bacterial diseases, Hermann von Schrenk the timber diseases, W. A. Orton and W. W. Gilbert the other portions of the book; though all responsibility for any errors that may occur rests entirely with the authors. Acknowledgment is due to Mrs. F. L. Stevens and Mrs. J. G. Hall for aid in preparation of the manuscript and proof.

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INTRODUCTORY

Subdivisions of Plant Pathology

Plant Diseases may be considered under five heads: —

1. Those caused by cryptogamic parasites, fungi, bacteria, and slime molds.
2. Those caused by parasitic flowering plants.
3. Those caused by animal parasites, insects, worms, etc.
4. Those due to adverse inanimate environmental conditions, light, water, soil, nutriment, etc.
5. Physiological diseases due to other internal derangement.

Under the last head are grouped many diseases which undoubtedly will fall under one of the other groups when our knowledge concerning them is more nearly perfect.

Owing to the entirely different nature of the causes of the diseases classed under these groups, their study falls to the lot of separate specialists: the first group to the mycologist and bacteriologist; the second to the botanist; the third to the entomologist and zoölogist; the fourth to a large extent comes within the scope of the agronomist, and the last is in the domain of the physiological botanist.

Scope of this Book

This book treats primarily of the diseases of the first group only, with mention of a few of the most important diseases of the second, fourth, and fifth groups. A very brief statement regarding the nature of bacteria and fungi and the most fundamental facts of plant physiology are given in the Appendix.

HISTORICAL

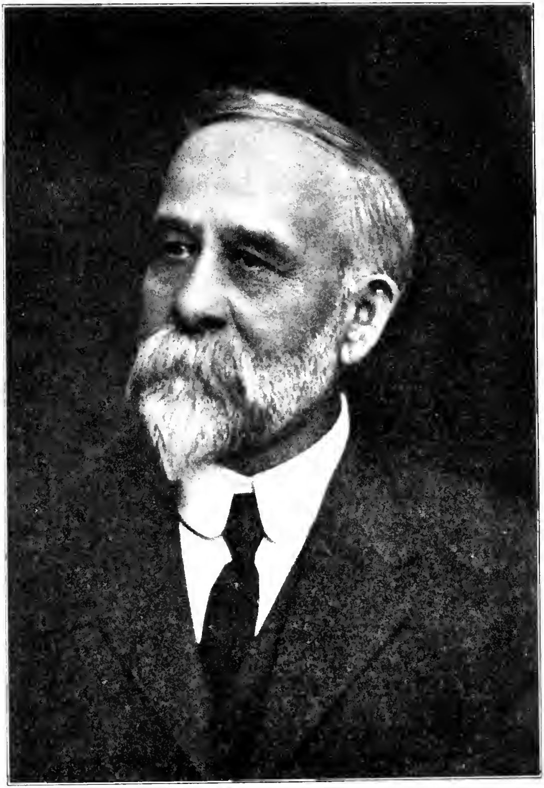
A SCIENCE of Plant Disease was an impossibility until knowledge existed concerning the nature of the parasitic organisms, the fungi and bacteria. The science of Plant Diseases or of Phytopathology was in its early formative period between 1853 and 1870, the very foundations being laid in the pioneer work of Berkeley and De Bary in establishing the parasitism of the fungi, and in Pasteur's fundamental work on Bacteria and Spontaneous Generation.

To be sure some of the most conspicuous diseases had long been known by sight. Blight and mildew were referred to in both the Old and the New Testament. Wheat rust was mentioned by Aristotle 350 B.C. and reference to mildew is found in *King Lear,* Act III, Sc. 4. There was even legislation regarding wheat rust as early as 1760. Yet there was little or no real knowledge of plant diseases in those times, beyond the fact that diseases existed.

Following the pioneer publications of Berkeley and De Bary came the more complete treatises of Frank (1880, 1895), Sorauer (1874, 1886, 1906), Kirchner (1890), Tubeuf (1894), and others.

It was not until 1873 that plant pathology became a part of instruction in botany, and not until 1875 that special courses in pathology were given in any of the schools of America.

A series of papers begun by Burrill in 1873, another by



Charles E. Bessey

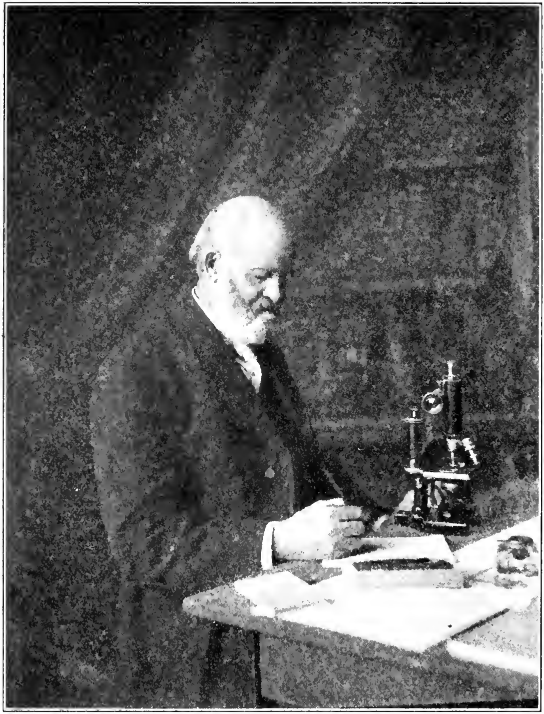
Farlow in 1875, and other publications by Bessey, contributed to the knowledge of plant disease and served especially to awaken interest in the problems and to attract students to this field of research.

In 1879 Burrill, working upon the blight of the pear and apple, was the first to attribute a plant disease to bacterial origin. His work was confirmed and his conclusions more fully established by Arthur.

During the seventies from two or three workers in this field the number rapidly grew, augmented especially by the introduction of plant pathology into the Agricultural Experiment Stations and the United States Department of Agriculture in the middle eighties, until the number of papers published in the United States upon plant pathology between 1888 and 1900 is estimated at over four thousand. While only a few dozen American plant diseases had been even cursorily described prior to 1880, to-day a total of some 525 diseases, more than 250 of them serious, have been carefully investigated.

Historical concerning plant disease prevention. — Though little could be done to devise rational methods of combating plant diseases until their causes were known, a very few rule-of-thumb, empirical ways of meeting them had been suggested in very early days. As might be expected many of the methods used were valueless. Thus Parkinson early in the seventeenth century advocated the use of vinegar to prevent canker on trees, and Forsyth in 1790 gave the following directions for making a mixture to "cure disease, defects, and injuries of plants."[1] "Take one bushel fresh cow dung, one half

[1] Lodeman, E. G., "The Spraying of Plants," p. 6.



T. J. Burrill

bushel lime rubbish from old buildings, one half bushel wood ashes, one sixteenth bushel pit or river sand. The last three are to be sifted fine before they are mixed. Then work them well together with a spade, and afterward with a wooden beater until the stuff is very smooth, like fine plaster used for the ceilings of rooms." Soapsuds or urine was used to make the composition of the consistency of plaster or paint. After being applied it was covered with a sifting of powder made of "dry powder of wood ashes, mixed with the sixth part of the same quantity of the ashes of burnt bones."

Among the early chaff, however, there were some grains of wheat. Thus Robertson in 1821 said: "Sulphur is the only specific remedy that can be named for the treatment of mildew on peaches. It should be mixed with soapsuds and then applied by dashing it violently against the trees by means of a rose syringe;" thus advocating a remedy which, modified, is still prominent for this class of diseases.

The aggressiveness of several plant diseases in Europe between 1878 and 1882, particularly the downy mildew upon the grape, which, about 1878, had invaded Europe from America, stimulated a search in the former country for effective spraying mixtures. Trials of many chemicals were made, but it was left to accident to suggest and to the genius of Millardet, of Bordeaux, France, to perfect the happy combination of lime and bluestone that we now know as the Bordeaux mixture. It was customary in certain vineyards to sprinkle a few rows of grapevines near the road with a mixture of milk of lime and bluestone to give them a poisonous appearance to ward off depredation of the hungry passer-by. The vines so treated in 1882 were noted by Prillieux and Millardet to be less injured by the mildew than were other vines, and they

Fig. 1. — Millardet, father of the Bordeaux mixture.

ascribed the beneficial effect to its proper cause, the lime-bluestone mixture.

While several investigators were engaged simultaneously in experimenting with these chemicals upon the mildew, it was Millardet who first planned and executed experiments and published results which demonstrated the commercial value of the lime-bluestone treatment.

The first systematic applications of copper, and of copper with lime as a disease preventive, were made under the direction of Millardet, August 18, 1883. In 1884 the work was repeated, and in 1885 Millardet published the first directions for preparing

BORDEAUX MIXTURE

Water	130 liters	(34 gallons)
Bluestone	8 kilograms	(17.6 pounds)
Lime	15 kilograms	(33 pounds)

This mixture was to be shaken upon the plants with a broom.

Following this demonstration came the introduction of an era, not yet at an end, of active experimentation with fungicides, wet and dry, which has already yielded results of incalculable value.

In 1885 also appeared for the first time the Ammoniacal Copper Carbonate proposed by Professor Audoynaud of the Montpelier Agricultural School.

Saunders, in the *Canadian Horticulturist* in 1884, suggested the use of several liquid spraying mixtures for apple scab, but little, if any, liquid spraying for plant diseases was done in America prior to 1885.

In 1885, from Section of Mycology, Division of Botany, United States Department of Agriculture, appeared an article by Lamson-Scribner, giving directions for making "the copper mixture of Gironde," the primitive Bordeaux mixture. In 1886 the spraying campaign may be said to have been well started in this country.

The disinfection of seeds by bluestone was practiced first with the cereals as early as 1807 by Prévost of France, and improved by Dreisch in 1873, by the addition of a limewater bath to follow the bluestone. In 1887 Jensen of Denmark improved upon these methods by developing his hot-water treatment, which has since proved of great value, not so much for its primary use, in which it has been superseded by formalin, but owing to its applicability to those loose smuts which cannot be successfully treated by surface disinfection. Similar seed treatments have been extended to the potato by Bolley, and to cabbage by Harding.[1]

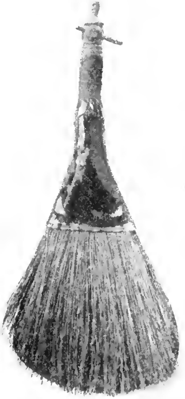


FIG. 2. — An improved brush for distributing Bordeaux mixture. After Lodeman.

The production, by breeding, of new and disease-resistant varieties is one of the latest and most promising methods of combating plant diseases. Grapes resistant to Phylloxera were produced by Millardet; others resistant to coulure by Pierce; cotton, cowpeas, and watermelons resistant to wilt by Orton.

No small part in the progress that has been made in the prevention of plant disease is due to the improvement of appliances, dusters, pumps, nozzles, etc., for distributing the disinfectants upon the plants. This progress is well illustrated by comparing the broom of Millardet with the knapsack, barrel, or power sprayer of to-day.

[1] Harding, H. A., and others, N. Y. (Geneva) Agr. Exp. Sta. Rpt. 23, pp. 62–78.

IMPORTANT EVENTS IN PLANT DISEASE HISTORY

Ancient. Recognition of the existence of plant diseases in early Biblical times.

1683 The discovery of bacteria. Loewenhoek.

1807 The efficiency of copper against smut spores discussed. Prévost.

1821 The use of sulphur as a fungicide recommended. Robertson.

1845 The use of boiled sulphur and lime for mildew advocated.

1846 The studies of Rev. M. J. Berkeley.

1853 The beginning of the "Morphology and Physiology of the Fungi" and the proof of parasitism of fungi. De Bary.

1861 The publication of the first American paper on plant pathology. Engelmann.

1860–1864 The founding of bacteriology. Pasteur.

1864 The proof of alternation of hosts, heterœcism. De Bary.

1869 The first university publication in America regarding plant pathology. University of Illinois.

1873 Plant pathology taught incidentally with botany in America. Burrill.

1875 Plant pathology first taught as a special subject in America. Farlow.

1879–1880 Proof of bacterial disease in plants. Burrill.

1880 The discovery of the cyclone principle in nozzles. Barnard.

1882 The beginning of "Sylloge Fungorum." Saccardo.

1884 Systematic introduction of plant pathology into American Agricultural Experiment Station work. Arthur.

1885 The announcement of the Bordeaux mixture. Millardet.

1885 Organization of a Section of Mycology in the Division of Botany, United States Department of Agriculture. Lamson-Scribner.

1887 The hot-water treatment for smut. Jensen.

1888 The introduction of formalin as a disinfectant. Trillat.

1888 Organization of the State Agricultural Experiment Stations.
1890 The beginning of pump improvement for spraying.
1906 The passage of the Adams Act.

DAMAGE CAUSED BY PLANT DISEASES

The crop grower, in his ignorance of what plant diseases are, often suffers much damage from them, entirely unconscious of the fact that his crop is affected by disease. Or, if the presence of disease is recognized, the amount of damage is often underestimated. Thus oat smut to the extent of 15 or even 40 per cent is sometimes entirely overlooked by an otherwise observant man.

An attitude of willful disbelief in the prevalence of a disease is often couched in such terms as these: "I don't see why I must work to protect my apples from rot. My grandfather used to raise fine apples without any attention to these things."

It must be recognized that plant diseases are with us; that they are increasing by importation from other countries or other states; that diseases formerly insignificant are, in many instances, becoming serious; that long, intensive culture of one crop in a locality permits new diseases to develop. Diseases have many means of dispersal: on seed, hay, or other produce shipped by mail, express, or freight; on animals; by wind; by water; by birds. Diseases will continue to spread and to increase in destructiveness until the individual and the general public are aroused to such active appreciation that conditions of plant sanitation and plant protection become much more general and effective than they now are.

Aside from diminishing the value of the produce and the thrift and future productiveness of perennials, as trees, vines, etc., plant diseases entail depreciation in the value of land, and in some cases even occasion large loss of life. Thus the famous famine in Ireland in 1845 is directly traceable to the injury done to the potato crop by the potato blight. The presence of ergot in grain used as food for cattle or man may result in disease and death.

The presence in land of the causal germ of the melon, cowpea, cotton or tobacco wilts, of onion smut, cabbage club root or black rot, or of any one of many other soil-borne diseases precludes the possibility of successful culture of the susceptible plant for a long period of years, perhaps forever, upon the soil in question. Such restriction may prevent the raising of just the crops that are most profitable in that particular section, and in some instances depreciation of 50 per cent or more in the market value of land has resulted from the invasion of one of these ineradicable soil diseases. Still more serious is this kind of injury if the crop in question is one which requires large money outlay before the presence of the disease germs is manifest. In the case of Sumatra tobacco under shade, or lettuce grown under canvas, the money expended to prepare for the crop may aggregate from $700 to $1000 or even more per acre the first year. The capture of such acreage by the lettuce drop or the tobacco wilt is a far more serious matter than a plant disease is usually considered to be. Some of the money losses caused by diseases of a few crops are given below, merely as illustrative instances. The authority is named with each estimate.

The California vine disease in 1892, $10,000,000.	Pierce.
Wheat rust in the United States, 1898, $67,000,000.	Galloway.
Wheat rust in Illinois, 1885, $1,875,000.	Burrill.
Violet, leaf spot in the United States, 1900, $200,000.	Dorsett.
Peach leaf curl in the United States, 1900, $2,335,000.	Pierce.
Potato late blight in New York, 1904, $10,000,000.	Stewart.
Oat smut in the United States, annual, $6,500,000.	Orton.
Wheat loose smut, United States, annual, $3,000,000.	Orton.
Wheat bunt in the United States, annual, $11,000,000.	Orton.
Potato blight in the United States, annual, $36,000,000.	Orton.

SYMPTOMS OF DISEASE

Every part of a plant — root, stem, leaf, flower, fruit, bark, wood, veins — is subject to disease, and the same disease may be manifest in many, even all, of these parts at once.

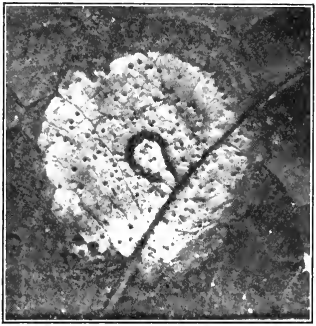


Fig. 3. — Cowpea leaf spot (amerosporiose). Pycnidia scattered throughout. × 4. Original.

Rot is perhaps the most common symptom of disease to be noted in any plant part. Rot is of many characters, — soft, wet, dry, hard, offensive or inoffensive of odor.

Blight is a symptom often exhibited by leaves, roots, stems, flowers, or fruit. It indicates complete death of the part affected, may be local or general, and may or may not be followed by rot.

Wilt of stems or leaves is caused usually by either a plugging, or other interruption, of the sap-carrying veins, or by some injury to the absorbing root system.

Spots of leaves, bark, or fruit may be caused by local blight, rot of tissue, imperfect coloration, or by local over-development or under-development of color.

FIG. 4. — Sori of rust of asparagus. Original.

Scab in fruit, leaves, or bark is due to the growth of the causal parasite upon or near the surface, or to thickening of the outer layer or layers of tissue caused by the irritation of a parasite.

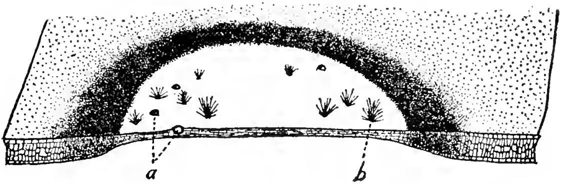


FIG. 5. — Hyphae in a leaf spot much enlarged. Redrawn after Garman.

Mildew upon any plant surface consists of a whitish powdery fungous growth.

Burn is a general term applied to all cases where the leaves turn red or brown, especially if the edge first shows the symptom.

Smut consists of a mass of spores, usually black and powdery. It is most common in the ovaries and other floral parts of the cereals.

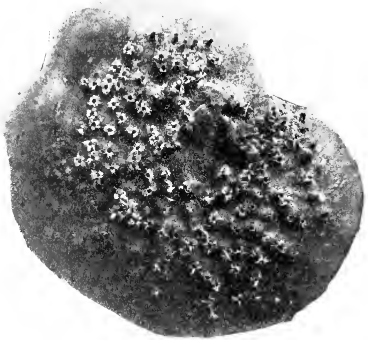


Fig. 6.—Clustercups of rust enlarged. After Clinton.

Rust should properly be applied only to cases where the special rust fungi (Uredinales) are present. Rusts usually show the spores in sori.

Yellowing of leaves, due to diminution in green coloring matter, is a common symptom of disease.

Chlorosis is a lack of proper green, a whitening of tissues which should be normally green.

Canker consists of a roughening or splitting of the bark.

In addition to the somewhat general characters accompanying diseases, it is necessary for purposes of diagnosis to note closely the detail characters of each sick part.

In a spot the **color** of its **margin** and **center**; its **border**, whether **sharp** or **indefinite**; whether the same upon both upper and lower surfaces are important items to observe.

In a rot these same details, also the **texture**, **soft** or **hard**, **wet** or **dry**, the **odor**, and **taste** are important.

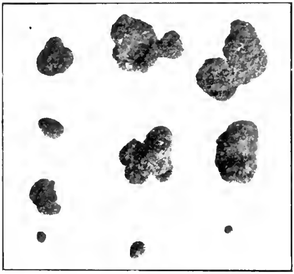


Fig. 7. — Sclerotia of lettuce sclerotiniose, natural size. Original.

In the plant, on a whole, it is well to note whether the disease is **local** or **general**, **progressive** or **stationary**, spreading regularly or otherwise.

Certain minute structures should be looked for upon rots, spots, cankers, or other diseased parts. Some of these, which may be recognized with the naked eye or a good hand lens, are: —

Pycnidia or **perithecia**. — Small, nearly microscopic, covered sporiferous pustules on the surface of the diseased area.

Acervuli. — Structures like pycnidia, but uncovered.

Sori or spore clusters.

Hyphae. — Erect, hair-like, very nearly microscopic growths coming from the diseased area. Their presence upon a white background may often be recognized by the dirty ashen color which they lend to the spot.

Cluster cup. — The cup-like sorus in which the spring spores of many rusts are borne.

Sclerotia. — Small, hard bodies variously colored, but usually black; masses of compact fungous threads.

PREVENTION OR CURE OF PLANT DISEASES

Owing to the comparatively small value of the individual among plants, cure of a plant already sick is seldom attempted except in the case of plants of exceptional value. Such value very rarely attaches to annuals or biennials; hence it is only with perennials, valuable vines, bushes, or trees, that cure of the individual is attempted, and here only in a few special cases.

The burden of the effort of the plant pathologist must be directed toward methods of prevention, which are here worth far more than their proverbial ratio.

The science of plant pathology, barely antedating 1880, is yet young; its founders in America are still alive and are still vigorous workers. In comparing this youthful science with its far more aged prototypes, human and veterinary medicine, one is astonished at the progress already made, rather than abashed at the multitude of diseases as yet unconquered.

Among all classes of crops are diseases, single or many, which have given way to the control of man, many of them diseases of fearful destructiveness, yet which are now completely under the subjugation of the intelligent educated crop producer.

The remedies, with one or two exceptions, are entirely the result of patient, scholarly investigation, careful deduction, followed by experimenting, testing, and improving. Such investigation is ever proceeding with increasing activity, and yearly new or improved methods of combat are devised, so that the future may with confidence be relied upon to see the subjugation of many of the foes that are as yet unconquered.

Methods of Prevention

All methods of prevention aim at the destruction of the causal organism, the diminution of its numbers, or the strengthening of the crop plant so as to withstand its attack. The various methods employed may, for convenience of reference, be here summarized as follows:—

1. Killing the causal organism as it rests upon the seed. — *Examples:* oat or wheat smut, cabbage black rot. For this purpose the seeds (sometimes cuttings or even whole plants are similarly treated) are subjected to the action of disinfecting chemicals long enough to kill the organism causing the disease, but not long enough to kill the seeds. Chief among such disinfectants are:—

A. Formalin (40 per cent formaldehyde).

B. Corrosive sublimate.

C. Copper sulphate, followed by weak limewater.

D. Formalin gas generated in a gas-tight disinfecting room.

2. Killing superficial fungi by applications upon the green parts of the plant. — *Examples:* powdery mildew upon grape, gooseberry, or rose. This method is applicable only with the purely superficial fungi, since internal parisites cannot be so reached without injury to the host plant itself. It finds prominent application with the powdery mildews. The chief applications used are:—

A. Liver of sulphur.

B. Bordeaux mixture.

C. Ammoniacal copper carbonate.

D. Flowers of sulphur.

3. Killing superficial fungi hibernating upon the bark of the dormant plant or plant supports. — *Examples:* apple hypochnose, peach curl. For this purpose *Cleansing Sprays*, often called *dormant sprays*, may be used. Since the parts of the host receiving the spray are highly resistant to their poisonous action, the sprays thus employed may be much stronger than could be safely used when the plant is in foliage. For this purpose use:—

A. Copper sulphate with lime sufficient to color.

B. Lime-sulphur mixtures.

4. The use of protective sprays. — *Examples:* grape black rot, apple scab. A *protective* spray is one applied to the plant upon its bark, foliage, or fruit, to kill any offensive germs that may fall upon its surface, or to prevent their growth upon or into the plant. Such sprays are distinguished from the cleansing sprays, which are not primarily for protection against future invasion, but rather for the purpose of cleaning off or killing all spores actually upon the plant. Protective sprays are usually employed when the plant is in foliage, and therefore must be used with due regard to the susceptibility of the plant to the poison employed. The protective spray should be applied:—

1. Often enough to replace any previous protective spray that may have been removed by rain or other means.

2. To give protection to any new surface of twig, leaf, or fruit which has developed since the last protective spray was applied.

The first protective spray should be given as soon as possible after susceptible surfaces have developed, and before the attacking organisms are expected to make their invasion. The time varies of course with each special crop, with each disease, with the climatic relations and section of the country. Nor can any absolute rule be laid down for the application of subsequent protective sprays. Frequency of rain is an important controlling factor. A fungicide, if rained upon just after it is applied and before it has time to dry, is much more easily washed off than is the case if it dries well before the rain falls.

New tissue and new surfaces develop every day; therefore theoretically to secure complete protection, sprayings need to be very frequent, much more frequent than is practicable. To meet the needs occasioned by new growth, protective sprays are usually given at intervals of from ten to fourteen days, though special rules must govern special cases.

The chief protective sprays are: —

A. Bordeaux mixture, full strength or weak.

B. Ammoniacal copper carbonate.

This solution possesses the advantage that it does not spot the fruit and may therefore be used near the period of maturity, when the Bordeaux mixture, owing to its spotting effect, would be less desirable.

C. Lime-sulphur mixtures.

5. Excision of the affected parts. — *Examples:* Ash white rot. Excision is resorted to chiefly in the case of trees which from their location or quality possess value sufficient to warrant the necessary outlay of labor. It is so practiced as to remove the diseased wood and sufficient of the healthy wood to expose an entirely uncontaminated surface. The wounded surface is then treated with a strong antiseptic (tar, bluestone, or corrosive sublimate), and if the wound be deep, it is filled with cement to remedy any mechanical weakening incident to the operation.

6. Removal and destruction of diseased twigs, leaves, or fruit. — *Examples:* pear blight, peach rot. The removal and destruction of diseased parts diminishes the number of bacteria, spores, etc., that are available to spread the disease and thus lessens infection. Mummified fruit may be picked from the plant or the ground and destroyed, or it may be removed by appropriate pasturage by fowls, swine, etc. Affected leaves in many instances may be similarly removed. Blighted twigs and cankers may be cut out at any time when they are seen.

7. Removal, in whole or in part, of complementary hosts. — *Examples:* apple rust, wheat rust. Complementary hosts always serve as multiplying places for the causal parasite, and in some instances are absolutely essential to its hibernation. Such complementary hosts should, when practicable, be removed from the immediate vicinity, and when possible, not allowed to exist within considerable distance, one eighth to one half mile, or better still, a greater distance. When it is not practicable to remove the host, the offending portions may be cut away, *e.g.* in the case of the apple rust the cedar balls may be removed from adjacent trees.

8. Avoidance of disease-bearing material or material favoring disease. — Infection may reach hay through sick melon vines (melon wilt), or manure through sick plant parts (potato scab, cabbage rot, melon wilt, etc.). Soil may wash from one field to another and bear disease with it (tobacco wilt, melon wilt, etc.).

9. Prevention of wound infection. — *Examples:* heart rots, sap rots, cankers, fruit rots. Wound infection may often be avoided by care in handling the plant so as not to wound it. In trees place ladders carefully, not roughly, among the limbs; avoid walking on limbs with nailed or hard boots, etc. Gather all fruit, root crops, etc., carefully to avoid breaking the skin or bruising the underlying tissue. In case of removal of large limbs coat the exposed wood with paint or tar to prevent invasion by parasites.

10. Avoidance of susceptible varieties; selection of resistant varieties. — There is much difference in the susceptibility of different varieties of plants. Study the different varieties of the crop to be raised, particularly in this regard, and use those that are most resistant. In case resistant individuals are observed among sick plants, save their seed carefully and test the resistance in succeeding years. In this way new and resistant varieties may be developed.

11. Avoidance of diseased localities. — This is in many cases imperative where the soil is invaded by a germ inimical to the growth of crops of certain kinds, as in the case of cabbage black rot, cotton and melon wilt, etc. Similarly, low damp locations favor diseases of some crops (potato blight), and the proximity of certain kinds of plants leads to disease with others (apple rust). All this should be considered in the selection of land for the crop.

12. The practice of crop rotation. — Constant growth of the same crop in any locality tends to increase the enemies of that crop. Rotation breaks the continuity and hinders the multiplication of the parasite.

PUBLIC PLANT SANITATION

In addition to the means suggested above, which may be applied by the individual plant producer, much can be done toward the eradication of these pests by the creation of a more enlightened public sentiment regarding them. So long as these diseases are regarded as natural, as inevitable, no progress will be made. When it becomes generally known that they are contagious, that they are preventable, steps to overcome them will be generally made, and their increase checked. To create a much-needed, enlightened, aggressive public opinion is part of the duty of plant pathology. It may be done in several ways: —

1. By disseminating knowledge concerning the nature of plant diseases, the damage they do, how to recognize them, and the means of controlling them. This may be done through the common rural schools, the high schools, the agricultural colleges, the farmers' institutes, and other educational channels.

2. By instructive articles in the agricultural papers.

3. By collections of plant diseases displayed so that the visitor may learn both the appearance and control of the important ones.

Legislation which shall guard against shipment of any infectious material should be enacted and enforced. With all the advances of the past twenty years in the control of plant diseases we have but barely kept pace with their increase. Diseases will continue to increase for some decades yet, if not indefinitely, and increased efforts to control them are necessary on the part of the crop producer. At present many wise laws prohibiting the shipment of infected stock, particularly peach yellows and rosette, the various crown galls, and certain insect pests, are inoperative on account of lack of proper means of enforcement or too often owing to absence of the necessary sustaining public opinion.

FUNGICIDES

Bordeaux mixture. — While the early formulas for this mixture called for 6 pounds of copper sulphate and 4 pounds of lime to 22 gallons of water, and other similarly strong mixtures were in use for several years, experimental evidence soon showed that the strength could be reduced without disadvantage. The chief strengths of Bordeaux now used are as follows: —

Ordinary Bordeaux

5 — 5 — 50

Copper sulphate (bluestone)	5 pounds
Quicklime	5 pounds
Water	50 gallons

This strength may be used on most plants the foliage of which is not especially delicate or sensitive to copper.

Strong Bordeaux

6 — 4 — 50

Copper sulphate (blue stone)	6 pounds
Quicklime	4 pounds
Water	50 gallons

This strong solution is particularly for grapes, potatoes, and tomatoes; crops which possess good resistance to the copper of the mixture, and upon which a strong solution is desired.

Weak Solutions

2 — 2 — 50

Copper sulphate	2 pounds
Lime	2 pounds
Water	50 gallons

$2\frac{1}{2}$ — 6 — 50

Copper sulphate	$2\frac{1}{2}$ pounds
Lime	6 pounds
Water	50 gallons

Plants with sensitive foliage, such as the stone fruits, peach, plum, cherry, and apricot, are injured by the stronger solutions, and very weak solutions must be used upon them.

There is no certainty as to what strength of mixture is best. To most crops no damage can come from the use of as strong a solution as the 6–4–50, yet it is possible that all of the benefit can be derived from a 4–4–50 mixture. If so, there is loss of material through use of the stronger solution. This matter is still open to experimentation.

In the preparation of the Bordeaux mixture it is well to have on hand stock solutions of copper sulphate and of lime. The stock solution of copper sulphate is made by dissolving a certain number of pounds of copper sulphate in one half the number of gallons of water. For example: 80 pounds of copper sulphate in 40 gallons of water. Every gallon of this solution contains 2 pounds of copper sulphate, and the necessity for further weighing is avoided. This solution will remain good for any length of time if the water evaporated is replaced.

In order to dissolve the copper sulphate, suspend it in a coarse bag near the top of the water in a barrel. In this

Fig. 8. — A convenient arrangement for mixing Bordeaux mixture. After Vermont Agricultural Experiment Station.

way it will dissolve in a few hours. If it is placed in the bottom of a barrel, it will dissolve but slowly, even with frequent stirring. When dissolved, the solution may be made uniform by stirring.

A stock solution of lime should be made. Quicklime of good quality, which is not at all slaked, should be weighed out, placed in a trough, and slaked slowly, using the minimum quantity of water. Thus a fine quality of slaked lime is secured. After the lime is thoroughly slaked enough water should be added to make a putty-like mass. It should then be covered with more water to keep out the air and may be used when needed. Since this mass was originally weighed, estimate can be made sufficiently accurate to determine the amount of the paste to use in any given amount of Bordeaux mixture.

In preparing the Bordeaux mixture from stock, measure out the proper amount of stock solution of copper sulphate, dilute it with half of the amount of water needed. In a similar way measure out the proper amount of lime from the stock and dilute it with the other half of the water in a separate vessel.

The lime should be passed through a fine wire strainer of about eighteen meshes to the inch, or through cheese-cloth, to remove particles of stone which would otherwise cause great difficulty in the pump nozzle when spraying.

The two ingredients are now mixed each with one half the amount of water called for in the formula. All that remains is to pour them together slowly and stir thoroughly.

It is a matter of considerable importance that the stock solutions be diluted before they are mixed with each other, since the quality of Bordeaux mixture resulting from this method is superior in several respects to that which would be made if strong solutions were mixed together and afterwards diluted. The Bordeaux should be freshly made each time before using.

An excess of soluble copper compounds in the completed

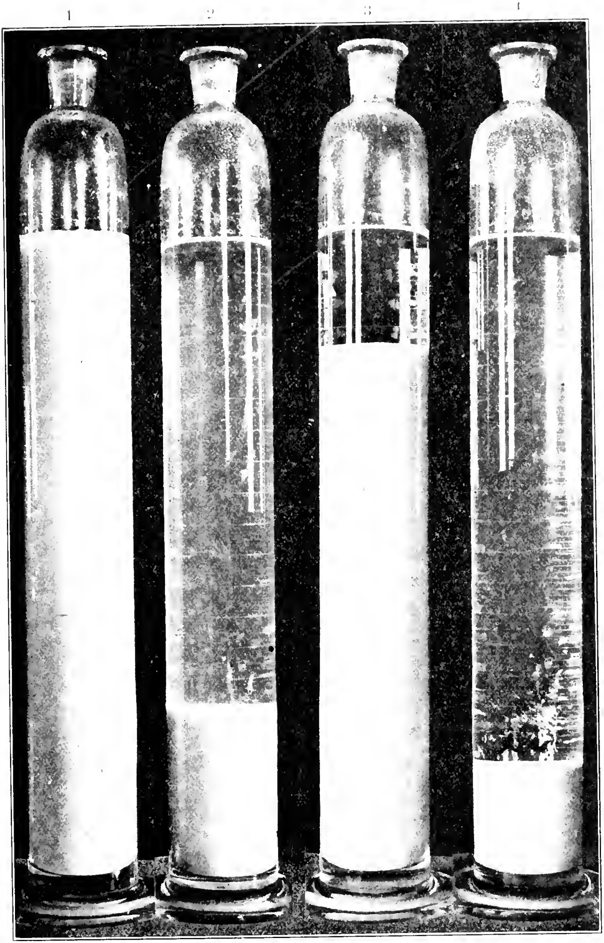


Fig. 9. — Bordeaux mixture, 1 and 3 properly and 2 and 4 improperly made. 1 and 2 after standing 45 minutes; 3 and 4 after standing $4\frac{1}{2}$ hours. After Sheldon.

Bordeaux mixture is dangerous to the foliage, while a slight excess of lime is a point of safety. It is therefore advisable, unless it is certain that sufficient lime of good quality is used, to apply a test in this regard. If an excess of lime be present in the mixture, the breath expired upon it for a few moments, as held in a saucer or cup, will cause a flaky film to form upon the surface; if no such film forms, more lime is needed. If an excess of copper sulphate is present and a bright piece of iron or steel, a knife blade or nail newly filed or sanded, be held in the solution for a few moments, a distinct deposit of metallic copper will appear upon the bright iron. It is well to practice each of these tests with solutions known to have excess of copper and lime respectively, to thus become familiar with the working of the test. No metal cans or utensils should be used in preparing Bordeaux mixture.

Soda or potash Bordeaux mixture. — While the usual lime-Bordeaux mixtures are very successful in preventing plant diseases, slight difficulty is sometimes encountered in using them, owing to the occurrence of small stones, imperfections in the lime. These, if not thoroughly strained out, clog the spraying nozzle and are troublesome. To escape this difficulty and to render the preparation and application of the Bordeaux mixture easier, as well as to give a mixture which can be used as the fruit approaches maturity, without spotting it, use of potash or soda as a substitute for the lime has been recommended. Soda is most acceptable for this purpose. For general use there is no indication that these mixtures will supersede the ordinary lime-Bordeaux.

The Soda Bordeaux

Copper sulphate (bluestone) . . . . . . 5 pounds
Commercial caustic soda sufficient to combine with the copper sulphate and leave a slight excess of soda.
Water . . . . 50 gallons

It will be noted that the amount of caustic soda to be used is not stated definitely. It is impossible to make a definite statement, since the strength of the various commercial sodas varies greatly.

The following table gives the amount of copper sulphate required for a single can of several of the more common sodas. In the last column is found the amount of mixture which a can will make. For example, if the Champion soda, a can of which weighs 13.75 ounces, is used, one should use 1.6 pounds of copper sulphate to each can of soda.

	Gross Weight of Can	Weight of Substance	Copper Sulphate required	Amount of Mixture
Soda (Troy) .	11.2 lb.	10.17 lb.	46.22 lb.	462 gal.
Babbitt's Potash .	17 oz.	14.5 oz.	3 lb.	30 gal.
Champion . .	13.75 oz.	12 oz.	1.6 lb.	16 gal.
Red Seal . .	17 oz.	14.5 oz.	2.4 lb.	24 gal.
Leggett's . .	17. oz.	14.75 oz.	2.5 lb.	25 gal.
Lehman's . .	14.75 oz.	12.25 oz.	2.4 lb.	24 gal.
Hirsh . . .	14.5 oz.	12.75 oz.	1.8 lb.	18 gal.
Washington . .	14.25 oz.	12.75 oz.	1.7 lb.	17 gal.
Saponifier (Solid)	15.75 oz.	14.25 oz.	2.5 lb.	25 gal.
Saponifier (Granulated) . .	17 oz.	14.75 oz.	2.6 lb.	26 gal.
Natrona . .	42.75 oz.	36.75 oz.	7.2 lb.	72 gal.

One can of soda contains 12 ounces of substance and the 1.6 pounds of copper sulphate together with the one can of Champion soda will make 16 gallons of soda Bordeaux.

In a similar way, by consulting the table, one can find how much copper sulphate to use per can with any of these brands and how much mixture it will make.

Dissolve the caustic soda in water. Dissolve the copper sulphate also in water in another vessel and dilute each solution to half the volume desired in the completed mixture; then mix the two solutions together.

If used in the above proportions, the mixture will be alkaline. If too little soda is used, the mixture will be acid, and is then liable to injure the leaves.

The amounts as given in the above table are equivalent to the 5–5–50 Bordeaux mixture. If one comparable to the 4–4–50 is desired, increase the amount of water by 25 per cent.

In order that the mixture may be more easily seen on the trees, and thus enable the operator to know when a tree has been completely sprayed, a small quantity of lime, about one half pound to every 50 gallons of mixture, should be added.

Prepared or dry Bordeaux. — To meet trade demand various forms of ready prepared Bordeaux mixture have been placed upon the market. While some of these may be good, there is no sufficient reason for their use, since better and cheaper mixtures can be made at home with little or no difficulty.

Ammoniacal solution of copper carbonate. — This solution contains no sediment, and on drying leaves no unsightly marks upon the fruit. It may therefore be used upon fruits in the latter stages of ripening, when the spotting that the Bordeaux mixture causes precludes the use of that fungicide. The mixture consists of a solution made by dissolving copper carbonate in ammonia-water in the following proportions:—

Copper carbonate	6 ounces
Ammonia, about	3 pints
Water	50 gallons

Weigh out the proper amount of copper carbonate. Set a very small portion of this aside, and dissolve the remainder of it in diluted ammonia, using only enough ammonia to dissolve it. Then add the portion of copper carbonate which was reserved. This will insure the use of no more ammonia than is necessary. It is better to have a little too much of the carbonate in the solution than to have too much ammonia. The strong solution made in this way can be diluted with the proper amount of water. The copper carbonate may be purchased directly from the drug-store, or it may be prepared at home.

To make copper carbonate proceed as follows: Dissolve 10 pounds of copper sulphate in 10 gallons of water. Also dissolve 12 pounds of carbonate of soda in the same amount of water. Allow these two solutions to cool, then mix them slowly together stirring in the meantime. Allow the mixture to settle about 12 hours, pour off the liquid, and add water equal in amount to the liquid poured off. Stir thoroughly and allow it to settle as before. Repeat this operation again, then drain off all of the liquid possible, and dry the blue powder which remains. This powder is the copper carbonate.

Burgundy Mixture.

Copper sulphate	2 pounds
Sodium carbonate (sal soda)	3 pounds
Water	100 gallons

Each chemical should be dissolved separately in half the water, then mixed as in making Bordeaux mixture. This mixture may be used as may ammoniacal copper carbonate when it is advisable to avoid the spotting of fruit which would result from use of the Bordeaux mixture.

Copper sulphate solution, 1–17. — A solution consisting merely of copper sulphate and water to kill the spores on the bark and supports may be used before the leaves appear.

Copper sulphate	1 pound
Water	17 gallons

Dissolve the copper sulphate as in preparing the Bordeaux mixture, dilute it to the required strength, and spray upon the trees. The addition of a little lime, one half pound to 50 gallons of mixture, enables the operator to see exactly what portions of the tree have been sprayed.

This mixture must not be used after the leaves appear.

Copper sulphate, 1–7. — Made as above, but using 7 instead of 17 gallons of water.

Potassium Sulphide Solution.

Potassium sulphide (liver of sulphur)	1 ounce
Water	2 to 4 gallons

This solution should be freshly prepared. It is used as a substitute for the Bordeaux mixture, to avoid spotting, in the same way that the ammoniacal solution of copper carbonate is used, when the fruit has become so large that the Bordeaux mixture must be discontinued. Potassium sulphide is also especially efficient as a protection against the powdery mildews.

Formalin. — Formalin is a very powerful germicide which came into wide use about 1889. Its interest to the farmer lies chiefly in its power to prevent the potato scab, onion smut, and the various smuts of cereals. Full directions for its use are given under special crops.

This substance appears on the market under two names: "formalin" and "40 per cent formaldehyde." These substances are absolutely identical, and since 40 per cent formaldehyde is cheaper, owing to the fact that the word "formalin" is protected by patent, the customer will of course do well to purchase the 40 per cent formaldehyde.

Corrosive Sublimate.

Corrosive sublimate	1 part
Hydrochloric acid	2 parts
Water	1000 parts

This is employed chiefly as a seed disinfectant particularly for black rot of cabbage. It is intensely poisonous and should be so regarded.

Flowers of sulphur. — This substance is chiefly employed as a specific for the powdery mildews. See grape, p. 164.

Sulphur-Soda-Soap.

Caustic soda	10 pounds
Sulphur	35 pounds
Fish-oil soap	6 pounds
Water	100 gallons

Bring the soda and a little water to a boil in a kettle, then slowly add the sulphur and soap and boil for about one hour, with frequent stirring; strain and dilute to 100 gallons.

Lime-Sulphur Mixtures[1]

These mixtures are of both fungicidal and insecticidal value.

Home-boiled lime-sulphur wash. — This is the wash regularly used against the San José scale.

Lime	20 pounds
Sulphur	15 pounds
Water	50 gallons

The lime, the sulphur, and about half of the water are boiled together for forty-five minutes in a kettle over a fire or in a barrel or other suitable tank with steam. Strain and dilute to 50 gallons and the wash is ready for application.

For spraying trees in the dormant state this wash may be substituted for Bordeaux mixture as a fungicide; but it is injurious to foliage, and cannot be safely used as a summer spray unless greatly diluted.

Factory-boiled or commercial lime-sulphur wash. — This solution is practically the same as the home-boiled wash and is placed on the market as a substitute for the latter. The home-boiled wash is troublesome to make and does not keep well. The prepared wash keeps indefinitely and is ready for use when received, requiring only dilution with water.

[1] Modified from Scott, W. M., U. S. Dept. Agr. Bur. Plant Indus. Circ. 27.

For insects and fungous diseases on dormant trees a strength of 1 gallon of the solution to 9 to 11 gallons of water gives satisfactory results.

Self-boiled lime-sulphur wash. — The self-boiled lime-sulphur wash is a combination of lime and sulphur boiled

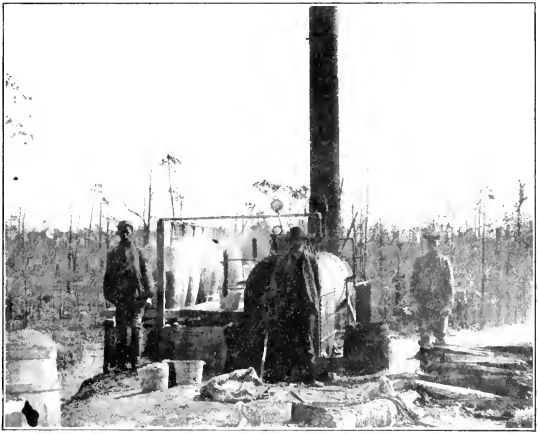


Fig. 10. — Making lime-sulphur wash. After Sherman.

with only the heat of the slaking lime, and is primarily intended for summer spraying as a substitute for Bordeaux mixture where the latter is injurious to foliage or fruit. For most purposes the Bordeaux mixture is as yet to be regarded as the better fungicide and should be used except when it is liable to injure the plants. Peach foliage is so susceptible to spray injury that ordinary Bordeaux mixture cannot be used as a summer spray on peach trees; neither can the sulphur washes which contain any considerable quantity of sulphides in solution. The self-boiled lime-sulphur wash, however, when prepared as a mechanical mixture of lime and sulphur with only a small percentage of the sulphur in solution, is not injurious to peach foliage and has proved to be a good fungicide. It may also serve a good purpose in spraying varieties of apples, like the Ben Davis and Jonathan, which are often injured by applications of Bordeaux mixture.

The mixture that appears to be the most satisfactory is composed of

Lime	10 pounds
Sulphur	10 pounds
Water	50 gallons

This can best be prepared in rather large quantities — 20 pounds, or even 40 pounds at a time — so as to get enough heat to produce a violent boiling for a few minutes. Place the lime in a barrel and pour on enough water (about 3 gallons to 20 pounds) to start it slaking and to keep the sulphur off the bottom of the barrel. Then add the sulphur, which should first be worked through a sieve to break up the lumps, and finally enough water to slake the lime into a paste. Considerable stirring is necessary to prevent caking on the bottom. After the violent boiling which accompanies the slaking of the lime is over, the mixture should be diluted ready for use, or at least enough cold water added to stop the cooking; 5 to 15 minutes, according to whether the lime is quick-acting or sluggish, are required for the process. At the end of 30 or 40 minutes, if the hot mass is permitted to stand undiluted as a thick paste, a liquid is produced that is dangerous to peach foliage and in some cases even to apple foliage.

The mixture should be strained through a sieve of 20 meshes to the inch in order to remove the coarse particles of lime, but all the sulphur should be worked through the strainer.

Hot water may be used to good advantage in preparing the mixture with sluggish lime, but with quick-acting lime hot water is not best. If desired, the mixture may be kept for a week or more without deterioration, but it should be thoroughly stirred before using.

In applying the self-boiled lime-sulphur wash the spraying outfit should be equipped with a good agitator. The agitator of the ordinary barrel sprayer is not usually adequate.

Combined Bordeaux and Arsenates

When an insecticide and a fungicide are to be used at the same time, it is usually possible to combine the two, so that only one application is necessary.

Bordeaux-Paris-green. — To the usual Bordeaux mixture Paris green is added at the rate of 5 ounces to each 50 gallons of mixture. The other arsenical mixtures, as London purple, arsenate of lead, or arsenite of lime, may also be combined safely with the Bordeaux mixture.

SPRAYING MACHINERY

The needs as regards a spraying equipment necessarily vary with the amount of spraying to be done, whether a small garden or a large commercial orchard. In either event proper apparatus is needed. A machine of good quality is more durable and cheaper in the end.

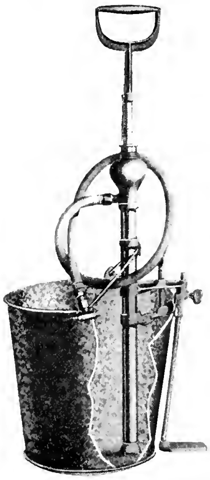


FIG. 11. — Bucket pump showing hose, nozzle, and bucket attachment. After Gould Mfg. Co.

In selecting a pump the following points[1] should be given consideration: —

1. The air chamber should be sufficiently large to ensure a steady spray and be so placed on the pump that the latter will not be rendered top-heavy.

2. Some means of keeping the spraying mixture thoroughly stirred is essential.

3. The working parts should all be of brass and be so arranged that they can be examined without undue difficulty.

4. The pump when mounted should not extend above the barrel more than is necessary.

5. It is desirable to have the device for attaching the pump to the barrel so arranged that the pump can be readily mounted on, or removed from, the barrel.

6. The different parts of the pump should be so constructed that they can be readily taken apart, especially those which inclose the valves.

7. All points for attachment of the hose should be cut with threads of standard size.

[1] Modified from the Maryland Agr. Exp. Sta. Rpt. 13, p. 73, 1899.

The chief types of pumps are briefly mentioned below.

Bucket pumps. — These pumps are suited for use in the garden; to spray the bushes or a few small fruit trees in the yard. The fact that they may be used in any ordinary bucket or pail gives them an advantage over some of the other outfits. By the attachment of a foot rest which extends outside the pail to the ground, the pump can be held firmly. They cost from \$3 to \$7 complete, including rubber hose and nozzle.

Compressed air sprayer. — After the tank is partly filled with the spray mixture and closed, air is pumped in, thus pressure is exerted upon the liquid, which is forced out in the form of a fine spray when the nozzle is opened.

This type of sprayer is satisfactory in some instances, and is adapted to about the same fields as the bucket pump. It is not well adapted for spraying large areas, since the sprayers are inconvenient to carry, are slow, and heavy. They cost from \$3 to \$7.

Knapsack sprayers. — These consist of 3 to 5 gallon tanks, with straps so attached that the outfit can be carried upon the back in the manner of a knapsack. The handle is so adjusted that it is operated in front of the carrier. These pumps are best adapted to spraying crops which grow breast high, as grapes. They may also be used in spraying small trees. For general garden use, or small areas, a half acre to an acre, they are to be recommended. Complete with hose and nozzle, these pumps cost from \$10 to \$20.

Barrel pump. — For ordinary orchard work the barrel sprayer is of most importance. The pump is adjusted to a barrel, at either the side or end, preferably the side. It should be provided with a good agitator to keep the spraying mixture stirred while in use. The pump should be fitted to carry two leads of hose. Without hose or nozzle the cost will be from $13 to $16.

FIG. 12. — Barrel pump showing agitator. After Gould Mfg. Co.

Tank sprayers. — These differ from the barrel pumps mainly in their larger capacity and mode of obtaining pressure. They cost about $25.

Field sprayers. — This sort of sprayer is used in spraying low plants, such as strawberries, potatoes, tomatoes, cabbage, etc. Several nozzles are attached, so that from

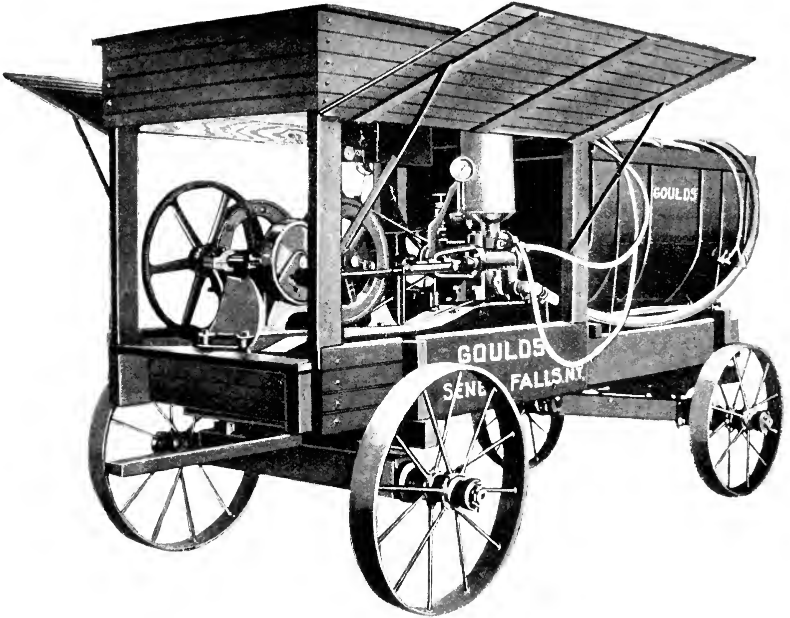


Fig. 13. — Tank sprayer with power attachment. After Gould Mfg. Co.

3 to 6 rows can be treated at one time. Where a number of acres of truck crops are grown, this sprayer is of great advantage.

Power sprayer. — Still larger sprayers, either geared to wheels to use horse power, or operated by steam or gasoline, are used by the large commercial growers.

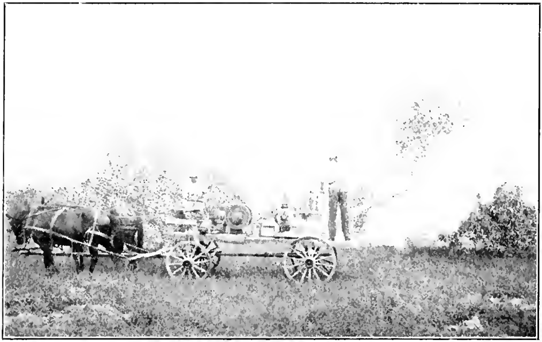


FIG. 14. — Sulphuring machine in use. After Faurot.

Nozzles. — The nozzle should be one that will throw the liquid into a very fine spray, a mist. From the Vermorel the liquid issues in the form of a cone-shaped mist. From the Bordeaux nozzle it issues in a fan-shaped spray which is not so fine as that given by the Vermorel type. The Bordeaux nozzle may be used to better advantage to spray tall trees.

Sulphuring and dusting machines. — These consist of various forms of bellows or blowers driven by hand or other power. The points to be desired are evenness of flow, economy of sulphur, and ease of operation. The discharge of the sulphur from the exit is shown in Fig. 14.

COST OF SPRAYING

Since both the cost of labor and of materials vary, and the amount of each required is determined by the size of the plants to be sprayed, no accurate estimate of the

Fig. 15.—The nozzles are turned at an angle to the rod so that the spray may be directed upward or downward. After Faurot.

cost of spraying can be given. Still reasonably reliable estimates may be made from the following examples.

Orton[1] estimates the cost of spraying cucumbers or cantaloupes as follows: "On the average, 15 acres per

[1] Orton, W. A., U. S. Dept. Agr. Farmers' Bul. 231, p. 22.

day were sprayed, making the labor cost 33 cents per acre. Assuming that 100 gallons per acre were applied, the total would be:—

Copper sulphate, 6 pounds at 7 cents per pound	$ .42
Lime, 12 pounds at 1 cent per pound	.12
Total cost of material	$ .54
Total cost of labor	.33
Cost per acre of each application	$ .87
Cost per acre of six applications	5.22

"There should be added for interest on investment, repairs, and depreciation of outfit, $1 per acre, which increases the total cost to $6.22 per acre."

Spraying potatoes, tomatoes, or any other crop which in like manner covers the ground costs approximately the same.

"The cost of treating pear, plum, and cherry stock the first year, or before and after the buds are inserted, will be about 25 cents for 1000 trees. The next year, or when the buds are making their first season's growth, the cost of the work will probably not exceed 25 cents, while the following season or the second year from the bud, the cost will be increased 10 to 15 cents, or about 40 cents per thousand. On this basis the entire cost of treating trees until they are two years old from the bud will range from $.85 to $1 per thousand, or about 1 mill per tree."[1]

At Southern Pines, N.C., a careful account was kept of the cost of treating grapes, including both material and labor. The Bordeaux mixture cost almost exactly 50 cents a barrel. The labor was estimated as the work of

[1] U. S. Dept. Agr. Div. Veg. Physiol. & Path. Bul. 7, p. 27.

three men, each at $1 per day. The following table gives the cost per acre of the material and labor for each of the 6 sprayings: —

Spraying	Cost of Material	Cost of Labor	Total Cost per Acre
1st	$ .45	$1.13	$1.58
2d	.68	1.13	1.81
3d	.68	1.10	1.88
4th	1.36	1.47	2.83
5th	2.06	1.65	3.71
6th	2.06	1.65	3.71
Total	$7.39	$8.13	$15.52

For potatoes "the items of expense of spraying 10.4 acres five times were as follows: —

234 pounds copper sulphate at 7 cents	$16.38
195 pounds prepared lime at 1½ cents	2.92
90 quarts arsenite of soda solution at 2⅓ cents . .	2.10
70 hours labor for man and horse at 30 cents . .	21.00
Wear on sprayer	6.50
Total	$48.90

"The total expense of spraying was $4.70 per acre or 94 cents per acre for each application." [1]

According to Kinney [2] the cost of spraying apple trees twice with combined Bordeaux mixture and Paris green, and once with Bordeaux mixture, has been estimated as fol-

[1] Stewart, F. C., and others, N. Y. (Geneva) Agr. Exp. Sta. Bul. 290, p. 257.

[2] Kinney, L. F., R. I. Agr. Exp. Sta. Bul. 31, p. 15.

lows by Mr. George W. Burlingame who had charge of the work: —

466 gallons of Bordeaux mixture	$9.68
$1\frac{1}{2}$ pounds of Paris green	.45
Labor of 3 men, preparing and applying the mixture 60 hours	9.00
Use of team 20 hours	3.00
Total	22.13

This amount when divided among the 131 trees treated makes the cost of the treatment 16.9 cents per tree.

The cost of spraying in Missouri[1] is reported as follows: Arsenate of lead estimated at 12 cents per pound, blue vitriol at $6\frac{1}{2}$ cents, and lime at $\frac{1}{2}$ cent. In computing the cost of applying the sprays, $5.75 per day was taken as a liberal estimate for labor of team and three men and for gasoline and oil required to operate the power outfit. This placed the wages of each man at $1.25 per day.

COST OF SPRAYING INGRAM APPLES IN MISSOURI

	Gallons of spray per tree	Cost of spray mixture per tree (cents)	Cost of spray mixture per acre	Expense of applying mixture per tree (cents)	Expense of applying mixture per acre	Combined cost of material and application per tree (cents)	Combined cost of material and application per acre
1st spray	4.74	4.9	$3.19	3.86	$2.51	8.76	$5.70
2d spray	3.67	2.2	1.43	1.85	1.20	4.05	2.63
3d spray	3.44	2.0	1.30	2.06	1.34	4.06	2.64
All sprays	11.85	9.1	5.92	7.77	5.05	16.87	10.97

[1] Taylor, E. P., Mo. State Fruit. Exp. Sta. Bul. 21, p. 40, October, 1909.

SPRAYING AT AVON, VA., DURING THE SEASON OF 1905, AND ITS RESULTS[1]

Plot Numbers (2 Trees to Each Plot)	Treatment with Bordeaux Mixture (5–5–50 Formula)										Picked Sept. 19 to 23		
	Apr 8	May 1	May 9	June 12	June 27	July 10	July 25	Aug. 7	Aug 22	Sept. 4	Sound Fruit	Rotten Fruit	Percentage of Sound Fruit
											Bushels	*Bushels*	
1	"	"	"	—	—	—	—	—	—	—	18.50	30.25	37.9
2	"	"	"	"	"	—	—	—	—	—	47.50	22.50	67.8
3	"	"	"	"	"	"	"	—	—	—	56.00	2.00	96.5
4	"	"	"	"	"	"	"	"	—	—	54.00	1.75	96.8
5	"	"	"	"	"	"	"	"	"	—	32.75	1.15	96.6
6	"	"	"	"	"	"	"	"	"	"	68.50	.70	98.9
A	Check — one untreated tree										.00	10.00	00.0[2]
7	"	"	"	—	—	—	"	"	"	"	56.50	14.00	80.1
8	"	"	"	—	—	—	—	"	"	"	7.00	6.50	51.8
9	—	—	—	—	"	"	"	—	"	—	28.50	6.00	82.6
B	Check — one untreated tree										.00	17.00	00.0[2]
10	—	—	—	—	"	"	"	"	"	"	59.00	6.50	90.0
11	—	—	—	—	—	"	"	"	"	"	42.25	6.50	86.6
12	—	—	—	—	—	—	"	"	"	"	28.50	24.75	53.5
C	Check — one untreated tree										.00	13.00	00.0
D	Check — one untreated tree										.00	20.75	00.0[2]
15	—	—	—	—	—	"	"	"	"	—	52.25	5.25	90.8
16	—	—	—	—	"	"	"	"	—	—	52.50	3.75	93.3
17	—	—	—	"	"	"	"	—	—	—	40.00	5.00	88.8
E	Check — one untreated tree.										.25	16.25	1.5

In Arkansas 400 gallons of mixture were required for one spraying of 200 trees, and the work was accomplished with four men and one team in one half day. The 40 pounds of bluestone at 8 cents a pound cost \$3.20 and the same amount of lime at one half cent a pound cost 20 cents. The four men, at \$1.25 a day each, cost for the half day \$2.50, and the team cost \$1 for the half day. This aggregates \$6.90 for spraying 200 trees, or a little less than $3\frac{1}{2}$ cents a tree for the one application, making a total

[1] Scott, W. M., U. S. Dept. Agr. Bur. Plant Indus. Bul. 93, p. 23.

[2] Of the check trees, A had 1 sound apple, B 6, and D 2, but the percentages were too small to show in the table.

cost of $10\frac{1}{2}$ cents a tree for three applications. This is the cost of the bitter-rot treatment alone; if the cost of the arsenate of lead used for protection against the codling moth be included, $1\frac{1}{5}$ cents a tree for each application should be added.[1]

PROFITS FROM SPRAYING

Spraying protects the foliage and harvest from insect and fungous attacks. — By properly spraying, perfect produce and good yield are often obtained where the omission of spraying would mean poor yield and diseased products, or permanent injury to the plant in the case of perennials.

A marked increase in yield is often evident to even a casual observer. To accurately judge this value in first experiences some portion of the crop should be left unsprayed, and the yield from sprayed and unsprayed parts should be carefully measured and the gain compared with the cost of treatment. In the conduction of any large business every small increase in profit and every saving of leakage is important.

Perfection of produce. — The quality as well as quantity of the yield is improved by spraying. The perfect product proves its excellence on the market by its ready sale and the high price it commands.

One cannot afford to raise inferior produce. The increase in quality, even if the quantity of the yield were not affected, is sufficient reason for spraying. The keep-

[1] Scott, W. M., and Quaintance, A. L., U. S. Dept. Agr. Farmers' Bul. 283, p. 13; April 29, 1907.

ing quality of many kinds of produce is increased by spraying.

Protection of the plant. — In many cases the benefits are apparent the second and succeeding rather than the

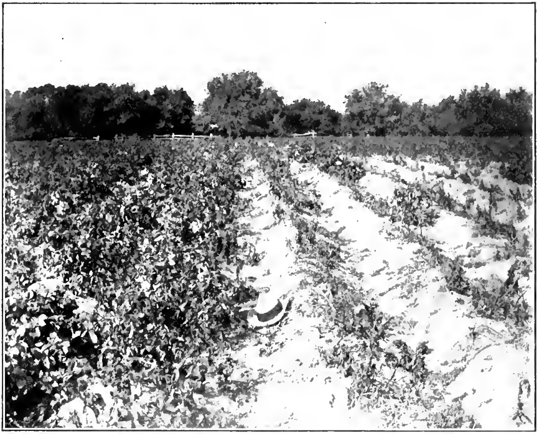


FIG. 16. — Potato field showing benefits of spraying. Portion at left received Bordeaux mixture and Paris green; portion at right received Paris green only. Original.

first year, since spraying protects the foliage, the function of which is to accumulate nourishment for the crop of the following year.

Spraying should be regarded as insurance. It protects the crop against the devastation of disease, yet in most cases it differs from insurance in the fact that it pays for itself year by year even if there be no general epidemic.

A few quotations from various sources to illustrate the benefits of spraying are appended.

"The return per acre from unsprayed area (grapes) is calculated at 316 baskets per acre, worth less than $10 per acre, while from the sprayed areas the average yield was 1252 baskets per acre, worth $125.20 per acre, secured at a cost of $7.50 per acre." — *Ohio Bulletin*, 130, p. 46.

In New York (Geneva) in one case spraying for pear scab at a total cost of 55 cents per tree increased the average yield from 45 cents to $6.55 per tree, a net profit of $6.10 per tree.

From records concerning plum spraying it appears that where the trees were sprayed, the average per tree of picked fruit was increased 44 per cent, the marketable drops increased 8 per cent, and the waste decreased 81 per cent. The total yield of marketable fruit as recorded in pounds was 45 per cent greater where the trees were sprayed than where they were not sprayed.

In experiments at Tryon, N.C., the average weight of good grapes obtained from a vine in the unsprayed rows was 1 pound 1.5 ounces, as compared with 4 pounds 5.8 ounces from those given 6 sprayings with normal Bordeaux mixture, a difference of 4 pounds 4.3 ounces to the vine, or over a ton to the acre. This gain of a ton or more of grapes to the acre was due entirely to the 6 sprayings, at a cost of $15.42.

The following table shows the results obtained with potatoes in the volunteer experiments in New York during the past five years, 1904–1908 inclusive: —

TABLE[1] SHOWING RESULTS OF VOLUNTEER EXPERIMENTS, 1904–1908

Year	Number of experiments	Total area sprayed	Average gain per acre due to spraying		Average market price per bushel of potatoes at digging time
		A.	Bu.	Lbs.	Cts.
1904 . . .	41	364	58	28	43.5
1905 . . .	50	407	59	32	57.0
1906 . . .	62	598	53	6	44.5
1907 . . .	24	264	30	28	58.0
1908 . . .	11	74	66	18	66.0

Average gain for 5 years (188 experiments) 50½ bushels per acre.

Thoroughness in spraying. — Unless thoroughly and carefully done the results from spraying may be disappointing. Spraying is an operation that requires careful heed to directions, and painstaking, patient execution. Poorly done, the benefits may be nil or damage may result from the chemicals applied. Failures to get good results from spraying, in the large majority of cases, have been due to lack of thoroughness on the part of the operator. By thoroughness it is meant that every part of the plant surface is to be coated with a film of the spraying mixture. Failure to do this leaves some points vulnerable. On the other hand too large an application of fungicide is undesirable, often resulting in injury and death of the green part, and always leading to waste of fungicide. When the fungicide accumulates in drops and drips or runs off, too much is present. To apply so little that none drips,

[1] Stewart, F. C., and others, N. Y. (Geneva) Agr. Exp. Sta. Bul. 311.

yet so much that all the surface is coated, is the aim. This necessitates a good nozzle giving a spray, or mist, and not drops. It implies also intelligent care and close attention to all the details of the operation.

SOIL DISINFECTION

Soil disinfection in the field has as yet in the main proved impracticable. All promising chemicals have been tried without avail. Electricity has not given beneficial results, and at present there is no hope of any practicable manner of ridding fields of parasites by any process of disinfection. In a few instances large applications of lime, formalin, or sulphur have proved beneficial (see sweet potato, onion, etc.), but the general practicability of such usage is doubtful.

Disinfection of limited areas is, however, practicable, is largely employed, and has already resulted in great benefit. Cutting benches, flats, and other benches in the greenhouse, cold frames, and seed beds, and other small areas may be disinfected with advantage. The means to be employed depend upon the area, its location, and the facilities at hand. The leading methods are given below : —

Baking. — Flats, pots, and other small containers of earth may often be satisfactorily disinfected by placing them for some time upon the boiler or over a stove, or in an oven for a comparatively long period.

Permanent steam disinfectors.[1] — A system of $1\frac{1}{2}$-inch pipes, which are perforated with $\frac{1}{4}$-inch holes on their

[1] Adapted from Gilbert, W. W., U. S. Dept. Agr. Bur. Plant Indus. Bul. 158, October, 1909.

under side at intervals of 6 inches throughout their entire length, may be placed about one foot below the surface of the soil. The pipes should run lengthwise of the bed, 18 inches apart, and be connected with a steam boiler capable of producing 80 to 100 pounds' pressure. Before treatment the soil should be thoroughly spaded up and pulverized to permit ready access of the steam to all parts, and all fertilizers except commercial ones should be applied at this time, since fresh spores of the fungus might be carried in if manure were added after disinfection.

The bed to be treated should be covered with several thicknesses of old burlap or blankets to confine the heat to the soil. The steam should be applied at a pressure of 80 to 100 pounds, since at high pressure it is much drier and the soil is not wet as much as when low-pressure steam is used. A treatment of from one to two hours is usually sufficient thoroughly to disinfect the soil to a depth of 18 inches. A few potatoes laid in the surface soil will indicate the thoroughness of the treatment by the degree to which they are cooked. The blankets might advantageously be left on for some time.

While this method offers some advantages for seed beds of limited area, in that the pipes may be left in the ground and used year after year with little extra labor and may also be used for subirrigation, the initial cost of installation, especially on large seed-bed areas, may be prohibitive.

Inverted-pan method. — The method which has given the best results in practice, and which because of its simplicity and small cost recommends itself for use on large or small areas, is the invention of Mr. A. D. Shamel, of the U. S. Dept. Agr. Bur. of Plant Industry, and was devised by him to disinfect nematode-infested soils in Florida. The apparatus consists of a galvanized iron pan, 6 by 10 feet and 6 inches deep, which is inverted over the soil to be disinfected, and the steam admitted under pressure.

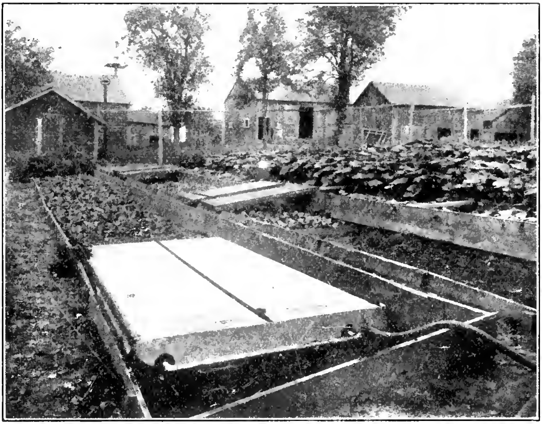


FIG. 17. — Disinfecting with steam by the inverted pan method. After Gilbert.

The pan is supplied with steam-hose connections, has sharp edges, which are forced into the soil on all sides to prevent the escape of steam, and is fitted with handles for moving it from place to place, the weight of the entire pan being not over 400 pounds.

The soil is prepared as in the greenhouse method, a few potatoes being buried at a depth of a foot to gauge the degree of heat attained, or a soil thermometer may be used if desired. The steam should be kept at as high a pressure as possible, 80 to 100 pounds being best, and the treatment should continue for one or two hours, depending on the pressure maintained. In experiments conducted on tobacco seed beds in the spring of 1907, one hour's steaming at 80° C. gave best results in killing both the fungi

FIG. 18. — Disinfecting soil with a Sargent disinfector. Original.

and the weed seeds. When one section of the bed is treated, the pan is lifted and carried to another portion, and the operation repeated until the entire bed is steamed.

The Sargent method. — Disinfection by a system of steam pipes arranged in the form of a harrow, with hollow, perforated teeth, has proved satisfactory under some conditions.

Surface firing. — Surface firing of seed beds has been a common practice for years in some tobacco sections, particularly Kentucky and other Southern States, the end in view being the improvement of the tilth of the soil and the killing of weed seeds rather than of any fungous diseases. In Italy, as well, burning is now considered a part of the regular method of tobacco seed-bed preparation, it having been resorted to as a preventive of Thielaviose.

Two methods of surface firing are in vogue; the first by **direct firing**, the second requiring the use of a pan. In the direct method, the land to be disinfected is first thoroughly pulverized and manure applied. It is then covered with straw, brush, and wood sufficient to make a hot fire. This is ignited and allowed to burn an hour or so. The ashes are raked into the surface soil, and the seed is sown.

The second method, **pan firing**, consists in the use of a sheet-iron pan, 3 by 9 feet, under which a fire is made. This is set in the middle of a 9-foot bed, and the soil on one side to a depth of 6 inches is shoveled in 'and heated, great care being taken to keep it moist, otherwise the humus would be burned out and the physical texture irreparably altered. After an hour this soil is put back and that from the other side of the pan subjected to the same treatment, and then the pan moved along to a new place. The soil underneath the pan itself is thereby subjected to heat for two hours.

Formalin disinfection. — The use of formalin for the disinfection of greenhouse soil and of tobacco seed beds against Rhizoctonia has been in vogue for some time with excellent results. It furnishes a very simple means of disinfection as follows: The beds are thoroughly prepared as for the other methods of disinfection described and are then drenched with a formalin solution composed of one part of commercial formalin (40 per cent formaldehyde) to 150 to 200 parts of water, three fourths to one gallon of this solution being used to the square foot of bed space. The solution should be put on with a watering pot with a rose and distributed as evenly as possible over the bed, so as thoroughly to wet the soil to the depth of a foot. It will in most cases be necessary to put this solution on in two or three applications, as the soil will not take in this quantity of water immediately. The beds should then be covered with heavy burlap or a tarpaulin to retain the fumes for a day or so, and then aired for a week before sowing the seed.

Spring applications of formalin are open to the following objections: The addition of such a large quantity of water to the soil keeps it wet and cold longer than would naturally be the case, thus delaying germination as well as subsequent growth; the necessity of airing the beds to remove the formalin fumes and to allow the soil to dry out also causes delay in seeding. To obviate these difficulties the beds should be treated in the fall, before freezing. In this case a stronger solution, 1 to 100, may well be used, as there will then be no danger of injuring the seedlings.

GENERAL DISEASES

THE causal fungi of the diseases discussed below are found upon so many different kinds of plants that it would seem that they are often indifferent as to the nature of their hosts. They may, therefore, be expected upon almost any kind of plant, and are here mentioned so that it will not be necessary to refer to them repeatedly in succeeding pages. Especial reference is also made to them under the hosts to which they are most destructive.

Damping off. — Seedlings, cuttings, and other weak, soft plants which lack in the vigor that affords them natural protection against their enemies, are subject to a disease which has come to be generally known to gardeners as "damping off." Damping off is most injurious to seedlings grown indoors or under crowded conditions, but it sometimes occurs in the field. Typically it occurs upon seedlings as a rot originating at or near the surface of the ground. The decay at this point so weakens the stem that the plant topples over or "damps off." Subsequently the whole plant may decay, either from the primary cause or from secondary attacks. A short time prior to the fall of the plant the leaves may appear sickly, although this sign is so evanescent that it may not be noted.

Upon cuttings the toppling over does not, of course, occur, but the rot at the ground line is of the same nature as in the case of seedlings, and since the diseases in the two cases are of similar nature and due to similar causes, they are placed under the same caption.

Damping off may be caused by any one of several species of fungi, prominent among them being Pythium, Rhizoctonia, Botrytis, Sclerotinia, Phoma, Volutella, Phytophthora, Colletotrichum, Glœosporium. The fungus which causes this condition may often be seen as a weft of mycelium around the base of the diseased plant, or even creeping over the ground to some distance. From its original points of attack it may spread rapidly to adjacent plants, often sweeping the whole seed bed.

Since the growth of these fungi is favored by moisture and warmth, the trouble may often be checked or prevented by keeping the beds cool and withholding any excess of water; also by means of adequate ventilation, preventing the accumulation of a vapor-laden atmosphere around the bases of the plants. Frequent stirring of the top soil around the plants aids in drying it and may stop an incipient attack of damping off.

Organic matter in the soil favors the growth of damping-off fungi, and should be avoided. Fresh, clean sand is best for most purposes of the seed bed and cutting bench.

Soil known to have once sustained damping off may be regarded as infected with a fungus which caused it. Such soils should not be used for seedlings or cuttings without disinfection. If disinfection is impracticable, the soil should be removed, the containers thoroughly disinfected with a spray of Bordeaux, bluestone, or formalin, and new uninfected soil introduced.

Rhizoctoniose (*Rhizoctonia*). — In America this disease is known to affect potato, beet, cotton, lettuce, bean, currant, celery, radish, rhubarb, Asparagus Sprengeri, aster, carnation, sweet william, coreopsis, violet, cherry, pine, cucumber, begonia, coleus, verbena, hydrangea, candytuft, sage, phlox, pyrethrum, snapdragon, raspberry, lambs'-quarters, tumble-weed, pigweed, and squash, while in Europe it is known upon many more species of plants. If conditions favorable to its attack obtain, the fungus may well be expected upon almost any species of plant, so wide is its range of hosts. For complete description see potato, p. 271.

Soil disinfection, when practicable, may be employed; otherwise general sanitary measures, destruction of infective refuse, and the use of resistant plants are remedial.

Sclerotiose (*Sclerotium Rolfsii* Sacc. in litt.). — The chief symptoms of this disease, with treatment, are described under pepper, p. 259. The causal fungus seems almost omnivorous, and may be recognized upon numerous hosts in the southernmost states. It has been identified upon tomato, eggplant, Irish potato, sweet potato, beet, peanut, bean, cowpea, cabbage, squash, watermelon, rhubarb, fig, cotton, violet, hydrangea, daphne, chrysanthemum, cantaloupe, morning-glory, carrot, Japanese fiber plant, grasses, cauliflower, sugar cane, and several weeds.

Texas root rot, Ozoniose. — Most destructive to cotton under the name of the Texas root rot (see p. 401) this disease affects a very wide range of plants in regions where the causal fungus exists. The disease has been reported from Texas, Oklahoma, New Mexico, and Arizona. It has been noted upon nursery stock (except Prunus), apple, mulberry, china berry, persimmon, elm, lime, maple, Sida spinosa, ragweed, cocklebur, and alfalfa.

Soil diseases. — A type of plant disease of special destructiveness comprises those of which the causal organism resides in the soil from year to year ready to infect any susceptible crop planted thereon.

Notorious among such are the wilts of the cotton, tobacco, cowpea, watermelon, flax, and potato; the club root of cabbage and other crucifers; black rot of similar plants; smut of onion; Texas root rot. Other soil diseases are wilt of tomato, cucumber, cantaloupe, eggplant, potato rosette and scab, beet scab, lettuce drop, and numerous others mentioned on following pages. Since all of these are to large extent similar in propagation and dissemination, they are given general treatment here.

The particular destructiveness of these diseases is due to the fact that they not only kill the crop, but they also prohibit successful culture of susceptible crops in succeeding years. This crop limitation, if the crop in question be an important one, perhaps the only really profitable one suited to the soil affected, may result in large depreciation in land values.

It is unknown how long the germs can live in the soil without their favorite host plant. That they can live from one season to the second season following is certain. A field slightly affected one year, if put to a susceptible crop the second year after will be even more seriously diseased, and the trouble will grow so long as susceptible crops are cultivated with but short intervening periods. Many cases are known where a rest of five and even eight years does not materially restore the soil to health.

The application of chemicals to the soil is of value only in rare instances, and is even then questionable. No

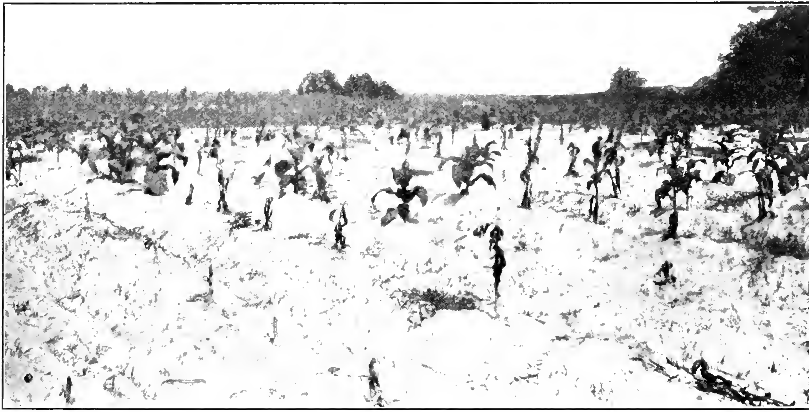


Fig. 19. — A tobacco field illustrating the destructive nature of soil diseases. Original.

means of soil disinfection applicable to fields is known Land once infected can therefore become again usable only by eliminating the causal organisms by a long system of rotation which is usually only partially effective, or by the use of resistant varieties of plants, and these in most instances are not yet known.

In view of these facts it is especially necessary to stress the importance of protection of healthy soils against these diseases. To understand the means of protection the modes of dissemination must be known.

All plants affected with these diseases harbor immense numbers of the reproductive parts of the causal organisms, bacteria, spores, mycelium, etc. Upon the death and disintegration of the host plant they are liberated in the soil, where they are able to live for considerable time. The immensity of their number in a diseased plant is inconceivable. Even a few diseased stems, roots, or leaves in the field will stock the soil thoroughly with them. Infected plants, or soil in which infected plants have been, or which bears parts of infected plants, can therefore convey such diseases to healthy fields.

Instances may be cited where the contagion has spread by **washing** from higher land to lower; so, too, may it be carried by any means which can convey soil from a sick to a healthy field, notably through **tools**, which have been used on diseased soil. Though apparently clean, such tools, if they bear even minute particles of infected soil, may convey hundreds of germs and thus start an epidemic in an uninfected field. The **hoofs** of animals or the **feet** of laborers may in a similar way bear disease-laden soil. **Wind** passing over an infected field may pick up broken bits of sick plants or germ-laden soil, and convey these to healthy fields. Infection by wind, however, seems to be rare, possibly because of the germicidal action of the sun's rays upon the surface layer of soil upon which the wind must act. If the crop be one which is used for **stock feed** or one which may become mixed with stock feed, the disease may be spread widely through **manure** which has here become infected from the feed (cf. watermelon, cabbage).

A field now healthy may be protected from higher land that is infected by proper arrangement of **dykes**. In some cases a thorough **cleansing of tools** so that there is no possibility of conveying the germs will aid in repression. The dirt may be knocked off, then wiped off, and the implement finally disinfected with a solution of 2 per cent formalin or 5 per cent carbolic acid. It is difficult to insure complete protection against disease dissemination by the feet of animals and man, but if uninfected land remains to be protected, every precaution should be exercised in this particular.

Where but a few plants in a field are affected, they should be removed from the soil and destroyed by fire, — root, branch, and leaf. Prompt action here may materially lessen the rapidity of spread of the disease in the field. Every particle of the sick plant burned means the destruction of millions of the causal organisms.

A long **rotation** of crops, one that will bring the susceptible plant back upon the affected field only after an intervening period of several years, perhaps after a period of eight or ten years, is useful in some cases, notably with potato wilt, though in other cases, notably watermelon wilt, such rotation is of little avail.

The one means of overcoming these soil diseases which is most promising to farmers who own affected soil lies in the discovery of a variety of the crop plant that will not

Fig. 20. — Root knot (nematode) on salsify. Original.

succumb to attack even when planted upon sick soil. Varieties of cotton that can resist the cotton wilt, of flax that can resist flax wilt, and of cowpeas that can resist the cowpea wilt have been discovered. There is similar hope in regard to other crops.

Root knot, Nematode galls. — Root galls, varying from a few millimeters to a centimeter or more in size and superficially resembling the root tubercles of the legumes, are common upon a large variety of crops and, though they do not properly fall within the province of this book, a word is due to them on account of their extreme destructiveness. They are due to a microscopic worm which enters the root from the soil and by irritation of the root causes the gall to develop. Soil infected with these worms will produce disease symptoms upon susceptible crops, and considerable diminution in the vigor of the plant results. The cotton, cowpea, watermelon, and tobacco are especially susceptible, though the list to include all susceptible species would extend into the hundreds, including many prominent ornamentals. The only remedies are those suggested under soil diseases, with especial stress upon crop rotation and the use of resistant varieties.

DISEASES OF SPECIAL CROPS

POMACEOUS FRUITS

APPLE

Bitter rot, ripe rot (*Glomerella rufomaculans* (Berk.) Spaul. & von Schrenk). Untrue to its two common names, this malady does not always render apples bitter, though

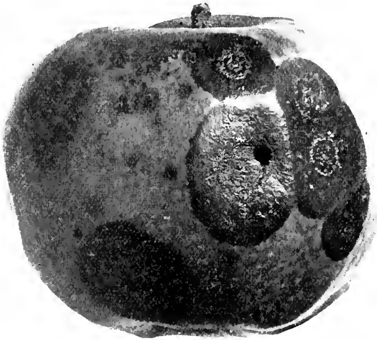


FIG. 21. — Apple bitter rot (glomerellose) in early stage showing pycnidia. After Scott.

this is sometimes the case; nor is the disease always limited to ripe fruit. Its effect is seen upon both the fruit and the twig.

Upon the fruit it produces a soft, wet, or in later stages corky, more or less dry, brown, tan-colored, or black, circular, rotten spot. This spot under favorable conditions rapidly increases in diameter, the rate varying from 1–10 mm. each day. The spots may be either single upon the fruit or very numerous, depending upon the abundance of the infecting spores. When a spot becomes quite large, it is usually somewhat depressed, with a shriveled, wrinkled surface, due to loss of turgor of the underlying tissue caused by evaporation. As the spot ages minute sporing pustules of the causal fungus, barely visible to the naked eye, appear, first at or near to its center. The tissue of the fruit is affected to some depth, although the progress of the disease is not so rapid downward as laterally. The pulp of the apple at the margin of the rotten region is usually bitter, thus giving rise to one of the common names of the disease.

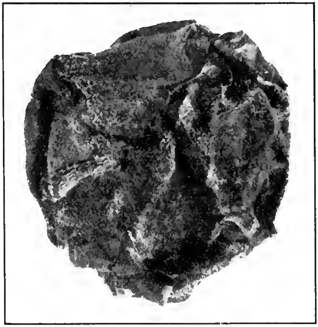


Fig. 22. — Apple in advanced stage of bitter rot (glomerellose). After Scott.

Fruit of any age after its formation is liable to infection if suitable climatic conditions and infective material obtain, though the disease is most noticeable and does most damage as the fruit approaches maturity. A series of hot, wet days favors a destructive attack, while cold checks it. The fruit as soon as it is badly rotted usually falls from the tree, covering the ground beneath, while apples less advanced in disease still hang upon the limbs.

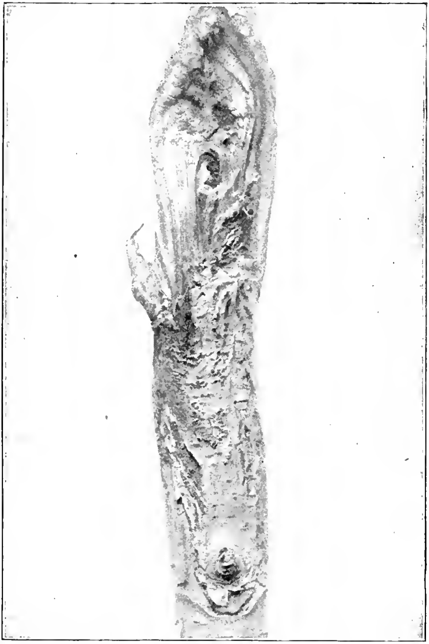


Fig. 23. — Bitter rot canker formed where a limb was broken. After Burrill.

This same disease affects twigs and young branches, causing **cankers** or rough spots on the bark, which (Figs. 23,

24) vary in size according to their age, persisting and enlarging year after year. Young cankers are slightly rough, owing to the dead bark, and extend only partly around the twigs. Old cankers are very rough, and may extend several centimeters longitudinally along the twig, thus giving it a flattened appearance.

The fungus causing the rot upon the fruit was described in 1856 by Berkeley. That the cankers are caused by the same fungus was recognized independently by two research parties, Burrill and Blair, and von Schrenk and Spaulding in 1902. Upon both twigs and fruit the spores are borne in great numbers. The fungus is, moreover, perennial upon the twigs, the cankers serving as initial points of infection for each year's epidemic.

The natural course of the disease is thorough twig infection; spores from some older lesion are transferred to points of weakness on the twig, such as ruptured bark due to any cause. The fungus here grows rapidly, produces a canker, and forms many spores. These in turn, carried chiefly by rain, partly by insects, wind, or other agencies, reach other susceptible twigs and cause other cankers or fall upon apples, and there initiate spots of rot. Apples thus infected serve as multiplying ground for the further infection of other apples, thus giving rise to the chief part of the fruit rot. Six days after an apple is infected a crop of spores may mature and be ready to further spread the disease. To some extent the causal fungus hibernates in mummified fruits, which thus become sources of initial infection for the succeeding year.

Bitter rot occurs throughout the United States wherever apples grow, but has been most destructive heretofore in sections southwest of Virginia between the parallels of 35° and 39° north latitude. In 1900 it was estimated that

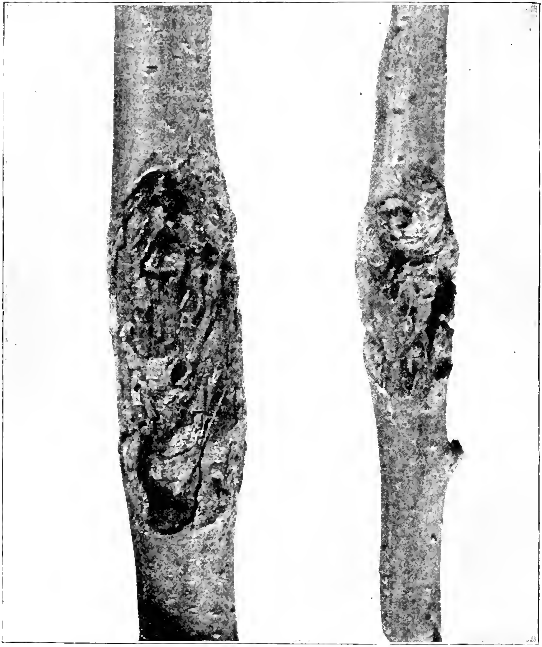


Fig. 24. — Bitter rot cankers in which perithecia were found. After Burrill.

the loss in four counties of Illinois was $1,500,000. The president of the National Apple Shippers Association estimated the damage to the apple crop of the United States that year as $10,000,000. There is often a loss of from 50 to 75 per cent of the crop.

Two modes of treatment used in conjunction are useful: first, to cut off and burn the cankers and to hand pick and destroy mummified fruit; second, to spray the growing fruit with a fungicide. The mummified fruit should all be collected and all cankers, so far as they can be detected by the most searching inspection, should be taken out. The trees should be sprayed once before the buds open, and frequently thereafter until the fruits are almost ripe, with Bordeaux mixture, or self-boiled lime-sulphur wash. A non-spotting spray should be used for the last application.

Scab (*Venturia inaequalis* (Cke.) Wint.). — This is justly called the most injurious disease with which the apple grower has to contend. It affects both fruit and leaves, probably in all localities where apples are grown, and is serious in Europe, Australia, and New Zealand, as well as in America.

Upon the fruit, the scab first causes the skin to take on a dark olive-green color; later as the outer skin breaks and exposes the fungus underneath the color changes to black. An apple in this stage is shown in Fig. 25. Still later the scab enlarges, and the spores and fungous cells at the center of the spot may fall away, leaving a skin of rusty appearance surrounded by a dark ring where the fungus has not yet fallen off. Still further out may be an olive-green or silvery ring, showing the still younger stage of the disease. Cracking and distortion occur in cases of very badly affected fruits. Scabby fruits are much more susceptible to bin rot than are clean fruits, p. 94.

Upon the leaves and twigs the fungus forms a thick velvety coat, varying from dark olive-green to black, in spots at first circular in outline, later irregular and coalesc-

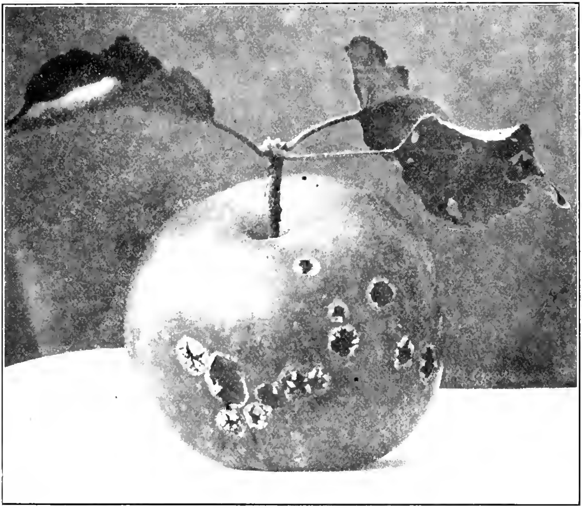


Fig. 25. — Apple scab. After Craig.

ing. The irritation and retardation of growth caused by the presence of the fungus induces the leaves to curl and wrinkle in a characteristic manner.

The injuries by this disease may be enumerated as follows: lessened leaf value, retarded twig and wood growth, premature fall of fruit, retardation of full development of fruit, injury to sale of fruit, injury to keeping quality of fruit.

Snow, Spitzenburg, Maiden Blush, Greening, and Twenty Ounce are more susceptible than Baldwin, while Golden Russet and Hubbardston are among the most resistant varieties.

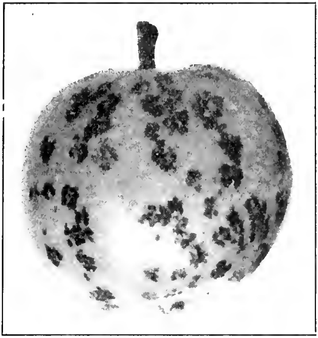


FIG. 26. — Apple blotch (phyllostictose). After Scott and Rorer.

The spray recommended on page 100 will to a very large extent prevent the apple scab. It is especially important to apply the mixture at just the dates indicated, *i.e.* just before the blossoms open, again just after the petals fall, followed by one or two more sprayings later.

Blotch (*Phyllosticta solitaria* Ell. & Ev.). — In some sections of this country this disease of bark, leaf, and fruit is even more troublesome than any of the preceding, though its distinct identity was not recognized until 1897, when the first specimens came from Maryland and Texas. Since then the disease has been frequently seen in the eastern part of the United States though not as a very serious pest. Its most destructive center heretofore has been in the Ozarks of Arkansas and Missouri, where 75 per cent of the crop is commonly rendered unfit for barrel-ing. One county alone is estimated to have suffered a loss of $950,000. Owing to its superficial similarity to the scab, it has perhaps been confounded with it in some instances. The first publication concerning the disease appeared in 1902,[1] and the first detailed description in 1907.[2]

Upon the fruit the blotches are from 5–10 mm. in diameter, dark in color, with an advancing margin of very peculiar, irregular, jagged, or fringed appearance. By coalescence large spots may form, and owing to tension, cracks appear, enlarging to a centimeter in length, or even girdling the fruit, and reaching to the core. In the older portions of the blotch, minute pycnidia develop. These blotches mar the appearance of the fruit and injure it as a salable product.

Fig. 27. — Apple blotch (phyllostictose) on twigs. Original.

Upon twigs, spurs, or shoots are produced cankers,

[1] Clinton, G. P., Ill. Agr. Exp. Sta. Bul. 69, pp. 190–192.

[2] Scott, W. M., and Quaintance, A. L., U.S. Dept. Agr. Farmers' Bul. 283, pp. 14–18.

which, during the first year, consist of small spots 2–10 mm., tan colored, each bearing several pycnidia. The margins of the spots are sharply limited, and are usually bordered with a narrow red line. In older cankers the diseased bark becomes cracked, furrowed, and much roughened.

On the leaf this fungus causes small, irregular, light brown, yellowish, or whitish spots, usually 1–2 mm. in diameter, each of which may bear one or several pycnidia.

The Ben Davis, Missouri Pippin, Limbertwig, Northwestern Greening, Smith Cider, and Maiden Blush are highly susceptible, while Winesap, Jonathan, and York Imperial are almost immune.

Ordinarily four applications of Bordeaux mixture suffice to control the blotch. The first spraying should be made three or four weeks after the petals have fallen; the second about four weeks later; the third and fourth at intervals of three weeks thereafter. Careful pruning to remove affected twigs is beneficial.

Scurf (*Phyllosticta prunicola* (Opiz) Sacc.). — This affection of the bark of twigs causes it to shrivel. The diseased part is thickly studded with the very minute pycnidia.

Affected twigs should be cut out and burned.

Rust (*Gymnosporangium macropus* Link). — The rust of the apple may usually be readily recognized by its characteristic yellowish orange spot on the leaf, or more rarely upon the fruit or twig. This spot, yellowish green at first, gradually becomes darker, approaching orange. Upon close examination, the upper surface of one of these discolored spots is seen to contain very numerous pustules, at first honey yellow, finally black, smaller than a pinhole, while upon the lower surface of the diseased spot appear some weeks later the fringe-toothed cluster cups. This spot is sometimes so abundant that its presence upon orchards may be recognized at great distances by the characteristic hue imparted to the foliage mass as a whole. It robs the tree of nourishment and renders normal fruitage impossible.

Fig. 28. — Apple leaf affected with rust. Original.

A peculiar relation exists, in that the causal fungus spends part of its life on one plant, the apple, and the remainder upon a totally different plant, the red cedar, the **Alternate Host** of the apple rust. The fungus summers upon the cultivated apple or the wild crab-apple tree, at the approach of winter its spores are borne by the wind from the apple trees to an adjacent juniper or red cedar tree. There the fungus grows and causes the familiar "cedar apple."

In the spring the cedar apple produces gelatinous, hornlike projections, each bearing myriads of spores, which, when conveyed by the wind to the susceptible apple tree, cause the apple rust. Evidence that this relation really exists is readily found if one examines an orchard having red cedar trees upon its windward boundary.

It is clear that the more red cedar trees there are in the neighborhood of an orchard, especially to windward, the more probability there is of damage from the rust. The rational treatment, therefore, is to remove these trees in so far as possible.

In rare instances spores may be carried several miles, but orchards are reasonably secure if all possibility of infection from the immediate neighborhood be removed. In case the red cedars are too numerous, or if for other reasons it is impossible to cut them, spraying the tree as recommended for the apple scab will lessen the evil to some extent, but its success is not complete or certain.

Resistant apple varieties are: Duchess, Sweet June, Yellow Transparent, Red Astrachan, Ben Davis, Maiden Blush, Winesap, Oldenburg, Gano, York Imperial. The following are more susceptible: Wealthy, Red June, Whitney, Jonathan, Missouri Pippin, Prairie Crab.

Blight (*Bacillus amylovorus* (Burr.) De Toni). — Description and discussion of this disease will be found on page 101 under Pear, the blight of which is identical with the apple disease. Its character and treatment are the same upon both hosts. While the blight is preëminently a pear disease, it also affects the apple very seriously, particularly the form of "body blight" upon the trunk.

The Lowell, Isham, Smith Cider, and Yellow Transparent are especially susceptible varieties, while the Celestia, Buckingham, Mammoth Black Twig, White Winter Pearmain, Winesap, and Ben Davis are resistant, the last almost entirely so. In general the crab varieties are more susceptible than others.

Black rot, canker (*Sphæropsis Malorum* Peck). — In many respects this disease closely resembles the bitter rot, particularly in that it appears both as rot of the fruit and as cankers upon the limbs, each of which is almost indistinguishable from bitter rot upon the similar part. In some instances it also appears as a twig blight and as a leaf spot.

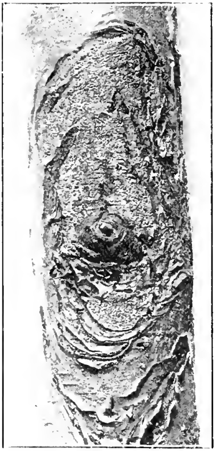


Fig. 29. — Apple black rot canker (sphaeropsose) showing numerous pycnidia. After Whetzel.

Upon the fruit the spot, though sometimes of a darker hue, is often quite indistinguishable from that of the bitter rot. As seen under the hand lens the coils of exuding spores are black, instead of pink, as is the case with bitter rot. A compound microscope is necessary to bring out other distinguishing characters.

The limb cankers, first studied by Paddock,[1] consist of swellings with the bark rough, and black, or in many cases expose the black and decayed wood from which the bark has disappeared. This cankerous infection sometimes

[1] Paddock, W., N.Y. (Geneva) Agr. Exp. Sta. Bul. 163, December, 1899.

extends for nearly a meter along the branch, and occasionally girdles it. When occurring upon the trunk or main branches, **body blight** is caused, similar in appearance and effects to that mentioned under blight.

The Tolman Sweet is said to be quite resistant to the canker, while Twenty Ounce is very susceptible. Four other varieties range in susceptibility as follows: Baldwin, Wagener, Greening, King.

The Sphæropsis twig blight somewhat resembles the fire blight with which it is often associated, but may be distinguished from it by the presence of myriads of minute pimples distributed thickly over the affected region. With a hand lens coils of spores may often be clearly seen issuing from these pustules.

Upon the leaf blighted spots are caused, irregularly circular in outline, often marked by concentric rings. The body of the spot is brownish and the margin sharply limited. Similar spots are caused in several other diseases, and definite knowledge of the nature of leaf spots must depend upon microscopic diagnosis in each special case. Yet it is certain that many of the spots upon apple leaves, especially when Sphæropsis prevails upon fruit and twigs, are caused by this fungus.

The various forms of this disease which have been noted in Nebraska, Michigan, Missouri, Ohio, West Virginia, Wisconsin, Kentucky, and Vermont, and throughout the Allegheny and eastern apple sections, are troublesome each year.

The treatment should be the same as that recommended for bitter rot with special care to avoid bark wounds of all kinds, as from ladders, workmen's boots, etc.

Pacific coast canker, black-spot canker[1] (*Macrophoma curvispora* Peck). — The Pacific coast canker is particularly destructive in the northwestern states west of the Cascade Mountains. It was first noted about 1893 when it developed in such destructive form as to cause the Washington State Board of Horticulture to call upon the Federal Government for its investigation. It has since been reported in Oregon, Idaho, Nebraska, and British Columbia.

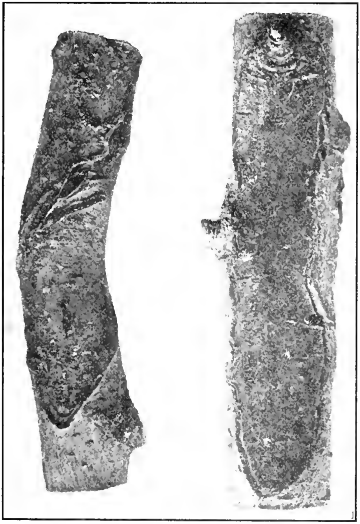


FIG. 30. — Black spot canker (macrophomose). After Cordley.

The bark or sapwood of twigs and larger branches is the seat of infection, but the disease may occur also upon the fruit when in storage. The loss of an entire orchard within a few years has resulted from the black-spot canker. Young trees, owing to their tender bark, are especially susceptible.

[1] Lawrence, W. H., Wash. Agr. Exp. Sta. Bul. 66, p. 5, 1904.

Upon twigs, cankers in the early stage appear as round or oval, slightly sunken, dark areas which increase but slowly in diameter. As soon, however, as the fungus penetrates into the cambium and sapwood the canker enlarges very rapidly, making its most rapid development through the cambium, and advancing more tardily through the overlying bark. The resulting spots are nearly circular, quite black, and from 5 mm. to 12–14 cm. in diameter. When old, the bark becomes brittle and a definite fissure separates the dead from the healthy portions, indicating cessation of advance of the fungus. Acervuli appear first in the oldest parts of the canker, later toward the periphery, rupturing the epidermis and exposing the spore masses which are at first creamy white, but later black. After the spores have matured the diseased bark becomes separated from the wood and eventually falls away, leaving a scar. Branches, or even trees, may be killed by girdling cankers.

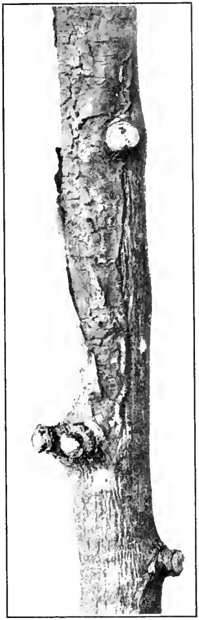


FIG. 31. — Black spot canker. After Lawrence.

Upon stored fruit the disease appears first as light brown, circular, rotten spots. These later turn very dark or black, and become depressed, dry, and tough. Acervuli similar to those upon the bark soon develop in concentric circles.

Lawrence notes the Baldwin, Blue Pearmain, Gravenstein, Newton Pippin, Wagener, Wealthy, and Yellow Bellflower as especially susceptible; the Hubbardston, Nonesuch, Imperial Pippin, King of Tompkins County, Maiden Blush, Olympic, Red Astrachan, Rhode Island Greening, Spitzenburg, Striped Astrachan, Twenty-ounce Pippin, and Yellow Transparent as less susceptible, while the Northern Spy, Waxen, and Ben Davis are comparatively free from the disease; but these generalizations are largely modified by a great variation in resistance among individual trees.

FIG. 32. — Black spot on fruit. After Lawrence.

When the cankers are few, on small trees, excision may be practiced to advantage; when, however, there are hundreds of cankers upon each tree, this treatment is manifestly impracticable. Spraying with strong Bordeaux mixture, 12–8–50, in the fall after the crop is gathered is valuable to prevent the formation of new cankers, and has established practical control of the disease.

Illinois canker (*Nummularia discreta* (Schw.) Tul.). — Attention in America was first called to this as an active parasitic disease in 1902 by Hasselbring,[1] who attributed to it more serious results than from any other canker disease of Illinois. It has been reported from West Virginia, Missouri, Arkansas, and Nebraska.

The cankers are at first inconspicuous, unhealthy, dirty brown, usually depressed spots in the bark, sometimes 15 cm. in diameter, which enlarge rapidly, particularly lengthwise upon the limb, a crack often marking the boundary between dead and sound bark. The interior of the bark of such spots is mottled with dead regions.

In autumn the sporiferous bodies appear near the borders of the diseased spots, first pushing through cracks in the bark, and exposing pale grayish ochre-colored fungous growths 3–6 mm. in diameter, which, when mature, are slightly saucer- or dish-shaped, and dark in color. These bodies are attached to the dead wood, and remain there even after the bark has fallen away, thus constituting a diagnostic character of absolute reliability, separating this from all other cankers. Discoloration of the heartwood often occurs at a distance of a meter or more from the apparent seat of disease.

When the cankers become large, injury to the distal parts through interruption of the water supply results. The leaves show symptoms of disease, and the fruit fails to grow to full size. With complete girdling the limb dies.

Since all infection seems to occur through wounds, pre-

[1] Hasselbring, H., Ill. Agr. Exp. Sta. Bul. 70, April, 1902.

vention must look largely toward the avoidance of wounds by tools, machinery, harnesses, pickers' ladders, boots, etc. It is also an excellent sanitary measure to cut out and burn all infective material, and even excision of diseased tissue in a limb may be practiced with profit in incipient cases.

European canker (*Nectria ditissima* Tul. and *Nectria cinnabarina* (Tode) Fr.). — The European canker was not recorded upon the apple in America prior to 1899,[1] when Paddock mentioned its presence in Nova Scotia and New York. Later it was noted in New Hampshire. It constitutes a serious disease in Europe and may spread so as to be injurious here. The canker enlarges year after year, but more slowly than the Sphæropsis canker, and displays when fruiting numerous minute, deep red perithecia which serve to distinguish it from other cankers.

Bark canker (*Myxosporium corticolum* Edg.). — This canker in general aspect closely resembles the cankers previously mentioned, except that the injury does not penetrate the cambium zone. It is of little economic importance.

Leaf spot (see also black rot). — Aside from the leaf diseases of apple already mentioned there are numerous other leaf spots due to various, partly to unknown, causes. These spots partake of the same general character. That is, they are brown to tan colored, at first circular, later irregularly circular, definitely bordered, and usually concentrically marked. If abundant, or if they enlarge rapidly upon the leaves, they cause their premature fall, and largely defoliate the tree. Such spots prevail to greater or less extent in all apple orchards. Numerous species of

[1] Paddock, W., Sci. n. s. *12*, 297.

FIG. 33. — Apple leaf spot in late stage of development, showing concentric rings. Original.

fungi have been isolated from these spots,[1] some of them may sustain a causal relation to the disease.

Whatever the actual causal fungus may be, these spots are all, or nearly all, of fungous origin and are amenable to preventive spraying with Bordeaux mixture. The first of three or four applications should be given with the opening of the leaf buds.

Illosporiose, leaf spot (*Illosporium malifoliorum* Shel.). — This is said by Sheldon[2] to be the cause of much of the defoliation of apple orchards in West Virginia and adjacent states. The spots are circular, 5–15 mm. in diameter, brown or mottled and gray, concentrically marked.

For treatment see page 100.

[1] Notably by Hartly, Minnesota, and by Lewis, I. M., New Hampshire Agr. Exp. Sta. Rpt. 19–20, November, 1908.

[2] Sheldon, J. L., Torreya, *8*, 141, June, 1908.

Hypochnose[1] (*Hypochnus ochroleuca*, Noack). — Hypochnose is principally a leaf affection causing blight and loss of the leaves, and thereby weakening the vitality of the tree.

FIG. 34. — Hypochnose, showing matting of leaves. Original.

Superficially this disease resembles the blight, with which it might be confounded by the casual observer. It may be readily distinguished, however, by two characters: first, the manner in which the leaves droop and mat together, which is quite different from the habit of the blight, the leaves of which neither droop nor mat; second, by the presence of small sclerotia, white when young, cinnamon-brown when mature, upon the twigs adjacent to the affected leaves. These sclerotia usually measure about 2–3 mm. in diameter. To-

[1] Stevens, F. L., and Hall, J. G., Ann. Mycol. VII, 49, 1909.

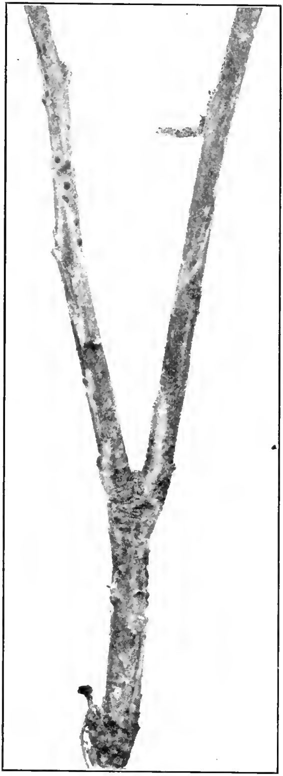


Fig. 35. — Hypochnose, showing sclerotia on twig at left and rhizomorphic strands on twig at right. Original.

gether with the sclerotia and extending along the twig longitudinally are also found silvery, glistening, thread-like, fungous growths.

This fungus hibernates in the sclerotia on or near the terminal bud and thence invades the new twigs as they develop, reaching out upon each leaf, spreading over its under surface in almost invisible thinness, and causing it to droop, die, and eventually to fall away. Thus in early autumn such trees are nearly or quite defoliated. The fruit may be also invaded by the fungus. This annual premature loss of leaf is a serious injury to the tree, hindering its proper growth and preventing proper fruitage.

Hypochnose, first described from Brazil, is known from Maine to Florida in the United

States. It seems to be especially destructive in regions of excessive humidity, particularly in the deep mountain valleys of the Appalachians, where whole orchards are sometimes seriously affected.

Owing to the entirely superficial nature of the fungus which causes the disease, and its habit of hibernating upon the twigs, the trees should be sprayed with a strong cleansing mixture, Bordeaux or bluestone, before the buds open, and again just before the blossoms open.

Fruit rot (*Hypochnus sp.*). — Eustace[1] first described this rot of the fruit upon Baldwins and Rhode Island Greenings. In that it follows scab it is similar to pink rot, to which in appearance it also bears superficial resemblance. A distinguishing feature of this disease is that there is normally no large surface growth of fungus in the center of the diseased spot. In this disease the rot often extends to the core, while in the other similar diseases the spot is shallow.

The treatment is the same as for pink rot.

Pink rot (*Cephalothecium roseum* Cda.). — This rot, known in many states, is stated by Eustace[2] to be particularly prevalent in western New York. It follows apple scab and may be recognized by the white, mildew-like growth which appears in conjunction with the scab and soon after entirely overgrows it.

While the decay is really caused by the Cephalothecium, the rupture made in the skin by the scab fungus is the usual place of entrance. The decayed spot is shallow and slow

[1] Eustace, H. J., N.Y. (Geneva) Agr. Exp. Sta. Bul. 235, July, 1903.

[2] Eustace, H. J., N.Y. (Geneva) Agr. Exp. Sta. Bul. 227, December, 1902.

growing as compared with other rots. It is accompanied by a bitter taste which is so pronounced as to injure cider made from affected apples. The chief destruction follows the harvest, though the disease is sometimes found in fruit still upon the tree.

The Rhode Island Greening, Fall Pippin, Fameuse,

FIG. 36. — Pink rot (cephalotheciose) following scab. After Eustace.

Maiden Blush, Tompkins King, and Twenty Ounce are especially susceptible.

Chief attention should be directed to the prevention of the scab. In storage a dry house, well ventilated, kept at 45° F. or below gives best rot resistance.

Brown rot (*Sclerotinia fructigena* (Pers.) Schroet.). — One of the most serious apple rots in Europe, this disease is fortunately as yet less destructive in America, though it is occasionally met with as one of the minor causes of apple losses and has been noted in several states, notably Missouri, Nebraska, West Virginia, and North Carolina, in abundance enough to call for printed mention.

Brown rot produces complete decay of the affected apples, which turn brown, become soft and wrinkled, and soon show pustules of bushy mycelium breaking through rifts and fissures in the skin over the diseased tissue. The diseased fruits may mummify upon the tree or more frequently fall to the ground and there shrivel to dry, hard, wrinkled masses, in which the rot fungus winters.

FIG. 37. — Brown rot (sclerotiniose) produced by inoculation. Note the fungus forms the letters A. M. C. Original.

Powdery mildew, Sphærothecose (*Podosphæra leucotricha* (E. & E.) Salm.). — The general appearance of this mildew is much like that described for the grape; that is, the surfaces of the leaves are more or less covered with a white or grayish fungous growth, in the later stages of which are found numerous very small black fruiting bodies approximately 0.25 mm. in diameter. This fungus, while of comparatively little significance to old apple trees, causes much injury to nursery stock, often becoming so serious as to prevent successful budding. Mildew has been reported as serious in California and other western states, — in Kentucky, Iowa, Washington, and

West Virginia. The use of ammoniacal copper carbonate as the leaves unfold, and continued at intervals of two weeks until budding time, will usually prevent damage from the disease. Sulphur or sulphide sprays have given best results in dry climates.

Podosphærose (*Podosphæra leucotrichia* (Ell. & Ev.) Salm.). — This mildew is similar to Sphærothecose.

Crown gall. — See peach.

Soft rot, bin rot, blue mold (*Penicillium glaucum* Link). — Perhaps the most common apple rot is found upon stored apples late in the year. The light tan-colored rotten area is soft and watery. The decay results in the complete loss of the affected fruit, and, by contagion, in loss to the fruit mass.

Upon cracks in the rotted surface, and eventually over the whole rotten part, appear tufts of very short delicate fungous threads, at first white, soon bluish green, very like the common blue mold so familiar to the housewife upon canned fruit, the seal of which has permitted air to enter. This blue substance upon the rotten apple consists of myriads of the spores of the causal fungus. This fungus is comparatively unaggressive and cannot force its way into perfectly healthy tissue; a bruise or rupture of the skin is necessary to its invasion. The best preventive is care to avoid bruising.

Sooty blotch (*Phyllachora pomigena* (Schw.) Sacc.). — Irregular, sooty, black blotches, especially conspicuous on the lighter colored varieties, are frequently seen upon unsprayed fruit.

The individual blotches measure from 0.5–2 cm. across and are often so abundant that they coalesce, giving the fruit a dirty appearance. The fungus attacks the fruit late in the season, and is strictly superficial. It may be easily rubbed off with a cloth. The loss in ready salability, due to the unsightliness of the fruit, is reason enough for protective sprayings.

The Bordeaux mixture applied at intervals of about two weeks from the middle of June until the middle of August is effective.

FIG. 38. — Apple flyspeck. Original.

Flyspeck (*Leptothyrium pomi* (Mont. & Fr.) Sacc.). — Growing upon the surface of the fruit and forming numerous clustered black specks closely resembling flyspecks, this disease causes disfigurement of the apple. Though the disease is of very wide distribution, the loss occasioned by it is not serious and is almost entirely prevented by the sprayings employed against other diseases.

Coniothyriose (*Coniothyrium Fuckelii*, Sacc.). — A rot upon fruit very similar to bitter rot, and a twig blight very similar to Sphæropsose is caused also by Coniothyrium. This disease is of less importance than the others mentioned, and the remedies already given suffice.

Volutellose (*Volutella fructi* S. & H.). — In general appearance Volutellose is not to be distinguished from Sphæropsose, though the texture of the rotted tissue is much firmer and dryer. Under the hand lens the sporiferous pustules are seen to be clothed with numerous hairs, which character sufficiently marks it as a separate disease. As yet it has been reported only from North Carolina.[1]

New Hampshire fruit spot (*Cylindrosporium pomi* Brooks). — This disease, which has been noted in Delaware, New York, Pennsylvania, Michigan, Maine, Massachusetts, New Hampshire, Toronto, and Montreal, appears in late summer as very small, deep red, slow-growing spots, usually at the lenticels. A little later these spots turn brown and then resemble closely the young spot of black rot or ripe rot in appearance though not in texture. At or after harvest the spots are somewhat depressed, through failure of the sick tissue to keep pace in growth with the surrounding tissue. This disease has been demonstrated by Brooks[2] to be of fungous origin and to be amenable to treatment by the Bordeaux mixture applied late in June or early in July.

Black mold (*Alternaria sp.*). — The blossom end of the fruit is affected by the rot. The spot is dark purplish to brown and slightly sunken, enlarges very slowly, and may not be noticeable until the fruit is in storage. Often no disease is noted until the apple is cut through, when the core is found blackened and discolored, and the seeds covered with the dark mycelium. In more serious cases the effect extends into the surrounding pulp. This black mold was first described by Longyear.[3]

[1] Stevens, F. L., and Hall, J. G., N.C. Agr. Exp. Sta. Bul. 196, p. 41.

[2] Brooks, Charles, N.H. Agr. Exp. Sta. Rpt. 19, 1908.

[3] Longyear, B. O., Colo. Agr. Exp. Sta. Bul. 105, 1905.

FIG. 39. — Clitocybe upon apple. After Wilcox.

The Lawver, Loy, Mann, Dominie, Jonathan, Ben Davis, and Winesap are especially susceptible.

The methods of treatment recommended are clean culture, a cleansing spray, and one or two applications of a preventive spray.

Texas root rot. — This is destructive to apples in the regions where it prevails. See cotton.

Wound infections and wood rot. — See general discussion of the subject, p. 410.

Wood rot (*Schizophyllum commune* Fr.). — Decay of the roots and lower trunk occur here much as in cherry.

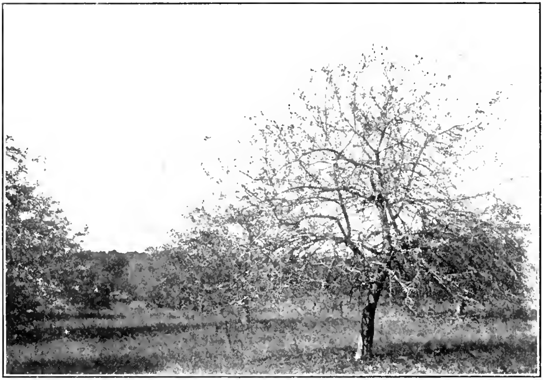


FIG. 40. — Unsprayed apple trees. After Scott and Rorer.

The causal fungus seems to enter through wounds in the bark or roots. Later the characteristic sporophores are produced. See page 120.

Clitocybose, root rot (*Clitocybe parasitica* Wilcox). — This root rot, very similar to that caused by Armillaria mellea, p. 173, was described by Wilcox in Oklahoma in 1901 [1] as characterized chiefly by a copious exudation of gum from the crown of the diseased trees. The leaves

[1] Wilcox, E. Mead, Okla. Agr. Exp. Sta. Bul. 49.

turn yellow or wilt and black mycelial strands are found in abundance attached to the roots. Later, groups of sporophores are found about the base of the tree. These

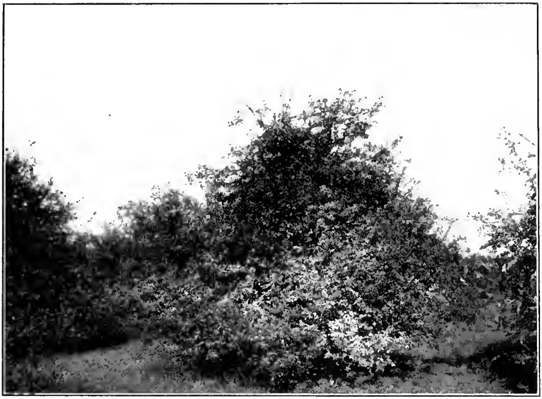


Fig. 41. — Sprayed apple trees from the same orchard. After Scott and Rorer.

in general resemble the sporophores of Armillaria. See page 425.

The isolation of diseased trees by trenching may prevent the infection of other trees. Orchards should not be located in soil containing old oak stumps. All infected material should be burned.

Combination Treatment for Apple Diseases

The following treatment is designed to meet all of the fungous enemies of the apple. In event certain diseases are absent, this treatment may be modified in the light of what is said on preceding pages.

1. Employ methods 6, p. 22, and 9, p. 23.
2. Apply a cleansing spray No. 3, p. 20.
3. Use protective sprays No. 4, p. 20: 1st, before blossoms open; 2d, after petals fall; 3d, three or four weeks later; 4th, about five weeks after the third; 5th, about three weeks later; 6th, about three weeks later.

Bordeaux Injury to Apples

Ever since the first trials of Bordeaux mixture upon the apple some injury has been noted upon both leaves and fruit, due to this mixture itself, the amount of injury differing with different varieties, and with the weather conditions.

The injury may first appear a few days after spraying or may be delayed for weeks, showing first on the fruit as small, round, black specks, which later become rough and russeted, and in severe cases distorted and badly scarred. Such fruit does not keep well, becoming mealy or soft. Upon the leaves brown dead spots are caused, often followed by yellowing and fall of leaf. Blossoms are killed, and the lives of visiting bees may be endangered. These effects are worse in wet weather, also when large amounts of copper sulphate are used than with smaller amounts.

This injury is far less than the fungous injury avoided by use of the mixture, but should be reduced to a minimum by spraying only when needed, giving less mixture to those varieties which possess fungous resistance, and to those varieties which prove most susceptible to Bordeaux injury. The use of too much Bordeaux, so that it drips from the leaves, increases the Bordeaux injury, as does also the presence of too much copper in the mixture.

PEAR

Blight, fire blight (*Bacillus amylovorus* (Burr.) De Toni). —The name "fire blight" is well chosen, since the affected tree, with its shriveled branches and shrunken, blackened twigs, gives the impression of fire injury.

During winter the disease may best be recognized from the fact that the leaves of the diseased twigs do not fall as do those of healthy twigs. In the early spring, when the disease is most aggressive, the blighted twigs may be known at a glance by their dead black leaves, while on closer examination the bark and wood are seen to be black and dead. This blight is the worst disease of the pear and is also bad on the apple, quince, and hawthorn, and to some extent affects plum, apricot, and mountain ash.

It has been known for more than a hundred years, and in many cases even whole orchards have succumbed to its attack. One pear grower near Washington, D.C., estimated his loss from this one disease in one year at $10,000. The disease is widely known throughout the United States, but is as yet confined to North America.

So diverse and numerous were the early theories as to the nature and cause of blight and so fruitless were the discussions in earlier years that the western New York Horticultural Society passed resolutions to prohibit further reference to the subject until entirely new facts were forthcoming. Among the numerous theories might be mentioned, those depending upon electrical or atmospherical influences, freezing of the bark, too long culture of par-

FIG. 42. — Pear blight; healthy and diseased twigs. Original.

ticular varieties, freezing of the roots, too high culture, insects, fungi, and absence of needed food. One of the most prominent of these was Downing's "frozen sap theory," according to which the disease is due to the freezing and thawing of the sap, resulting in loss of vitality and development of poisons in the tissues. It is unnecessary to discuss any of these theories further than to say that none of them explain the facts.

In 1878, Professor Burrill[1] discovered bacteria in the diseased twigs, and by transferring to healthy twigs some of the exudate from diseased tissue bearing these bacteria was able to cause the disease. Professor Arthur later grew the bacteria in pure cultures and with these cultures produced the disease. It was thus proved beyond question that it is these bacteria that cause the blight.

It has been demonstrated that the germs cannot gain access through healthy mature bark, but will readily penetrate into any wounded place, or into floral parts.

This blight bacillus deposited upon the flower or upon tender shoots gains entrance and rapidly grows downward through the cambium, causing the foliage upon the affected twig to die. The disease rarely progresses more than 5–8 cm. in one day, though even 0.3 meter is occasionally reached. Ordinarily, sick twigs dry out, progress of the disease soon stops, and the germs in the twig die. Waite[2] found that in some limbs, probably one of several hundred, the disease remains active. Two forms of the disease are thus distinguished: one very dangerous, the other no longer offensive. It is these limbs still in condition of "active blight" that carry the pest over winter.

[1] Burrill, T. J., Trans. Ill. Hort. Soc. for 1878, p. 80.

[2] Waite, M. B., U.S. Dept. Agr. Yearbook, 1895, p. 295.

With the flow of sap in the spring these infested limbs become centers of reproduction. From these a milky fluid teeming with the bacteria exudes. This attracts insects which then carry the infection to other twigs and to flowers. Two additional forms of this disease, according to the part affected, are recognized: (1) flower blight, (2) body blight and canker.

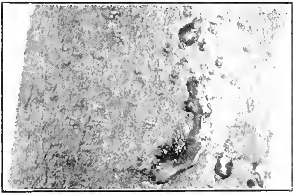


FIG. 43. — The blight showing exudate from bark, much enlarged. This teems with the causal bacteria. After Whetzel.

Neither of these differs essentially from the twig blight, though the body blight or canker is especially worthy of mention on account of its peculiar destructiveness. This form occurs where the disease is led by a spur, shoot, or sucker into the cambium under the bark of the body or main limbs of the tree, or where primary infection occurs through a wound so as to lead to disease in such parts. The result of such infection is a diseased area more or less circular, which may even girdle the tree or branch, and which in any event causes serious injury.

The susceptibility of the tree is largely influenced by external conditions. In general, anything which leads to rapid growth, resulting in tender shoots, favors the development of the disease. There is also much difference in resistance offered by different varieties. The Anjou, Kieffer, Angoulême, and Seckel possess more resistance than the Bartlett, Clapp, or Flemish Beauty.

Based on the facts as stated above, the following directions for avoiding the blight were deduced, and tested by Waite.[1] They have proved their worth in many states.[2]

1. Pruning in winter when the tree is dormant promotes growth and favors blight. Withholding the pruning knife, which may not otherwise be best for the tree, will reduce this tendency.

2. Overstimulation with fertilizers, especially those rich in nitrogen, is to be avoided.

3. A well-cultivated tree is more inclined to blight than one growing on sod or untilled land.

4. In irrigated orchards a reduction of the water supply to the minimum has been found effective.

5. The only really satisfactory method of controlling pear blight (that is, exterminating the microbe that causes it) is by cutting out and burning every particle of blight when the trees are dormant. Not a single case of blight should be allowed to survive the winter, either in the orchard or within half a mile of it. Every pomaceous tree, including the apple, pear, quince, Siberian crab apple, wild crab apple, the mountain ash, service berry, and all the species of Cratægus, or hawthorns, should be examined for this purpose, the blight being the same in all. The orchardist should not stop short of absolute extermination in every case, for a few trees or branches overlooked may go a long way toward undoing all his work. Cutting out the blight may be done at any time in the winter or spring up to the period when growth begins. The best time, how-

[1] Taken in modified form from M. B. Waite, U.S. Dept. Agr. Yearbook, 1895.

[2] Whetzel, H. H., and Stewart, V. B., N.Y. (Cornell) Agr. Exp. Sta. Bul. 272.

ever, is undoubtedly in the fall, when the foliage is still on the trees and the contrast between that on the blighted and that on the healthy limbs is strong. It is further necessary to make a weekly inspection of every tree throughout the growing season, beginning when the blossoms fall, and to cut out blight whenever it is found.

In each case it is necessary to cut well below any external evidences of the disease. To avoid spreading the infection, in case the pruning tools should accidentally cut into the diseased tissue, the cutting blade should each time be disinfected by wiping it with a cloth saturated with a strong solution of corrosive sublimate (1 part to 1000). When the wound made by this excision is at all large, it should be disinfected with the corrosive sublimate solution. Particular care should be taken to remove and burn all diseased spurs and watersprouts.

Unless continued careful inspection is given, but little benefit will follow.

Rust (*Gymnosporangium globosum* Farl.). — The rust of pear is very similar in nature to the rust on the apple, though less often injurious. It consists of two stages, a summer stage and a winter stage. The summer stage produces the rust on the leaves of the pear, while the winter stage forms the familiar cedar apple upon the cedar tree.

The remedy, as in the case of the apple, consists in removing all red cedar trees from the neighborhood of the pear orchard; thus eliminating the source of infection. When this is impossible, the trees should be sprayed with the Bordeaux mixture immediately after the early rains which cause the gelatinous horns on the cedar apple, and thus furnish the supply of spores for the spring infection.

This disease of pears is particularly abundant upon several varieties of the Japanese strain.

Bitter rot, ripe rot (*Glomerella rufomaculans* (Berk.) Spaul. & von Schrenk). — This disease is of much less frequent occurrence upon the pear than upon the apple. For description and treatment, see pp. 64 and 74.

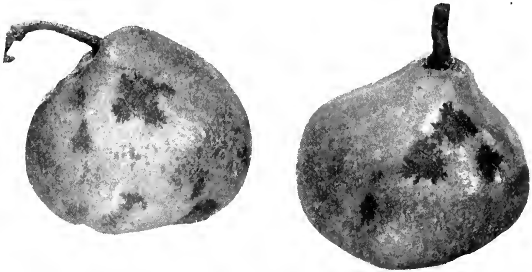


FIG. 44. — Scab on California pears bought in Raleigh. Original.

Powdery mildews, sphærothocose and podosphærose. — See **apple**.

Scab (*Venturia pyrina* Aderh.). — This scab much resembles that of the apple and consists of a surface blotch or scab, often accompanied by a peculiar cracked appearance of the skin. This symptom, however, is a secondary effect which is not necessarily present. Upon the twigs rough cankers are formed.

Smith[1] of California recommends plowing under or clearing away dead leaves and using a dormant spray followed by two applications of Bordeaux mixture while

[1] Smith, R. E., Cal. Agr. Exp. Sta. Bul. 163, p. 17, 1905.

the buds are unfolding, first using an 8–10–50 mixture; second a 5–7–50 mixture.

Leaf spot (*Mycosphærella sentina* Desm.). — The leaf spot, while rarely completely destructive to foliage or crop, does interfere with the general productiveness and health of the tree by diminishing its green surface and sometimes by causing defoliation. It is known over a wide range.

FIG. 45. — Pear leaf spot (septoriose). Original.

The leaf spot may be distinguished from the scab and the blight by the fact that the diseased area is rather sharply defined and characteristically angular in outline. The center of the spot, usually ashen in color, is surrounded by a narrow brown zone, and this in turn by one of purplish hue. The ashen center bears several very minute dark-colored pycnidia.

The treatment recommended for pear scab is effective in preventing this disease.

Leaf blight (*Fabræa maculata* (Lev.) Atk.). — This leaf blight is almost as widely distributed as is the pear itself, though less abundant in the South and West than in the North and East. Its spot does not exhibit the striking zonal arrangement described for the leaf spot (septoriose), than which it is a much more serious pest, and the whole leaf more often takes on a diseased appearance, eventually turning yellow or brown and falling. This disease is also prevalent upon the fruit, where it causes a red spot, which soon becomes darker, and may later be accompanied by cracking similar to that of the pear scab.

The treatment already recommended for the pear scab will suffice for the pear leaf blight.

Black rot canker (*Sphæropsis malorum* Peck). — In appearance and treatment this disease is similar to the black rot of the apple.

Anthracnose (*Colletotrichum sp.*). — Diseased pear trees in New Jersey were noted in 1892 by Stevens, nearly every fruit upon the tree being destroyed. While very serious, it is, fortunately, not of frequent occurrence. In nature, cause, and appearance it resembles closely the bitter rot of the apple, and the treatment may be the same as for that disease.

Hypochnose. See **apple.**

Brown rot. See **apple.**

Thelephorose (*Thelephora pedicellata* Schw.). — This appears in the form of spots 5 mm. to 8 cm. or larger on the trunk of the tree near a dormant bud, on branches at the bases of fruit spurs, or at the bases of other branches. The spots are nearly circular, surrounded by a whitish, uneven edge. Older, larger spots are depressed and the bark, cambium, and wood beneath are dark and dead.

Galloway[1] recommended excision of the diseased wood, followed by washing with sulphate of iron (copperas) and covering with grafting wax or some similar substance.

[1] Galloway, B. T., Jour. Mycol., *6*, 113, 1891.

Texas root rot. See **cotton.**

Black mold (*Alternaria sp.*). — In addition to the ravages of this disease as upon the apple, the leaves and shoots are also attacked and the fruit injury is not limited to

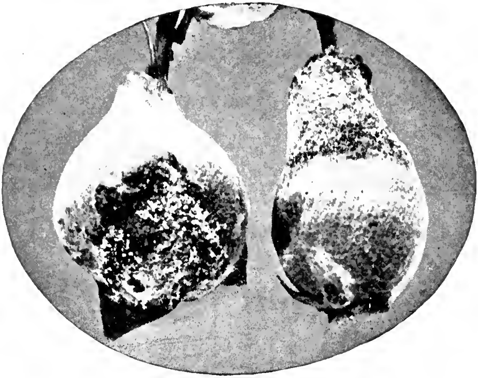


Fig. 46. — Young quinces showing rust. After Bailey.

the blossom end. The disease has been noted chiefly upon the Kieffer.

For treatment, see **apple.**

QUINCE

Rust (*Gymnosporangium clavipes* C. & P.). — The quince rust, spring stage, agrees with the apple rust in general characters. The causal fungus grows upon the fruit in the summer and produces there myriads of spores which, on the approach of fall, are carried by the winds to adjacent cedar trees, and there produce swellings upon the branches and twigs during the fall and winter. In the spring, these give origin to long gelatinous horns, which consist of masses of spores embedded in a matrix of jelly. These spores upon drying are conveyed to the quince tree by the winds, and there produce again the quince rust. The cedar is a necessary resting place for this fungus during the winter.

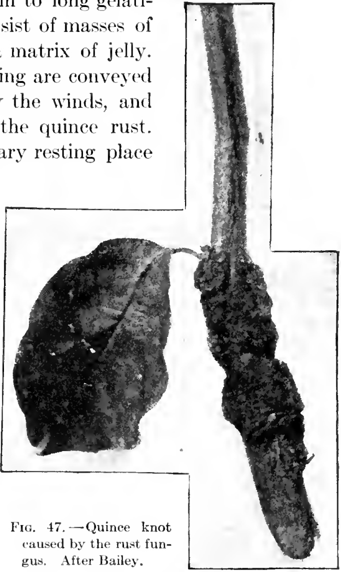


FIG. 47.—Quince knot caused by the rust fungus. After Bailey.

The remedy therefore is, if possible, to remove the cedar trees from the neighborhood of quince trees. This will almost entirely prevent the rust, although in rare instances a few spores may be carried a considerable distance. Reasonable protection is secured if all of the cedar trees in the immediate vicinity of the orchard be removed. In case the cedar is too abundant to permit of its complete removal, resort must be had to spraying the leaves and fruit of the quince trees with the Bordeaux mixture at the time when the rust spores are expected to arrive; that is, at the time when the gelatinous horns are present on the cedar apple.

Blight (*Bacillus amylovorus* (Burr.) De Toni). — This disease has been thoroughly discussed in connection with the pear and apple. It is only necessary here to indicate that it is the most serious known disease of the quince. The treatment is the same as that recommended for this disease on other pomaceous fruits.

Leaf blight, black spot (*Fabræa maculata* (Lev.) Atk.).— Both the fruit and foliage are affected by this blight, the foliage spotting and falling prematurely so that the vitality and vigor of the tree is much reduced. Upon the fruit it causes black blotches, first seen as small brown spots which soon increase in size and turn darker in color. While this spot does not materially injure the fruit for use, it does retard its full development and because of impaired beauty decreases its selling price.

The means of prevention consists in protecting parts which have not yet been attacked by a thorough application of Bordeaux mixture. Repeated trials have shown that this treatment is thoroughly effective, increasing the value of the quince crop very materially; the increase being both in the size and the quality of the fruit. The first application should be made soon after the blossoms fall, and should be followed at intervals of two or three weeks with two more treatments.

Black rot (*Sphæropsis malorum* Peck). — This rot, often amounting to a loss of 10 per cent, and being widely distributed, is due to the same fungus which causes the black rot of the apple, and the treatments recommended for the apple will prove efficient for the quince disease. It has not yet been proved that this fungus causes cankers on the quince trees such as have been described for the

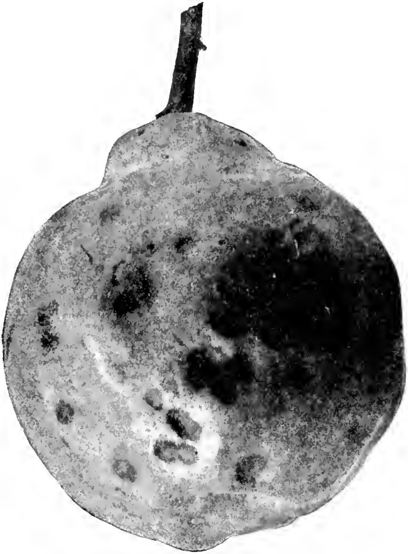


FIG. 48. — Black spot of the quince, natural size. After Bailey.

apple. The grower should, however, watch carefully for the presence of canker, as the relation between the canker and the rot in apple indicates that the canker may possibly be found on the quince also.

Fig. 49. — Quince leaf blight ; twig at right sprayed ; twig at left not sprayed. After Bailey.

Ripe rot (*Glomerella rufomaculans* (Berk.) Spaul. & von Schrenk). — This disease is caused by a fungus identical with that causing the ripe rot of the apple. The treatments already recommended for other diseases will also prove efficient here.

European canker (*Nectria cinnabarina* (Tode) Fr.), (*Nectria ditissima* Tul.). — This canker is readily distinguished from the ordinary cankers produced by Sphæropsis or Glomerella by its brilliant red or cinnamon-colored pustules scattered abundantly over the affected areas. While cankers due to each of these fungi have been collected upon quince in America, no case of serious injury is known.

Pale rot (*Phoma Cydoniæ* Sacc. & Schulz.). — This disease is second only to the black rot in prevalence and destructiveness. The rot begins as a pale soft spot, from which the skin can easily be removed. This spot soon wrinkles, the skin ruptures, and through the ruptured places short tufts of fungous threads develop. These small spots are at first colorless, but they soon turn to a pale blue.

The treatment is the same as for sphæropsose.

Hypochnose. See **apple**.

DRUPACEOUS FRUITS

ALMOND

Yellows. See **peach**.

Blight (*Coryneose*). See **peach**.

Crown gall. See **peach**.

Cercosporose. See **peach**.

APRICOT

Yellows. See **peach.**

Phyllostictose. See **peach.**

Brown rot. See **peach.**

Blight (*Bacillus amylovorus* (Burr.) De Toni).—The

Fig. 50.—Unsprayed cherry tree defoliated by leaf spot. After Scott.

usual blight of the apple and pear has been reported upon the apricot by Paddock.

CHERRY

Leaf spot (*Cylindrosporium Padi* Karst).—For description, see **plum.** The disease is very widespread throughout the United States, and it is often very destructive. The loss in Ohio in one year was estimated at

$25,000. This disease is identical with that of the plum, but since the spraying mixture adheres to the fruit, it cannot be applied on to the plum without injury to the market value of the product. Spraying as for plum leaf spot with

FIG. 51. — Cherry tree from same orchard sprayed with self-boiled lime-sulphur to control leaf spot. After Scott.

such modifications as are needed to avoid spotting the fruit is the only recourse.

Recent experiments by Scott[1] showed that the self-boiled lime-sulphur wash (10–10–50), the factory-boiled lime-sulphur wash (1–40), and the Bordeaux mixture (2–4–50) were equally effective in controlling the cherry leaf spot.

[1] Scott, W. M., U.S. Dept. Agr. Bur. Plant Indus. Circ. 27, April 21, 1909.

The results are shown in the accompanying figures. The trees, located in Illinois, were sprayed May 20, June 20, and July 17, the first spraying being about a month after blooming, the second just after picking.

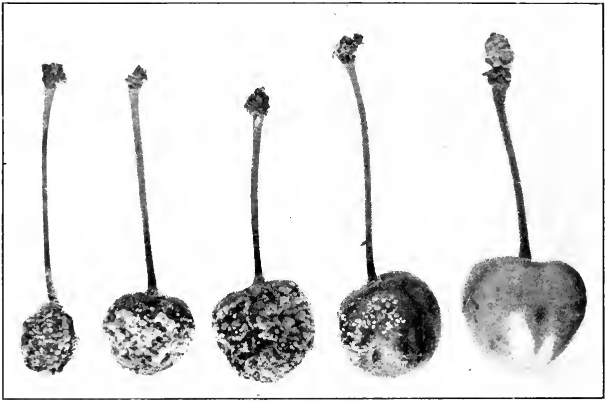


FIG. 52. — Brown rot (sclerotiniose) showing various stages of decay. After Clinton.

Rust. See **peach**.

Black knot (*Plowrightia morbosa* (Schw.) Sacc.). — As upon the plum, this knot causes serious injury to the cherry. In some sections it has spread to the wild cherry and plum trees in such abundance as to render control practically impossible, and in this way it has killed the cherry-growing industry. Taken in time it is easy to control. See **plum**.

Brown rot, mold (*Sclerotinia fructigena* (Pers.) Schrœt.). — The same fungus which produces disastrous results upon the peach also causes rot of the cherry. Several stages of its development are illustrated in Fig. 52. The disease is known practically everywhere the cherry is grown, and large losses are frequent. Fifty per cent loss was reported from New York, and 25 per cent from Missouri. Treatment is the same as for the peach.

Yellows. See **peach.**

Curl (*Exoascus Cerasi* Fckl.). — The cherry curl is closely related to that of the peach. The leaves become wrinkled before they are full size, and spores are produced on the surface of the leaf, as they are in other curls. Instead of forming flower buds and spurs, affected regions develop a profusion of twigs, "witches' brooms." The disease is not common in America; but should it become so, it can be held in check by pruning out the diseased twigs. It is perennial in the twigs and should be avoided in budding and grafting.

Scab. See **peach.**

Powdery mildew (*Podosphæra Oxycanthæ* (DC.) DeBy.). — This mildew, described in connection with the apple diseases, sometimes does damage to the plum and cherry, especially on nursery stock, where it prevents either the growth of the seedling or successful budding or grafting.

On old leaves the disease does not cause great damage, but when the attack is made on young growing tips, or on young leaves, these delicate structures suffer greatly from loss of nourishment.

Contrary to the nature of most fungous diseases the mildew grows best during fair, dry weather. A light rain, which spreads the spores and furnishes moisture enough to allow them to germinate, followed by a dry spell, best favors the development of this disease.

The use of the Bordeaux mixture has proved very satisfactory. Apply about every ten days during the early growing season; more frequently if necessary to replace any poison washed off by the rain.

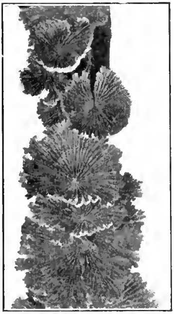


FIG. 53. — Schizophyllum commune, frequently the causal fungus of wood rot of cherry and other trees. After Atkinson.

Wood rot (*Schizophyllum commune* Fr.). — Small white specks, the sporophores, appear upon the limbs and trunk in early summer.[1] In the autumn they are well developed and abundant; white and very hairy, 1–3 cm. in diameter, usually attached on one side with the margins incurved. The gills are white, woolly, branched, deeply split along the edge, and revolute.

The affected wood is brittle and penetrated by black lines. Apparently this disease starts in roots injured by tools during cultivation.

PEACH

Brown rot, mold (*Sclerotinia fructigena* (Pers.) Schrœt.). — Probably no other disease is so destructive to peaches, plums, and cherries as is the brown rot, which attacks the fruits as they approach maturity, turning them brown, soft, and useless. Aside from injuring the mature

[1] Heald, F. D., Neb. Agr. Exp. Sta. Rpt. 19, p. 29.

fruit, it attacks the flowers and twigs. The disease ranges over the entire peach-growing territory, and in some years the loss has amounted to 50 per cent of the crop or more.

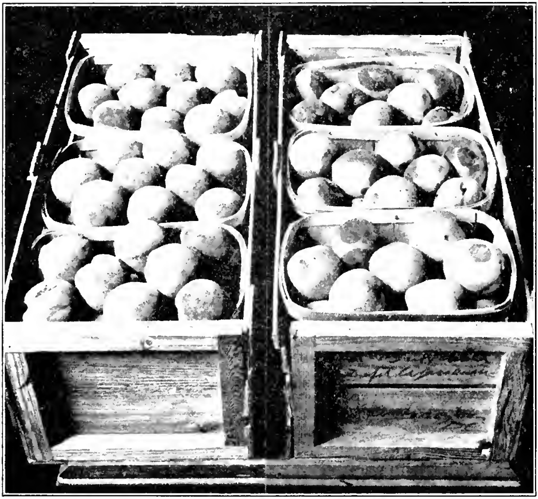


FIG. 54. —Two packages of peaches, one healthy, the other affected with brown rot (sclerotiniose). After Scott.

The estimated damage in Ohio alone in one year was a quarter of a million dollars; in one year in Pennsylvania twenty carloads were lost. Apples, pears, and quinces are attacked, but to lesser extent.

Its characteristic appearance on the **fruit** enables one to recognize it easily. It first appears as small, circular, brown, decayed spots. These rapidly enlarge until they embrace the whole fruit, which at the same time shrinks slightly. As the decay advances, small tufts of brown threads appear near the centers of the original spots, and spread rapidly until the whole fruit is covered with them.

If the fruit hangs in clusters, adjacent fruits begin to decay at the points of contact, and the disease spreads from fruit to fruit until whole clusters are lost. Fruit, after it is picked, may also succumb to attack, and peaches that were apparently sound at picking may be seriously damaged when they reach market. Thus the loss falls upon grower, dealer, and consumer. The decay is so rapid that infection to-day may mean a totally unsalable peach two days hence. Peaches diseased on the tree may fall to the ground, or remain on the tree, where they shrivel and hang over winter, to constitute the "mummy" peaches so familiar in infected orchards.

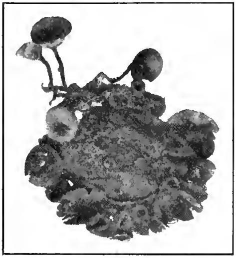


FIG. 55. — Mummy peach showing Sclerotinia ascophores. After Scott.

Upon the **blossom** the disease is first evident as a slight brownish discoloration which spreads rapidly, causing the flower to wither and eventually fall off as a rotten mass, carrying contagion to everything in its path. This damage to the flower is often confounded with frost effects. From the flower the rot may spread to adjacent **twigs**, through the flower stalk. Infection of the twigs may also occur directly from diseased fruit.

From repeated observations it seems probable that the branches cannot be infected through their unbroken skin, or if so, only rarely. Smith[1] states that the examination of hundreds of twigs in all stages of disease showed that every one was associated with blighted and persistent flowers.

The inroads of this disease are so serious that many peach and plum growers have been obliged either to secure a remedy for this pest or abandon the crop. Years in which there is full fruitage, accompanied by damp, warm weather, are almost certain to bring a severe attack. But it is not the weather which directly causes the rot; rather it is the fungus which causes the rot when the weather gives the proper conditions for the development of the fungus.

The mummified fruit that falls to the ground serves as the hibernating quarters of the causal fungus. If these mummies be carefully observed in the spring, some of them will be seen to bear small stalked disks (Fig. 55). These are the organs which furnish spores for the following spring.

It follows that any practice which destroys or covers up these mummified fruits lessens the spring infection. Active treatment in the form of spraying is also necessary. The most successful spray is that employed by Scott,[2] which gave the following results: —

[1] Smith, E.F., Jour. Mycol., 7, 37, September, 1891.

[2] Scott, W. M., U.S. Dept. Agr. Bur. Plant Indus. Circ. 27, April, 1909.

Results of Experiments for the Control of the Peach Brown Rot, Marshallville, Ga., 1908

Plot	Treatment	Peaches affected with Brown Rot	Peaches Scabbed	Peaches badly Scabbed
		Per cent	*Per cent*	*Per cent*
1	Lime-sulphur wash (15–10–50), hot water . . .	10.56	20.75	0.80
18	Lime-sulphur wash (15–10–50), cold water . . .	12.22	16.60	0.60
36	Check — no treatment . .	36.98	93.63	42.12

The treatment recommended by Scott for brown rot and scab based upon these results is as follows: For the combined treatment of peach scab and brown rot, at least three applications of the self-boiled lime-sulphur wash are necessary, "the first, three to four weeks after the petals drop, the last about a month before the fruit ripens, and the second midway between. Scab infection begins four to six weeks after the trees bloom, and in order to control this disease the first treatment must be made not later than a month after the petals drop. The time of the last application must be determined by the ripening date of the variety. To avoid staining the fruit the last spraying should be made a month before the fruit ripens, though a later treatment would be more effective against the brown rot. Three applications distributed in this manner are sufficient for the Elberta and earlier varieties. A fourth treatment will doubtless often be desirable for later maturing varieties.

"There seems to be no question as to the advisability of spraying the peach orchard where the brown rot and scab are troublesome, but many disappointments are naturally to be expected. The curculio and other insects readily break the skin of the peach and admit the brown-rot fungus even through a coating of the spray mixture, so that a certain amount of rot may always be expected when the conditions are favorable."

Scab (*Cladosporium carpophilum* Thuem.).—This disease, which is widespread and so common that many people regard

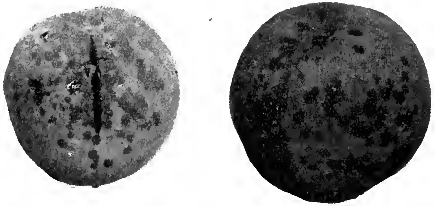


FIG. 56.—Peach scab. Original.

it as an integral part of the peach, may consist of isolated, sooty, black specks, or of black specks so numerous as to coalesce into large blotches. These sometimes cover as much as one third or one half of the peach. The side which is attacked is dwarfed, often cracked, and the flesh adjacent to the diseased part is bitter and green, even after the normal portions are ripe.

The disease develops in most serious form during rainy seasons, and is worse upon some varieties than upon others. It is especially bad upon Hill's Chili. It is reported from Missouri to have done damage equal to 70 per cent of the value of the crop, and Selby estimated the loss in one crop in Ohio at from 20 to 50 per cent.

The beneficial effects of the self-boiled lime-sulphur

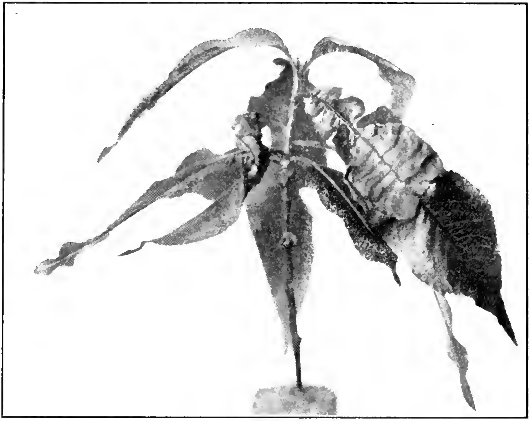


Fig. 57. — Peach leaf curl. After Atkinson.

treatment, and the method of using it, have been given under peach brown rot.

Curl (*Exoascus deformans* (Berk.) Fckl.). — Throughout the peach-producing region this disease abounds, it being particularly injurious in the more moist localities. The annual loss caused by it approximates $3,000,000 in the United States.

The disease is due to a fungus which grows in the leaves, causing the peculiar malformation which justly gives rise to the popular name of curl. This fungus destroys the utility of the leaf as a starch-producing organ, and eventually causes defoliation, and thus direct loss to the trees. This loss may be manifest in two ways: first, by the present effect upon the vitality and vigor of the tree, and immediate injury to the crop; second, by a weakening of the tree in succeeding years, due to the lack of full nourishment during the period of attack. The injury in the present year, manifest by a loss in productiveness, is obvious to the grower. The injury in succeeding years, often fully as great, is frequently overlooked, or is not attributed to its true cause.

It was formerly thought that this fungus persisted in the twigs over winter, and thus lurked ready to infect the new leaves as they began to develop. It has, however, been proved that nearly, if not quite, all spring infection is due, not to perennial mycelium, but to spores which remain on the bark of the trees.

Prevention of the disorder lies in killing these spores of the fungus by winter spraying. For this purpose Bordeaux mixture, the lime-sulphur, or a simple copper sulphate solution is efficient. In many ways the Bordeaux is more satisfactory than the copper sulphate solution. It does not have as strong corrosive action upon the pump. It is easily seen upon the trees, and consequently it is not difficult to determine when a thorough application has been made. There is probably little choice between these two solutions on the ground of efficiency. The lime-sulphur is preferable when insects also are to be met. The spraying should be made from one to three weeks before the buds open in the spring, and thoroughness is the chief point desired. Spraying should be done in dry calm weather, during the middle of the day, in order to avoid dew or frost upon the limbs.

Pierce[1] states that as a result of treatment of the peach curl, in California, from 95 to 98 per cent of the spring foliage was saved. A net gain of 600 per cent in the foliage over that retained by adjoining unsprayed trees resulted in the case of several different sprays. The Bordeaux mixture, when applied to the dormant tree, increased the weight and starch-producing power of the leaves, and the sprayed trees showed great gain over the unsprayed in the number and quality of the fruit buds which they produced for the following year. The gain in the number of spur buds was over 100 per cent in some cases. The sprayed trees also produced more vigorous growth of new wood, the wood to produce the crop for the next year. Thus, in one experiment the spring growth of the unsprayed tree averaged 7.85 inches; on the sprayed trees it was 24.75 inches. The average value of fruit, per tree, in rows treated with the most effective Bordeaux mixture ranged as high as $6.20 above that in adjoining untreated rows, or the equivalent of a net gain of $427.80 per acre. Over *one thousand* per cent net gain in the set fruit has resulted from the use of some of the more effective sprays.

The trees should be sprayed each season, since experiments prove that treatment one season will not prevent the disease the following year. Spraying should be done even though the trees are not expected to bear, since the loss of the crop of leaves is as great a drain upon the trees as is the maturing of one half to two thirds of a crop of fruit.

[1] Pierce, N. B., U.S. Dept. Agr. Div. Veg. Phys. & Path. Bul. 20 1900.

Die back (*Valsa leucostoma* (Pers.) Fr.). — This disease of limbs, trunk, and twigs is serious in Europe and Australia. It was first described in the United States by Rolfs of Missouri in 1907,[1] who noted it upon peach and Japanese plum.

Infection occurs upon buds or wounds during the growing season, and in early winter and spring the tips of young branches, especially water sprouts, are killed back from 2.5 to 46 cm. As many as 300 such dead twigs have been noted on a single tree. It develops most rapidly in a warm spell following freezing weather in the spring, and is more serious upon trees which have been weakened by any cause.

Twigs killed during the winter show at first a dark, purplish skin, changing later to leathery, scarlet, or purple, finally drab. Then the skin loosens and wrinkles. At this time black pycnidia appear under the skin. These soon push out a white cap through a transverse slit in the skin, and in wet weather exude very fine red threads of spores. Gum flow usually accompanies the constriction, marking the juncture of dead and healthy wood. During summer, leaves on infected twigs frequently wilt, owing to the girdling of the stem. Upon the trunks large wounds, often regarded as sun scalds, are produced, while upon young limbs the wounds appear as enlargements or "knots." Large limbs or even whole trees succumb.

Excision should be practiced.

Blight, shot hole (*Coryneum Beyerinkii* Oud.). — This disease, which has been troublesome in California for years, often destroying the crop and weakening the trees,

[1] Rolfs, F. M., Sci. n. s. *26*, 87.

was first noted by Pierce,[1] and has been fully described by Smith.[2]

It consists in dying of the buds of fruiting wood, spotting of green twigs, and dropping or underdevelopment of young leaves and fruit, accompanied by gummy exudate, especially upon the one-year-old fruiting twigs. Leaves opening from buds which survive the disease are marked by small dead areas of tissue, which soon fall out, leaving " shot holes." It is essentially a winter or early spring disease of fruiting twigs and one-year-old wood, and the principal damage is from death of buds and twigs before the fruit develops. Infection occurs in winter before new growth begins.

By pruning, then spraying with the Bordeaux mixture or other cleansing spray, during the early winter (in California between November 1 and December 15), the best results are obtained.

Crown gall (*Pseudomonas tumefaciens* E. F. Smith & Townsend).—Crown gall consists in a swelling, a tumor-like outgrowth, near the ground line on certain trees and shrubs, particularly upon members of the rose family, pomes, drupes, raspberries, etc. Careful cross inoculations by Hedgcock,[3] using fragments of galls, have demonstrated that crown gall of the almond, apricot, blackberry, cherry, peach, plum, prune, chestnut, and walnut are intercommunicable. It has also been demonstrated by Smith and Townsend that crown gall of the peach tree as well as of tomato, potato, tobacco, beet, hop, carnation, grape, raspberry, and

[1] Pierce, N. B., U.S. Dept. Agr. Div. Veg. Phys. & Path. Bul. 20, p. 179, 1900, and Sci. n. s. 25, 305, February, 1907.

[2] Smith, R. E., Cal. Agr. Exp. Sta. Bul. 191, p. 93, September, 1907.

[3] Hedgcock, G. G., U.S. Dept. Agr. Bur. Plant Indus. Bul. 131.

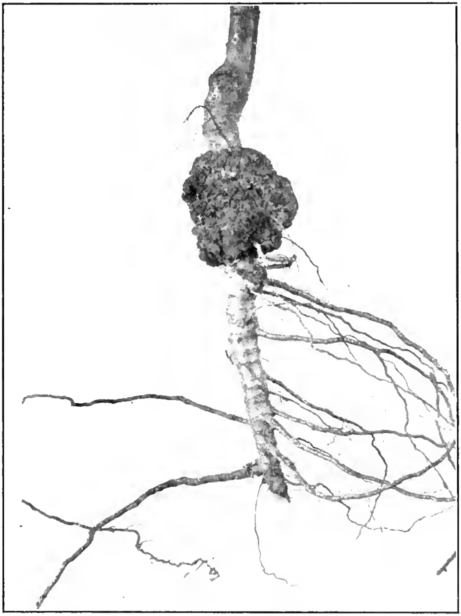


Fig. 58. Peach crown gall. After Hedgcock.

apple[1] can be produced by inoculation with *Pseudomonas tumefaciens*, also that the organisms of the peach, apple, hop, rose, and chestnut galls are interchangeable. It is

[1] Smith & Townsend, Sci. n. s. *25*, 671, April, 1907, and Sci. n. s. *29*, 273.

probable, therefore, that at least one cause of crown gall is the organism mentioned.

All diseased stock should be avoided, as well as stock from nurseries where the disease is known to exist.

Bacteriose (*Bacterium pruni* E. F. Smith[1]). — A "shot hole" disease of peach leaves, which causes premature defoliation, is attributed by Smith and by Rorer[2] to bacteria. The disease has been found during several years in different states and is believed to constitute one of the most common of the "shot-hole" diseases in the South and Middle West. The fruit and twigs are also affected. Upon the leaf it appears as somewhat angular purplish brown spots, 2–5 mm. in diameter, which may coalesce and involve large areas. Upon twigs it kills the bark, forming purplish black sunken areas, 2–3 mm. wide, which may extend to 3–8 cm. in length, and even girdle the twig and kill the shoot. Infection is most frequent at a leaf scar. Upon the fruit small purplish spots appear. Over these the skin soon cracks. The Elberta is especially susceptible. No effective treatment has yet been demonstrated.

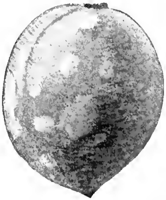


FIG. 59. — Mildew upon peach fruit. After Bailey.

Powdery mildew, podosphærose (*Podosphæra Oxycanthæ* (DC.) DeBy.). — This widespread mildew is in general appearance very similar to the powdery mildew of the grape-cherry, lilac, and rose, etc. It sometimes becomes so abun-

[1] Smith, E. F., Sci. n. s. *17*, 456, and Bacteria in Relation to Plant Disease, I, Figs. 11, 15, 70, 71, 72, and Pl. 19.

[2] Rorer, J. B., Mycologia *1*, 23, January, 1909, and Sci. n. s. *30*, 224.

dant as to almost completely ruin the crop, by attacking the leaf, fruit, and twig. When on the fruit, it appears first while the peach is small, causing irregular, grayish, moldy blotches. As these enlarge, cracks often develop.

The winter cleansing sprays recommended for the peach curl are effective in killing wintering spores, and thus largely diminish the injury from this pest.

Powdery mildew, sphærothecose (*Sphærotheca pannosa* (Wallr.) Lév.). — This powdery mildew, in general appearance like podosphæria, sometimes interferes with the growth of leaves and young twigs and stunts the trees. For treatment, see **podosphæriose**.

Frosty mildew (*Cercosporella Persica* Sacc.). — In damp, shaded localities, especially on trees of dense foliage, a disease occurs in the form of pale yellowish leaf spots. These show, on the underside, a delicate frostlike appearance, due to the growth of white spore-bearing hyphæ. It is not usually serious, though widespread, and the treatments recommended for the other diseases will suffice to hold this disease in check also.

Texas root rot. See **cotton**.

Shot hole, cercosporose (*Cercospora circumscissa* Sacc.). — This is very widespread, producing spots, or, when the diseased tissue falls out, oval holes, in the leaves. It also infects small branches. The chief injury lies in destruction of leaf tissue and of valuable shoots.

The dormant spraying recommended for the curl is useful here.

Shot hole, phyllostictose (*Phyllosticta circumscissa* Cke.). — This is similar in appearance and treatment to cercosporellose.

Pustular spot (*Helminthosporium carpophilum* Lév.).—Peaches with this disease are described by Selby[1] as "Badly disfigured, having numerous pimply red spots with light brown centers." The peach, in an earlier condition of the disease, shows small rusty brown spots upon its upper side. These spots increase in size and develop light brown centers, 1–2 mm. in diameter. Upon yellow varieties the pustule is commonly lacking, there being but a light brown center with a red border.

As the fungus which causes this spot rests purely upon the surface its development may be prevented by spraying. Selby[2] reduced the injury from 16 per cent to 1 per cent by three applications of the Bordeaux mixture.

Rust (*Puccinia Pruni-spinosæ* Pers.).—A true rust exists parasitically upon the peach and its relatives, the plum and cherry. While more common upon the plum, it very frequently does damage to the peach, in some cases being so serious as to cause almost complete defoliation. The alternate stage is not uncommon upon the hepatica in the spring.

This malady will be recognized by the presence of small, round, dusty sori on the lower surface of the leaves and on the young shoots, while in the immediate region of these spore-bearing pustules the leaf, seen from above, often presents a reddish or reddish yellow color.

Reliance must be placed upon a cleansing spray such as is recommended for the peach curl, to lessen the effect of the attack of the rust.

Stem blight, phomose (*Phoma Persicæ* Sacc.).—A fungus on the bark which fructifies in minute pustules sometimes

[1] Selby, A. D., Ohio Agr. Ex. Sta. Bul. 92.

[2] Selby, A. D., Ohio Agr. Exp. Sta. Bul. 92.

causes twigs to die. The disease may be readily recognized by the dead bark thickly studded with small pycnidia. Burning of the diseased branches will prevent the spread of the pest.

Yellows. — The peach yellows has been known in the United States something like a hundred years. From a region near Philadelphia, as a center, it has spread until now it is known throughout a large territory and is constantly extending its frontier in every direction. The disease is of unknown cause, but it has been proved beyond question that it is contagious. The roots of diseased plants, however, do not infect the soil, and trees may safely be set in the places from which diseased trees have been removed.

Recognition marks, which leave no uncertainty as to its identity, are described by Smith [1] as follows: "Prematurely ripe, red-spotted fruits, and premature unfolding of the leaf buds into slender, pale shoots, or into branched, broom-like growths, are the most characteristic symptoms of yellows. The time of ripening of premature fruit varies within wide limits; sometimes it precedes the normal ripening by only a few days, and at other times by several weeks. The red spots occur in the flesh as well as on the skin, making the peach more highly colored than is natural. The taste of the fruit is generally inferior and often insipid, mawkish, or bitter. Often this premature ripening is the first symptom of yellows. The peaches are then of good size and quite showy, and occur on trees in full vigor, upon limbs bearing abundant green foliage, and sometimes also other fruits which afterwards ripen normally.

[1] Smith, E. F., U.S. Dept. Agr. Farmers' Bul. 17, p. 7, 1894.

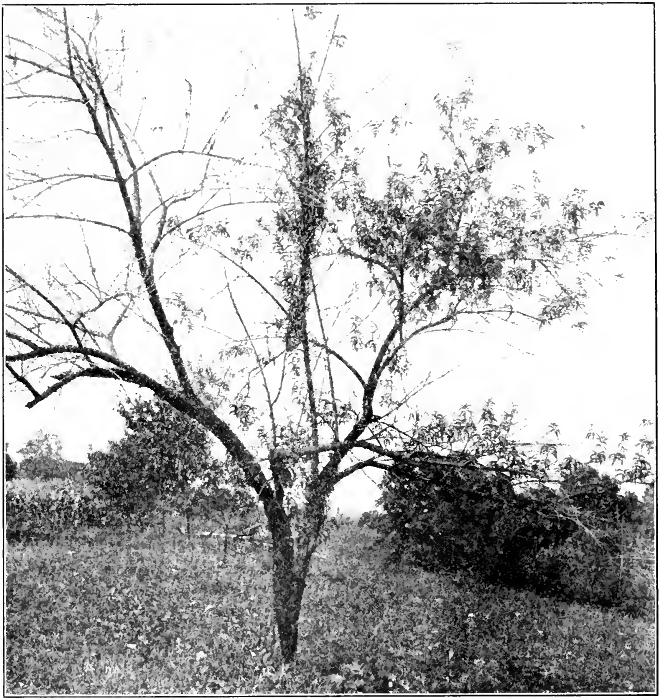


Fig. 60. — Peach tree showing yellows. After Sheldon.

"Often during the first year of the disease this kind of fruit is restricted to certain limbs, or even to single twigs, which, however, do not differ in appearance from other limbs of the tree. The following year a larger part of the tree becomes affected and finally the whole of it, the parts first attacked now showing additional symptoms, if they have not already done so. These symptoms are the development of the winter buds out of their proper season. Like the prematuring of the fruit, the date of this also varies within wide limits. The buds may push into shoots only a few days in advance of the proper time in the spring, or may begin to grow in early summer, soon after they are formed, and while the leaves on the parent stem are still bright green. This is a very common and characteristic symptom, and is especially noticeable in autumn when the normal foliage has fallen. Usually under the influence of this disease feeble shoots also appear in considerable numbers on the trunk and main limbs. These arise from old resting buds, which are buried deep in the bark and wood, and remain dormant in healthy trees. Such shoots are sometimes unbranched, and nearly colorless, but the majority are green and repeatedly branched, making a sort of broomlike, erect, pale green, slender growth, filling the interior of the tree."

A tree exhibiting these symptoms should be cut and burned. It is valueless, and its presence is a serious menace to the owner as well as to the state at large.

Rosette. — The peach rosette is southern in distribution, being known principally in Georgia, South Carolina, and Kansas. As to its nature, means of spread and of prevention, precisely what has been said of yellows applies. Its distinguishing characters are given by Smith as follows:[1] —

"Rosette clearly belongs to the same type of diseases as yellows, but its first stages are more striking and its progress is much more rapid. It may first attack part of the tree and then the remainder, the same as the yellows, but it is more likely to appear at once on the whole tree, and generally in early spring. In trees attacked in this manner, all of the leaf buds grow into compact tufts or rosettes. These rosettes, though seldom more than two or three inches long, usually contain several hundred small leaves. A tree thus attacked always dies during the following winter or autumn. When part of a tree is thus attacked, that part dies as above described, and the remainder shows symptoms the next spring, to die in turn after about six months.

"The prevailing color of the foliage is yellowish green or olivaceous. The older leaves at the base of the tufts are largest, and frequently grow to a length of several inches, but have inrolled margins and a peculiar stiff appearance, due to the fact that they are straighter than healthy leaves. These outer leaves turn yellow in early summer and drop as readily as though it were autumn, while the inner leaves of the rosette are still green and delicate. The compact bunching of the leaves is very conspicuous, and makes the trees look quite unlike those affected by yellows. Where a tree is attacked in all parts, it matures no fruit. In all the cases which have been noticed the fruit borne by affected trees either shrivels while green and drops off, or else ripens naturally.

[1] Smith, E. F., U.S. Dept. Agr. Farmers' Bul. 17, p. 14.

"In the absence of premature, red-spotted fruit, in the severity of the disease from the outset, and in its rapid progress, it is quite unlike yellows, which is decidedly chronic, and the first slight symptoms of which usually occur in very green and thrifty trees, and are frequently overlooked the first season."

The treatment is to cut and burn. No carelessness should be tolerated as regards this disease or yellows.

Little peach. — This seems first to have been publicly noted by Smith in an address in Michigan in 1898,[1] in which state it had been of alarming character prior to 1893; since these years it has appeared in New York and New Jersey. The most prominent symptom is that the fruit remains small, one half to one third the usual diameter, and ripens some 10 to 14 days later than normal fruit, and then with insipid or bitter flavor and "stringy" flesh. The leaves are small, one half normal size, and vary from light green to yellowish green, and droop somewhat. An orchard once affected is of no further value,[2] and should be removed and burned because of the possible danger to other trees that their presence creates.

PLUM

Black knot (*Plowrightia morbosa* (Schw.) Sacc.). — The black knot receives its name from the swollen black distortions, 3–15 cm. long, upon the branches. In a young condition the galls are olivaceous, but as the season advances they become darker and eventually coal black. At the same time the texture changes from soft to hard and brittle.

[1] Smith, E. F., Fenville (Mich.) Herald, October 15, 1898.

[2] Blake, M. A., N.J. Agr. Exp. Sta. Bul. 226, p. 10, January, 1910.

When the disease extends completely around the twig, the supply of nourishment to more distant parts is seriously interfered with. If less than the whole of the circumference be involved, the damage is not so great, but it is even then sufficient to very seriously impair the fruiting of the tree. Black knot may either kill the tree in a year or two, or simply destroy its value. All varieties of plums and nearly all cherries are subject to the disease, which is therefore very widely distributed.

Fig. 61. — Portion of a plum tree badly infested with black knot. Original.

It is probable that infection can occur only through injured bark. One step towards lessening the disease is therefore to exercise all care not to bruise the tree. Effective measures, however, must consist of pruning out and burning all black knots. This course, if followed persistently and thoroughly, will remove all danger. Experiments show that spraying very materially lessens the spread of the black knot, and while it might not pay to spray to prevent this disease, spraying in an orchard for other reasons really diminishes this danger.

Plum pockets (*Exoascus Pruni* Fckl.). — The name "plum pocket," or "plum bladder," arises from the curious hollow deformity of the plum, caused by a fungus. The pulp and stone of the fruit are replaced by a thin, soft, inflated shell, and in place of the seed merely a hollow cavity exists.

The disease appears soon after the flowers fall. The affected fruits vary in size from 2–5 cm. in length, and can be readily distinguished from the healthy fruit by their pale yellow color. As they age, they become coated over with a fine powder, consisting of the spores of the fungus which caused the malformation. Later the pockets turn black and fall.

The disease is local in character. A single tree in an orchard may bear "pockets," sometimes every fruit on the tree being affected, while surrounding trees are normal. A tree once affected continues to bear pockets in succeeding years. Treatment consists in cutting and burning the affected branches or trees.

Leaf spot (*Cylindrosporium Padi* Karst). — The leaf spot or shot-hole disease attacks plums and cherries, causing a portion of the leaf tissue to become discolored, the spot often bearing a red or purple border. If abundant several spots may coalesce as they enlarge. The tissue involved dies, turns brown, and eventually drops from the leaf, leaving circular or ragged holes. This character gives rise to the common name "shot-hole disease." The disease is also frequent upon petioles.

The attack is very insidious, and the disease often does much damage before its presence is really known. Defoliation is the chief injury, the leaves falling freely after the attack of the fungus. This checks starch production, and thus impairs the tree's general vigor and productiveness, even weakening the tree to such an extent that it cannot withstand the winter. As high as 80 per cent damage has been reported. The loss in Ohio was estimated as $20,000 in one year.

The disease is especially injurious to nursery stock, as it may interfere with successful budding and grafting. The following recommendation in the way of treatment is made:[1] —

1. Apply the Bordeaux mixture about ten days after the blossoms fall.
2. About three weeks later repeat this treatment.
3. About four weeks later repeat again.

See also treatment for cherry.

In one instance, in the New York Station, "The treatment resulted in an average increase per tree of twenty-four and one half pounds of marketable fruit, at an estimated cost of less than one cent per pound. The average yield per tree of picked fruit was increased 44 per cent, the marketable drops increased 8 per cent, and the waste was decreased 81 per cent. The total yield of marketable fruit, as recorded in pounds, was 45 per cent greater when the trees were sprayed than when they were not sprayed."

Scab (*Cladosporium carpophilum* Thuem.). — The plum scab consists of spots on the fruit similar to the scab

[1] Beach, S. A., N.Y. (Geneva) Agr. Exp. Sta. Rpt. 15, p. 399, 1896.

of peaches. When plums begin to ripen or are just turning in color, small round patches, pale greenish or grayish in color and not larger than the head of a pin, appear. These increase in size, in some cases to a centimeter across. In older specimens the diseased spots are frequently confluent and of darker brown color. In very old specimens, especially where the fruit has undergone decomposition, the patches become black and uneven.

Treatment identical with that recommended for the peach scab will apply in this case.

Blight (*Bacillus amylovorus* (Burr.) De Toni). — The blight of the apple and pear have been discussed on preceding pages. A very similar blight is rarely known[1] to affect the plum tree, and careful studies by Jones[2] show that the diseases on plum and pear are identical. While the plum blight is exceedingly rare, it is important that fruit growers should recognize that the disease is identical with pear blight, since this knowledge will help very materially in its control.

For treatment see **pear**.

Yellows. See **peach**.

Brown rot (*Sclerotinia fructigena* (Pers.) Schrœt.). — Brown rot is very serious with the plum as it is with the peach and cherry. The loss in Ohio in one year was estimated at $25,000.

For description and treatment see **peach**.

Powdery mildew, podosphærose. See **cherry**.

Rust (*Puccinia Pruni-spinosæ* Pers.). — The rust of the

[1] Whetzel, H. H., & Stewart, V. B., N.Y. (Cornell) Agr. Exp. Sta. Bul. 272.

[2] Jones, L. R., Centrbl. f. Bakt. Parasitenk. u. Infek. 2 (Abt. II), 825.

plum, like that of the peach, usually causes but slight injury. See **peach.**

Root rot, armillariose. See p. 173.

Bacteriose. See **peach.**

Die back, valsose. See **peach.**

SMALL FRUITS

BLACKBERRY

Leaf spot (*Septoria rubi* Westd.). — Upon the leaves of blackberries, raspberries, and dewberries small spots frequently appear, having a central region white or ashen in color, and the border brown or often of reddish tint. These spots are about 3 mm. in diameter. Close examination of the central ashen region, especially with a hand lens, reveals exceedingly small, black pycnidia scattered throughout.

While this disease is exceedingly common and of wide distribution, it does not often develop an epidemic and usually does but little injury, though its damage has been estimated as high as 20 per cent in Florida and Ohio. No treatment has yet proved of sufficient value to warrant its use.

Anthracnose (*Glœosporium venetum* Speg.). — The anthracnose is one of the most serious diseases of this crop. For description and treatment see **raspberry.**

Crown gall. See **raspberry.**

Orange rust (*Gymnoconia interstitialis* (Schlecht) Lagh.) — In the early spring the under sides of the leaves of blackberries and raspberries often present a livid red or orange color. On walking through a region so affected the shoes become coated with a reddish dust, shaken from the diseased leaves. This rust was observed as early as 1817, in Kamchatka, and is very widely distributed in the United States, Europe, and Asia, upon some nine species of Rubus, both cultivated and wild. It is known from Maine to Minnesota and Florida to California, and is in some cases very destructive.

Examination of a diseased plant shows that its growth has been much retarded by the fungus; the leaves are curled, distorted, unusually small, and lacking in green color. Plants so affected never recover, and are useless. Preceding by some two or three weeks the conspicuous red rust above referred to occurs another stage of the disease that is often overlooked. This consists of a thick growth of small columnar, glandlike structures, chiefly upon the upper side of the leaf, and present even before the leaves unfold. These structures (*spermagonia*) become more distinct as the leaves enlarge.

The mycelium of the causal fungus when once established in the cane lives in it from year to year, spreading throughout the plant. Spraying is therefore useless. In fact the only successful way of combating this disease is to remove and burn all affected plants. Diseased plants are valueless and are a menace to the healthy plants.

Late rust (*Kuehneola albida* (Kühn.) Magn.). — As the name implies, this rust usually appears late in the season, this distinguishing it from the red rust, which is most abundant in the spring. The spores are not so abundant as those of the red rust, but occur in small, pale yellow or whitish spots scattered on the underside of the leaf. This disease has not as yet been sufficiently prevalent to be of serious import, although its increase at any time under favorable climatic conditions may place it among the important plant enemies.

CRANBERRY[1]

Scald, blast (*Guignardia Vaccinii* Shear). — The fruits are attacked as soon as the blossom falls, or even the

FIG. 62. — Cranberry scald and blast. After Shear.

blossom itself may be blighted. The affected berry shrivels, turns black, and is covered with pycnidia. From such fruits the disease spreads to other fruits and to the leaves. In some bogs as much as 50 per cent of the crop is thus destroyed. This form of disease is commonly

[1] The information given here is taken largely from Shear, C. L., U.S. Dept. Agr. Bur. Plant Indus. Bul. 110, and Halsted, B. D., N.J. Agr. Exp. Sta. Bul. 64.

designated as the "blast," while still another form of it has been termed the "scald."

The scald may appear upon the berries, causing small, light-colored, softened, watery spots. These rapidly increase in circumference, and even envelop the whole fruit. Sometimes the diseased portion shows more or less distinct brownish zones. In other cases the zones are lacking, and the whole fruit becomes very soft and of light, watery color.

Upon the leaves irregular reddish brown spots with pycnidia are more rarely produced.

Plants after several years of disease die, as do also cuttings during the first or second year after planting. Thrifty plants resist the disease much more than weak plants. Particular attention should therefore be given to provide such irrigation as to best favor the health and vigor of the plants. Sanding the fields often gives good results, doubtless partly removing contagion by covering infective material. It is also advisable for the same end to rake out and burn all dead and infected plants in the autumn. Cuttings should be taken from such plants as show resistance to the disease.

In spraying experiments by Shear [1] five applications of 6–6–50 Bordeaux mixture, with 4 pounds of resin-fish oil soap added to increase adhering power, showed 2.36 per cent of rotten berries, while the unsprayed plats showed 92.6 per cent of rotten berries. The cost of application was \$15 to \$20 per acre, using 200 gallons of mixture at each application.

Rot (*Acanthorhynchus Vaccinii* Shear). — An ef-

[1] Shear, C. L., U.S. Dept. Agr. Bur. Plant Indus. Bul. 110.

fect upon the berry very similar to that of the scald fungus appears first as small, light-colored, soft spots, which soon destroy the whole berry. Later small, dark-colored blotches show under the skin, but no pycnidia appear. The disease is found in New Jersey, West Virginia, Mississippi, Wisconsin, and Nova Scotia. In importance it is the second cranberry disease.

The treatment suggested for the scald is also effective against this rot.

Anthracnose (*Glomerella rufomaculans* (Berk.) Spaul. & von Schrenk; *Vaccinii* Shear). — This is less injurious than the rot or scald in New Jersey, but is more common in Massachusetts and New England. The treatments already suggested apply.

The three diseases just considered cannot well be distinguished except by microscopic examination. In some cases the berry is soft and light colored, but if the fungus develops slowly, the sick portion is not so soft. To control them the water supply should be regulated so as to avoid great fluctuations during the growing season. Too little water is more to be avoided than too much. Vines dead from disease should be pulled and burned. Bordeaux mixture, at fourteen-day intervals, as suggested above, is recommended.

Hypertrophy (*Exobasidium Oxycocci* Rostr.). — Hypertrophy is known only in Massachusetts, where in 1906 it did considerable damage in some bogs.

In this disease the buds in the leaf axils, which normally remain dormant, grow out into short shoots bearing swollen enlarged leaves of pink or light rose color. This character has given rise to the name "false blossoms."

The disease usually appears before blossoming, and by sapping the vigor of the vine prevents fruiting. No treatment is known.

Sclerotiniose (*Sclerotinia Oxycocci* Wor.). — Just as the plants begin to blossom the tips of green shoots first show this disease by withering. Then a thin, soft, white moldlike outgrowth appears upon the stem and leaves. From here the spores spread to the open blossoms and infect the young fruit. No further evidence of the disease is seen until the berry is nearly mature, when the affected berries are found to be full of a cottonlike growth, the fungous mycelium. At harvest time such berries show a grayish, wrinkled spot, and later the whole berry becomes gray, shriveled, and often spotted with dark brown masses which break through the skin. Such berries carry the disease over winter.

The destruction by fire of all diseased fruit will lessen the evil in succeeding seasons.

Gall (*Synchytrium Vaccinii* Thomas). — The cranberry gall though not widely known has been serious in some bogs, and on account of its rapid spread may become of much import in any bog to which it gains entrance. The first collection of the disease in America was by Halsted[1] in New Jersey in 1886.

It is found upon the leaves, stems, flowers, and fruit as small, 0.8–1 mm., red galls which occur in such abundance upon the affected part as to cause marked distortion.

The disease is known to recur year after year, resulting in almost complete loss of the crop in infected portions of the bogs.

[1] Halsted, B. D., N.J. Agr. Exp. Sta. Bul. 64, December, 1889.

Other plants upon which the same disease occurs are: Azalea (*Rhododendron viscosum* Torr.); sheep laurel, or lambkill (*Kalmia angustifolia* L.); sweet pepper bush, or white alder (*Clethra alnifolia* L.); leather leaf (*Cassandra calyculata* Don.); huckleberry (*Gaylussacia resinosa* T. & G.); the teaberry, or wintergreen (*Gaultheria procumbens* L.).

Burning of the infected areas is recommended.

Fly speck (*Leptothyrium Pomi* (Mont. & Fr.) Sacc.). — Fly speck is identical in character with that described for the apple.

CURRANT

Knot (*Pleonectria Berolinensis* Sacc.). — This disease was described by Durand[1] in 1897 as prevalent in some regions of New York State. It has since been found in several other states and may be expected wherever currants are grown.

The first symptom is wilting of the foliage, which soon turns yellow, dries up, and falls away. The diseased clusters of fruit are smaller than normal, color prematurely, and fall with the foliage, leaving only the bare stalks, which soon die. Cuttings made from the apparently healthy bushes in a diseased field usually grow slowly, which seems to indicate that the fungus causing the disease is present in even those stalks which appear healthy. After the death of a stalk small, wartlike, sporiferous tubercles appear in great number upon its surface.

Cuttings should not be taken from diseased fields.

[1] Durand, E. J., N.Y. (Cornell) Agr. Exp. Sta. Bul. 125, February 1897.

Here even the apparently healthy plants may be affected. After the disease has once gained access to a field, all diseased plants should be pulled and burned as soon as they are recognized, and the soil should be allowed to rest some years before again putting either currants or gooseberries upon it.

Fig. 63. — Diseased currant canes; *a*, Tubercularia; *b*, Nectria; *c*, Pleonectria. After Durand.

Cane blight (*Fungus indet.*). — A sudden wilt of the leaves on one or more canes in a bush is the first symptom of disease. The entire bush may succumb, but not usually during the first season. Upon splitting the stems a discoloration of the bark and wood near the base is noticed. This disease, while similar in many of its symptoms to the knot, may be distinguished from it by the absence of wartlike growths upon the surface of affected twigs.

As an effective measure all diseased canes may be cut out and burned, cutting well below the diseased area.

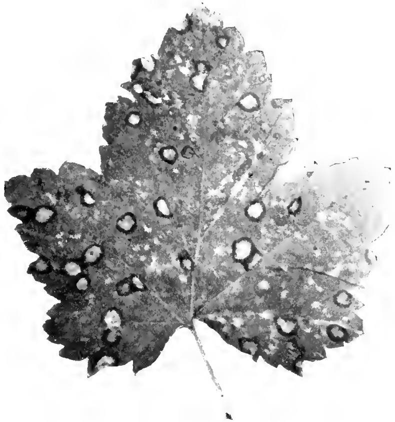


FIG. 64. — Currant leaf spot (septoriose). After Stewart and Eustace.

Septoriose } The leaf spots { (*Septoria Ribis* Desm.)
Cercosporose } The leaf spots { (*Cercospora angulata* Wint.)

The " currant leaf spot " is a term applied to a peculiar spotting of the leaves of both currants and gooseberries. It is likely to occur wherever these plants are grown. The spot is of rather characteristic appearance, usually circular, although sometimes irregular in outline, generally about 3 mm. in diameter. In the center of the brown or gray discolored area very minute pycnidia may be seen in the case of septoriose; hyphæ in the case of cercosporose. Defoliation, often serious to the plant, results.

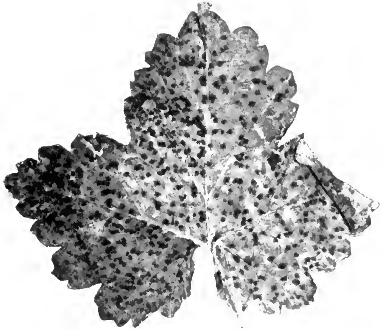


FIG. 65. — Currant anthracnose. After Stewart and Eustace.

The Bordeaux mixture is far superior to ammoniacal copper carbonate for these diseases. Five applications at ten- to fourteen-day intervals are needed, beginning as soon as the leaves are open.

Anthracnose (*Pseudopeziza Ribis* Kleb.). — The leaves, fruit stalks, berries, and canes are affected. Usually the disease is not present to great extent, but a few serious outbreaks have occurred, notably in central New York and in the Hudson River region. It has also been noted in Ohio, Iowa, New Jersey, and is probably often present to a slight extent in a number of other states.

In a severe outbreak which is necessary to attract attention to the disease the leaves first become covered with small dark brown spots, change to yellow, and soon fall. By the time the fruit has ripened practically all of the

Fig. 66. — Anthracnose of white currants. After Clinton.

leaves may be lost. Upon the leaf stalks, also upon the fruit, stems, and canes, the disease appears as little black sunken spots. On the berries the spots are circular and black, much resembling fly specks. The causal fungus probably winters upon the canes, ready to initiate the spring infection.

Anthracnose can readily be distinguished from the two leaf spots mentioned above by the fact that the spots produced in anthracnose are very much smaller, less angular, and lack in every way the distinguishing characters of the other leaf spots.

No conclusive evidence as to the best treatment is at hand. The best recommendation is probably that of the Geneva Experiment Station: "Spray thoroughly with Bordeaux mixture, commencing before the leaves appear. Make the second treatment as the leaves are unfolding and thereafter at intervals of ten to fourteen days until the fruit is two thirds grown. In wet seasons make one or two applications after the fruit is gathered. When worms appear, add Paris green or green arsenoid to the Bordeaux."

Rust (*Puccinia Ribis* DC.). — The rust formed upon the fruit and leaves of currants is rare in the United States. It may be recognized by the sori characteristic of the rusts. Diseased parts should be gathered and burned, and the bushes and the ground beneath should be thoroughly sprayed with a cleansing spray before the leaves appear.

European rust (*Cronartium Ribicola* Fisch de Waldh.). — This produces an orange-colored powder upon the lower surface of the leaves. The spring stage occurs upon trunks and branches of the white pine. The disease has been rarely noted in America on plants introduced from Europe, where it is quite common.

Powdery mildew, sphærothecose. See **gooseberry.**

Root rot, dematophorose. See **gooseberry.**

DEWBERRY

Double blossom[1] (*Fusarium Rubi* Wint.). — Double blossom occurs on dewberry and, to some extent, on the

[1] Written for the authors by Mel. T. Cook.

high-bush blackberry. It is most abundant on the Lucretias, but is also a serious pest on the Rathbone. The disease makes its appearance in the spring, just as

FIG. 67.—The Dewberry double blossom showing witches' broom of the vine. After Cook.

the leaf buds are opening, although it can be detected previous to that time by the enlargement of the diseased buds.

Instead of the normal shoots and leaves a witches' broom is produced; the entire bud being involved or only a part, according to the attack. When the flower buds open, they show a great variety of deformities: sometimes only slightly distorted; sometimes with increased number of stamens and petals and with enlarged, thickened petals and sepals. Even those flowers which appear most nearly perfect have diseased ovaries, and the fruits from these brooms are always worthless.

Double blossom usually appears during the second harvest and continues to increase until the plants entirely succumb. Numerous late blossoms appear during the first season and increase in number from year to year.

The disease is due to a fungus, and the infection of new buds occurs during the blooming and fruiting season. For this reason it is impossible to control the disease by spraying, but it may be held in check by removing and burning the deformed buds as soon as they begin to open, and can be easily detected. If this is done early in the season before the leaves are large enough to hide the diseased parts, a man working alone can care for plants at the rate of 400 per hour.

Two other diseases are known to be particularly common on the dewberry; namely, the **leaf blight** and the **cane blight.** Both of these are treated under the blackberry and raspberry.

GOOSEBERRY

The powdery mildew (*Sphærotheca Mors-uvæ* (Schwein.) Berk. & Curt.). — Sphærothecose may be recognized by the characteristic mildewed appearance of the leaves, stems, and fruit, all of which appear whitened as though dusted with blotches of flour. Close inspection shows each blotch to consist of cobwebby threads densely matted in the central portions of the spot, and less dense towards its circumference. Later these blotches turn brown, irregularly blend into fewer spots, and form large diseased areas. As the spot ages, its threads weave together into a thick felt.

The young leaves and growing parts are robbed of nourishment, and thus their growth is checked, resulting in serious injury. The berries if subjected to one-sided attack become deformed and curved, owing to the retarded growth of the diseased side. They often crack open and decay. Diseased leaves turn brown. Toward the completion of the season's growth small, nearly microscopic, black perithecia are produced in the centers of the diseased spots.

The damage caused by this disease is excessive and presents the most serious obstacle to the successful culture of the gooseberry. It has quite prohibited the cultivation of the finer sorts of English gooseberries in America and is a grave menace to the culture of gooseberries in Europe. Its destructiveness is due not alone to the injury to the foliage, bush, and to the fruit yield, but also to lack in salability, owing to the unsightliness of the partially diseased fruits.

This powdery mildew has been very successfully combated at the New York Experiment Station at Geneva.[1] Of a large number of fungicides tried potassium sulphide proved to be most efficient, using one ounce to two gallons of water and spraying seven times. This cost but three tenths of a cent per bush for material, and reduced the

[1] Close, C. P., N. Y. (Geneva) Agr. Exp. Sta. Bul. 161, November, 1899.

percentage of mildewed fruits from sixty-three on the untreated bushes to eighteen on the treated bushes. The proper time to spray is indicated in the accompanying

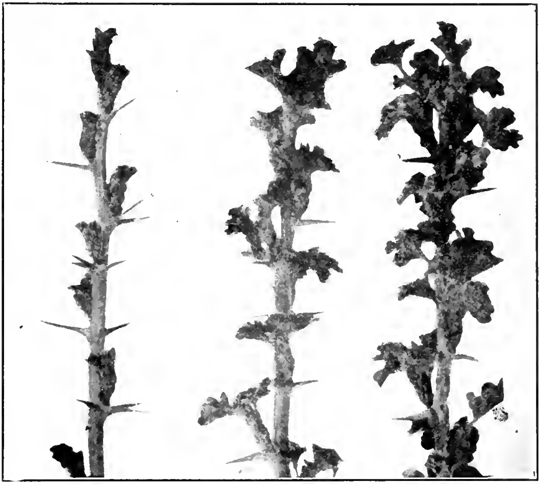


FIG. 68. — Stages at which spraying should be given for mildew. After Close.

figure. Treatment should be begun at the condition shown in the left-hand figure, and continued at intervals of ten days or two weeks until seven applications have been made. Spraying begun when the bushes are in the condition shown in the left figure gives decidedly better results than when the spraying is delayed until the condition shown in the other two figures.

Black knot. See **currant.**

Anthracnose. See **currant.**

Septoriose, leaf spot. See **currant.**

Cercosporose, leaf spot. See **currant.**

Cluster cup (*Puccinia Grossulariæ* (Schum.) Lagerh.). — Occasionally reddish swollen or thickened spots are noticed over the leaves and sometimes upon the fruit. Close examination shows each spot to consist of a cluster of minute cups embedded in the tissue of the leaf, whence the name "cluster cup." With a lens each cup is seen to consist of a fringed rim extending above the surface of the leaf, and to be filled with very small red spores.

The winter condition is found upon quite different plants; namely, various common sedges, upon the leaves of which it constitutes a genuine rust.

The damage from this disease is not serious, and no experiments on a large scale, in prevention, have been undertaken. If it should prove destructive, thorough eradication of the sedges in the neighborhood, particularly any that are rusted in autumn, would be deemed necessary.

Root rot (*Dematophora sp.*). — Root rot upon both the gooseberry and currant has been reported from some states.

The plants die slowly. When dead and living canes are found in the same hill, the living canes are somewhat dwarfed. The disease apparently spreads through the soil, and the diseased soil area enlarges year by year. Upon roots of diseased plants there are conspicuous white threads, the mycelium of a fungus which has been held responsible for the damage to the plant although conclusive proof of its causal relation to the disease has not yet been adduced.

Little can be suggested in the way of treatment. It is, however, best to pull up and burn affected plants, and it is inadvisable to place susceptible crops upon soil which is known to be diseased.

GRAPE

Black rot (*Guignardia Bidwellii* (Ell.) V. & R.). — This widespread and exceedingly destructive disease has been responsible for the abandonment of grape raising in many sections of the country. It is found in all sections to greater or less extent. In 1906 in Michigan the loss from black rot was estimated at 30 to 40 per cent of the crop; in Ohio in 1905 at 30 per cent of the crop worth $95,000. In many sections the loss is practically total unless measures are taken to check its ravages.

In its most familiar form the disease consists of spotting and decay of the fruit. Black or brown spots, one or more in number, at first infinitesimal in size, appear upon the berry. The spots enlarge with great rapidity, one spot in a few days encompassing the whole berry and changing it into a black mass. As the rot progresses the skin remains intact, and soon the berry begins to shrink and shrivel until it is eventually merely a dry, hard, wrinkled, mummified fruit. The rapidity with which this change takes place is shown in the accompanying figure. Many of the berries so mummified fall to the ground, others remain upon the vine.

Upon the leaves the disease appears considerably earlier than upon the fruits. Here it produces tan-colored spots

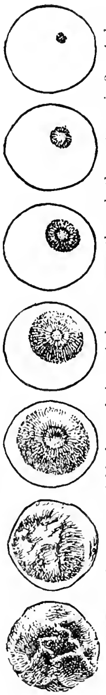


FIG. 69. — Successive stages of black rot lesion. A berry passes through these stages in 3 or 4 days. After Wilson and Reddick.

about 3–8 mm. in diameter, many or few according to the severity of the infection. In or near the centers of the older spots upon the upper surface of the leaves are seen the nearly microscopic pycnidia which are often arranged in concentric circles.

On the young shoots the spots are somewhat more reddish and are often cracked longitudinally, but otherwise they are as upon the leaves.

This rot is much worse in warm, humid weather than in dry times, and a few days of muggy weather may so favor the growth of the causal fungus as to develop an epidemic, which may in turn be checked by a dry spell. Often the disease appears in distinct waves during the season, each wave corresponding to a climatic condition favorable to infection and usually lagging behind such favorable condition a period of 8 to 14 days, the time necessary after infection for the disease to become conspicuous enough to attract the attention of the vineyardist. The first infections of each season occur upon the stem; leaf, petioles, and tendrils.

While the Scuppernong occasionally shows a few spots upon leaf or berry and the blossom is sometimes affected, this variety is practically immune.

To prevent the inroads of the black rot thorough, clean culture should be practiced. All mummified fruit should be burned to avoid infection. Keep sprouts and all other growths off the ground. Allow no weeds or grass. Plow early so as to cover all remaining leaves and berries that bear the hibernating fungus. Cover crops are beneficial. Use a cleansing spray while the vines are still dormant to clean the bark, trellis, etc. The utility of this first spraying may vary with climatic conditions and latitude. Use protective sprays of 4–3–50 Bordeaux mixture[1] throughout the summer. Five or six applications are usually necessary. The first should be made when the shoots are 20–30 cm. long. The others at intervals of ten to fourteen days. After the first two sprayings the spray must reach the clusters to be effective. Spray each season. Neglect one season brings large increase in the rot the following season.

Fig. 70. — Grape black rot. Original.

The following table shows the benefits of careful, thorough spraying.[2]

[1] Shear, C. L., Miles, G. F., and Hawkins, L. A., U.S. Dept. Agr. Bur. Plant Indus. Bul. 155.

[2] Wilson, C. S., and Reddick, D., N.Y. (Cornell) Agr. Exp. Sta. Bul. 266, p. 405.

Result of Black Rot Experiments in 1908

Plat No.	Treatment	Net Weight Harvested	Weight Firsts	Weight Wine	Weight Rotten	Firsts Per Cent	Wine Per Cent	Rotten Per Cent
		lb.	*lb.*	*lb.*	*lb.*			
1	Bordeaux 4–4–50, 6 applications	8084	7252	742	90	89.7	9.2	1.1
2	Bordeaux 5–5–50, 4 applications	7872	7461	305	106	94.8	3.9	1.3
3	Bordeaux 5–5–50, 6 applications	9157	8726	306	125	95.3	3.3	1.4
4	Sprayed according to weather conditions . .	7997	7588	338	71	94.9	4.2	0.9
5	Cultivated but not sprayed	3175	2232	451	492	70.3	14.2	15.5
6	Neither cultivated nor sprayed . .	3334	2169	594	571	65.1	17.8	17.1

Powdery mildew, uncinulose (*Uncinula necator* (Schw.) Burr.). — This mildew, a native of the United States, first noted in Europe about 1845, near London, and shortly after in Belgium and France, is said to have reached every grape-growing country of Europe before 1851. It increased in severity until 1854 when it began to be held in check by sulphur applications. It is known in all parts of the United States.

The powdery mildew attacks all parts of the plant except the roots, showing first upon both the upper and lower surface of young leaves as whitish circular spots, which appear somewhat as though dusted with flour. These spots enlarge, coalesce, and may cover the whole leaf. The affected leaf is retarded in growth and becomes distorted. Mildewed blossoms fail to set their fruit, and fruit that is mildewed soon ceases growth and falls, or develops irregularly and fails to ripen.

The mildew fungus is strictly superficial and may be easily rubbed off, leaving a discolored spot. In late stages perithecia may be recognized as very small black bodies, about 0.1–0.12 mm. in diameter, lying within the diseased areas. The disease develops in most destructive form in shaded, damp, poorly ventilated situations. Rain and fogs favor it, while very dry weather inhibits it. The American vines are less susceptible than the European varieties.

Ventilation and removal of shading trees are beneficial. Close planting should be avoided in order to allow quick drying, and trellises should run in such direction as to allow free access of sun. But these means are only palliative.

To control the mildew in dry climates employ flowers of sulphur. The sulphur, when the temperature is above 75° F., passes into the air, and its fumes, coming in contact with the fungus, kill it. Below the temperature at which sulphur is effective the fungus will make but little progress. When the air, shade temperature, is from 90° to 95° F., the killing effect of the sulphur may be seen within 24 hours [1]; if above 100°, one or two days are sufficient to rid the vineyard of the disease. The sulphur must be distributed to every part of the vine. Sulphur upon the ground is of no use. The vines should be sulphured from one to seven times, according to conditions, susceptibility, climate, etc. The first sulphuring should be done when the blossoms begin to open; a second application should be made before the first sign of the mildew, and other applications should follow as need indicates. It is necessary to resulphur if from one to two days

[1] Bioletti, F. T., Cal. Agr. Exp. Sta. Bul. 186, February, 1907.

at 90° to 95° or four to five days 85° to 90° do not intervene before the sulphur is removed by rain. If the disease was bad the previous year, it is well to sulphur even earlier than indicated above, *i.e.*, when the shoots are about 15–20 cm. long.

After the grapes commence to ripen they are nearly safe from mildew, but for the future good of the vine the leaves should be protected by further sulphuring if need be. Young vines should similarly be protected. To properly sulphur use good dust sprayers which give an even flow of sulphur and are easy of operation. The cost of sulphuring an acre three times is about $1.25.

In climates where sulphur cannot be used to advantage reliance must be placed upon Bordeaux mixture applied as for the black rot.

Downy mildew, brown rot, gray rot (*Plasmopara viticola* (Berk. & Curt.) Berl. & De Toni). — Each of the downy mildews produces a more or less distinctly visible downy or velvety growth upon the affected surface. This appearance is caused by myriads of spore-bearing stalks that rise from the diseased surface. If these stalks are close together, the appearance is thoroughly characteristic and the diagnosis clear. As the spores mature the spots assume a gray or frosted appearance.

The European are more susceptible to this mildew than the American varieties. All the green parts of the plant are affected. Upon the lower side of the leaf the disease may be recognized by the description given above. The upper surface of the leaf over a diseased spot becomes pale, yellowish, and finally turns brown and dies. The area so affected is definitely bordered and does not nec-

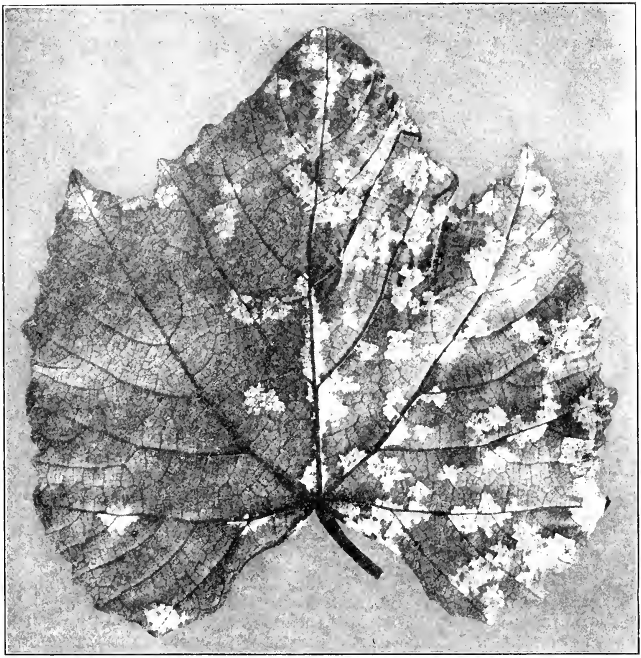


FIG. 71. — Downy mildew as seen from the lower surface of the leaf. After Heald.

essarily cause the death of the whole leaf, though it may do so.

Upon shoots the same characteristic appearance is noted as upon the lower surfaces of the leaves. Sometimes the

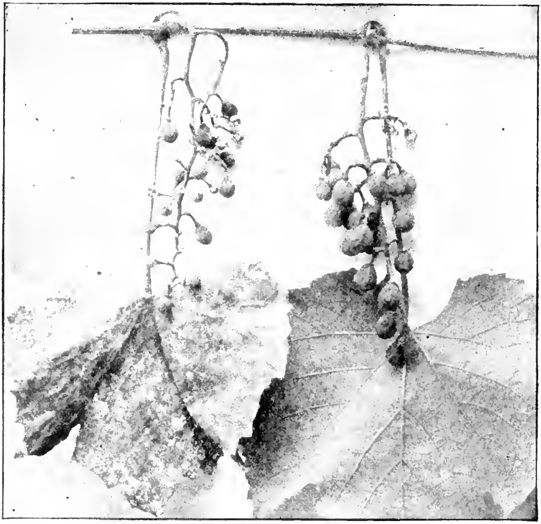


Fig. 72. — Young Niagara clusters attacked by brown or gray rot. After Lodeman.

death of the affected twig or even of the whole vine results. Immature berries which are affected stop growing and develop the same coating noted upon the leaves, giving rise to the name "gray rot." If the berries be more mature when attacked, they turn brown, thus calling forth the name "brown rot." The berry in dying shrivels and becomes wrinkled, but does not become hard and dry, as in the case of the black rot. The disease is usually more troublesome in the early part of the season than in autumn.

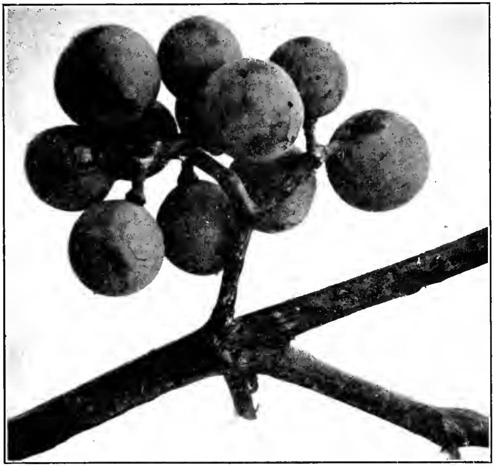


Fig. 73. — Bird's eye on the fruit. After Paddock.

Effective management requires early spraying, though sometimes it may be found advantageous also to protect the leaves after harvest for the future good of the vine. Bordeaux mixture or ammoniacal copper carbonate are the most suitable fungicides.

Bird's eye, anthracnose (*Sphaceloma ampelinum* DeBy.). — This anthracnose, probably introduced into America from Europe prior to 1880, is now widely distributed throughout grape-growing sections. While not usually so destructive as the black rot or the brown rot, it sometimes increases to such an extent as to do great damage, even causing in some instances the loss of all the berries upon a vine as well as much injury to the canes. During damp, warm weather it develops rapidly, affecting some varieties more than others. The Brighton and Moore's Diamond may be mentioned as especially susceptible.

Upon the canes the anthracnose is first seen as small, dark brown or black spots, which soon become sunken in the centers. The spots usually enlarge most rapidly in the direction lengthwise of the stem, though they may sometimes girdle it. Girdling is particularly common upon stem clusters, where it is always fatal. The centers of the older spots are ashen in color, the edges dark, and the cankerlike spot extends from the bark deep into the wood, rendering the shoot weak and brittle.

Upon the fruit spots 3–5 mm. in diameter are produced similar to those upon the canes, except that the center does not always become ashen. Here, too, a band of red often surrounds the diseased part. The parts of the berry adjacent to the diseased spot remain green and develop normally, which, associated with the red border, results in the peculiar appearance which has led this disease to bear the name "bird's-eye disease."

If the berry is attacked while young, it may either outgrow the disease or succumb to it. Several spots upon one berry destroy its value, and spots upon one side may cause distortion, cracking, and exposure of the seeds.

Upon the leaves the dead spots are usually bordered by a fine black line, and as the leaf grows the dead tissue of the spot may rupture irregularly.

Badly anthracnosed canes must be cut out and burned, and cleansing sprays should be used.

Necrosis (*Fusicoccum viticolum* Reddick).—This disease is said by Reddick[1] to cause perhaps 50 per cent of the death of vines usually attributed to root worm or other causes. It has been noted in New York, Ohio, Georgia, Indiana, and is in some instances very abundant, causing death to 30 per cent or more of the vines in the vineyard. The Concord, Niagara, Moore's Early, Agawams, Pocklingtons, Wordens, Lindleys, Catawbas, Isabellas, and Scuppernong are affected.

FIG. 74. — Necrosis of the vine. After Reddick.

Necrosis may be recognized in the field by the following characters[2]: A trimmed and tied vine that has failed to put out shoots; one that has sent forth shoots, the latter dying after a few weeks; vines on which all or part of the

[1] Reddick, Donald, N.Y. (Cornell) Agr. Exp. Sta. Bul. 263, February, 1909.

[2] Quoted from Reddick in abbreviated form.

Fig. 75.— Grape necrosis as it appears on the canes. After Reddick.

shoots and leaves exhibit a dwarfing, with leaves small and often crimped about the margin; leaves of nearly normal size but blanched; apparently healthy vines with leaves and fruit shriveling and dying in the summer; fleshy or corky longitudinal excrescences on the stem, which in the autumn dry down and become reddish brown and the following spring slough off; the presence of minute black pustules on a dead spur, bark, or wood under the bark; small reddish brown spots 3–4 mm. long on the green shoots.

The disease is conveyed to new tissue by spores from the pycnidia, also probably by pruning tools which cut sound wood after cutting into diseased tissue. It may also enter the older parts through wounds. Cuttings bearing the fungus probably spread the disease.

Spraying shoots when from $7\frac{1}{2}$–15 cm. long will probably reduce infection. Diseased vines should be pulled and burned, or if the root crown be still sound, they may be cut back to near the ground, and the renewal will be healthy. In the spring and summer it is well to mark sick vines for future eradication. Cut off the diseased parts, using tools separate from those used in ordinary pruning.

Root rot, dematophorose (*Dematophora necatrix* Hartig). — This rot attacks a few roots at first, but eventually reaches all, and results in death of the vine. It is very destructive in Europe and has been noted in several places in the United States.

The top growths of affected vines show symptoms first;[1] then follows one division after another until a large vine is reduced "to the size of a bushel basket," though numerous lateral canes may arise, especially near the base of the plant. The leaf color usually remains normal with no dead tissue, though the leaves sometimes turn yellow, and many of then are reduced in size. After the vine dies the leaves still remain attached to the canes.

The mycelium of the causal fungus may be seen as a tufted expanse of white dense hyphæ, extending along and winding about the roots. Later brown hyphæ appear.

The best treatment is to remove and burn the affected stock, thoroughly stir, air, and dry the adjacent soil.

Cercosporose (*Cercospora viticola* (Ces.) Sacc.). — Irregular dark to black spots upon the leaf often indicate this disease.

The treatment employed for Plasmoporose will be useful.

Root rot, armillariose (*Armillaria mellea* Vahl). — Growing within the wood of the roots is the root-rot fungus. When it has attained sufficient vigor and consumed nutriment enough, it develops its spore-bearing part, an edible mushroom, from the surface of the diseased wood.

This mushroom is from 7–12 cm. high with a cap 10–15 cm. in diameter. The stem is swollen near the base, and the cap is conical, frayed at the edge, yellowish, and darkened with age. Upon its lower surface are the

[1] Pierce, N. B., U.S. Dept. Agr. Div. Veg. Phys. & Path. Bul. 2, 1892.

gills, white, spotted with reddish brown. It often grows in large clusters near the base of the vine.

The disease occurs in local areas in the vineyard, and the regions of affected soil enlarge irregularly. The disease may further be recognized by the fact that the yield is not lessened the first year of the attack; the vine does not succumb until two or three years later. The leaves are reduced in size, but are normal in color. Upon the roots are found dark-colored rootlike cords of mycelium passing into and among the irregularities of the bark.

Excision and destruction of the diseased parts by fire will lessen the spread of the disease.

Bitter rot, ripe rot (*Glomerella rufomaculans* (Berk.) Spaul. & von Schrenk). — Ripe berries only are attacked. At the point of injury the color changes to reddish brown and eventually the whole berry assumes this color. It then decays and finally dries and shrivels. Acervuli appear early upon the sunken portion, much as in the black rot, except that the berry does not assume the dark hue characteristic of the latter disease.

Ammoniacal copper carbonate is recommended as a spray as soon as the disease is noticed.

Bitter rot, melanconiose (*Melanconium fuligineum* (Scrib. & Viala.) Cav.). — The chief effect upon the berry as it ripens consists in the appearance of a ripe rot, also accompanied by a very bitter taste. The fungus also attacks the shoots and stem clusters.

White rot (*Coniothyrium diplodiella* (Speg.) Sacc.). — This disease, known in America since 1887, resembles the black rot except as to color. It appears upon the fruit and shoots, but is not often serious.

Septosporiose (*Septosporium heterosporium* Ell. & Gall.). — As seen from above in its first appearance upon the leaves, this disease resembles the downy mildew. From below the spots are round, black, and irregular. As they enlarge they may involve the whole leaf.

This disease is common upon wild vines, often causing loss of the leaves in damp situations, but has been as yet of no serious injury to cultivated vines in America.

Scab (*Cladosporium viticolum* Ces.). — The leaf spots produced by this disease show considerable resemblance to those of the black rot, but bear no pycnidia. When numerous, they coalesce, forming patches of dead tissue. They are often bordered by a ring, red in the living tissue, black on the dead dried leaf. Spore-bearing hyphæ abound in the centers of the spots upon the lower side of the leaf.

Pestalozziose (*Pestalozzia uvicola* Speg.). — This is characterized by small black pustules under and protruding through the epidermis of the fruit and associated with rotting.

It has seldom been observed in America and is as yet of small importance.

RASPBERRY

Anthracnose (*Glœosporium Venetum* Speg.). — The first publication in America regarding this disease seems to have been made in 1882 by Burrill.[1]

Since then numerous papers from many sections attest its importance. It is widely distributed and often serious. In 1907 it was estimated to have injured one third of the

[1] Burrill, T. J., *Agricultural Review*, November, 1882.

crop in Nebraska, 50 per cent in Wisconsin, and even more in Illinois. The chief seat of attack is the cane, especially young ones, though the disease appears also upon both petioles and leaves.

The fungus often appears upon young canes before they are 25 cm. high, making small, purplish spots, which soon become grayish or dirty white in the centers. The borders of the spots are purplish and slightly raised. Later as the spots enlarge they coalesce, making irregular blotches 2 cm. or more long, which often encircle the cane. The cane then withers and dies from lack of sap supply. Badly diseased canes present a bark of rough, scabby appearance due to the efforts of the cane to heal the wound. Canes occasionally crack from this disease. The chief injury is to the cambium layer or the sappy outer wood. The leaves on affected canes are dwarfed, the fruit ripens prematurely, is undersized, and often dries up.

Upon the petioles of the older leaves the disease appears early, spreading thence along the ribs to the leaf. Owing to the one-sided attack upon the veins and petioles, the leaves develop unequally, often with inrolled edges. Upon the lower surface very small spots about 1 mm. in diameter are produced, from which the diseased tissue often falls. In the older diseased spots the spore-bearing acervuli are just visible to the naked eye.

Occasionally the disease, even though bad, may escape observation during the first and second years, and even well into the third year. Then, with prospect of a good yield, the berries may shrivel on the stems and later many plants may die. More often the disease remains moderately injurious from year to year, weakening the plants and diminishing the yield.

In localities subject to this disease it is best to rotate crops so as to avoid keeping raspberries more than three years on the same soil. When the disease appears, cut out and burn diseased parts immediately after picking. Spraying young canes with a protective (Bordeaux) spray the following spring will lessen infection. Whether the spraying is of enough benefit to warrant its use is questionable.[1] If spraying is done, it should be begun when the new canes are about 15 cm. high, and one or two more sprayings given at intervals of 10 or 14 days thereafter.

Crown gall (*Pseudomonas tumefaciens* Smith & Townsend). — Frequently small swellings are noticed on the roots of the raspberry in abundance enough to injure the health of the plant. These galls very closely resemble the crown gall of the peach, almond, apple, etc., which has recently been attributed to a species of Pseudomonas. It is desirable to pull up and destroy diseased plants and avoid placing blackberries and raspberries on ground which is known to be affected.

Leaf spot, septoriose. See **blackberry.**

Rust, gymnoconiose. See **blackberry.**

Cane blight (*Coniothyrium Fuckelii* Sacc.). — First noticed in literature in 1899 by Stewart and Eustace[2] as occurring in the Hudson valley, this disease seems to be widespread and destructive upon both red and black rasp-

[1] Paddock, W., N.Y. (Geneva) Agr. Exp. Sta. Bul. 124, p. 273, April, 1897.

[2] Stewart, F. C., and Eustace, H. J., N.Y. (Geneva) Agr. Exp. Sta. Bul. 226, December, 1902.

berries. Principal damage occurs to the fruiting canes, the foliage of which suddenly wilts and dries. New canes are frequently killed during the first season's growth. The disease often starts in stubs exposed in pruning, and progresses toward the root.

Infection usually occurs through wounds, especially pruning wounds, or those made by insects. Sometimes the disease remains upon one side, while in other cases it encircles the cane.

Upon diseased canes the bark is lighter colored and disfigured by smoke-colored patches of spores extruded from the pycnidia within. The pycnidia appear as very minute pustules. The wood is much discolored and eventually brittle. This cane blight is often attributed to a borer or to drought or winter injury.

The damage is often as high as 25 or 50 per cent of the crop, and the disease is said to be present to some extent in nearly all the raspberry plantations in New York. Cuthbert, Marlboro, Ohio, Gregg, Kansas, and the wild red raspberry are susceptible. Columbiana is more resistant.

The disease is disseminated largely by diseased nursery stock or even in the dirt upon the roots of plants from diseased fields, and is conveyed from plant to plant by wind or rain, by pickers, and by workmen while pruning and layering, also by tools in cultivation. See **soil diseases**. Since the fungus can live on dead fragments of canes, etc., upon the ground, these prove fruitful means of propagating the pest.

To prevent the disease care in the selection of healthy plants and planting area is necessary. Plants should not

Fig. 76. — Raspberry cane blight. After Stewart and Eustace.

FIG. 77. — Raspberry discolored by Sphærellose. After Stewart and Eustace.

be set where the disease has been in previous years. When the fungus has gained access to a plantation, all dead canes should immediately be cut out and burned and all fragments scrupulously removed from the ground. Spraying is of doubtful value.

Mycosphærellose (*Mycosphærella rubina* Stewart and Eustace). — On red raspberry canes in autumn sharply defined brown or bluish black areas from 2–10 cm. long occur on the bark, never on the wood. In the spring these spots bear numerous small pycnidia.

This disease, due to Sphærella, does not often cause appreciable injury.

Yellows. — Plants in this disease are stunted, yellowish, and recall peach yellows.[1] Laterals are dwarfed, leaves are small, curled downward at the margins, and yellow mottled. Berries dry up without ripening or are insipid when mature. Health and disease may occur upon the same plant. The cane itself and roots appear normal.

The cause and remedy are not yet known.

[1] Stewart, F. C., and Eustace, H. J., N.Y. (Geneva) Agr. Exp. Sta. Bul. 226.

STRAWBERRY

Leaf spot (*Mycosphærella fragariæ* (Tul.) Sacc.). — The most conspicuous disease of the strawberry, one nearly always present to some extent on both wild and culti-

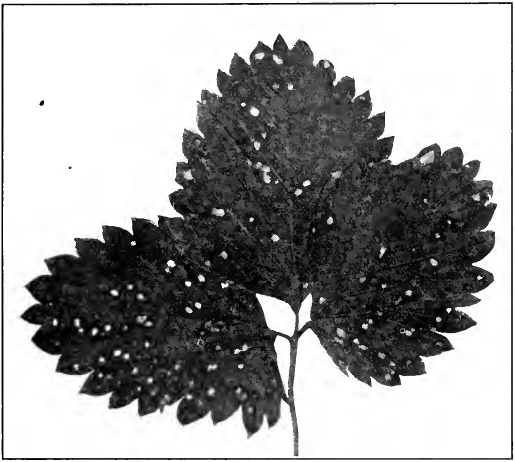


FIG. 78. — Strawberry leaf spot. After Freeman.

vated varieties, is known by the presence of small 4–6 mm. purple or red bordered spots upon the leaves, the older spots bearing white or ashen centers. Late in the development of the spots the hyphæ of the causal fungus are barely visible in these centers with a good hand lens. The spots, when numerous, may coalesce, forming large, irregular blotches. The disease is also very injurious in its attacks upon the fruit stems, resulting in diminution of food supply to the fruit and its improper development.

It attacks all varieties, precluding the use of especially susceptible varieties in some localities, often killing the plants, and in any event lessening their vigor and productiveness. In some localities entire plantings have been destroyed. One grower reports a loss of $1500 on a six-acre field in one season.

Moisture and heat favor the disease, while moisture, dew, etc., upon the leaves are necessary to infection. Weather favorable to infection followed by hot, dry days may be attended by great injury. Plants growing upon heavy, wet, undrained soil suffer more than those upon dryer soil.

The following comparison of resistance is quoted[1]: —

"1. Blight very rare — Daisy, Eureka, Jewell, Triumph de grande.

"2. Blight rare — Belmont, Lady Rusk, Scarlet Queen.

"3. Blight frequent — Annie Forest, Bomba, Bubach, Burt, Captain Jack, Covill, Crawford, Cumberland Triumph, Dutter, Gandy, Gold, Gypsy, Haverland, Henderson, Itaska, Jessie, Lida, Logan, Mammoth, May King, Miami, Ontario, Parry, Pearl, Phelps, Pineapple, Primo, Summit, Sunset.

"4. Blight abundant — Barton's Eclipse, Cloud, Gandy Pride, Great America, Loudon's 15, Piper.

"5. Blight very abundant — Monmouth, Ohio, Photo, Sanafee, Warfield."

[1] Garman, H., Ky. Agr. Exp. Sta. Bul. 31, p. 13.

Hume reports the Lady Thompson and Michel's Early as quite resistant.

Frequent change of beds; also cutting, gathering, and burning or burying of tops in place after harvest lessens this disease. The use of Bordeaux after the removal of the diseased leaves will also lessen the infection of the next year.

Hume[1] in Florida found that three early sprayings of 4-4-40 Bordeaux mixture checked the disease completely, so that "it was a difficult matter to find a leaf at all diseased in the whole patch." Later, when the disease began to make headway again, another spraying stopped it.

Leaf blight, aposphæriose (*Aposphæria* sp.). — This disease was first found by Stevens[2] in 1892 in New York and in New Jersey,[2] and it is probably of wide distribution. It is in some instances very destructive, causing loss of more than half the crop. It may be distinguished from the other leaf diseases by the shape of its spot, which usually begins at the leaf margin and extends toward the center, forming a more or less V-shaped region. The spots are brown.

The treatment should be the same as that for Sphærellose.

Leaf spot, ascochytose (*Ascochyta fragariæ* Sacc.). — This leaf spot is very similar to sphærellose, for which it may be mistaken without microscopic diagnosis. The treatment for the two is the same.

Powdery mildew, sphærothecose (*Sphærotheca humuli* (DC.) Burr.). — This mildew may be recognized by the characters usually pertaining to the powdery mildews. (See **grape**.)

[1] Hume, N. H., Fla. Agr. Exp. Sta. Rpt. 1901, p. 95.

[2] Halsted, B. D., N. J. Agr. Exp. Sta. Rpt. 1893, p. 329.

Upon the strawberry it induces curled, inrolled leaves and the white mycelium is found upon their lower surfaces. The disease is not usually very troublesome.

TROPICAL FRUITS

AVOCADO

Anthracnose (*Colletotrichum glæsporioides* Penz.).— Attack upon the leaves eventually causes defoliation. Early infection of the fruit results in its complete loss. If the fruit is not attacked until late, it may remain upon the tree, but becomes spotted with brown and finally cracked. On both leaves and fruit it can be controlled by the use of Bordeaux mixture.

CITRUS FRUITS

Brown rot (*Pythiacystis citrophthora* Sm. & Sm.).— This fungous disease has caused a very considerable loss, 30 per cent in some cases, in California for the past seven or eight years,[1] but the real cause of the trouble was not known until 1906 or 1907. It chiefly affects the fruit after it has been packed and shipped to market, although the infection takes place in the orchard or packing-house where the disease is largely disseminated by the fruit washers.

The rot has a peculiar characteristic rancid penetrating odor, and its presence is further indicated by an abundance of small flies in boxes where there is any diseased fruit. One affected fruit in a box communicates disease to the whole.

[1] Smith, R. E., Cal. Agr. Exp. Sta. Bul. 190, July, 1907.

The brown rot is found in its purest condition on the fruit in the orchard, especially the fruit on the ground or hanging low on the tree. It is most prevalent in wet weather or on low ground after irrigation. The fungus is

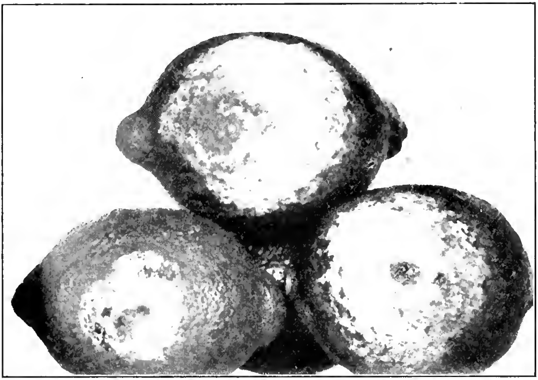


FIG. 79. —Brown rot of lemons, showing white growth of the fungus. After R. E. Smith.

visible to the eye in the packing-house, as of a mass of white filaments. It is spread by contact alone.

Orchard infection can be controlled by the use of a heavy mulch under the trees, either straw or a heavy cover crop. In the packing-house the use of disinfectants in the washer prevents trouble; one and one half pints of formalin in the morning, and 1 pint at noon, or 1 pound of bluestone in the morning and 8 ounces at noon.

Scaly bark.—Small, circular or oval, rusty-colored bark spots, with well-defined margins, characterize this disease. The bark cracks and forms scales. The spots are at first scattered, but in time coalesce and form large areas upon the larger branches and trunk, giving it a scaly appearance.

Sweet oranges are most affected, the fruit ripening prematurely. It is claimed by Fawcett [1] that the disease may be due to the wither-tip fungus.

Top working is recommended, also heading back and painting the trunk and the stumps of the branches with carbolineum, one part to one part of water.

Gum disease. — Several diseases recognized by the exudation of gum from the trunks and branches of the trees are called "gum diseases." Their causes are not definitely known; by some they are attributed to mechanical injury alone; by others to poor cultivation or water injury in irrigation; by others to the presence of soil around the trunk.

Sooty mold (*Meliola Camelliae* (Catt.) Sacc.). — Sooty mold has been known in Florida for twenty or twenty-five years, but was at first considered to be of but little import, though it is now regarded as injurious to both fruit and trees. The disease covers the fruit and leaves with a black, velvety, membranous coating which may be stripped from the leaves.

As the disease follows certain insects that exude a honey-dew, it may be successfully combated by destroying these insects. Fumigation or thorough spraying with a resin wash or kerosene emulsion is recommended.

Blue mold (*Penicillium italicum* (Wehm.), *and Penicillium digitatum* (Fr.) Sacc.). — This decay of citrus fruits in transit from California causes a loss estimated at from $500,000

[1] Fawcett, H. S., Fla. Agr. Sta. Bul. 98, Mch. 1909.

to $1,250,000 annually. Careful investigations of G. H. Powell and his assistants have shown that the chief trouble results from handling the fruit in such way as to wound it, and thus provide an entering point for the fungus. Without mechanical injury no decay from blue mold can occur. Hence the only method of control that is necessary

Fig. 80. — Two forms of blue mold: at left, Penicillium Italicum; at right, P. digitatum. After R. E. Smith.

is painstaking care in handling the fruit to prevent bruising or puncturing the skin.

Black rot (*Alternaria Citri* Pierce). — This disease was described and its cause given by Pierce in 1902. It attacks only the navel orange, causing from 2 to 5 per cent loss of the whole crop. It is easily recognized by the premature ripening which it induces, and by the deep red color and extra large size of the fruit. The diseased fruits are very conspicuous on the trees before the main crop has colored.

The spores of the fungus that causes the decay gain entrance through slight imperfections of the skin at the navel end and make rotten areas under the skin.

All diseased fruit should be collected and burned or buried deeply.

Scab (*Cladosporium elegans* Penz.). — The scab has been

Fig. 81. — Scab of the sour orange. After Hume.

known for twenty years, and occurs on the sour citrus fruits such as the pomelo, kumquat, and sour orange, though its presence on the last is of little importance.

The disease attacks the young leaves, twigs, and fruit, and causes them to produce conspicuous, warty, corky growths, that give a rough, uninviting appearance. Often the leaves are twisted and drawn out of shape. The warts are at first yellowish, but as the disease ages they become almost black, and finally crack open.

Ammoniacal copper carbonate or Bordeaux mixture will prevent this.

Anthracnose, wither tip (*Colletotrichum glœosporioides* Penz.). — In this disease the leaves become spotted. The spots are circular in outline, yellowish in color, and bear small, dark spots, the filaments and spores of the causal fungus.

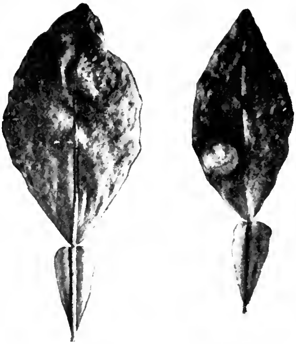


FIG. 82. — Orange leaves showing spots caused by anthracnose. After Hume.

The disease also occurs upon the fruit of various citrus trees. Rolfs noted its attack upon the lemon, where it caused the fruit to fall prematurely, and Hume reports that it may occur upon the pomelo either before or after the fruit is picked. Here the disease causes brownish spots which enlarge with age and become dirty black in color. The fungus invades the interior of the fruit as well as the rind.

In all possible cases the diseased parts should be cut out, care being taken to cut far enough back to get all injured parts; also affected fruits should be removed and destroyed. Spraying with Bordeaux mixture controls the disease upon the fruit.

Foot rot, mal-di-gomma (*Fusarium Limonis* Briosi). — The first symptoms of the disease are abundant exudations of gum upon the trunk of the tree; at the same time the bark becomes brownish in patches, which are thrown off and other patches come. The tree appears as though it does not secure sufficient nourishment, the leaves becoming yellow, scanty, and smaller than usual.

Though the trees bear considerable fruit, the amount of damage in Florida is estimated at $100,000 annually. No treatment has proved satisfactory.

FIG

Fruit rot (*Colletotrichum Carica* S. & H.). — This disease was first described in 1909 by the authors. A rot due to an undescribed species of Collectotrichum, and possibly identical with this, was reported from Louisiana in 1907.

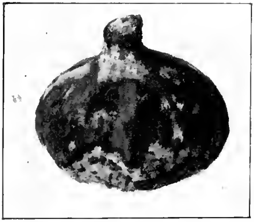


FIG. 83. — Fig in well-advanced stage of fruit rot. Original.

Fruit rot is easily recognized by the sunken, rotten, more or less circular fruit spots, nearly always covered with a white mass of fungous mycelium. As they grow older they produce numerous pustules of the salmon-pink color characteristic of the spores.

The amount of damage caused is very great by reason of premature falling of the fruit, at times destroying the whole of the crop.

Infected fruit should be gathered and destroyed and the bushes should be given a dormant spray and two or more applications of Bordeaux mixture when in foliage.

Rust (*Uredo Fici* Cast). — This rust does considerable damage to the fig crop, causing premature falling of leaves and thus removing a source of nourishment for the development of the fruit. The rust appears as brown spots upon the leaf, which can easily be seen with the aid of a lens.

Root rot (*Dematophora necatrix* Hartig). — Attack upon the roots of the fig at any period of growth, a sudden loss of leaf, and premature death characterize this disease.

The one treatment is to remove the diseased bushes and thoroughly stir and dry the soil where the disease occurred. See **grape.**

Leaf blight (*Cercospora Bolleana* (Thuem.) Speg.). — This disease has been noted in the United States, though but slight attention has been given it. It causes injury similar to that of rust.

Texas root rot. See **cotton.**

Yellow rust (*Fusarium roseum* Link). — This disease attacks the leaves, causing yellowish spots which fall away, giving the leaf a ragged appearance.

GUAVA

Ripe rot (*Glomerella psidii* (G. Del.) Sheldon). — This disease was described from greenhouse material collected at Washington, D.C., and afterward it was reported from Florida and California. The affected fruit shows circular brown decayed areas. In the older stages of the disease masses of salmon-colored spores are visible over the decayed areas. The entire fruit at length becomes rotten, wrinkled, and shrunken.

LOQUAT

Scab (*Fusicladium dendriticum* (Wallr.) Fckl., *var Eriobotryæ* Scalia.). — This disease is reported as very serious

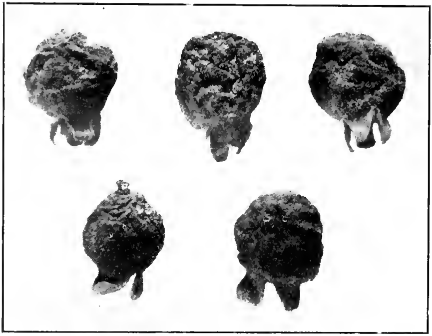


Fig. 84. — Guava affected with ripe rot. After Rumsey.

upon both fruit and leaves in the western part of California.

Anthracnose, blossom blight. See **citrus fruits.**

MANGO

Anthracnose. See **citrus fruits.**

OLIVE

Knot (*Pseudomonas Savastanoi* E. F. Smith). — Tubercles or galls upon the leaves and branches, and even upon the trunk of the tree, are the first signs of attack. Upon the leaves, the knots are always small, particularly if they are numerous. Upon the small twigs the knots attain the size of a garden pea, while upon the trunk they become 2–3 cm. or more in diameter and finally destroy the tree. The disease was noticed in California in 1893 and appears to be confined to a very small range.

Fig. 85.—Olive knot. After R. E Smith.

Peacock leaf spot (*Cycloconium oleaginum* Cast). — According to Bioletti this disease is very prevalent in certain regions of California, occasionally causing the leaves to turn yellow and injuring the appearance of the fruit. Usually it does but little harm. Spots 2–4 mm. in diameter occur upon the leaves. They are composed of concentric rings of different colors, giving them somewhat the appearance of the spots on a peacock's tail feathers. The spots on the fruit are smaller and more decidedly brown in color.

The use of Bordeaux mixture checks the trouble.

Sooty mold. See **citrus fruits.**

VEGETABLE AND FIELD CROPS

ASPARAGUS

Rust (*Puccinia Asparagi* DC.). — The asparagus rust, though observed in Europe as early as 1805, was not noted in epidemic form in the United States until 1896, when it was recorded by Halsted[1] as occurring in several New England States. In 1897, though it had extended to South Carolina and to some extent westward, the interior and western part of the United States seemed still free from it. In 1898 it was first found in Michigan; in 1899 in Illinois, Ohio, and Kansas; in 1900 in Dakota, Nebraska, and Texas, completing its westward march into California in 1900 or 1901. It is now known in every state where asparagus is grown.

The rust usually first attracts attention by its effect upon the green tops which redden under the disease, this symptom appearing at any time after blossoming or coming to leaf. Diseased areas in the field enlarge rapidly, and soon the affected leaves yellow and fall, leaving the bare, dead stalks. Close examination of the diseased regions in the field shows that the twigs and leaves bear many small blisters (sori), consisting of the raised skin of the plant. Under this skin is a mass of powder nearly the color of iron rust. In early stages of attack these blisters are few and scattered, but they rapidly increase in number. When young, the skin covering the sori is unbroken; later it ruptures, setting loose the rusty powdery mass of spores be-

[1] Halsted, B. D., N.J. Agr. Exp. Sta. Rpt. 1893, p. 329, and N.J. Agr. Exp. Sta. Bul. 129, 1898.

neath. This, the summer stage, is chiefly responsible for the hibernation of rust in the east. Later in the season the sori become black instead of rusty colored, thus constituting the winter stage of the rust.

FIG. 86. — Sori of the asparagus rust upon the stems, enlarged. Original.

In the spring still another stage, the spring stage, may occasionally be seen, though it is rare east of the Rocky Mountains. This consists of small, oval, pale spots upon the branches or leaves. In the centers of these spots small round pustules develop in concentric lines. Soon each pustule opens, constituting a very minute cup which is sunken into the leaf. From these cups issues a powder quite similar to that from the sori of the summer stage, though more orange in color. All three stages of rust — spring, summer, and winter — may occur simultaneously upon the same plant.

The disease spreads rapidly throughout the field during the spring and summer stages. The winter stage is the hibernating condition in which the causal fungus must rest until the following spring before it can induce further infection.

During the first two stages spores in enormous quantities are liberated by the least movement of the plants by animals or wind, and the spores, carried to their new prey, produce infection if conditions of moisture are present.

The effect upon the plant is serious. While the salable part of the plant is not attacked, the green part is largely decreased and its starch-forming power diminished, so that the amount of nutriment that can be stored away in the underground parts is lessened. This must result in diminished vigor and productiveness of such roots the following season.

The loss may range from 15 to 35 per cent of the crop the year after the first attack, while in three years the more susceptible varieties may be so nearly destroyed that the beds must be abandoned. In some states the invasion of this disease has almost, if not quite, prohibited commercial asparagus growing.

The rust is most injurious in light dry soil; irrigation is, therefore, beneficial. Dew has been found to favor the rust; therefore shaded, dewy localities should be shunned, as should also rows running at right angles to the prevailing winds. Clean culture methods, cutting and burning all tops in the fall, and destroying all wild asparagus aids in preventing the propagation of the rust.

The Palmetto varieties are quite resistant and offer a solution of the rust problem in some localities. In dry climates dusting with sulphur 150 to 200 pounds per acre about three weeks after cutting is finished and before the rust appears is beneficial.[1] It is best to sulphur early, and only when dew is present.

In regions subject to rain, where the sulphur treatment is not applicable, three sprayings with sulphur-soda soap are recommended: first in July, with other applications at intervals of three weeks. In New York three sprayings with Bordeaux mixture with resin added as an adhesive gave a gain of $132.75 per acre.[2]

Colletotrichose (*Colletotrichum sp.*). — This disease is known by its very numerous black acervuli borne in a blanched background upon the stem. It develops late in the season.

Leopard spot. — The asparagus leopard spot is strikingly suggestive of its name. It consists of long irregular spots, ashen in color, with dark borders. No treatment is known.

FIG. 87. — Anthracnose spots upon bean pods. After Stewart.

[1] Smith, R. E., Cal. Agr. Exp. Sta. Bul. 165, January, 1905.

[2] Sirrine, F. A., N.Y. (Geneva) Agr. Exp. Sta. Bul. 188, p. 251, & Bull. 189.

BEAN

Pod spot, anthracnose (*Colletotrichum lindemuthianum* (Sacc. & Magn.) B. & C.). — First described in 1878 in Germany, this disease is very widely known and is especially destructive. It develops so rapidly that beans delivered to the cars for shipment in apparently healthy condition may, upon arrival at their destination, be quite badly spotted. The loss is often 20 per cent, and occasionally is reported as total.

Upon the pods the disease appears as dark-colored spots, usually sunken, varying in size from 1–10 mm., or more if several spots coalesce. The border of the spot is often tinged with red, the center rust colored. Old pod spots overlying seeds within cause spots upon these seeds. The pod spots are much more noticeable and unsightly upon light-colored than upon green beans.

Upon the stems and leaves similar spots are found. They are especially noticeable upon young stems still blanched and upon the seed leaves. On older leaves they may be upon the veins, blackening and killing them and bringing death to the leaf. Leaves are thus often entirely cut off from the plant.

The wax varieties are especially susceptible, while the limas are quite resistant.

The fungus is carried to fields largely by diseased seeds, by beans bearing the spots above mentioned. Such seeds result in infected seedlings which serve as a multiplying ground for the fungus and result in its spread and general attack upon the field.

In fields where the disease is well established upon stems and leaves the damage is great in loss of starch-producing power through the destruction of green tissue. Still greater loss follows from the spread of the disease to the pods as

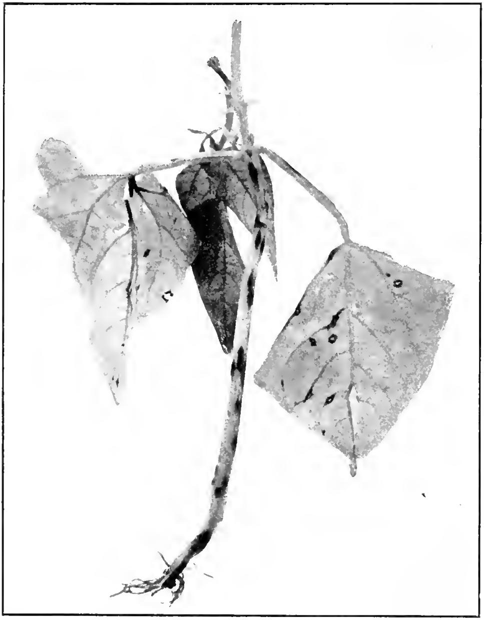


FIG. 88. — Bean anthracnose upon stem and leaves of young plants. After Whetzel.

they form, the unsightliness of the spotted pods greatly injuring their salability.

Since the spores are spread only when they are wet, handling or disturbing the vines in any way while the

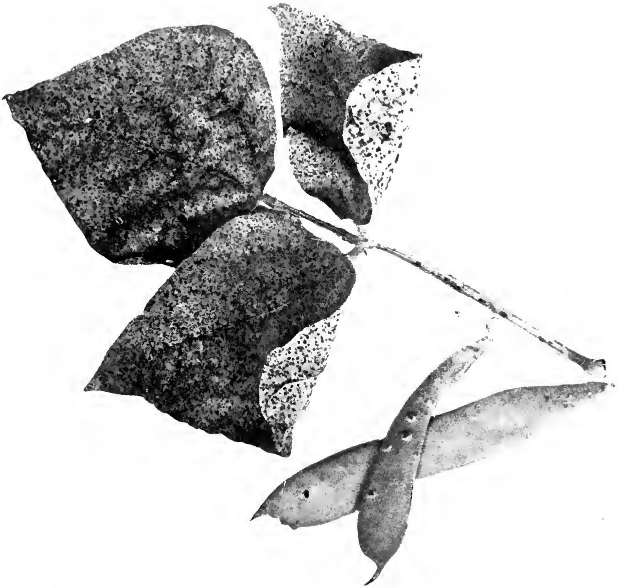


FIG. 89. — Bean rust upon leaf and pods; note the numerous sori upon both surfaces. After Beach.

dew or rain is still upon them should be avoided. Seeds already bearing the fungus, *i.e.*, spotted seeds, should never be planted, since they not only raise sick plants, but also carry the disease to the field to infect other plants. One infected seed in a thousand is enough to infect the field, and spraying is not effective[1] to check the spread of the disease after infection occurs. Since no effective remedy is at hand except the use of healthy seed, the greatest care should be given to this point. Home fall-grown seed known to be free from disease is preferable to seed of unknown origin that is perhaps diseased. If a few seeds known to be free from disease can be secured and multiplied in a special seed plot, they will give clean seed for future use. Treatment of the seed to kill the fungus is not yet upon a practicable basis. Clean culture, the removal from the field and destruction of diseased stalks and plant parts eliminates a source of spring infection which may be important.

Rust (*Uromyces appendiculatus* (Pers.) Link). — This rust may be recognized by its sori upon the leaves and occasionally upon other structures. The sori are at first blisters of pinhead size, covered by the epidermis of the plant. Later this covering ruptures and discloses a mass of spores the color of iron rust, or later in the season chestnut colored, which fall away in quantity, smudging the leaf and spreading the disease. The upper side of the leaf opposite a sorus usually shows a spot, pallid, yellowish, lacking in true leaf-green color. Sori are sometimes found upon the upper surface, but not so frequently as upon the lower.

The rust usually develops somewhat late in the season and is not so destructive as are many of the other bean troubles.

[1] Whetzel, H. H., N.Y. (Cornell) Agr. Exp. Sta. Bul. 255, May, 1908.

It is reported upon many species of true beans (Phaseolus) and upon related genera a Visgna, Falcata, Strophostyles. If the disease proves destructive, clean culture, the destruction of all wintering forms, is advisable.

Blight (*Pseudomonas phaseoli* E. F. Smith). — Beans of various kinds are subject to a blight which manifests

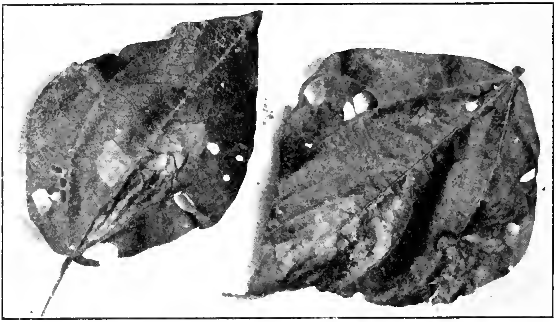


FIG. 90. — Bacteriosis of bean leaves. After Fulton.

itself upon the pod, leaf, or stem. It has been reported from various states, from Canada, is widely distributed, and often quite destructive. It was first observed by Beach[1] in New York.

Usually the leaves are the parts first attacked. Here large watery patches, brown in color, are produced. These spots later dry, become papery in texture, and rupture, leaving the foliage ragged and torn. After

[1] Beach, S. A., N.Y. (Geneva) Agr. Exp. Sta. Bul. 48, December, 1892.

the leaves, and from them the pods, soon become infected with watery, ulcer-like spots without definite boundary, similar to those upon the leaves, though often amber coated. Attack upon young pods kills them.

Fig. 91. — Bacteriosis of the bean. After Halstead.

This disease is carried over the season largely by infected seed and is conveyed from plant to plant in the field by insects.

Diseased seed and seed from fields bearing the disease should be avoided, and clean culture, including the burning of all infected plant parts, should be practiced. The following list shows the variation in resistance, the least susceptible being placed first and the most susceptible last: Schindler's

Round Pod Wax, Refugee Wax, Burpee's White Wax, Grenell's Rust-proof Golden Wax, Wardwell's Kidney Wax, Dwarf German Black Wax, Early Valentine.[1]

Stem rot, pod rot (*Rhizoctonia sp.*). — This disease is manifest in three forms:[2] —

1. Damping off of seedlings. See **damping off.**

2. Dry rot of the stem. In this condition the tissue is dead, discolored, and dry-rotted at from 2–5 cm. above the

FIG. 92. — Bacterial disease upon bean seeds. After Clinton.

ground. The rot extends to the pith and usually encircles the stem, and thus so weakens the plants that they are often broken by the wind. In any event they soon wilt and die.

3. As brown sunken areas upon pods, penetrating to and discoloring the seeds. The germination of the seed is not stopped by this attack, and a fruitful source of dissemination is thus afforded. Such seeds should be avoided.[3]

Downy mildew (*Phytophthora Phaseoli* Thaxt.). — The downy mildew is a northern disease regarded by Halsted[4]

[1] Duggar, B. M., and Stewart, F. C., N.Y. (Cornell) Agr. Exp. Sta. Bul. 186, January, 1901.

[2] Fulton, H. R., La. Agr. Exp. Sta. Bul. 101, January, 1908.

[3] Hedgcock, G. G., Sci. n. s. *19*, 268, February, 1904.

[4] Halsted, B. D., N.J. Agr. Exp. Sta. Bul. 151.

as the most serious disease of the lima bean. It was first observed by Thaxter in 1889.[1]

Upon the pods the disease appears as dense, woolly-white growths in irregular patches. These consist of myriads of the spore-bearing hyphæ of the causal fungus, laden with their spores.

The mildew also attacks young shoots, petioles, flower clusters and leaves, causing them to develop in dwarfed, imperfect fashion and destroying their value.

The spores are largely carried by nectar-seeking insects, as is shown by the abundance of flower infection. Spores are also carried by wind. Even in a season favorable to the development of the disease thorough use of Bordeaux mixture, three sprayings, will insure the crop. The destruction of infected trash is advisable.

Southern blight (*Sclerotium Rolfsii*, Sacc. in litt.). — The symptoms are wilting of the leaves, temporary recovery, yellowing, dying, and eventually dropping. The fungus usually attacks the plant just below the surface of the ground, invades the cambium, and destroys it. For further details see **pepper**.

Leaf blotch, cercosporose (*Cercospora cruenta* Sacc.). — This occurs only upon the foliage as brownish patches, causing the leaves to fall away. The spots are large, angular, and limited by the vines.

Leaf spot, isariopsose (*Isariopsis griseola* Sacc.). — This disease is chiefly limited to the foliage, producing small, angular spots, over the undersurface of which the fungus forms a gray, moldy covering.

Pod blight (*Phoma subcircinata* Ell. & Ev.). — Phomose

[1] Thaxter, R., Bot. Gaz. *14*, 273, November, 1889.

is destructive upon the lima bean, producing upon pods and leaves large, brown patches, with the pycnidia arranged in concentric circles. When the disease is very prevalent, the pods fail to mature their seeds.

Fig. 93. — Lima bean pods showing Phomose. After Halsted.

Spraying with Bordeaux mixture is recommended.

Powdery mildew (*Erysiphe polygoni* DC.). — The characters of the powdery mildews as described for the grape apply here sufficiently to serve for recognition purposes. This disease is not usually serious, and is amenable to treatment with flowers of sulphur or spraying with liver of sulphur.

BEET

Leaf spot (*Cercospora beticola* Sacc.). — This, one of the several leaf spots upon the beet, is very widespread in the eastern and middle states. Very few fields are entirely free from it. It occurs upon all varieties, but is especially injurious to the sugar beet.

The round, brownish, purple-bordered spots turn ashen in the center, and when mature, often become so thin and brittle as to drop out, leaving ragged holes. The sporiferous hyphæ may be seen with a good lens upon the spot centers.

These spots may destroy the greater part of the green tissue of the leaf and its value to the plant as a sugar producer, or even cause the leaves to die, in which event they blacken and remain standing nearly upright upon the crown. The death of the older leaves causes the crown to elongate, suggesting the name "pineapple disease." Dry weather followed by a damp spell most favors the disease.

Sprayed plants in New Jersey[1] gave a much cleaner foliage and yielded 480 pounds of root as against 380 pounds from the unsprayed plants from an equal area, a gain of nearly 26 per cent. The spray used was Bordeaux mixture, 5–5–50, applied first when the plants were six weeks old and subsequently at intervals of ten days for ten sprayings.

Root rot, rhizoctoniose (*Rhizoctonia betæ* Kühn). — Beets affected with this rot usually first show disease at the bases of the outer leaves, which turn black. The stalks weaken and allow the leaves to fall prostrate, though they do not lose their color at once. The disease thence passes into the crown, turning the attacked parts brown and later leading to cracking of the root. In this condition the mycelium of the fungus is clearly evident in the cracks. Eventually the whole top may rot off. The disease spreads rapidly from plant to plant in the field. Dry or cold weather may so retard the disease that the plant can recover if not too badly affected.

The disease is probably the same that has been destruc-

[1] Halsted, B. D., N.J. Agr. Exp. Sta. Bul. 107, p. 10, January 10, 1895.

tive to sugar beets in Germany. It has been reported from several places in the United States.

Air-slaked lime, 60 to 70 bushels per acre, has been recommended.

Scab (*Oospora scabies* Thaxt.). — This scab resembles closely the scab of the Irish potato and is caused by the same fungus.[1] It usually covers more completely the sur-

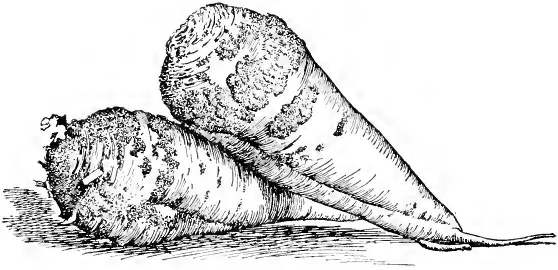


FIG. 94. Potato scab on beets.

face of the beet than in the case of the potato, and tends more to form corky growths upon the surface than to make deep cavities. Usually the corky growth takes a brown color which frequently penetrates to some depth into the beet.

Beets should not be grown upon land known to be infected with the potato scab or to have borne a badly infected crop of beets. See also **potato scab**.

Soft rot, bacteriose (*Bacterium teutlium* Met.). — Soft rot described by Metcalf[2] in 1904 is prevalent in Nebraska and in many other states where beets are grown.

[1] Bolley, H. L., N. Dak. Agr. Exp. Sta. Bul. 4, December, 1891.

[2] Metcalf, H., Neb. Agr. Exp. Sta. Rpt. 17, p. 69, 1904.

It consists of a rotting away of the lower portion of the root, the crown and leaves remaining normal except in the most severe cases, when the outer leaves may fall. The rotted portion is honeycombed with cavities which are filled with a viscous, colorless, sour-smelling fluid which exudes on pressure. The decayed tissue is usually yellowish gray. The rot seldom appears above the surface of the ground. Young beets are not susceptible.

The disease is favored by damp surroundings, as poorly drained soil. In some cases large damage is known to result, sometimes fully 90 per cent of the crop being affected.

It is inadvisable, if the disease is noted, to grow beets in wet soil.

Leaf spot (*Pseudomonas sp.*). — The leaves in this disease bear irregular, dark brown or black spots, 1 mm. to 3 cm. in diameter, chiefly upon the petiole, midrib, and larger veins. Occasionally the discoloration extends along a vein for some distance, and the tissue on either side becomes brown and dry.

The disease was first observed by Townsend in Utah and Colorado, and its bacterial origin was demonstrated by Nellie Brown.[1]

Rust (*Uromyces betæ* (Pers.) Kühn). — Rust has long been known in Europe, where it was studied as early as 1869. It is occasionally met in some of the western states. Though not serious, it has been reported as injuring the beet in market gardens in California. It is recognized by the characters of the true rusts, *i.e.* blister-like sori, consisting of pustules of spores under the skin. With the rupture of the skin the rusty pulverent mass of

[1] Brown, Nellie A., Sci. n. s. *29*, 915, June 4, 1909.

spores is uncovered. As in the case of the asparagus rust there are three stages, — spring, summer, and winter.

Removal of the leaves bearing the spring stage and spraying with Bordeaux mixture has been recommended. Affected leaves used as feed may carry the disease through the manure to plants of the following season.

Root rot, phomose (*Phoma betæ* Frank.).— Upon the roots a shrunken, coal-black discoloration, extending sometimes quite to the center, indicates the presence of this dry rot. No disagreeable odor attends the rot. Upon the affected surface pycnidia appear as very minute pustules. Upon the leaves this same fungus forms large circular dead spots.

All infected leaves should be removed from the roots before placing in storage.

White rust (*Albugo bliti* (Biv.) Ktz.). — The white rusts are in some aspects similar to the true rusts, but they are always white, never rusty or black in color. The sori are blister-like, as in the true rusts. The rupture of the epidermis releases masses of snow-white spores.

This disease is seldom of serious import, and no preventive measures have been recommended. Should it become troublesome, clean culture will be necessary. The same disease occurs upon the pigweeds (Amaranthus), which are botanically close kin to the beet.

Damping off. — Damping off of seedlings near the surface of the ground soon after they come up, often before thinning, is a frequent cause of loss. The leaves yellow, the roots turn brown, and the plants topple over and die. This is in some instances due to the usual causes of damping off, p. 60; sometimes to a heavy crust formed upon the soil, thus preventing the safe emergence of the seedling.

CABBAGE

Black rot (*Pseudomonas campestris* (Pamm.) E. F. Smith). — Not only does black rot destroy the crop of the year, but since its causal germ remains in the soil, it seriously endangers, if it does not quite prohibit, the subsequent use of the same field for susceptible crops. Its damage in a single season in two counties in Wisconsin was estimated at between $50,000 and $60,000. A large per cent of the damage to cabbage in storage is also attributable to this disease. Cabbage, kale, rape, broccali, kohlrabi, Brussels sprouts, collards, turnips, rutabagas, radish, black mustard, charlock, and other members of the cress family are affected.

FIG. 95. — Cabbage leaf showing an incipient stage of black rot. The disease, which enters at the ends of the veins, is progressing toward the base of the leaf. After Stewart and Harding.

It was first noted in 1895[1] in Wisconsin, and has since proved very disastrous in its effects in practically all sections of the United States.

The first sign of the disease appears upon the edges of the leaves as a blackening of the veins. The affected region

[1] Proc. Amer. Assoc. Adv. Sci. 1895, p. 93; cited in Wis. Agr. Exp. Sta. Bul. 65, p. 10, February, 1898.

rapidly enlarges, the blackening extending toward the stalk, and throughout the system of veins. Soon this blackening reaches the stem of the plant and proceeds up and down the stem, thus gaining entrance to other leaves, and finally reaching the entire plant. Usually many leaves are infected simultaneously. Affected leaves soon yellow and wilt, owing to the obstruction of the water channels, then dry, become parchment-like, and fall to the ground. General infection of the plant is followed by death. Other rots may supervene, giving offensive odors. If plants with the smallest amount of disease are placed in storage, the disease continues to develop, resulting in complete loss.

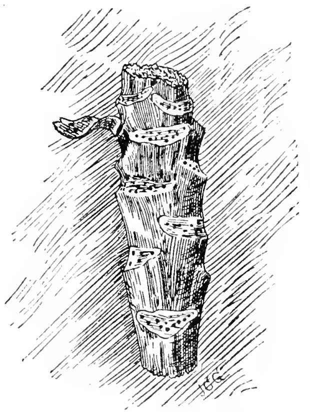


FIG. 96. — Portion of cabbage stem showing blackened veins. Redrawn after Russell.

Reliable diagnostic characters are the blackened vein areas of the leaf, blackened veins as seen in cross sections of the leaf stalk or of the stem of the plant.

Infection arises from the causal bacteria which are often present in the soil from preceding years. These bacteria gain access to the drops of water at the water pores on the leaf edge. Hence they enter the plant and parasitize it.

The bacteria may also travel upon seed from diseased localities, infect the young plants, and initiate an epidemic in a new locality. Diseased plants shipped across the country also carry infection.

The disease may be carried from field to field in any diseased plant part or in infected soil, upon tools, feet, etc., and especially in manure that has become infected by the use of diseased plants as cattle feed. To avoid carrying the disease to near-by fields all the precautions suggested under soil diseases must be employed.

It has as yet been impossible to kill the bacteria in the soil. The only recourse is such crop rotation as will avoid the planting of any susceptible crop upon infected soil for a period of several years. Just how long the bacteria can remain alive in the soil is not known. In practicing crop rotation for elimination of this pest all cruciferous weeds, mustard, shepherd's purse, etc., must be avoided, since they are susceptible and harbor the disease just as effectively as would cabbage.

Since the seed may bear the bacteria, it is well to soak them for fifteen minutes in corrosive sublimate one part, hydrochloric acid two parts, water one thousand parts, or in formalin one pound to thirty gallons of water, to kill these germs and thus avoid introducing the disease into new localities. If this had been done, many counties now so infected as to prohibit cabbage culture would still be free from this pest.

Club root (*Plasmodiophora brassicæ* Wor.). — Club root is widely known, very destructive, and easy of recognition. It consists of a greatly enlarged growth of the root, either the main root or the lateral roots, or both, as is shown in the accompanying figure. It cannot be confounded with any other disease unless it be that caused by eel worms (nematodes), and from this it may be easily distinguished by the greater magnitude of the club-root galls. These enlargments may be noted in the seed bed, though they are usually overlooked until they become larger in the field. They so diminish the vigor of the plant that it assumes a sickly appearance, ceases to develop, and fails to head. The affected parts usually succumb to offensive secondary rots, the causal organism is released, and the soil is thus infected.


Fig. 97. — Cabbage club root. Original.

The proof of the parasitic origin of this disease was made by Woronin in 1873, after three years of intensive study.

In general the precautions against its spread are those suggested under the general heading **soil diseases.** All diseased refuse is infective, as is also manure to which it has had access. Fields which are diseased remain so for several years; therefore rotation to nonsusceptible crops should be followed. Seedlings should be examined carefully to guard against the use of plants from an infected seed bed, and special care should be taken to avoid infecting the seed bed with soil, manure, or refuse. Air-slaked stone lime, 75 bushels per acre, applied each year some weeks before planting, has given beneficial results. In New York, where 90 bushels of shell lime were applied per acre, an excellent crop was grown, while upon untreated soil only 60 heads were cut from 472 plants.[1]

Club root occurs upon cabbage, kale, cauliflower, turnip, rutabaga, collards, Brussels sprouts, radish, stocks, candytuft, sweet alyssum, and upon wild cruciferous plants, shepherd's purse, peppergrass, pennycress, black mustard, charlock, false flax, hedge mustard.

Alternariose (*Alternaria Brassicæ* (Berk.) Sacc.). — This disease is described under **collard**. Upon the cabbage, particularly in the South, it is quite destructive, both in the field and in storage.

Sclerotiniose (*Sclerotinia Libertiana* Fckl.). — This malady is thoroughly discussed under **lettuce**. Upon the cabbage it may be recognized by the cotton-like mycelium and the black sclerotia which appear in advanced stages of disease.

A form of this rot is described by Hedgcock[2] as closely resembling black rot, except that it is more watery. Often, too, the petioles rot away at the base and the leaves droop. Sclerotia are often found.

Downy mildew (*Peronospora parasitica* (Pers.) DeBy.). — The downy mildew produces the characteristic downy patches of sporophores upon the lower surface of the leaves, much as is the case of the grape. Seen from above

[1] N.Y. (Geneva) Agr. Exp. Sta. Rpt. 14, p. 528.

[2] Hedgcock, G. G., Mo. Bot. Gard. Rpt. 16, p. 149, 1905.

the diseased spots are angular, limited by the veins, pale yellow, and the tissue is somewhat shrunken.

The disease is common to cabbage, collards, cauliflowers, turnips, radish, and many other numbers of the cress family. It has been reported in several states, notably Ohio, New Jersey, New York, Delaware, Maryland, South Carolina, North Carolina, West Virginia. Though it is seldom of importance in the field, it occasionally does damage in the seed bed.

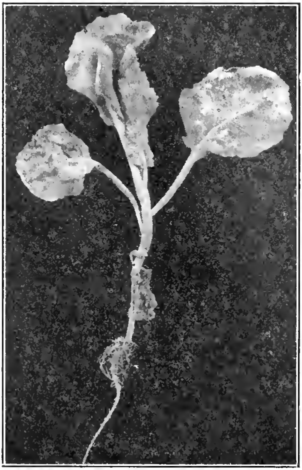


Fig. 98. — Seedling cabbage plant spotted with downy mildew. Original.

Spraying the seed bed with Bordeaux mixture will hold the disease in check. Diseased plants should be destroyed by fire as soon as the bed has been used.

Powdery mildew. See **turnip.**

Soft rot. See **cauliflower.**

White rust (*Albugo candida* (Pers.) Ktz.). — This white rust is similar in appearance to that described upon the beet. It has not often been reported as a pest.

Wilt, fusariose (*Fusarium sp.*). — This wilt of cabbage, commonly known in the South as yellow sides, is very destructive through a large territory, particularly in the Southern States, and at least as far north as Ohio.

The chief symptom is yellowing and falling of lower leaves, and eventually all of the leaves except those of the head. This character may be strongly emphasized upon one side or even upon one side of single leaves. Affected plants are retarded in growth and often die. After death abundant pink acervuli are seen.

In treatment the same methods should be followed that are suggested for cabbage black rot; especially should affected land be avoided, and the young plants grown in healthy soil.

CANTALOUPE AND MUSKMELON

Leaf blight (*Alternaria Brassicæ* (Berk.) Sacc. *var. nigrescens* Pegl). — The leaf blight and downy mildew are the most destructive diseases of the cantaloupe and muskmelon in this country. In Florida, in some seasons, nearly the whole commercial crop is lost. Much damage has been reported from Ohio, Indiana, and Colorado.

The leaf blight begins as small round brown spots usually marked by concentric rings. In the centers of these spots the hyphæ develop a moldlike growth. The spots enlarge to a centimeter or more, coalesce, dry, and cause the leaf to curl and shrivel at the margin. The petioles and veins are also affected. The ripening of the melons is hastened, but the quality is destroyed, the fruit becoming soft, wilted, insipid, and valueless.

If melons be repeatedly grown upon the same field, the disease increases year by year; hence rotation should be practiced, and resistant varieties should be used. A promising resistant variety has been reported by Blinn.[1] Spraying as recommended for cucurbs is effective.

Downy mildew (*Peronospora cubensis* B. & C.). — This disease is described under **cucumber**. It is widespread and constitutes one of the most serious cantaloupe diseases.

FIG. 99. — Cantaloupe showing complete death of vines attacked by leaf blight. After Blinn.

Wilt, fusariose (*Fusarium vasinfectum* Atk. *var. nivea* E. F. Smith). — Under **watermelon** this wilt is sufficiently discussed. It is not nearly so frequently met as the bacterial cantaloupe wilt. See below.

Wilt, bacillose (*Bacillus tracheiphilis* E. F. Smith). — With the cucumber and squash, as with the watermelon, the wilt is serious. The attack in first stages causes the

[1] Blinn, P. K., Col. Agr. Exp. Sta. Bul. 104, November, 1905.

vine to droop throughout its length. This is followed by death. The infection is spread by insects also through diseased soil.

The disease has been reported from many states, — among them Nebraska, Wisconsin, Maryland, Massachusetts, Indiana, — and is presumably present in many others.

FIG. 100. — The Pollock cantaloupe vines adjacent to those shown in Fig. 99, showing complete resistance to the leaf blight. After Blinn.

Spraying with Bordeaux mixture, while beneficial in retarding the development of other diseases, by repelling insects, also lessens the spread of this wilt. Diseased vines should be pulled and burned, rotation practiced, and in general the suggestions given under **soil diseases** should be followed.

Anthracnose (*Colletotrichum lagenarium* (Pass.) Ell. & Halst.). — This is a serious pest of the cantaloupe in many states. From 50 to 100 per cent damage was reported from Nebraska in 1905. The disease is discussed under **watermelon.**

Southern blight (*Sclerotium Rolfsii* Sacc. in litt.). — A large percentage of the cantaloupe crop in the southern-

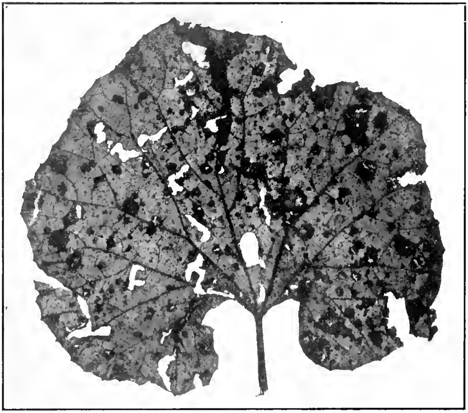


Fig. 101. — Leaf spotted with downy mildew. Original.

most states is often destroyed by this disease. It is particularly noticeable on fruit upon the side touching the ground, first as a slight rot, followed by a white fringe of fungous threads which soon surround the whole fruit. Later sclerotia appear as small round bodies, dirty white to dark brown. For further description and treatment, see **pepper.**

Powdery mildew (*Erysiphe polygoni* DC.). — This mildew of the cucumber and cantaloupe in general appearance resembles that described for the grape. It is more common under glass than in the open, and here indicates too much moisture and too little ventilation. It is seldom injurious in the field.

Flowers of sulphur applied to the hot water or steam pipes in the form of a paste is useful.

FIG. 102. — Sclerotium Rolfsii Sacc. in litt. growing upon a cantaloupe at point of contact with the soil. After Hume.

Leaf blight, cercosporose (*Cercospora Cucurbitæ* Ell. & Ev.). — The spots of this disease are much like those of alternariose, but are of lighter brown color and more angular form, being limited by the veins.

Bacillose, rot (*Bacillus melonis* Giddings). — This soft rot was described first by Giddings[1] as causing 25 per cent loss in certain fields in Vermont in 1907. The decay

[1] Giddings, N.J. Sci. n. s. *29*, 911, June 4, 1909; also Vt. Agr. Exp. Sta. Bul. 148, 1910.

usually begins on the lower side of the fruit, resulting in shrunken diseased areas over which the skin remains un-

FIG. 103. — Muskmelon 65 hours after inoculation with Giddings germ. After Giddings.

broken. The flesh near the infection point becomes completely decayed and has an offensive odor.

The cause is a bacillus which gains entrance through wounds, often through ruptures occasioned by excessively rapid growth.

Spraying with Bordeaux mixture is recommended; also turning the melons so as to expose all sides to light and air.

Fig. 104. — Portions of muskmelon vine showing pycnidia and perithecia of Mycosphærellà. After Dorsey.

Wilt (*Mycosphærella citrullina* (Sm.) Gr.). — This wilt seems to be rare, perhaps affecting to serious extent only greenhouse-grown cantaloupes. It is known upon watermelon in the field.

Infection is local at the nodes, never at internodes, and seems to originate at the leaf axil, perhaps due to retention at that point of the water necessary for germination of the spores. The edges of the infected areas are "oily green" in color, often with resin-colored, gummy exudate. The older parts are either darker and gummy, or dry and gray, and bear many brown pycnidia.

The fungus is not killed by winter or by fumigation with hydrocyanic acid gas. Spraying with Bordeaux mixture after the plants are about half grown, but before the dis-

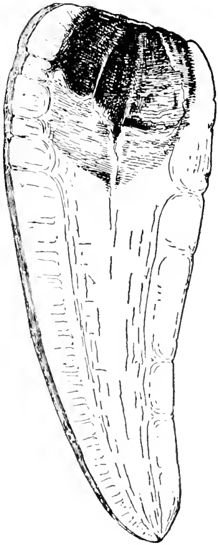


Fig. 105. — Carrot showing soft rot; shaded portions represent the rotted part of the root. Redrawn after Jones.

ease appears and often enough thereafter to cover growing parts, is recommended.[1]

Phyllostictose (*Phyllosticta cucurbitacearum* Sacc.). — This leaf spot has been destructive in several states, notably so in New Jersey and Ohio. The spots are light colored and the fungus appears as a pycnidium in their centers.

Cladosporiose. See **cucumber.**

CARROT

Soft rot, bacillose (*Bacillus carotovorus* Jones [2]). — In Vermont serious loss from rotting of carrots was reported to the Experiment Station in 1898. Investigation by Jones showed it to be due to bacteria and that numerous other crops, namely, turnip, rutabaga, radish, salsify, parsnip, onion, celery, hyacinth leaves, and the fruit of tomato, eggplant, and pepper were susceptible to the same disease. Cauliflower, Irish potato, sweet potato, beet, and asparagus were not susceptible.

[1] Grossenbacher, J. G., N.Y. (Geneva) Agr. Exp. Sta. Tech. Bul. 9, February, 1909.

[2] Jones, L. R., Vt. Agr. Exp. Sta. Rpt. *13*, 299, 1901; also N.Y. (Geneva) Agr. Exp. Sta. Tech. Bul. 11, 1910.

Rot begins in the field, but becomes serious during storage. The initial attack is either at the crown or root tip, from which points it proceeds rapidly through the core, which becomes softened and somewhat browned with a rather sharp boundary between diseased and healthy tissue.

Fields known to be infested should be relieved of susceptible crops by suitable rotation. Manure, which may have become infected in any way, *e.g.*, by feeding diseased crops to stock, should be avoided. Drying of the roots kills the causal organism, as does also exposure to sunlight. Drying in the light is therefore equivalent to surface disinfection and serves to reduce the damage. Storage below 10° C. (50° F.) gives best results.

CAULIFLOWER

Black rot, pseudomonose (*Pseudomonas campestris* (Pamm.) E. F. Smith). — This disease affects the cauliflower in much the same way as it does the cabbage. Local infection in the head often produces the effect shown in Fig. 106. For discussion of symptoms and treatment, see **cabbage**.

Sclerotiniose. See **cabbage.**

Soft rot, bacillose (*Bacillus oleracea* Harr.). — A soft rot affecting cauliflower, cabbage, and turnips, and in some cases destroying as much as 64 per cent of the crop, is described by Harrison.[1] The disease may be identical with the soft rot of carrot.[2]

[1] Harrison, F. C., Ont. A. C. & E. F. Bul. 137, August, 1904.

[2] Harding, H. A., Jones, L. R., and Morse, W. J., N.Y. (Geneva) Agr. Exp. Sta. Tech. Bul. 11, 1910.

CELERY

Leaf spot, early blight, cercosporose (*Cercospora Apii* Fr.). — The leaf spot is common in both Europe and America, constituting probably the most destructive disease to which the celery plant is subject. It is known from

Fig. 106. — Cauliflower affected with black rot. (Pseudomonose). Original.

Colorado to New Jersey. In Florida in 1906 it is said to have injured 80 per cent of the crop. The crop is largely reduced, and the unsightliness of the spots injures the salability of the product.

The spots appear first upon the outer, older leaves as pale yellowish regions, showing from both sides of the leaf. They are irregular with slightly raised border and are angular in outline, owing to their limitation by the veins. They seldom exceed 3–6 mm. in diameter unless by the coalescence of several spots. The spots soon become brown, and the central part turns ashen-white and is seen by the

FIG. 107. — Cercosporose of celery. Original.

aid of a hand lens to bear numerous hyphæ. The leaves may bear so many spots as to appear as though scorched, and often death results to the entire plant.

The disease spreads most rapidly in damp warm weather.

Marked difference in varietal resistance was reported by Tracy[1] as early as 1885, the Boston Market and Golden

[1] See Lamson-Scribner, F., U.S. Dept. Agr. Rpt. for 1886, p. 117.

Heart suffering much, while the White Plume was but slightly injured.

All plants showing a trace of disease should be rejected. Healthy plants from infected lots may with advantage be dipped in Bordeaux mixture to cleanse them of adhering spores. Spraying with ammoniacal copper carbonate or Bordeaux mixture is effective. Treatment should be begun before the disease appears, *i.e.*, in the seed bed, and continued at ten-day to fourteen-day intervals, throughout the growing period. All spore-bearing refuse should be burned.

Leaf spot, late blight, septoriose (*Septoria Petroselini* Desm. *var. Apii* Br. & Cav.). — In Italy late blight was first reported in 1890; in the United States in 1891. A loss of 1950 carloads and a money loss of $550,000 was estimated in California in 1908.

In its beginning it consists of leaf spots very like those of the last disease, though more irregular and indefinite in boundary. In later stages, the infection of the leaf becomes general, numerous black pycnidia are scattered upon all parts of the leaf and even upon the blanched petioles, which through their unsightliness injure the salability of the crop. In extreme cases wilting of the leaves and destruction of the plant follows. After the celery is put in storage the disease may still progress and do great damage, rotting off the leaves and forcing early marketing. This disease is often found in the seed bed, and is probably carried by the seed, since the pycnidia are abundant upon the seeding stalks and fruit. If the disease has been troublesome in preceding years, the plants in the seed bed should be sprayed with Bordeaux mixture as soon as they are above ground, and once or twice a week thereafter until transplanted. If the disease develops in the field, the crop should be sprayed with Bordeaux mixture at ten-day intervals.

To minimize loss during storage no diseased plants should be stored. If storage is imperative, badly infested leaves should be picked off, and in extreme cases the plants should be dipped in a fungicide (ammoniacal copper carbonate) before they are stored away.

Leaf spot, phyllostictose (*Phyllosticta Apii* Halst.). — This leaf spot begins as a dull brown patch and never becomes the light ashen color of the cercosporose spot. The spots, too, are not angular, as in the latter disease, and are fewer in number and larger. They usually begin at the leaf edge. In older spots pycnidia are apparent.

Center blight, soft rot (*Bacteria*). — A soft, light brown rot of the central bud, sometimes of the leaf or leaf stalks, is characteristic of a disease which is probably bacterial; possibly nearly related to the carrot soft rot.

Rust (*Puccinia bullata* (Pers.) Wint.). — This true rust has not yet been destructive in America. It may be recognized from its sori, which resemble those of the asparagus rust.

Damping off due to Sclerotinia (see **lettuce**), Rhizoctonia (see p. 61), and Fusarium have caused much loss in the South. See also p. 63.

COLLARD

Black rot. See **cabbage.**

Wilt, bacillose. See **cabbage.**

Club root. See **cabbage.**

Downy mildew. See **cabbage.**

Black mold (*Alternaria Brassicæ* (Berk.) Sacc.). — The affected spots are nearly black, marked concentrically, are circular, and are not definitely bordered, *i.e.*, they shade off gradually into the surrounding healthy tissue.

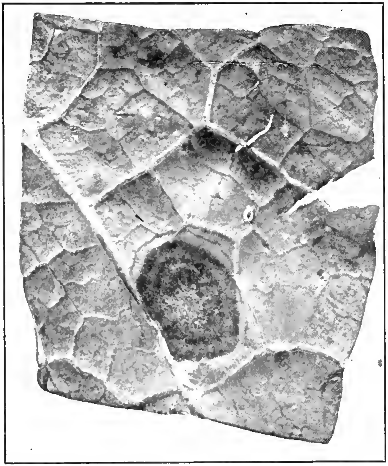


FIG. 108. — Collard black mold as seen from upper side of the leaf. Original.

They enlarge sometimes to 2–3 cm. in diameter. The tissue dries, becomes brittle, and often falls away, leaving ragged holes.

The general appearance of the spot as seen from above is pale green; as seen from the lower surface, shown in Fig. 108, it is densely black, strongly contrasting with the white spots of the downy mildew which may occur in association with this disease. The damage may be very great, in many instances resulting in the death of the plants or complete loss of their usefulness.

CUCUMBER

Downy mildew (*Pseudoperonospora cubensis* B. & C.) Rosten. — This downy mildew first shows its presence by yellowish angular spots 3–6 mm. in diameter upon the leaves as seen from above. These appear first upon the older leaves at the center of the plant. The spots become more distinct, enlarge, increase in number, and soon the whole leaf becomes pale, sickly, and dies. If the weather is moist, the characteristic white hyphæ and spores tinged with purple may be seen on the undersides of the older spots. The disease progresses to the younger leaves, slowly in dry or cool weather, but very rapidly in warm, wet weather. The field is soon reduced to a mass of dry dead leaves.

The mildew was first described in 1868 from Cuba. In 1889 it suddenly attracted attention in the United States (New Jersey, Florida, and Texas) and in Japan. Since that time it has been destructive in many states. The loss in Wayne County, Ohio, alone was estimated at $45,000 in one season.

It grows upon cantaloupes and cucumbers in most destructive form and is injurious to squashes, pumpkins, watermelon, gourds, and other cucurbs. The fungus winters out of doors in the South and in the greenhouse in the North and spreads thence to the fields annually if weather conditions are favorable.

This disease is often injurious to cucumbers under glass as well as in the field. It is well to sulphur the greenhouses thoroughly when empty and to clean and whitewash

FIG. 109. — Spots of downy mildew upon cucumber leaf. After Orton.

all walls and wood in order to kill any fungi present. Should the disease appear, spray at once as in field practice. For direction for field spraying see cucurb spraying.

Anthracnose (*Colletotrichum lagenarium* (Pers.) Ell. & Halst.).— Upon the cucumber leaf this disease makes circular, not angular, spots which, instead of yellowing, turn brown, die, and often tear. Upon the stems it forms elongated light brown spots, and on the fruit sunken spots much like those upon the watermelon. Twenty-five to sixty per cent injury has been estimated in New Jersey, and $10,000 to $15,000 damage has been reported from a single county in Nebraska. This disease is more fully described under **watermelon.**

It is especially bad under glass. The treatment is as for the downy mildew, see above. In the field, spraying has proved effective.

Wilt, bacillose. See **cantaloupe.**

Wilt, fusariose. See **watermelon.**

Phyllostictose. See **cantaloupe.**

Cercosporose. See **cantaloupe.**

Sclerotiniose, timber rot (*Sclerotonia Libertiana* Fckl.). — Upon cucumbers under glass this disease occasions serious loss. It is rare out of doors. The first indication of the disease is the appearance of a dense mass of white mycelium near the nodes of the stem which is still green. As the disease progresses the stem shrinks and yellows, the softer parts decay, and the stem finally dries up. In the interior of sick stems the white mycelium may also be found, and later near the nodes smooth, slender, black sclerotia. Sclerotia are also sometimes found on the exterior of the stem in the mycelial masses. The germination of the sclerotia, described under lettuce sclerotiniose, results in immense numbers of spores. These falling upon dead cucumber tissues grow upon it and form a mycelium which attains such vigor as to enable it to attack healthy tissue and rapidly destroy it.

To control this disease all infected plants should be destroyed by fire before they have had opportunity to form sclerotia, and the place from which they are taken sprayed with a heavy application of some fungicide.

Damping off. See p. 60.

Powdery mildew (*Erysiphe polygoni* DC.). — This mildew has the general characteristics of the powdery mildews, a whitish flourlike coating upon the leaves and stems; at first in circular spots, but later diffuse. Its presence in America was first announced by Humphrey.[1] It has since been frequently reported in the field and occasionally under glass. The fungus appears chiefly upon the upper surfaces and is most developed upon the older leaves. It renders the fruits bitter and distorts them.

The disease is not usually serious. If it is so under glass, the treatment suggested under cantaloupe will be found effective.

Leaf blight, fruit spot (*Cladosporium cucumerinum* Ell. & Arth.). — This spotting of the fruit was first noted at Geneva, N.Y., in 1887,[2] where it was so abundant as to ruin the crop for pickling. In 1905–1906 in Wisconsin it caused abandonment of several pickle factories.

The spots begin when the fruit is only 2–5 cm. long, as gray, slightly sunken places with minutely velvety surfaces. They are about 3 mm. in diameter, but coalesce into irregular patches, particularly toward the flower end. As the spots age they darken to greenish black, and a gummy exudate often appears.

Upon leaves where injury is more rare than upon the

[1] Humphrey, J. E., Mass. Agr. Exp. Sta. Rpt. 9, p. 222, 1892.

[2] Arthur, J. C., N.Y. (Geneva) Agr. Exp. Sta. Rpt. 316, 1887.

fruit the spots are at first watery and translucent; later the leaf wilts, and is soon reduced to a rotten mass. The disease progresses so fast that a plant may be practically destroyed in a few days. Immediate and thorough spraying may be of service.

Acremoniose (*Acremonium*[1] *sp.*). — In this disease shoots are stunted, fruits deformed, and leaves yellowed and killed. Upon the lower leaf surfaces a delicate white, glossy film like dried albumen is seen. This is in reality a web of fungous threads. Plants that are attacked may put forth new vigorous shoots to survive for a time, then die. The disease has been known to reduce the yield 90 per cent. No treatment has been advocated.

Cucurb Spraying[2]

Planting should be at such distance as to facilitate machine spraying; that is, relatively close in the row, but with the rows wider apart than is usual in most sections of the country. In cultivating, the vines should be induced to spread along the row, and by the use of a vine turner a one-foot open alley should be maintained throughout the season for the wheels of the sprayer.

Geared sprayers with proper length of axles to cover one row may be used, and three rows may be sprayed at one time. Particular attention must be given to reaching the undersides of the leaves with the spray. Spray first when the vines begin to run, using Bordeaux mixture

[1] Humphrey, J. E., Mass. Agr. Exp. Sta. Rpt., pp. 227–228, January, 1892.

[2] Orton, W. A., U.S. Dept. Agr. Farmers' Bul. 231, 1908.

3–6–50. For subsequent sprayings use 4–4–50 Bordeaux at intervals of about ten days if the weather is dry; oftener, if growth is rapid.

The cost of six applications is placed at $5.22 per acre, including labor. The net profits from this have been as high as $163.50 per acre.

EGG PLANT

Wilt, bacillose (*Bacillus solanacearum* E. F. Smith). — This disease is closely like the wilt described for the tobacco, and the remarks made in that connection concerning cause, spread, and treatment apply to this crop plant as well.

Wilt, nectriose (*Nectria Ipomœæ* Halst.). — Unlike so many diseases there is no leaf or fruit spot whatever, though whole fields have been so badly attacked that scarcely a fruit was gathered. The affected plants when half grown take on a yellowish, sickly appearance, the foliage wilts, the lower part of the stem becomes coated with a whitish mold, and the plant usually dies. Numerous small pink perithecia are found upon the stem just below, or at the surface of the ground.

This disease is close kin to the wilt of cotton, and most that is said there regarding treatment applies here.

Damping off (*Pythium DeBaryanum* Hesse, and *Phoma Solani* Halst.). See p. 61.

Leaf spot, phyllostictose (*Phyllosticta hortorum* Speg.). — Plants in the hotbed are subject to leaf-spot attack, the transplants dying, or it may appear later upon leaves and fruit and result only in more or less serious leaf spots.

Upon the leaf large irregular brown or gray patches are produced. Here numerous black pycnidia appear, and later the leaf becomes torn. Upon the fruit are large sunken spots of similar appearance.

Treatment with Bordeaux mixture or ammoniacal copper carbonate before transplanting is recommended, followed by similar spraying in the field. Eight sprayings with Bordeaux mixture in one test yielded 100 fruits, while a similar plat but unsprayed gave only about half as many. Clean culture should be followed.

Gray mold (*Botrytis fascicularis* (Cda.) Sacc.). — In this rot the purple fruits assume a tan color in blotches, followed by softening of the tissue and rapid development of a gray mold; the fruit in the meantime changing into a completely rotten mass.

Anthracnose, glœosporiose (*Glœosporium melongenæ* Ell. & Halst.). — Pits appear upon the fruits, and in these the pink-tinted acervuli.

Blue mold (*Penicillium sp.*). — This rot is very similar to blue mold of apples.

Leaf spot, ascochytose (*Ascochyta Lycopersici* Brun.). — This leaf spot is very similar to that of phyllostictose.

GINSENG

Blight, alternariose (*Alternaria panax* Whet.[1]). — Brown cankers upon the stem and watery spots in the leaf, often involving the entire top of the plant, mark this disease. Badly blighted plants appear as if drenched with boiling water.

It is a serious menace to the ginseng industry of New York State, often causing the leaflets of entire beds to be

[1] Whetzel, H. H., Sci. n. s. *29*, 912, June 4, 1909.

spotted, depleting the vigor and productiveness of the plants. The seed crop is sometimes completely lost. It can be controlled by thorough spraying. Use copper sulphate, 1 pound to 10 gallons, before the plants come up, thoroughly soaking the soil; then Bordeaux mixture 5–4–50 as soon as the plants come up, and repeat every other day during the first few weeks, less often later. The mixture will adhere better if 2 pounds resin, 1 pound sal soda, and 1 gallon of water, boiled together until clear brown in color, be added.

Wilt, fusariose (*Fusarium vesinfectum* Atk.). — The most disastrous ginseng disease in the West is the wilt described by Reed,[1] which caused destruction, in Missouri, of whole plantations in a single week. With the first symptom of attack the leaflets droop, yellow, and die; then the entire leaf dies to the base, drys up, and falls off. The immature seeds shrivel and fail to mature. The dead, black stem alone remains standing. The roots are not killed, but the season's growth is ended, and the buds to produce the next season's growth are dwarfed. Secondary decays, soft rots, may follow.

The cause of this disease is said to be the same as that of the watermelon wilt, and remarks made in that connection as to its habits, spread, etc., apply here also.

It is claimed that the wilt fungus cannot attack ginseng plants unless they are previously weakened by the inroads of some other parasite. Prevention of other diseases therefore renders the wilt harmless. Thorough spraying for all diseases affecting this crop is thus doubly important. Diseased plants should be removed and burned.

[1] Reed, H. S., Mo. Agr. Exp. Sta. Bul. 69.

Stem anthracnose (*Vermicularia Dematium* (Pers.) Fr.). — Numerous black scars appear on the stems a few weeks after the plants come above ground. These spread and sometimes encircle the stems. The leaflets then brown. Often the plants fall over, even before they wilt.

Since the plants are not killed but usually recover, the greatest loss lies in the destruction of the seed crop.

Bordeaux mixture applied about three weeks after the plants appear in the spring and each three weeks thereafter, until August, more often if the season is wet, will control the disease. All dead stalks, leaves, etc., should be collected and burned in the fall.

Wilt, acrostalagmose (*Acrostalagmus albus* Preuss.). — This wilt is due to stoppage of the veins by fungous growth, and the chief symptom is wilting of the leaves, followed by death of the stem and leaves. Sections of the rootstock reveal a yellowing of the water ducts and veins, which contrasts strongly with the normal white of a healthy plant. This unnatural coloration of the veins may also be seen upon stripping the bark from the root lengthwise.

The disease is largely confined to the older, less vigorous roots. It is advisable to remove and dry the infected roots and to replace the soil of infected beds with new, healthy soil. Soil disinfection should be employed if practicable.

Black rot (*Sclerotium sp.*). — Black, warty growths (sclerotia) upon the rhizome indicate sclerotiose. The roots are very black, but upon drying, bleach somewhat. In old age this blackening may extend to the center of the root, which becomes wet, spongy, and pliable. The disease remains in the soil some years after infection. Sick roots should be removed, and burned if not marketable. Treat also as for wilt.

Soft rot. — This rot occurs widely and causes large loss, placing it among the worst ginseng diseases. The root decays rapidly, is sticky and ill smelling. The leaves color red and yellow and soon die.

Damping off (*Rhizoctonia*, etc.). — Damping off is largely avoided by thorough ventilation, and the avoidance of excess of moisture in soil and air. Stirring the soil to hasten drying aids. See p. 61.

Leaf anthracnose, pestalozziose (*Pestalozzia funerea*, Desm.). — A disease more destructive to young plants than to older ones is pestalozziose,[1] which appears as a black, velvety growth at the bases of the leaves and flower stalks, causing them to die and fall off.

Spray as for alternariose.

End rot, fiber rot (*Thielavia basicola* (B. & Br.) Zopf.).— This is especially bad upon seedlings, resulting in sudden wilting, which causes them to bend over and dry up. The fine roots are affected as are the roots of tobacco.

GOLDENSEAL (*Hydrastis*)

Blight (*Alternaria sp.*). — Spots occur upon the leaves The disease seems to be identical with that of ginseng.

HOP

Powdery mildew (*Sphærotheca Humuli* (DC.) Burr.). — This powdery mildew, while serious in many parts of Europe, has been seen but rarely on the hop in America, and has never been reported as seriously injurious. It is recognized

[1] Reed, H. S., Mo. Agr. Exp. Sta. Bul. 69, October, 1905.

by the usual characters of the powdery mildews. See **grape.** If it should become troublesome, spraying with Bordeaux mixture or ammoniacal copper carbonate must be practiced.

Cylindrosporiose (*Cylindrosporium Humuli* Ell. & Ev.). — Small, rusty brown, angular leaf spots largely limited by the veins are present. They show most clearly upon the lower sides of the leaves. Minute black acervuli are present.

The disease has been reported from several states, but has not been regarded as serious.

HORSE-RADISH

Leaf blight, septoriose (*Septoria Armoraciæ* Sacc.). — Ruin is occasionally brought to a crop by this disease, which is nearly always present to some extent. The leaves bear numerous circular spots, blanched in the center and pale yellow at their borders. Pycnidia are borne in the centers of the spots. Badly affected leaves turn yellow and become filled with holes caused by the dropping of the dead tissue of the spots.

Ramulariose (*Ramularia Armoraciæ* Fckl.). — This spot is much like the septoriose except that no pycnidia are present.

Black mold, macrosporiose (*Macrosporium herculeum* E. & M.). — In late summer the leaf spots of this disease are often abundant. They are circular, blanched, and later coated with a black mold. The injury does not warrant treatment.

White rust (*Albugo candida* (Pers.) Ktze.). — The disease is the same as that upon cabbage. It is often present upon horse-radish, but does not usually become serious.

Leaf spot, cercosporose (*Cercospora Armoraciæ* Sacc.). — This spot is much like that of ramulariose.

LETTUCE

Sclerotiniose, drop, wilt (*Sclerotinia Libertiana* Fckl.). — The disease begins with wilting of the outer lower leaves,

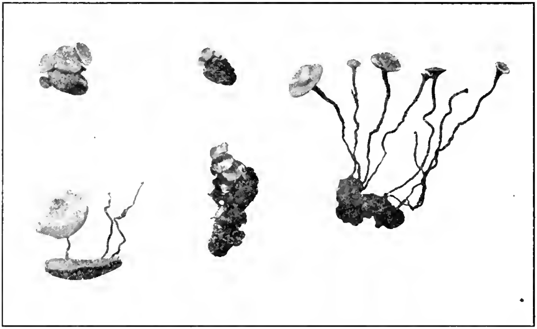


FIG. 110. — Sclerotia of Sclerotinia from lettuce germinating.

which droop and fall flat upon the ground; a similar fate rapidly overtakes the inner leaves, and so on over the whole plant, until within a few days the entire plant is dead, lying flat upon the ground, appearing much as though scalded by a dash of hot water. The disease progresses with wonderful rapidity, the plants appearing to die in a day.

Upon the undersides and at the bases of the leaves occur, at this time, dense, cotton-like growths of mycelium, and in later stages small black, irregular bodies, the sclerotia, which vary from 3–10 mm. long, somewhat less in thickness. The sclerotia and the mycelium are unmistakable signs of this disease.

Sclerotiniose was first definitely recognized in America in 1900, though it doubtless did much damage before then. It has since then followed the rapidly extending lettuce industry into many states and is particularly destructive in the South Atlantic seaboard states from Virginia to Florida, where its inroads upon the crop grown under cover are especially damaging. The causal fungus may persist from year to year as sclerotia in beds once infected, — beds costing originally often $1000 per acre, — and thus destroy their value for lettuce culture. The damage is thus much more than injury wrought merely to the present crop.

The fungus passes from one season to the next, as the sclerotia which, favorably situated, are capable of germination, each producing several trumpet-shaped organs, Fig. 110, with stems about 15 mm. long and disks 3–8 mm. or less in diameter. Spores capable of initiating the fungous growth upon dead or sick lettuce tissue issue in great numbers from these disks, and from material thus infected the fungus can make its way into the healthy lettuce plant.

If all infected plants be pulled and burned as soon as the first indication of disease is observed, the formation of sclerotia will be prevented. As an additional precaution it is well to spray the locus of the diseased plant thoroughly with Bordeaux mixture or bluestone solution.

A few years of such procedure will much reduce the infection or perhaps eliminate it entirely. All lettuce trash should be removed from the beds, since it serves as the initial point of attack for the fungus. Those who are free from the disease should guard against its introduction upon diseased refuse in any form. Compost which may be contaminated with lettuce refuse bearing this disease should be avoided. Those growing lettuce under glass have found soil disinfection effective and practicable.

Damping off. See p. 60.

Gray mold (*Botrytis cinerea* Pers.). — Gray mold is essentially a leaf disease, beginning usually at the leaf edges, and there causing wilted, flaccid patches which soon become coated with a straw-colored downy fuzz, the sporiferous hyphæ. The whole leaf, usually an outer one, may droop and die.

Weak plants may succumb entirely to such attack, the disease passing slowly from the outer leaves toward the central ones. In all cases the affected parts after death become coated with the dirty fuzzy down characteristic of the disease. This disease may be distinguished from sclerotiniose by the absence of the white mycelium and sclerotia, and by the presence of the gray, dirty, botrytis growth which does not belong to sclerotiniose. The two diseases, while often occurring separate, may both infect the same beds or the same plants. Botryose may also cause damping off.

High temperature, lack of ventilation, and lack of vigor in the plant, resulting from improper care, are essentials to attacks of botryose. If these be avoided, this disease will do no serious harm.

Rosette (*Rhizoctonia sp.*). — A moist rot sets in first upon portions of leaves which touch the ground, and spreads thence throughout the leaves, rotting away the blades but leaving the midribs standing,[1] thus distinguishing this from all other diseases. Infection proceeds from leaf to leaf at point of contact, often reaching the center of the head, while the outer leaves are infected only in spots. The inner leaves may all be reduced to a slimy mass though the outer leaves still remain, surrounding it as a rosette.

Downy mildew (*Bremia Lactucæ* Regel). — This occasionally destructive mildew shows the character of the downy mildews, *i.e.*, downy fuzz below, yellow spots above (see **grape**). It has been reported from Massachusetts as causing much loss to lettuce under glass, especially upon the older leaves. It is also noted upon old leaves on seed plants of both cultivated and wild lettuce.

Close attention to proper cultural conditions in the greenhouse, especially as to moisture, ventilation, and temperature, usually suffice to hold it in check. Evaporated sulphur also aids in suppressing the mildew.

Soft rot (*Bacteria*). — Several different diseases due to bacteria occur upon this host. Notable among them is a soft rot of the head and a hollowing of the stems. Peculiar translucent watery spots upon the leaf are also caused by bacteria.

These diseases have not yet been fully studied nor treatments suggested.

Leaf perforation, anthracnose (*Marsonia perforans* Ell. & Ev.). — The most conspicuous character is the perforation resulting from the fall of the tissue killed by the attacking

[1] Stone, Geo. E., and Smith, R. E., Mass. Agr. Exp. Sta. Bul. 69, September, 1900.

fungus. These perforations are from 1–2 mm., or more, in diameter, with irregular borders. Upon the midrib and petiole depressed spots result. With small young leaves distortion is produced, especially at the apex. The disease appears to be limited to greenhouses and to be spread largely by watering.

It was first described by Selby[1] in Ohio in 1896 and has since been noted in other states.

Blight, septoriose (*Septoria lactucæ* Pass.) and (*Septoria consimilis* E. & M.). — Upon the old outer head leaves there often appear very numerous, black pycnidia, so small as to remain unnoticed unless by special search. The injury is usually insignificant, though some dwarfing and curling of the leaf results. Upon seed plants these same diseases attack the leaves with greater vigor, causing pale brown, discolored areas and the death of the older leaves. Sometimes, through neglect to destroy plants of the seed bed, these diseases may gain such foothold as to cause injury in other beds. This can usually be avoided by destruction of the seed-bed plants as soon as transplanting is over.

The diseases are not usually troublesome until late in the season. The Trianon, Wonderful, and Salamander varieties are very susceptible. The Boston is quite resistant.

MUSHROOMS

Mycogonose (*Mycogone perniciosa* Magn.). — Though noted in Germany as early as 1887 by Magnus, this disease was not called to attention in America[2] until March, 1909.

[1] Selby, A. D., Ohio Agr. Exp. Sta. Bul. 73, December, 1896.

[2] Mrs. Flora W. Patterson, Am. Photopath. Soc., 1st annual meeting, Boston, Mass., December 31, 1909.

French experts detect the disease first in the spawn as an abnormal, white, fluffy growth. Later the mycelium of the mushroom fails to develop normally, but instead produces monstrous soft growths. Whole clumps develop into moldy masses, which soon putrify with disagreeable odor.

Infected beds or houses may be abandoned or cleaned thoroughly, then sprayed once or twice with a $2\frac{1}{2}$ per cent solution of lysol in water, or with copper sulphate, 1 pound to 15 gallons.

MUSKMELON

See **canteloupe.**

ONION

Smut (*Urocystis Cepulæ* Frost). — As with the wilt of tobacco and cotton, this disease resides in the soil and is therefore destructive not only to the present crop, but is also prohibitive of successful culture of susceptible crops in the future.

The smut, which seems to have originated upon a wild variety of onion, occurs in both Europe and America. It was known in Connecticut as early as 1860, Massachusetts, Pennsylvania, and Ohio in 1889, later in New York, New Jersey, and Delaware, and has since been recorded from Iowa and Georgia. The first mention of serious loss by onion smut in America was in 1870. Its inroads upon the crop are often such as to prohibit profitable onion culture unless preventive measures are taken against the disease.

The smut attacks the very young seedlings through the still tender, delicate leaf sheaths. Onions grown from sets are immune, and onions from seed, if they pass the very young state without infection, are so protected by hardening of the outer plant parts that no infection is

Fig. 111. — Young onion plants showing effect of smut; at left smutted plants, at right healthy plants same age. After Hinman.

likely to result, even if the bulb be surrounded by thoroughly infested soil.

Upon the infected seedling's leaves dark opaque spots may be noted, especially upon holding the leaves against the light. The portions of the leaf above such spots soon die, and the spots rupture, exposing sooty, powdery masses. Badly infected seedlings succumb early, while others may survive until harvest. The disease is more fatal if attended by dry weather, which reduces the vigor of the host plant. Plants surviving the disease show smut in the outer leaves, often also within. Diseased bulbs dry up and rot. In handling they may be readily distinguished from sound bulbs.

The spores are liberated in abundance in the soil, where they remain alive for many years. There is no record of soil once smutted having become free of the smut. The disease may be carried to adjacent fields by insects, also by the means suggested under soil diseases. There is little or no danger of disease carriage by the seed.

Since onion sets are immune, the effects of the smut can be avoided by sowing seed in soil that is free of disease and then transplanting into the field. With this mode of onion culture the only difficulty is to secure plats free from infection, and this is not often a serious one. In extreme cases disinfection of the soil in plats may be resorted to. (See **soil disinfection,** p. 54.) On farms once infested all refuse (screenings, tops of infected sets,) should be collected and burned to reduce the amount of spores. Where soil known to be infected is to be planted, formalin[1] (1 pound in 25 to 33 gallons of water) should be used and applied with a drip attachment on a seed drill at the rate of 500 to 700 gallons of solution for each acre for

[1] Selby, A. D., Ohio Agr. Exp. Sta. Bul. 131, p. 51.

onion set seeding (about one fifth to one fourth as much for field onions); or it may be applied with a sprinkler so as to well moisten the scattered seeds, which should then be covered promptly with earth.

Ground quicklime or stone lime, better the former, applied at the rate of 75 to 125 bushels per acre on the freshly prepared soil just before seeding, has been useful. If applied by drill, harrowing will not be required; if broadcast, harrowing should precede planting.

These methods used separately or combined are sufficiently established to warrant general use on smutted soils devoted to onions.

Downy mildew, blight (*Peronospora schleideni* Ung.). — Close kin to the disastrous blight of potatoes, this disease partakes of many of its characters, particularly in the rapidity of its spread through an infected field. It may first be noted on a small area of the field in which the tips appear as though dashed with scalding water. Often under favorable climatic conditions the affected areas increase manyfold in a single night, carrying complete destruction.

It was first described in 1841 by Berkeley as "common and destructive," and has been long known to onion growers in this country, in Europe, and in Bermuda. In the latter place it was so injurious that the legislature applied to the mother country for investigation and aid. The first reference to it in the United States was in 1872. It is now known from coast to coast.

The blight was described fully by Thaxter in 1889,[1] again by Whetzel in 1904,[2] during which latter year it was par-

[1] Thaxter, R., Conn. Agr. Exp. Sta. Rpt., 1889.

[2] Whetzel, H. H., N.Y. (Cornell) Agr. Exp. Sta. Bul. 218, April, 1904.

ticularly destructive in New York, causing a loss of half the yield, or more in some instances.

The attack in the field occurs first upon a few plants during warm, damp weather. Examined while the dew is still present, these plants, seen from considerable distance, display a peculiar violet tint especially easy to discern through the dewy covering. Close examination shows the affected part to be covered with a furry coating. On the second day these parts lose their green color, turn pale, or even yellow. On the third or fourth day the plant is entirely collapsed.

Fig. 112. — Onion plant illustrating manner of death of leaves affected with downy mildew. After Whetzel.

The diseased spots in the field may each cover an area of only a few feet in diameter, enlarging slowly. If the weather favors the fungus, the disease may sweep rapidly across the whole field. Affected plants, under suitable weather conditions, brilliant, dry atmosphere, slowly recover, putting out new leaves to replace the dead and lost. Subsequent attacks may occur if the weather favors the growth of the fungus. The injury from this disease is through the loss of leaf surface, thus reducing the growing power of the plant. Usually little or no increase in the size of the bulb occurs after a severe attack.

To prevent the spread of the disease, and to lessen the danger from subsequent attacks, a spray of Bordeaux mixture, 5-5-50, applied as soon as the disease is noticed, is needed. Careful supervision and spraying to check renewed attacks of the fungus, particularly if the weather continues to favor the fungus, should not be neglected. New growth should also be protected by the use of Bordeaux mixture.

If subject to this disease in previous years, it is well to spray before the disease appears; also throughout the season, reaching all sides of the leaf with the fine spray and using high pressure to make the mixture stick to the smooth onion leaves.

Wet lands are more subject to this disease and should be avoided if possible. It is recommended to rake and burn the dead tops, to destroy the infective spores within them, and to practice crop rotation.

Vermiculariose (*Vermicularia circinans* Berk.). — The outer scales of the bulb after harvest often show black growths of peculiar and striking character. They consist of central black dots or very small rings, around which from one to several larger rings are arranged concentrically. Under moist conditions these markings enlarge rapidly by the production of more rings or wavy lines, or, under some circumstances, the whole area may be overgrown with black. Later the disease may extend through the outer bulb scale and into the next and succeeding layers to considerable depth, causing a dry, black rot.

The black spots and rings are due to the pycnidia of a fungus, each pycnidium closely studded with numerous stiff black spines or hairs. Sometimes flattened black sclerotia accompany these growths.

While the disease is not conspicuous before harvest, it is really present in incipient stage upon the bulbs in the field and continues to develop rapidly under storage conditions. Here it may pass to new bulbs by contact or by air currents. These dangers are much augmented by a moist atmosphere. While the growth is not retarded appreciably by this disease, the value of the onion is often much reduced by the disfiguring growth, and the loss from rot induced by it is also considerable.

Onions before they are placed in storage should be well dried. Storage bins with good ventilation, so arranged as to prevent all heating or sweating of the bulbs, should be provided. No infected bulbs should be stored, since they will carry infection to the sound bulbs. Bins that are known to be infected, *i.e.*, which held infected onions in any preceding year, should be disinfected by a thorough spraying with Bordeaux mixture or plain bluestone solution.

Soft rot (*Bacillus*[1] *sp.*). — This soft rot appeared in New York in 1898. In many cases one third to one half of the crop was destroyed, and the sale of the balance injured because the news of the presence of the rot had reached the buyers.

Where the rot starts at the tip of the bulb, the onion may appear sound, but pressure at the top or sectioning with a knife reveals the rot within. Frequently a single leaf scale is rotten entirely around the onion, which is other-

[1] Stewart, F. C., N.Y. (Geneva) Agr. Exp. Sta. Bul. 164, December 1899.

wise sound: or again several scales may be rotted. If the outer scale is rotted, the bulbs are designated as "slippery onions" by the growers. The rot does not spread from scale to scale within the bulb. In storage it does not progress rapidly in dry onions, but wet onions do rot

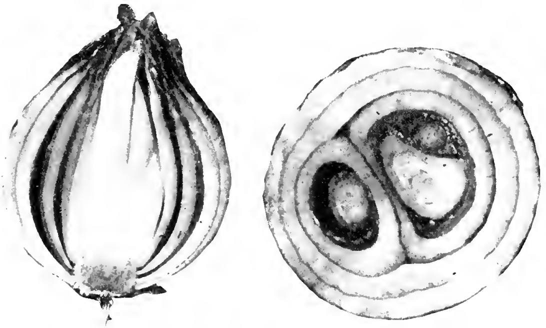


FIG. 113. — Onion affected with soft rot; longitudinal and cross section. After Stewart.

rapidly. The only suggestion toward control is to keep the onions dry in storage.

Black mold (*Macrosporium parasiticum* Thuem.). — Frequently onion leaves which have been injured by some cause, also old stems or seed stalks, assume a velvety, black coating which often covers them entirely. This condition follows only upon previous injury, weakening, or death, from some other primary cause, chiefly as a sequel of the downy mildew. Though not a primary disease its presence extends the injury started by other causes, breaks stalks which would otherwise stand, and aids in rapid rotting.

Treatment against other diseases and maintenance of the plants in full vigor is of most service in this case.

Black mold (*Macrosporium Porri* Ell.). — This black mold much resembles the last, but its spots are somewhat more pale and usually more definite, less diffuse, and less liable to induce rotting. It does not habitually associate with the downy mildew, and is more truly saprophytic than the black mold above mentioned. While usually upon the seed onions, it is sometimes found upon market onions.

The treatment suggested above applies here.

Damping off. See p. 60.

PARSLEY

Sclerotiniose, drop, crown rot (*Sclerotinia Libertiana* Fckl.). — Parsley in the greenhouse is sometimes affected with this disease, which is identical with the lettuce drop.

PARSNIP

Leaf spot (*Cercospora Apii* Fr.). — This is the most common disease of the parsnip, occurring as a leaf spot similar to that upon celery, and caused by a very similar fungus.

PEA

Spot, ascochytose (*Ascochyta Pisi* Lib.). — Spotting of the pea leaves and pods has been known to farmers for many years. It is most conspicuous upon the pods as circular, somewhat sunken spots, 3–6 mm. in diameter, which are dark bordered, pale in the centers, or, when

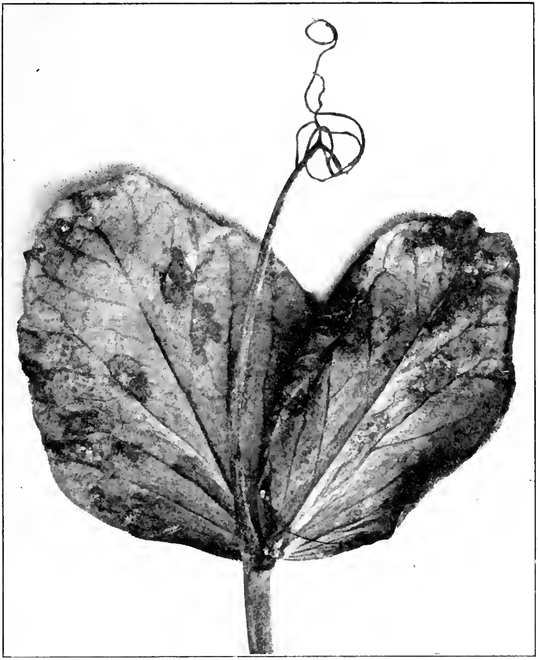


Fig. 114. — Pea leaves showing spots due to the blight (ascochytose). After van Hook.

mature, somewhat pink. In these spots pycnidia are visible in abundance, and under favorable conditions the spore masses may be seen issuing from them, even with the naked eye. Upon the leaves similar oval spots, 3–10 mm. in diameter, with the pycnidia usually in concentric circles, are very abundant. The lower older leaves are affected first, resulting in their death. The younger leaves die later. Stems are subject to the same attack — first near the ground, later upon all parts; the spots often penetrating through the woody part, thus causing wilting and death of the parts beyond. The stem attack is the most serious form, since it directly causes death to a large part of the plant. This is especially true if the disease be followed by dry weather.

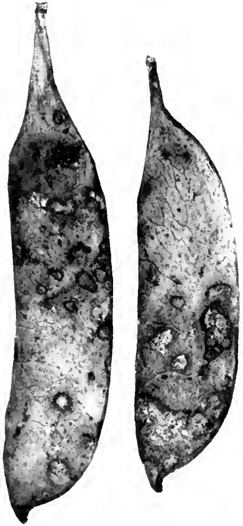


Fig. 115. — Pods of French June field pea spotted by ascochytose. After van Hook.

All forms of the disease tend to decrease the yield just in proportion to their prevalence. Plants not killed before flowering may develop pods, though of lessened yield.

Disease upon the pod may penetrate completely through it and appear upon the opposite side, or more frequently it may grow into the seed within the pod. Seeds badly diseased in this manner adhere to the pod; if less badly diseased, they thresh out, are shrunken, and show, according to the color of the variety, more or less discolored spots. Often seeds are diseased, and yet so slightly disfigured as to escape observation.

Trial has demonstrated that of badly infested seeds only 6 per cent are capable of germination, and that even when they do germinate, the resulting plants seldom reach maturity. On young plants the disease often assumes the character of damping off.

Selby[1] makes the following notes as to varietal resistance to this disease.

Very badly affected: French June, Market Garden, Dwarf Telephone, American Wonder.

Badly affected: Admiral, Telephone, Prosperity, Advancer.

Slightly affected: Alaska.

Aside from the pea this disease is said to attack alfalfa, bean, and hairy vetch. The disease was a grave menace in Europe in 1894, in Canada in 1903, in Ohio in 1904. In New York, in 1906, from 50 to 80 per cent of the crop was injured.

Two years' rotation in nonsusceptible crops lessens the evil very much. Diseased seed should be avoided.

Powdery mildew (*Erysiphe polygoni* DC.). — This mildew presents the usual character of the powdery mildew as described for grape — a whitish, powdery coating upon the plant surfaces. It develops most conspicuously late in the season, and sometimes becomes so injurious that the plants do not mature seed, though it is not usually very

[1] Selby, A. D., Ohio Agr. Exp. Sta. Bul. 173.

destructive. Twenty per cent injury has been reported from Ohio; 33 per cent from some parts of Nebraska. The fungus hibernates in seed derived from affected pods. Such seed should not be used for planting. Liver of sulphur or Bordeaux mixture is effective in the field.

Damping off. See p. 60.

Rust. See **bean.**

Leaf spot, septoriose (*Septoria Pisi* Westd.). — This disease cannot well be distinguished from ascochytose without the use of the microscope.

Pleosporose (*Pleospora Pisi* (Sow.) Fckl.). — Frequently moldy black spots are noted upon pea pods, leaves, or other parts. This condition is chiefly a secondary disease following injury by some other disease.

Rhizoctoniose. See p. 61.

PEANUT

Leaf spot, cercosporose (*Cercospora personata* (B. & C.) Ell.). — This leaf spot is circular in outline, indefinitely bordered, black to brown in the center and grading to green on its outer edge. The lower leaves are first affected and suffer most; later the disease spreads to upper leaves. The leaves begin to fall soon after they spot, and in many cases the death of the plant results. It is often a pest.

The fungus causing this disease was first collected in Carolina and Alabama by Ravenel.

PEPPER

Southern blight, wilt (*Sclerotium Rolfsii* Sacc. in litt.). — The blight shows itself first as a slight drooping of the leaf tips by day, followed by night recovery. The wilting becomes more pronounced on succeeding days until in the third or fourth day the leaves wilt permanently, lose color,

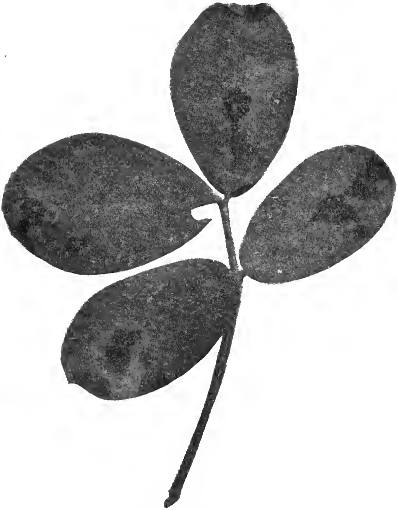


Fig. 116. — Peanut leaf spot cercosporose. Original.

dry, and soon fall. These stages may succeed each other so rapidly as to appear almost simultaneous. The roots appear normal; but on the stem near the ground are found shrunken, discolored areas in the bark, often extending considerable of the way around the stem. Later the roots may rot from secondary causes.

Upon the diseased spots are fine mycelial strands, especially abundant under humid conditions. Soon these strands aggregate into tufts which round off, become hard

Fig. 117. — Pepper plant showing wilt (sclerotiose). After Fulton.

and smooth, and change from white to yellow, and finally to dark brown. These bodies, the sclerotia, are about as large as a mustard seed. Attacks usually begin when the pods are forming and continue through the season.

This disease was first described by Rolfs[1] from Florida and has since been found in many Southern States upon a wide range of plants.

The application of a clear, preventive fungicide, such as ammoniacal copper carbonate, to the ground at the base of the plant, and where any part touches the ground, so that it can soak into the ground near by and cover the stem itself, has proved beneficial. The first application should be made at the earliest sign of the blight, or still better, in anticipation of it, and should be followed by other applications at intervals of two to three weeks. Bordeaux mixture is not suitable, since the effective part of it is filtered out by the soil.

FIG. 118. — Pepper plant showing fungus, *Sclerotium Rolfsii* Sacc. After Fulton.

Anthracnose (*Glœosporium piperatum* Ell. & Ev.). — Soft, circular, pale, sunken spots upon the fruit accompanied by small, ruptured spots in the skin, through which the pink spore masses protrude, indicate this disease.

[1] Rolfs, P. H., Fla. Agr. Exp. Sta. Rpt., 1893.

Anthracnose, colletotrichose (*Colletotrichum nigrum* Ell. & Halst.). — This disease resembles the last except that the centers of the soft spots change to a decided black as they age.

Leaf spot, phyllostictose (*Phyllosticta sp.*). — Small, circular, leaf spots of ashen color bearing pycnidia indicate phyllostictose.

Macrosporiose (*Macrosporium sp.*). — This malady renders the fruit moldy and black, particularly at the blossom end. It is one of the most destructive of pepper diseases.

POTATO

Late blight, downy mildew (*Phytophthora infestans* (Mont.) DeBy.). — In the year 1889 Lamson-Scribner,[1] writing of this, the most serious potato disease, said, "It prevails in all potato countries of the world, and causes more damage to the potato than all other injuries combined." It is possible that all that Scribner regarded as blight would not to-day be included under the disease at present under discussion; still the disease holds its place among the worst of plant diseases of the world.

It is estimated that in New York State alone the blight has caused a loss of $10,000,000 in one year, and the annual loss in the United States is placed at $36,000,000.[2] The loss reported in one year from Ohio was $2,000,000; from Wisconsin $5,000,000. The blight is supposed to have originated in South America and to have been brought to this country about 1840.

The disease may appear on any part of the leaf, but the

[1] Lamson-Scribner, F., Tenn. Agr. Exp. Sta. Bul. *2*, 2, April, 1889.

[2] Orton, W. A., U.S. Dept. Agr. Yearbook, 1908, p. 453.

spots generally show first near the tip or margin, probably because surface water remains longer on these parts. The diseased area soon dies and blackens. It may temporarily dry out and curl up if the progress of the fungus is checked by drought, or it may, in rainy weather, rap-

FIG. 119. — Potato late blight. Rows at left sprayed with Bordeaux mixture and Paris green; rows at right received Paris green only. Original.

idly proceed to transform the entire foliage into a moist, putrid mass. In the earlier stage the blackened part is bordered by a narrow region of light green, characterized by a slightly watery, flaccid appearance. Under conditions of especially humid atmosphere a fine, white down may be seen upon the more recently invaded parts. This affection of the leaves is accompanied by an offensive odor discernible at considerable distance from the field. The disease usually soon shows on the stems also, which in turn blacken and die.

On the tuber the surface shows slightly depressed dark-colored areas, while internally the normal white color changes to dirty brown. If the soil is dry, dry rot results; if wet, the tubers decay as wet, slimy, ill-smelling masses. In storage the disease continues, and the loss sustained in the field may be greatly augmented.

This blight is closely dependent upon weather conditions of heat and moisture. A daily mean of 72°–74° F. accompanied by moist weather is best for its spread. A daily mean temperature above 77° F. for a few days retards its development.

Although the conspicuous signs above noted first attract the attention of the general observer, the disease really commences as soon as the sprouts appear upon some of the young plants grown from infected seed. Such shoots remain dwarfed, assume a reddish brown color, and when proper weather conditions obtain, furnish the spores to start the general epidemic.

Marked difference in resistance exists between different varieties. Thus Woods of Maine found that the Rust-proof showed the highest resistance, about 1 per cent of disease, while no other varieties tried gave less than 30 per cent of disease. Of the standard crop varieties the following are reputed to possess some degree of resistance: Carmen No. 3, Sir Walter Raleigh, Rural New Yorker No. 2, Rural Blush, Green Mountain, State of Maine, Delaware, Enormous, and White Beauty.[1]

[1] Jones, L. R., U.S. Dept. Agr. Bur. Plant Indus. Bul. 87.

Field trials by William Stuart [1] have shown that certain German and English varieties are more highly resistant than the American varieties. It is a hopeful sign, therefore, that American potato breeders are now giving attention to disease resistance and that new varieties of better value in this respect may be expected in the future.

Potatoes free from the disease should be used for seed. Diseased potatoes may be recognized by their reddish brown surface color, which extends toward the center of the potato; also by the slight shrinking of the surface in such parts, or by the black spotting described above.

The crop should also be sprayed as recommended under the general heading, p. 281. Though the disease may not develop every year in severe epidemic form, spraying is necessary each year as a preventive measure. Since the blight develops so rapidly, it is quite impracticable to wait for signs of the disease before spraying is begun. Moreover, experiments extending over several years have shown that even in years when the blight does not become epidemic, sufficient benefit is derived from spraying to warrant its adoption.

The Geneva Experiment Station says: [2] "Judging from the experiments thus far made, it appears that spraying for blight is an operation which no potato grower in New York can afford to neglect. Forty-eight farmers' business experiments made during the past four years show an average *net profit of* $20.51 per acre due to spraying.

[1] Jones, L. R., and Morse, W. J., Vt. Agr. Exp. Sta. Rpt. 16, p. 163, 1902–1903.

[2] Stewart, F. C., and others, N.Y. (Geneva) Agr. Exp. Sta. Bul. 290, p. 240, June, 1907.

Commence spraying with Bordeaux when plants are 6 to 8 inches high and repeat at intervals of 10 to 14 days throughout the season, making, in all, five or six applications. When bugs or flea beetles are numerous, add Paris green or other poison. In case the tops have blighted, the

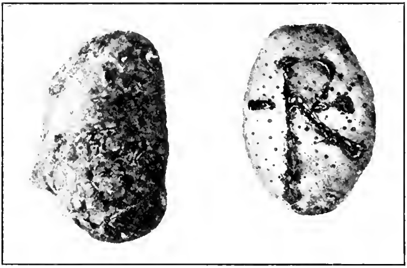


FIG. 120. — Potato scab. *a*, natural; *b*, produced by inoculation forming monogram R. T. After Conn. Agr. Exp. Sta.

danger of tuber infection and consequent rot is lessened by delaying the harvest of the tubers until at least a week or ten days after the death of the foliage.[1]

Scab (*Oospora scabies* Thaxt.). — Potato scab prevails in Europe, Africa, New Zealand, in all parts of the United States, and probably everywhere the potato is grown. Though practically all American potato scab may be classed as one disease, there is some evidence that there is more than one form of disease which passes under this

[1] Jones, L. R., and Morse, W. J., Vt. Agr. Exp. Sta. Rpt. 16, p. 163, 1902–1903.

name in Europe.[1] It was first attributed to its proper cause by Dr. Thaxter [2] in 1890.

The scab is recognized by all potato growers as a characteristic rough pitting of the tubers. If these are attacked when quite young, the scabs are deep; if the attack is later, they are more shallow. In very severe cases the tuber is furrowed or cracked.

The scab at first appears as a minute reddish or brownish surface spot, often when the potato is very young. It extends outward, deepens in color, and is attended with the development of an irregular corky incrustation.

The disease is often prevalent to such extent as to prohibit successful potato culture. The chief loss comes from depreciation in sale value, though there is also loss in yield. Estimates show that from 5 to 75 per cent of the potato crop is unsalable on account of scab. The loss in one county alone in California is placed at $300,000 yearly.

Scab is most prevalent in alkaline soils and is favored by moisture. Wood ashes, potash, soda, stable manure, lime etc., increasing alkalinity, favor the growth of the fungus, and cause increase in the amount of scab in soil already infected. Materials which tend to decrease scab are commercial fertilizers, potash salts (except carbonate), land plaster, and ammonium sulphate. Rotation of crops tends to diminish the amount of scab, provided other susceptible crops, as beets, turnips, cabbages, etc., are avoided. A three-year rotation without a susceptible crop largely reduces it, though after five or even ten years the disease is not entirely exterminated. During rotation any practice

[1] Jones, L. R., U.S. Dept. Agr. Bur. Plant Indus. Bul. 87.

[2] Thaxter, R., Ct. State Agr. Exp. Sta. Rpt. 14, pp. 81–95.

that increases the acidity of the soil aids in reducing the scab. Thus plowing under green crops is a favorable practice.

In general it may be said that scabby seed potatoes in any soil will produce a scabby crop, but the amount of scab is determined somewhat by the soil condition. Seed potatoes free from scab, in a soil free from scab, will raise a crop free from scab. Seed potatoes free from scab will not produce a healthy crop if grown in an infected soil.

There is much difference in varietal resistance to scab. The more resistant varieties should be used on soil at all scab infested. Cambridge Russett, Carmen No. 3, American Giant, Sir Walter Raleigh, Irish Cobbler, Scab Proof, and Aurora are recommended by the Maryland Station as possessing some scab resistance.[1]

Two conditions arise requiring different cultural methods: —

1. The management of clean soils.
2. The management of soils already infected.

If the land is free from infection, great care should be exercised to avoid introduction of the scab fungus by any of the general means suggested under soil disease. In particular, infection may occur by the use of scabby seed, or through the use of manure which has been infected by feeding uncooked scabby potatoes to stock. If seed must be planted that cannot safely be regarded as free from scab, and no seed from an unknown source can be so regarded, it should be disinfected to free it of all scab germs.

To disinfect potato seed the most effective method is by

[1] Norton, J. B. S., Md. Agr. Exp. Sta. Bul. 108, p. 67, April, 1906.

the use of formaldehyde gas[1] liberated by mixing the commercial solution with potassium permanganate. This method is adapted to the disinfection of large quantities of potatoes in a short time. To use it, an air-tight shed should be constructed of sufficient size to hold whatever quantity it may be desired to treat at one time. This may be made of rough lumber lined with building paper and provided with a tight door. The potatoes may be treated in sacks, but these sacks should be so piled as to permit free circulation of air all around them. It is suggested that they be piled in tiers with two 2-by-4-inch scantlings between each layer of sacks. Space should be left in the center of the building for placing the charge of formaldehyde, which should be set off in shallow vessels, such as galvanized washtubs. For each 1000 cubic feet 23 ounces of potassium permanganate and 3 pints of formaldehyde should be allowed. After the potatoes are properly stacked and everything is made ready, the permanganate should be spread in a thin layer on the bottom of the pan, the required quantity of formaldehyde poured in, stirred quickly, and the building vacated. The building should then be kept tightly closed for twenty-four hours, when it may be opened and the potatoes taken out.

The precaution should be taken not to pile any potatoes directly over the pans or within three feet laterally, since the gas there might be strong enough to injure the potatoes and destroy their germinating power. The formaldehyde works best in a humid atmosphere. It is therefore advised that the floor of the shed be dampened before the treatment is made. The potatoes, however, should not be moist,

[1] Jones, L. R., and Edson, A. W., Vt. Agr. Exp. Sta. Rpt. 14, 1900–1901, and Morse, W. J., Me. Agr. Exp. Sta. Bul. 141, p. 89, March, 1907.

since the disinfection is more thorough if the surfaces are dry.

The cost of materials for treatment need not amount to over one cent a sack. For example, a shed 12 by 24 feet and 7 feet high contains 2016 cubic feet and would require 3 pounds of potassium permanganate, costing 60 cents, and 6 pints of formaldehyde, costing $1.20; total, $1.80. Two hundred sacks can easily be treated at one time in such a shed.

Small quantities of potatoes may be disinfected by soaking in a solution of 1 pint of formaldehyde to 30 gallons of water for 2 hours, or 1½ hours in corrosive sublimate solution, 2 ounces to 2 gallons of hot water, then diluted to 15 gallons. Either the gas or the solution treatment may be applied some time previous to planting, provided the potatoes are not exposed to reinfection by being put into receptacles, bags, buckets, etc., that have previously held scabby potatoes. The treatment should be made before the potatoes are cut for planting.

No system of soil treatment has proved reliable in the management of infected land. Long rotation avoiding susceptible root crops should be practiced. The use of fertilizing materials which favor the fungus should be avoided and resistant varieties should be planted. The turning under of a green crop, *e.g.*, rye, may gradually decrease the scab tendency.

Rosette, stem rot, little potato (*Corticium vagum* B. & C. *var. solani* Burt.). — Though particularly prevalent in the Middle West and Rocky Mountain states this pest is known generally in the east from Connecticut south.

Aerial potatoes, potatoes borne upon the parts of the stem

FIG. 121. — Little potatoes and aerial potatoes. After Rolfs.

above ground, are conspicuous in this disease. Other characters are rotting of the stem, the rosette development of the tops, and a scabby growth upon the tubers. Infected potatoes in storage may give way to a wet rot. In Florida in 1904 scarcely a lot of seed potatoes free of this disease could be found, and the hibernating condition of the fungus was evident in 60 per cent of the seed tubers in some instances.[1] Such infected tubers are largely responsible for the contamination of new soil.

Diseased seed tubers may be recognized by the superficial, irregularly shaped, elevated, dark brown patches of fungous

[1] Hume, H. H., Fla. Agr. Exp. Sta. Bul. 75, p. 188, August, 1904.

threads (sclerotia), varying in size from a pinhead to a grain of wheat. They are seen clearly only when the tuber is wet.

Soon after planting the young sprouts are attacked by this waiting fungus. Black spots appear near the surface of the ground, destroying the bark and often girdling the stem. A dark network of fungous threads is sometimes seen upon the subterranean parts. This advances above ground and develops a gray spore-bearing layer about the green stem, often extending upward several centimeters, causing the young shoots to wilt, droop, and die. Often a loss of one fourth to one third of the plants follows. Those stems which survive this early attack, but which are attacked later, show the aerial tubers mentioned above and produce a few underground tubers; and these small and unsalable. Such tops may develop peculiar twisted leaves with prominent veins and bear their leaves in a crowded manner that enables their easy recognition, even from some distance. If these plants be examined closely, the injury caused by the fungus will frequently be found as a wound often 2–3 cm. long upon the stem at or near the surface of the ground.

In some of these symptoms this disease closely resembles the bacterial malady known as "blackleg," which is described upon a later page. Fortunately the remedial measures are similar.

Only clean seed should be used. If there is any doubt as to freedom of the seed from the disease, it should be treated as is recommended for potato scab. Liming the soil, clean culture methods, and crop rotation are preventive. Infected refuse should be destroyed by fire. Soil badly infested should not be planted in potatoes. In general the remarks made under soil diseases apply here.

While this disease as caused by Rhizoctonia has long been known in Europe, especially in Germany, no record of it

FIG. 122. — Potato attacked by Corticium. After Rolfs.

was made in America until 1891. Since that date it has been noted upon many hosts in many states. See p. 61.

Early blight (*Alternaria solani* (E. & M.) J. & G.). — This is one of the very serious potato diseases that prevail throughout the country. In 1906 the loss in Wisconsin was placed at about 5,000,000 bushels, and a 50 per cent loss was reported from Wyoming.

The grayish brown leaf spots, which are brittle, irregularly circular, and are concentrically marked, appear about the time the tubers begin to form. The coalescence of the spots involves large areas of leaf tissue and results in browned, withered leaves, the stems remaining green. The effect is often so complete as to lead the grower to think the vines have died a natural death. The progress of the disease is slow, covering three or four weeks before all the leaves are dead. The loss of efficient leaf tissue so diminishes the vigor of the plant that the yield is largely reduced. Though the tubers are not directly attacked and never rot from this disease, their growth is usually stopped at the attack of the disease. This is a disease characteristic of dry soils and seasons, and is liable to be associated with tip-burn.

The general spraying (p.281) will hold this blight in check.

Wilt, fusariose (*Fusarium oxysporum* Schlecht.). — This wilt is definitely known in Michigan, Virginia, North Carolina, Ohio, Kansas, Nebraska, District of Columbia, New York, Florida, California, Colorado, Wisconsin, Oregon, Washington, Massachusetts, Iowa, West Virginia, and Vermont, and is probably identical with a very destructive potato disease of England, Germany, France, and Belgium.

When the plants are about a foot high, or in mild cases a little later, the first trace of the wilt is noticeable.[1] The

[1] Smith, E. F., and Swingle, D. B., U.S. Dept. Agr. Bur. Plant Indus. Bul. 55, February, 1904.

leaves, which are usually light colored, assume a dull, unhealthy appearance, with rolling or curling of the margins. Progressive disease gradually causes the top to fall, and gives a general effect of premature ripening. When the diseased plants are pulled up, the roots are found to be partly dead, quite brittle, and frequently bearing a white or pink mold. When the underground portion of the stem is cut across, a pronounced brown discoloration is visible. This brown stain is also found in the branches leading to the tubers, and a thin slice across the stem end of the tuber will often reveal its presence there as well.

The loss caused amounts to millions of dollars annually, due: (1) to deficient germination; (2) to early ripening and thus to diminished yield; (3) to dry rot in storage.

When the potatoes are dug, there is rarely any external evidence of the disease on them. The major portion of the crop produced from wilted plants is nevertheless infected. If these potatoes are stored in a cold place, but little change occurs; but when infected potatoes are kept in a heated room or left outdoors in a warm climate, a dry rot soon develops.

Beginning at the stem end the tuber shrivels, the inside becoming brown and light in weight. Occasionally bacteria cause a secondary soft rot, which proceeds more rapidly. An early form of this dry end rot is frequently met with shortly after the potaoes are harvested. Potatoes thus affected are known to buyers as "jelly ends."

The presence of this disease can be detected in otherwise normal tubers only by making a thin slice across the stem end and searching for the brown discoloration. Such potatoes are not desirable for seed, but are not objectionable for cooking, provided they are consumed promptly or kept in cold storage.

This wilt is closely related to the watermelon and cotton wilt. Soils which have once borne a sick crop are infected and will infect future crops. The general means by which a field may become infected have been discussed on page 65. In addition to these means of infection, the potato wilt is often carried to new fields by infected "seed."

For this reason all seed introduced from other fields should be carefully inspected to guard against such infection. It is a matter of record that this disease was largely introduced into California from Oregon by means of infected tubers. A little care a few years ago would have accomplished what seems now to be impossible, the prevention of the disease in that region. Residents of other regions still uninfected should profit by this example and exercise such precaution as to avoid a similar fate. The disease may pass to the manure by feeding infected potatoes to stock, and this manure may lead to the infection of new fields.

Crop rotation will partially restore infected fields to health. Collecting and burning of the tops after digging will diminish the amount of the fungus and add to the benefit of rotation.

If diseased potatoes must be stored for any length of time, all that are badly diseased should be rejected, and the remainder kept as cool as possible without freezing them. It is best to sell or consume such tubers at once.

Wilt, bacillose (*Bacillus solanacearum* E. F. Smith). — This wilt, chiefly prevalent from Maryland southward, reported also from Indiana, Nebraska, and Iowa, is identical with that of eggplant, tobacco, and tomato, and is to a large extent transmitted to the plants by insects.

The leaves wilt, and dry up; the stems and tubers show yellowing and blackening in the veins, and the tubers give way in a soft rot. Squeezing the diseased tubers causes exudation of creamy drops from the diseased veins.

Tubers from diseased vines rot rapidly and should not be stored if it can be avoided. If stored, they should be kept at as low a temperature as possible. It is unwise to plant potatoes in land which has shown this disease upon any of its hosts without a long intervening rotation. The precautions suggested under soil diseases, use of clean seed and special attention to insect control, are preventive measures.

Cercosporose, leaf blotch (*Cercospora concors* (Casp.) Sacc.). — Cercosporose of the potato has been known in Europe since 1854, but was not known in the United States until 1902, when it was found in Vermont by L. R. Jones. Cercosporose appears when the plants begin to blossom. The lower leaves show obscurely defined pale spots, 3–5 mm. in diameter, sometimes blending to form larger areas. A pale gray or violet fungus becomes conspicuous upon the lower surface. As the disease progresses the spots encroach upon the upper leaves. The affected spots sometimes die, much resembling the alternariose spot, but more often the entire leaf slowly turns yellow and dies.

The damage, especially to late potatoes, is considerable, reducing the yield one fourth or more. In Europe the disease is troublesome, and its spread in this country may be anticipated.

The following varietal resistance was noted by Jones and Pomeroy: [1] —

[1] Jones, L. R., Vt. Agr. Exp. Sta. Rpt. *19*, 255.

Badly affected: Early Ohio, Early Rose, Holborn or Abundance, Swiss, Snowflake. Slightly affected: Blight Proof, Rural New Yorker No. 2. Not affected: Delaware, Rural Blush.

Rot (*Rhizopus nigricans* Ehrbg.). — Orton[1] has described a soft rot of potato native to the peat lands of California. It is characterized by dull brown discoloration of the skin and light brown or buff coloring of the flesh, accompanied by softening. Upon pressure a clear brown liquid without disagreeable odor exudes.

The disease spreads rapidly in warm weather, and entire shipments may decay en route to market. It gives no trouble after frost. To prevent infection the skin should not be broken in handling, and all infected refuse should be destroyed by fire.

Tipburn. — The leaves die at the tips and margins, blacken, roll up, and break off. The disease is widespread in the northeastern United States, especially in dry, hot summer weather.

It is not due to parasites.[2]

Blackleg, bacillose (*Bacillus phytophthorus* Appel.). — Much confusion has arisen concerning the identity of blackleg, since in many instances the mere occurrence of a black region upon the stem near the ground line has led to the use of the term. It is thus probable that in the literature of potato maladies several distinct diseases have been confused with the "blackleg."

A distinct, definite, and serious disease has, however, been known for several years under this name in Europe and

[1] Orton, W. A., U.S. Dept. Agr. Bur. Plant Indus. Circ. 23, January 23, 1909.

[2] Jones, L. R., Vt. Agr. Exp. Sta. Bul. 72, 1899.

England, and thorough study by Appel in 1903 led him to attribute it to the bacillus above named. American studies

Fig. 123. — Potato black leg. Original.

render it probable that this same disease is present in this country, but to just what extent is uncertain because of the confusion in diagnosis referred to above. L. R. Jones,[1] who studied blackleg in the field in Germany and England and what appeared to be the same disease in Vermont, described it essentially as follows: The earliest conspicuous symptom was that the diseased plants were slightly below normal size, of a paler or yellowish green color, the lateral branches and petioles becoming more erect and the leaf blades curving upward, giving the entire plant a narrowed aspect. The lower leaves in the meantime have possibly shriveled and died. The stem was more or less browned or blackened from near the surface of the soil downward. In extreme cases the discoloration was visible 2–3 cm. above the soil. The tissues of the discolored part died, and the softer parts decayed. Usually the seed tuber also was rotted. Rot of the resultant crop of tubers has been reported from Germany, but was not observed in Vermont.

A disease nearly related to this has been described by Harrison as due to *Bacillus solanisaprus*.

As yet there is little definite knowledge concerning means of distribution or prophylaxis. Until more definite knowledge obtains it is well to avoid badly diseased localities and seed potatoes from diseased regions and to give heed to the general suggestions under soil diseases.

Potato Spraying

The spraying of potatoes, as with other crops, should not be directed or planned to meet merely one of the diseases, but rather to give the plant the best possible protection against all of its enemies. The chief enemies to be met are

[1] Jones, L. R., Vt. Agr. Exp. Sta. Rpt. 19, p. 259. and U.S. Dept. Agr. Bur. Plant Indus. Bul. 87, p. 17, 1905.

the early and late blights, and the Colorado beetle or "potato bug."

The gains from spraying potatoes with Bordeaux mixture, as shown in trials at the Vermont Experimental Station,[1] begun in 1891 by Jones and extending over seventeen years, are shown below: —

GAINS FROM THE USE OF BORDEAUX MIXTURE ON LATE POTATOES

Planted	Sprayed	Yield per Acre		Gain per Acre
		Sprayed	Not Sprayed	
White Star,				
May —, 1891	Aug. 26, Sept. 8	313 bu.	248 bu.	65 bu. or 26%
May 20, 1892	July 30, Aug. 13, 25	291 bu.	99 bu.	192 bu. or 194%
May 20, 1893	Aug. 1, 16, 29	338 bu.	114 bu.	224 bu. or 196%
Apr. 26, 1894	June 16, July 17, Aug. 30	323 bu.	251 bu.	72 bu. or 29%
May 20, 1895	July 25, Aug. 13, 31	389 bu.	219 bu.	170 bu. or 78%
Polaris,				
May 15, 1896	Aug. 7, 21	325 bu.	257 bu.	68 bu. or 26%
June 1, 1897	July 27, Aug. 17, 28	151 bu.	80 bu.	71 bu. or 89%
White Star,				
May 10, 1898	July 21, Aug. 10	238 bu.	112 bu.	126 bu. or 112%
Average, 3 varieties,				
May 18, 1899	July 26, Aug. 17, Sept. 8	229 bu.	161 bu.	68 bu. or 42%
Delaware,				
May 23, 1900	Aug. 4, 23	285 bu.	225 bu.	60 bu. or 27%
May 25, 1901	July 20, Aug. 21	170 bu.	54 bu.	116 bu. or 215%
May 15, 1902	Aug. 1, 20	298 bu.	164 bu.	134 bu. or 82%
Green Mountain,				
May 1, 1903	Aug. 10	361 bu.	237 bu.	124 bu. or 52%
Delaware,				
May 25, 1904	Aug. 1, Sept. 1	327 bu.	193 bu.	134 bu. or 69%
May 15, 1905	Aug. 2, 21	382 bu.	221 bu.	161 bu. or 73%
Green Mountain,				
May 27, 1906	Aug. 13, 22	133 bu.	101 bu.	32 bu. or 32%
May 1, 1907	July 16, 25, Aug. 8, 22	171 bu.	63 bu.	108 bu. or 175%
Average of 17 years,		278 bu.	165 bu.	113 bu. or 68%

[1] Jones, L. R., and Giddings, N. J., Vt. Agr. Exp. Sta. Rpt. 20, p. 334 *et seq.*, 1906–1907.

Extensive experiments have been conducted for the past seven years by the New York Experiment Station. The following table taken from bulletin 311 summarizes their results.[1]

Year	At Geneva		At Riverhead	
	Gain per A. due to spraying Every Two Weeks	Gain per A. due to spraying Three Times	Gain per A. due to spraying Every Two Weeks	Gain per A. due to spraying Three Times
	Bu.	*Bu.*	*Bu.*	*Bu.*
1902 . .	123½	98½	45	27⅔
1903 . .	118	88	56	39½
1904 . .	233	191	96	56½
1905 . .	119	107	82	31½
1906 . .	63	32	53	21½
1907 . .	73⅔	44	31	18
1908 . .	39	29½	15⅓	10¾
Average .	110	84	54	29

Seven years of business experiments made on farms in order to determine the actual profits from spraying under farm conditions gave the following results:[2]—

Year	Number of Experiments	Total Area Sprayed	Average Increase in Yield per Acre	Average Total Cost of Spraying per Acre	Average Cost per Acre for Each Spraying	Average Net Profit per Acre
		A.	*Bu.*			
1903	6	61.2	57	$4.98	$1.07	$23.47
1904	14	180	62.2	4.98	.93	24.86
1905	13	160.7	46.5	4.25	.98	20.04
1906	15	225.6	42.6	5.18	.985	13.89
1907	14	152.75	36.8	5.90	1.18	17.07
1908	14	200.25	18.5	4.30	.92	8.53

Average increase in yield, for six years, 43.8 bushels per acre.
Average net profit, for six years, $17.94 per acre.

[1] Stewart, F. C., and others, N.Y. (Geneva) Agr. Exp. Sta. Bul. 311, p. 13, January, 1909.
[2] *Ibid.*, p. 29.

In the Geneva and Riverhead experiments rows sprayed three times received Bordeaux mixture and Paris green twice and Bordeaux alone once, the dates being July 3, 17, and August 3. Other rows were sprayed six times, twice with Bordeaux mixture and Paris green and four times with Bordeaux alone, the dates being July 3, 17, August 3, 18, and September 1, 16. Still other rows were not sprayed at all with Bordeaux, but were treated twice, July 3 and 20, with Paris green in limewater to control bugs. The Bordeaux mixture contained 6 pounds of copper sulphate to each 50 gallons of water and lime to correspond. Paris green was used at the rate of 1 pound to 50 gallons of mixture.

The recommendation of the Geneva Station is: "Commence spraying when the plants are six to eight inches high and repeat the treatment at intervals of 10 to 14 days in order to keep the plants well covered with Bordeaux throughout the season. During epidemics of blight it may be necessary to spray as often as once a week. Usually six applications will be required. The Bordeaux should contain 4 pounds of copper sulphate to each 50 gallons in the first two sprayings, and 6 pounds to 50 gallons in subsequent sprayings. Whenever bugs or flea beetles are plentiful, add one to two pounds of Paris green or two quarts of arsenite of soda stock solution to the quantity of Bordeaux required to spray an acre.

"Thoroughness of application is to be desired at all times, but is especially important when flea beetles are numerous or the weather favorable to blight. Using the same quantity of Bordeaux, frequent light applications are likely to be more effective than heavier applications made at long intervals."

"Those who wish to get along with three sprayings should postpone the first one until there is danger of injury from bugs or flea beetles, and then spray thoroughly with Bordeaux and poison. The other two sprayings should likewise be thorough and applied at such times as to keep the foliage protected as much as possible during the remainder of the season. Very satisfactory results may be obtained from three thorough sprayings."

"A single spraying is better than none and will usually be profitable, but more are better."

"Except, perhaps, on small areas, it does not pay to apply poison alone for bugs. When it is necessary to fight insects, use Bordeaux mixture and poison together."

PUMPKIN

Downy mildew. See **cucumber.**

Powdery mildew. See **squash.**

RADISH

Club root. See **cabbage.**

White rust (*Albugo candida* (Pers.) Ktz.). — This white rust has the characters described under beet, and in addition, upon this host, it often causes curious malformation of the flowers and pods, which become overgrown and distorted; often a flower is five times its normal diameter and is colorless. Chief damage is done to the seed crop, which may be quite ruined by this attack upon the flowers.

Burning of all infected trash is the best preventive.

Damping off (*Rhizoctonia sp.*). — Damping off and root rot of this crop have been noted in Connecticut.

See **damping off**, p. 60.

ROSELLE (*Hibiscus Sabdariffa*)

Powdery mildew (*Microsphæra Euphorbiæ* B. & C.). — This mildew of characteristic white, flower-like, circular patches has been noted in Florida.

Flowers of sulphur have proved effective in preventing its spread, according to Bessey as cited by Fawcett.[1]

Fig. 124. — White rust (albugese) upon salsify leaves. After Heald.

SALSIFY

White rust (*Albugo Tragopogonis* (DC.) Gray). — White, rustlike, blisters (sori) upon the leaf indicate this disease. The sori are longer than broad, extending lengthwise of the leaf. In late stages of the disease the leaf near the sori blackens and withers, often tearing lengthwise.

Bacteriose. — A soft rot of the roots, resulting in loss of green color and prostration of the plants, is attributed to bacteria.[2] The slimy, offensive decay usually begins at the lower end of the main root and progresses upward. See **carrot soft rot.**

Rust (*Puccinia Tragopogonis* (Pers.) Cda.). — This true rust is of somewhat general distribution, but is not harmful.

SPINACH

Anthracnose (*Colletotrichum Spinaceæ* Ell. & Halst.). —

[1] Fawcett, H. S., Fla. Agr. Exp. Sta. Rpt. 88.

[2] Halsted, B. D., N.J. Agr. Exp. Sta. Rpt. *11*, 351, 1890.

Blotches[1] appear upon the leaves, first as small, moist, watery areas, associated with slight local wilting, followed soon by the appearance upon either side of the leaf of very small brown acervuli. The spots then change to gray and dry up. The disease spreads rapidly from plant to plant and is very destructive both under glass and in the open, rendering the plant unfit for use.

Fig. 125. — Spinach leaf spotted by heterosporiose. After Reed.

White smut (*Entyloma Ellisii* Halst.). — The attacked plants are unmarketable, due to lack of uniform green color and the presence of pale bleached spots upon the foliage. These spots are not definitely limited, nor does their tissue die as it does in the case of other spinach leaf spots.

Black mold (*Cladosporium macrocarpum* Preuss.). — The black mold develops especially upon old leaves, and renders the plant unsalable. The spots are distinguishable from all other spinach spot diseases by their irregularity, indefiniteness, and color.

General. — To control all the above spinach diseases, it is well to burn diseased refuse, practice rotation, and

[1] Halsted, B. D., N.J. Agr. Exp. Sta. Bul. 70, July, 1890.

employ preventive sprays when the plants are young. Spraying the edible leaves as the plants approach maturity injures the sale and is not permissible.

Heterosporiose[1] (*Heterosporium variabile* Cke.). — This disease was especially injurious to spinach in eastern Virginia during the winter of 1908–1909, and has also been noted in Connecticut. It appears early in January and continues to increase until the spinach season is over. Numerous leaf spots are produced, at first brown, later sooty, as the conidiophores and conidia of the fungus develop. The older leaves usually show more injury than the younger, but at times all leaves are seriously affected. The presence of the fungus renders the leaves unsalable, and much additional labor is required at harvest time to trim off the injured leaves.

The disease does not seem capable of attacking healthy, vigorous plants, but usually follows injuries produced by some other agencies. In Virginia it has been found to follow the injuries produced by peronospora. Injuries produced by cold weather, prolonged rains, insects, etc., undoubtedly afford weak points where infection may begin.

The best preventive measures, so far as known at present, are to follow general hygienic precautions, rake up and destroy all dead and diseased leaves, keep the injuries from insects and other fungi at a minimum, and rotate crops as much as possible.

Downy mildew (*Peronospora effusa* (Grev.) Rbh.). — Gray to slightly violet, downy spots upon the lower surfaces of leaves, accompanied by pale yellow spots upon the

[1] This description was prepared at the request of the authors by H. S. Reed.

corresponding upper surfaces, indicate the downy mildew. The disease in its habit and damage resembles that of the grape, p. 166.

Serious loss is reported from New Mexico and Virginia.

Leaf blight, phyllostictose (*Phyllosticta Chenopodii* Sacc.). — This disease affects the leaves, especially at their bases, producing spots which bear minute pycnidia.

Cercosporose (*Cercospora beticola* Sacc.). — This disease often ruins crops by yellowing and dwarfing the plants, thus rendering them worthless for market. By causing local leaf spots it diminishes the vigor of the plant.

SQUASH

Powdery mildew (*Erysiphe cichoracearum* DC.). — This mildew is very common upon the squash, forming the usual whitish coating upon the surface of the leaves and stems.

Downy mildew. See **cucumber.**

Wilt, bacillose. See **cantaloupe.**

Anthracnose, colletotrichose. See **watermelon.**

SWEET POTATO

Soft rot (*Rhizopus nigricans* Ehrbg.). — The most prominent soft rot of the sweet potato, the only one that is commonly met, may be recognized by the soft, wrinkled condition of the potato, its sweetish odor, and usually by the presence of a white, later black, growth of mold, appearing through the skin of the rotten portion at points of rupture.

The decay most often begins at one end and passes rapidly through the root, but it may start at a wound upon any part of the potato. It progresses with such rapidity that the whole potato may give way in a few days after infection. Other tubers, if they have broken surfaces or wounds and lie in contact with affected ones, will also be infected. The rotten roots are therefore often found in

FIG. 126. — Sweet potato soft rot. Original.

groups through the pile. This rot is sometimes found in the field, but is not usually destructive until after digging.

Normally it cannot enter a sound potato; a wound must furnish it a passageway. Therefore all wounded roots should be laid aside for immediate consumption, and only sound roots put in storage.

The following directions for storing are given by a person of extensive successful experience. Divide the cellar into slatted stalls 6 feet wide, 3 to 4 feet deep, with a foot between stalls. If the stalls are one above another, leave 6-inch spaces between them. In a large cellar 20 or 30 by 50 or 75 feet, leave a 3 or 4 foot hall and build bins on each side. Take the sweet potatoes directly from the field to the cellar and put in bins 3 or 4 feet deep. If the ground is wet, sun for a time, so that the dirt will fall from the potatoes. Whenever the thermometer registers 40° F. above zero, especially at night, keep all ventilators wide open; but should it rise above 65° F. outside, close all ventilators tight, for hot air in the cellar will condense moisture or cause potatoes to become moist "sweat." Keep the inside temperature between 45° F. and 60° F. Never allow any part of this cellar to stand open when the air outside is 15° F. warmer than inside. Potatoes carefully sorted, then stored in well-constructed houses in the above manner, will not rot.

It is well to destroy all infective material, rotten roots, etc., in or near the storage place, and if the house is once infected, to spray its walls and floors thoroughly with a good disinfectant, such as Bordeaux mixture or formalin.

Black rot (*Sphæronema fimbriatum* (Ell. & Halst.) Sacc.). —This is among the most destructive of all sweet potato decays, causing much loss in storage as well as in the field. Infected potatoes are bitter and worthless. Black rot has been reported from Indiana, New Jersey, Ohio, Tennessee, North Carolina, Maryland, and Alabama.

The rot may be known by its dark brown to black, irregular patches upon the potato surface. These begin as points and gradually extend in all directions, involving the whole root. Older spots, 2–5 cm. across, often break or crack irregularly near the center. This decay differs from the soft rot in that the spots are dry and hard and that it is present upon the roots before digging. With the hand lens very small, hairlike, black structures, 1 mm. high, are seen studding the centers of the diseased areas. These are the beaks of the pycnidia of the causal fungus.

Fig. 127. — Black rot of sweet potato. Original.

Upon young sprouts before they are set out the disease causes black, dead patches, especially at the base of the shoot or even upon the young leaves. The wood of the stem may be browned. Such sprouts if set result in enfeebled plants with diseased roots.

The fungus throws myriads of spores into the soil. This disease thus falls under the general class of soil diseases.

In addition to the suggestions given on page 63, especial precaution should be exercised to avoid sets already affected. Badly affected shoots are easy of recognition, but the closest scrutiny is needed to cull out those only slightly affected.

Above all, infected seed beds should be avoided, and no infected potatoes should be used for growing sets. Crop rotation should be practiced, and every precaution taken to get the plants well established in the field. A strong, well-started plant will often resist the disease where a weak plant would succumb. Waite[1] says: "The best remedy is to use slip seed. It is advisable to grow the crop of vine cuttings on new land which is not infected or on land which has never grown sweet potatoes, thus making an absolutely clean start even though the vine cuttings are taken from an infected crop."

Soil rot (*Acrocystis Batatæ* (Ell. & Halst.). — The loss from this rot is sometimes almost total, and since this is a soil disease, the raising of the crop is prohibited for several years.

The roots are attacked when quite small, sometimes over the whole surface. The part infected ceases to grow, while adjoining parts enlarge. This results in a condition such as that shown in Fig. 128. The smallest rootlets are the points of attack, thence the disease proceeds to the potato and causes the surface spots pictured.

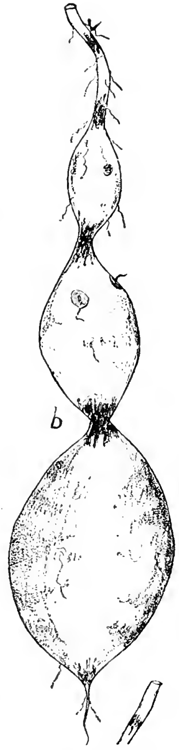


Fig. 128. — Soil rot of sweet potato. After Halsted.

[1] Waite, M. B., Encyc. of Agr., II, 622.

The chief loss is in the cessation of growth resulting from the disease. In badly infected fields no potatoes of marketable size mature, and the crop is not worth harvesting.

Long rotation to avoid placing sweet potatoes upon infected soil is advised.

Halsted[1] shows that soil rot, even upon land badly infected with the fungus, can be controlled by sulphur and kainit; 400 pounds of each applied to the soil when the new roots are to form gave the best results. Treated plats gave 60 bushels of clean potatoes as contrasted with 5 bushels for the untreated plat.

Wilt, stem rot, nectriose (*Nectria Impomœæ* Halst.). — In this disease, reported from New Jersey, California, North Carolina, Ohio, and Illinois, the stem dies near the surface of the ground, and the decay extends into the potatoes and vines. The whole vine dies unless supported by roots at some other place. Following the death of the original stem, the portion of the root still alive throws out a fresh growth of short stems and leaves near the center of the hill. Such efforts at recovery are valueless.

Rotation is necessary.

Dry rot (*Phoma Batatæ* (Ell. & Halst.). — In dry rot, the affected part, often the upper end of the potato, becomes dry, much wrinkled, and covered with numerous pycnidia, the flesh within changing to an almost powdery condition. From an economic point of view the rot is unimportant; still, affected potatoes should be destroyed.

Dry rot, lasiodiplodiose (*Lasiodiplodia tubericola* Ell. & Ev.). — The potatoes show dark, shriveled patches with

[1] Halsted, B. D., N.J. Agr. Exp. Sta. Rpt. 1898, 350.

scattered pycnidia.[1] The tissue within is spongy, moist, and from olive-gray to green in color. In the United States the disease was first noted in Louisiana on potatoes received from Java. It has also been noted in Florida.

Scurf (*Monilochætes infuscans* Ell. & Halst.). — A brown or rusty coat often forms over the whole potato. It causes no decay, but does result in shrinking, loss of volume, and unsightliness, which may reduce the money value of the crop a half dollar per barrel. The same affection occurs upon the roots from which the potatoes arise, but seems to do little or no damage there.

Blue mold, penicilliose (*Penicillium sp.*). — The diseased parts are of almost chalky color and consistency, dry and inoffensive. Until the root is cut this rot may escape observation. It may be first seen as a slight depression in the roots at the base of a fine fiber. These depressions enlarge and deepen and may involve the whole potato. In sections of these spots the diseased portion is found to have a dark border which upon exposure to the air rapidly changes to a dark olive color.

Leaf spot, leaf blight, phyllostictose (*Phyllosticta bataticola* Ell. & Mart.). — Spots of dead tissue from 1–10 mm. in diameter are frequent upon the leaf. They are somewhat angular, very definitely bordered, and bear numerous pycnidia, visible to the naked eye. In many instances these spots become so numerous as to cause the whole leaf to yellow and fall and thus seriously interfere with starch production, and lessen the crop.

Spraying with Bordeaux mixture would probably stop

[1] Clendenin, Ida, Bot. Gaz. *21*, 92, February, 1896.

the disease, but the outlay might not be warranted except in special instances.

White rust (*Albugo ipomœæ-panduranæ* (Schwein.) Swingle). — White, glistening sori, 1 mm. or so in diameter, appear upon the undersides of the leaves, and upon the stems. These rupture and set loose a mass of powdery, snow-white spores. The tissue surrounding the sorus is pale, or yellow, as seen from the opposite side of the leaf. The tissue surrounding old sori dies, and brown patches result.

No large injury usually comes from the disease.

TOBACCO

Root rot (*Thielavia basicola* (B. & Br.) Zopf.). — Known in Europe since 1897, thielaviose was first reported in the United States in 1904, as occurring upon tobacco, though it has probably been long prevalent in tobacco sections. It has been noted upon other hosts; namely, violets in Connecticut, Maryland, and District of Columbia; ginseng in Ohio and New York; also upon begonia, catalpa, and clover. Upon tobacco it is now known in Ohio, Connecticut, Kentucky, and North Carolina, and its territory is increasing yearly.

Thielaviose in the seed bed often causes the entire crop of seedlings to be discarded, delaying planting or compelling a change of crop. In the field the loss sometimes amounts to 25 per cent.

The disease is recognized by the black decay upon the roots, sometimes a cracking and deformation on the stem just above the roots, and the failure of the plant to develop normally.

Damping off may occur upon seed beds. The plants are attacked when very young, and death may result before

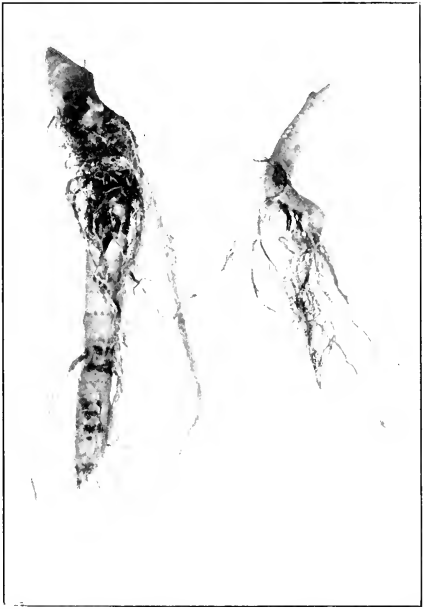


FIG. 129. — Tobacco roots showing effect of thielaviose. After Gilbert.

they attain a height of more than 5–10 mm. In other cases of milder attack the roots alone are invaded and the plants stunted. The tips of the rootlets are brown or black, and the entire root system is involved later. The decayed roots become so brittle that they are severed and remain in the ground when the plant is pulled. Numerous lateral rootlets are put out to replace these lost, but these also succumb sooner or later. The leaves of diseased seedlings on rich soil are usually abnormally dark green. They may, however, in poor soil be of a sickly yellow color.

In the field the diseased seedlings may remain for weeks without growth; some yellowing, wilting, and dying. Some in light soil may survive and yield a fair, but late, crop; in heavy soil few survive to be of value. When large roots are attacked, the effect is generally limited to the outer surface, where a brownish, scurvy appearance is produced.

Sick plants in healthy soil or healthy plants set in sick soil result in diseased crops, and the development of the disease when the causal fungus is present is favored by alkaline fertilizers.[1]

To avoid loss from this disease only uninfected plants should be used; to procure these an uninfected seed bed must be secured and maintained.

An infected seed bed can be rendered safe by disinfection by the means suggested under soil disinfection, selecting the method best applicable to the conditions. Surface firing is the method most widely used in connection with the tobacco crop. Formalin has also proved successful in many instances.

The following measures conduce to reduction though

[1] Gilbert, W. W., U.S. Dept. Agr. Bur. Plant Indus. Bul. 158, 1909.

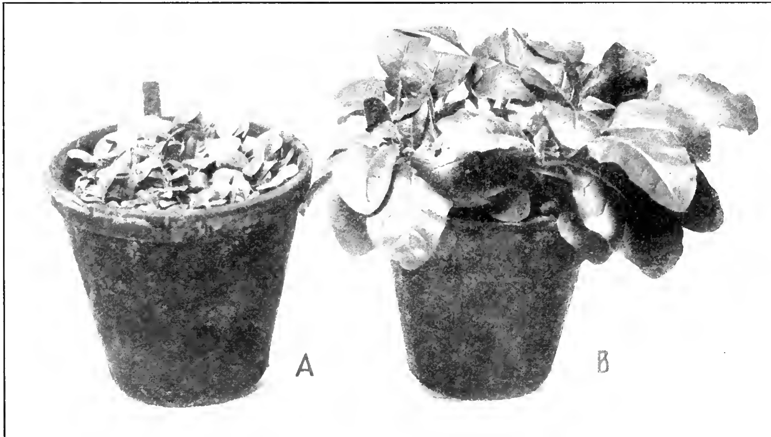


FIG. 130. — Tobacco seedlings; *A*, growing in soil affected with thielavia; *B*, in disinfected soil. After Gilbert.

not to complete eradication of the disease: The use of light rather than heavy soils for the seed bed; avoidance of excess of water or fertilizer; the use of a new bed each year; avoidance of too heavy seeding.

Infested fields should be given a rotation to relieve them of tobacco temporarily.

Granville wilt, bacillose (*Bacillus solanacearum* E. F. Smith[1]). — This wilt was first noted in print in 1903,[2] and it was first attributed to bacteria in September of the same year.[3] It was known to tobacco growers in Granville County, N.C., at least as early as 1881. It takes possession of the soil, prohibiting successful tobacco culture in succeeding years, and in sections where tobacco is the chief, possibly the only, profitable money crop the advent of this disease has caused great depreciation in farm values.

The wilt is now known in North Carolina, Florida, Georgia, possibly Connecticut, and what appears to be the same disease has been described in Cuba, Porto Rico, France, and Japan.

The first indication of the disease is given through the leaves, which droop, becoming soft and flabby as though suffering from want of water. This is not accompanied by change in color; the leaves remaining green for some time after the wilt appears. A typical case is shown in Fig. 131. Frequently the leaves on one side of the plant succumb earlier than those on the other side, and even a single leaf may show one-sided infection. The wilted leaves dry up,

[1] Smith, E. F., U.S. Dept. Agr. Bur. Plant Indus. Bul. 141, part II, 1908.

[2] Stevens, F. L., N.C. Agr. Exp. Sta. Press Bul. 11, August, 1903.

[3] Stevens, F. L., and Sackett, W. G., N.C. Agr. Exp. Sta. Bul. 188, 1903.

and eventually leaves and stalk die, though the stalk remains standing with its dead leaves still clinging to it.

Fig. 131. — Tobacco plant in early stage of the Granville wilt. Original.

At the stage of earliest wilting a section across the stem shows a yellowish discoloration of the woody portion. In more advanced stages, or in sections taken lower on the stem, the wood is found to be penetrated longitudinally by black streaks which are so abundant in stages immediately preceding death that the whole or nearly all of the wood seems to be so affected. Similar streaks penetrate the pith only in extreme cases. The blackening often progresses from the wood outward through the bark, producing shrunken, blackened patches on the surface of the stem.

FIG. 132. — Tobacco plant in late stages of the Granville wilt. Original.

In more advanced stages, when all the leaves are wilting, the wood and bark at the base of the plant are blackened almost throughout, and the pith is decayed, leaving the stem hollow or filled with a soft, rotten residue. The bark, near the level of the ground, turns black, and becomes dry and hard. The pith and wood in the upper portions of the plant usually dry up, resulting in collapse in irregular longitudinal folds. If a badly diseased plant is cut off near the ground, a dirty yellowish viscous exudate issues from the cut wood.

The root is the seat of the original infection, and any plant which shows symptoms in its foliage possesses roots already in pronounced stage of decay. In early stages one root or more may be diseased; in later stages all succumb; in the more advanced stages of root disease the bark is black, soft, and dry, a spongy mass of fiber left by the decay of the more watery parts. In the worst cases even this spongy covering may drop off, leaving the wood of the root bare.

In the root as in the stem the disease manifests itself first as longitudinal streaks of black in the woody cylinder close to the bark.

No corrective for a field once infected is known. After infection the only recourse would be to resistant varieties, if such were known, or to long rotation, and this is unsatisfactory and palliative only.

The means by which this disease spreads from field to field, and methods to prevent such spreading, are sufficiently discussed under soil diseases.

Cercosporose (*Cercospora Nicotianæ* Ell. & Ev.). — This disease, most abundant upon the lower leaves, is well illustrated in the accompanying figure. It appears as brown, circular spots from the size of a pinhead to a centimeter or more in diameter, thickly scattered over the leaves. Older spots bear white centers bordered by a darker raised line, and the centers often fall away, leaving irregular holes. The whole leaf yellows and ripens prematurely.

FIG. 133. — Tobacco leaf showing leaf spot (cercosporose). After Conn. Exp. Sta.

The disease was first described by Sturgis[1] from specimens sent from South Carolina. It was then very destructive, practically ruining the crop. A damage of $1000 to one crop alone was noted. It has since continued as a troublesome pest.

The use of Bordeaux early in the season is permissible and advantageous.

White speck (*Macrosporium tabacinum* Ell. & Ev.). — White speck consists of small, circular spots, rusty red or brown at first, but later with blanched centers, upon which the scattered hyphæ grow.

Brown spot (*Macrosporium longipes* Ell. & Ev.). — This spot differs from the above in its rusty brown color and in having

[1] Sturgis, W. C., Conn. State Agr. Exp. Sta. Rpt. 20, p. 273, 1896.

concentric markings. It is known to planters as the brown spot.

Bed rot, rhizoctoniose (*Rhizoctonia sp.*). — Damping off and rot of seedlings while in the seed bed occur in this disease. The causal fungus may often be seen as spots of web-like white mold upon the ground around the affected plants. The general characters and prophylaxis are discussed under **damping off** and **rhizoctoniose.** Seed beds known to be diseased should be avoided unless disinfected before use.

☞ **Stem rot** (*Botrytis longibrachiata* Oud.). — In this curing-house disease pure white, velvet-like patches of mold appear upon the stem, spread rapidly to the veins, and cause leaf decay, especially in the regions of the ribs and veins and other parts that dry but slowly.

The causal fungus matures its spores in great quantity upon the refuse stalks and stems, and thus persists from year to year.

To prevent the disease all refuse should be gathered and burned as soon as the crop is cured, and the floor and barn disinfected with Bordeaux mixture or bluestone.

Drop, damp off, sclerotiniose (*Sclerotinia sp.*). — Damping off due to sclerotinia is reported by Clinton[1] as a common trouble in seed beds. The injury to the plant is similar to that of the usual damping off, p. 60, while the fungus presents the characters described under lettuce sclerotiniose. Young plants are killed; older plants may survive, and if set in the field, develop poorly.

Poleburn, pole rot. — Poleburn is a curing-house disease occurring on hung tobacco. In warm, damp weather the

[1] Clinton, G. P., Conn. State Agr. Exp. Sta. Rpt. 1896, p. 326.

chief symptom consists in small blackened areas upon the leaf, limited at first to the regions near the vines. These spots may enlarge within two days to cover whole leaves, and the contents of the entire barn may become worthless, the leaf having become so wet and soft as to readily fall apart.

The disease is known in Connecticut, Virginia, Kentucky, etc. In some sections it occurs yearly in more or less destructive form. Its cause is not certainly known; indeed there may be several separate organisms, each capable of inducing the rot.

The trouble can be largely controlled by proper regulation of the moisture and temperature conditions, *i.e.*, by building such barns that the air of outdoors, when too damp, can be kept out, and yet with proper provision for ventilation to carry off the moisture from the drying tobacco.

Mosaic, calico, frenching. — The tobacco mosaic is very widely distributed and destructive. Depreciation of $50,000 in quality was attributed to it in Ohio in 1905. It causes a mottled appearance of the leaves due to variation in texture and greenness; parts of the leaf showing full green and normal thickness, other spots pale or yellowish green, and thin. Accompanying these signs are distortions due to unequal growth, wrinkled or curled leaves, and leaves of one-sided growth. Slightly affected leaves are depreciated in value; badly diseased leaves are worthless.

This disease is not perfectly understood, but it seems to be communicable from plant to plant by first touching a diseased plant and later touching a healthy one. Thus the disease is spread largely by topping. It is known also to be transmitted by means of soil that has grown a sick crop. Fertilizers which cause rapid growth favor the disease.

The seed bed should be either new or well disinfected, and it is advisable to destroy diseased seedlings in the bed if any appear. Young plants should not be forced with strong nitrogenous fertilizers and should be transplanted with great care to avoid injuring them. It is well to top, worm, and sucker the healthy and sick plants separately, on different days, with disinfection of the hands before passing from the diseased to the healthy plants.

Orobanche. — This is a true flowering plant, which draws its nourishment from the roots of the tobacco plant to which it is attached. The orobanche occurs in small clusters, its stalks are from 1–4 dm. tall, and entirely devoid of green color.

They should be pulled and burned before they produce seed.

TOMATO

Wilt, blight, bacillose (*Bacillus solanacearum* E. F. Smith). — This disease of the tomato is widespread, especially in the South, and prohibits the raising of tomatoes upon many thousands of acres of land. It occurs especially in the states south of Maryland, and has also been noted in New Jersey, Delaware, Ohio, and Colorado.

In this disease the leaves wilt, either singly or throughout the entire plant at once; growth stops and the plant dies. The stem is at first dirty green, then brown, then black. It soon shrivels, and the veins become brown and show as narrow black lines, or in section as black dots.

The wilting of the foliage and the blackening of the bundles are distinctively characteristic.[1]

A soil bearing diseased plants one season is subject to the malady in succeeding years and must be abandoned for tomato culture. The disease is spread from plant to plant largely by the potato bug (Colorado beetle) and other

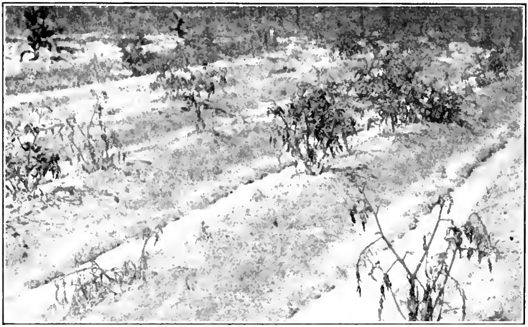


FIG. 134. — Tomato field showing effect of wilt (bacillose). Original.

insects. For this reason all leaf-infecting insects should be given special attention. Otherwise this disease in symptoms, cause, dissemination, and treatment is similar to the usual soil diseases.

Wilt, fusariose (*Fusarium sp.*). — A form of fusariose has been described in California by Smith[2] as follows: It occurs not infrequently as the cause of losses up to 100

[1] Smith, E. F., U.S. Dept. Agr. Div. Veg. Phys. & Path. Bul. 12, December 19, 1896.

[2] Smith, R. E., Cal. Agr. Exp. Sta. Bul. 175, January, 1906.

per cent of plants between half-grown and maturity. In 1905 the disease was probably more general than ever before, completely ruining many fields in southern California. The plants usually reach considerable size, blossom, and set fruit before showing the disease, which first appears in the field on single plants, which are generally sickly looking, and of unhealthy color, followed by symptoms of wilt. The leaves do not blacken or suddenly die, but the whole plant gradually sickens, loses color, wilts, and finally collapses upon the ground. The disease comes on gradually in the field, affecting plants here and there in a very scattering manner. In the worst cases they all die before the summer is over, sometimes quite suddenly at the last; again, the field goes through in a spotted condition, with plants missing more or less extensively. If a badly affected or dead plant be pulled up, the roots are found to be decayed or destroyed. When first affected, this is not the case; if a plant is pulled up as soon as it begins to show wilting and fading, the roots look healthy and sound. But if such plants be carefully dug, to avoid breaking off the smaller roots, it will be seen that many of the larger laterals are decayed at the ends and are in bad condition. The disease consists of a dry rot of the roots, commencing at the ends and working upward.

The first symptom is a pale yellowish color of the lower leaves, which soon dry from the tip toward the base without spotting. The veins and woody portion of the stem, if examined in cross section, are darkened, especially upon the side bearing the diseased leaf. The disease progresses from the old leaves to the youngest, resulting eventually in the death of the plant.

As to means of dissemination and control, what is said under soil diseases will apply.

Leaf mold (*Cladosporium fulvum* Cke.). — Under glass in the North and occasionally in the open, especially in the South, this disease is destructive. It occurs as rusty or cinnamon-brown blotches on the lower side of the leaf, which turns yellow above, then brown or black, curls, and dies. The loss of food supply consumed by the parasite together with the loss through destruction of the leaf green injures the yield seriously.

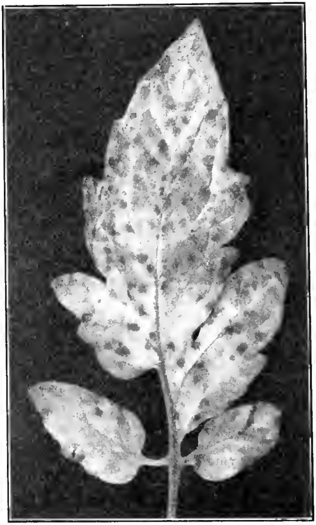


Fig. 135. — Tomato leaf showing spots (septoriose). Original.

Indoors, ventilation is the best remedy, coupled with clean culture to avoid carrying the pest over to another year. On fields Bordeaux mixture would doubtless serve well.

The causal fungus of this disease was first described in 1883 by Cooke from specimens collected in North Carolina.

Leaf spot (*Septoria Lycopersici* Speg.). — A very common leaf spot has almost precisely the general appearance illustrated in Fig. 135, except that small pycnidia occupy the spots.

The disease attacks the older leaves first and works toward the top of the plant, often causing the loss of so many leaves as to give the plant the appearance of blight, and resulting in complete ruin of the crop. The presence of the leaf spot distinguishes this from any of the blights. Spraying with Bordeaux mixture is effective against this disease though valueless against the various wilts.

Cylindrosporiose (*Cylindrosporium sp.*). — This disease in general appearance, damage, and treatment resembles septoriose. See above.

Downy mildew, blight (*Phytophthora infestans* (Mont.) DeBy.). — Arising from the same cause as the dreaded potato blight, of which host the tomato is close kin, is the very injurious tomato blight, causing complete devastation of the crop in some sections, and resulting in a loss of many thousands of dollars. It has been reported in Massachusetts, Colorado, and is serious in California.

As is the case with the potato, the amount of damage is closely dependent upon suitable weather conditions, the disease being greatly favored by a warm, humid atmosphere. It appears suddenly as dark, discolored spots on the fruit and other green parts. On the fruit the spot, usually upon the upper side, is watery and large. Many tomatoes, apparently healthy when picked, rot in shipment, the rot being accompanied, under humid conditions, by a fine, white surface mold. Dark spots upon stems and branches soon extend throughout the whole plant, giving it the appearance of one stricken by frost.

Protective spraying with 5–5–50 Bordeaux mixture, as recommended for the potato, will probably serve in case of this disease. In regions of infrequent rainfall it is necessary to spray only after each rain.

Blossom-end rot, point rot. — Readily recognized from its name, this very troublesome disease is essentially a dry, black rot appearing on the blossom end and injurious chiefly to early tomatoes. It is especially harmful, owing to the high value of the early fruit that it destroys. Various fungi and bacteria have been named as the cause, and it cannot yet be said with certainty which is the guilty one. Perhaps it is one, perhaps several. In any event it seems to be an infective disease that is probably carried by insects.

The trouble is more serious upon droughty soils and can be to some extent controlled by irrigation or moisture conservation, *i.e.*, increasing the water-holding power of the soils by the addition of organic matter and surface tillage.

Black spot, rust (*Macrosporium Solani* Ell. & Mart.). — Ruin is brought to the crop in many seasons, particularly in the southernmost states, by black spot, which is possibly identical with the potato early blight. The leaves bear numerous small, usually angular spots, often concentrically marked, which appear first as minute brown specks, later showing a pale center with a darker border. In badly affected leaves the tips dry and curl up. Petioles and stems are also attacked.

Thorough spraying with the usual Bordeaux mixture should be begun at the first indication of the disease and continued weekly, or semi-weekly if growth is rapid and weather damp. Often it is still better to begin spraying in the seed bed.

Southern blight (*Sclerotium Rolfsii* Sacc. in litt.). — This is the same disease discussed under **pepper.** Upon the tomato it is often completely destructive in the southernmost states.

The first sign is wilting of the terminal portion of the plant, distinguishing this trouble from the fungous wilt, which commences with the lower leaves.

For discussion and treatment see **pepper.**

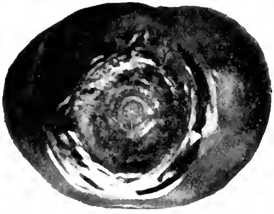


Fig. 136. — Tomato anthracnose. After Heald.

Anthracnose (*Colletotrichum phomoides* (Sacc.) Chest.). — This is chiefly a disease of the ripe fruit, either upon the vines or after harvest. It appears as sunken, discolored spots with wrinkled surfaces and black specks, the acervuli. The disease does much damage to fruit before it is picked, and also injures the keeping quality.

Fumagose (*Fumago vagans* Pers.). — Dense, olive-black growths of mold form upon the leaves, but little or no harm is done.

Damping off. — Tomatoes in the seed bed are subject to damping off.

Œdema. — This is a condition of overgrowth of certain cells of the plant, causing swelling of veins and leaf tissues, and curling of the leaves in irregular growth. Usually confined to the greenhouse, it is caused by excess of water, lack of light, improper temperature, and especially by too warm soil, and is readily controlled by careful management.

Mosaic. — Upon the tomato appears a disease very similar to the mosaic of tobacco. Aside from this apparent kinship little is known about it.

Rosette (*Rhizoctonia sp.*). — This rosette is possibly identical with the potato rosette,[1] showing similar lesions upon the root and stem near the ground. The tops have long internodes and dwarfed leaves which are somewhat curled. For further discussion see **potato.**

Upon the ripe fruits, especially those touching the ground, this disease occurs as a brown rot upon a slightly wrinkled epidermis.

TURNIP

Black rot (*Pseudomonas campestris* (Pamm.) E. F. Smith). — It was upon this crop in 1892 that the disease, now known in so destructive a form upon the cabbage and other cruciferous crops, was first noted by Pammel.[2] It then caused 10 per cent loss; the next year 50 per cent, and it has since been known to cause total ruin in many instances.

The rot is recognized by the blackened veins in the crown, root, leaf stems, and leaves. The softer tissue near such veins is abnormally watery, and the interior of the root undergoes dry decay with a characteristic strong odor. The cavities thus made are of peculiar radiate form, with black or brown walls. Diseased plants may live for considerable time with apparently healthy leaves,

[1] Selby, A. D., Ohio Agr. Exp. Sta. Bul. 145, November, 1903.

[2] Pammel, L. H., Ia. Agr. Exp. Sta. Bul. 27, 1895.

but the roots grow very slowly and assume an abnormal, narrow shape. The badly rotted hollow root may show no external signs of the disease.

The character, dissemination, and control of this disease are discussed under **cabbage**.

Club root. See **cabbage**.

Powdery mildew (*Erysiphe polygoni* DC.). — This powdery mildew is often a serious pest in England, but seems to be much less injurious in America, though it has frequently been seen in this country, forming conspicuous white patches upon the surface of the leaves.

Macrosporiose (*Macrosporium herculeum* Ell. & Mart.). — Numerous small, white spots occur upon the leaves, each spot later with a slight, black, moldy growth in the center.

Treatment is not warranted.

Scab. See **potato**.

White rust. See **cabbage**.

Downy mildew. See **cabbage**.

The two last-mentioned diseases often occur together and in such form as to cause considerable loss. If plants are badly affected, it is well to collect and burn all diseased refuse and to rotate crops.

WATERMELON

Wilt, fusariose (*Fusarium vasinfectum* Atk. *var. niveum* Sm.). — The melon wilt not only destroys the growing crop, but prevents the successful culture of melons upon the field in question in succeeding years. The disease has spread rapidly during the past decade and is now known in most of the southeastern United States; also in Iowa, Oklahoma, California, Oregon, Indiana, Kentucky, and Arizona.

The wilt is readily recognized from the fact that the leaves first droop, as though they were suffering from want of moisture, rapidly wilt, and soon die, the runner dying with the leaves. Soon the whole plant is dead. Upon cutting the main tap root across near the surface of the ground, such plants are found to present a yellow color in the wood, making a distinct contrast with the white color of the healthy plants. This one character, taken together with the wilted appearance of the vine, enables recognition of the true watermelon wilt. The further fact that a field once infected shows the same disease in succeeding years in the same or in extended areas is an additional recognition mark.

Its spread may occur in the ways mentioned under soil diseases and in particular through the use of infected manure.

To restrict it to its present confines crop rotation should be practiced and infected soil should not be replanted to watermelons until the wilt fungus is largely diminished in quantity. This will probably take more than four years, possibly eight or ten years, and even at the end of that time it is best to try a few hills before planting the whole field to melons. Cattle should not be allowed to pasture upon diseased vines and thus spread the wilt through the manure.

The practice of raising cowpeas after watermelons leads to the presence of some watermelon vines in the cowpea hay, and this likewise leads to the presence of the causal fungus in the compost heap. Manure so exposed to infection should never be placed on land which is still free from the germ, or which is to be used to raise watermelons, since this is a sure way of spreading the wilt.

There is no objection to the use of stable manure which does not contain the fungus, but experience has shown that when the wilt once gains entrance to the compost heap or barnyard, it remains there for years, and all of the manure taken out of such a yard is likely to spread the disease. Hence it is exceedingly dangerous in regions where the wilt prevails to use any stable manure on the field where melons are to be planted.

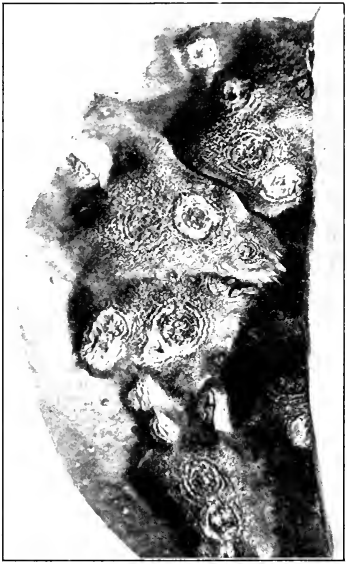


FIG. 137. — Portion of watermelon showing effect of anthracnose. After Sheldon.

Varieties resistant to this disease have been developed by the United States Department of Agriculture by crossing the citron, which possesses high resistance, with the watermelon, and then by selection attaining the desired edibility.

Wilt, bacillose. See **cantaloupe**.

Wilt, mycosphærellose. See **cantaloupe**.

Anthracnose (*Colletotrichum lagenarium* (Pass.) Ell. & Halst.). — This disease attacks all parts of the vine, sometimes causing complete failure of the crop. Its most conspicuous form is upon the fruit at any age, especially at maturity. Here very characteristic sunken spots with pink centers, much like the bean-pod spot, are produced. Upon old melons they do but slight injury, but to young fruit the attack is often fatal. A bitter taste is often imparted to the sick fruit.

Upon the stems while yet green the spots are irregular, elongated, light brown. Tendrils, buds, and petioles turn black and die. The leaves instead of yellowing, as with downy mildew, are covered with dark blotches of dead tissue which becomes brittle and often tears out.

Spraying as for the downy mildew is effective. It is also well to destroy infective refuse and to practice rotation.

Downy mildew. See **cucumber**.

Cercosporose. See **cantaloupe**.

Alternariose. See **cantaloupe**.

CEREALS

Cereal Smuts in General

These diseases show themselves to the farmer as dark to black, dusty or hard, masses occupying the places where the grain should be or involving also the near-by flower parts, glumes (chaff), etc., and in some cases the leaves and stem as well. The smut mass consists almost wholly of the spores of the causal fungus. This fungus gains entrance to the plants when they are in a susceptible condition of development, the time varying with different kinds of plants, and grows within the plant as an active parasite, drawing its nourishment from its involuntary host. When the host plant has attained the proper age, and correspondingly, too, the fungus has reached its proper stage of maturity, the disease becomes apparent to the eye as the only too familiar smut.

Smut spores under suitable conditions of moisture, food, and heat sprout, and produce smaller spores, *sporidia*, which, if they fall upon the proper host plant in the proper period of its development, penetrate into it and grow. The host plant may or may not outgrow its enemy. In any event, its presence is not apparent to the naked eye until the period of maturity arrives again, and another crop of dark-colored spores is produced.

Kinds of smut. — In all there are many kinds of smuts. Something more than 600 species are now recorded. Over

205 of these are found in the United States, growing upon some 442 different kinds of plants.[1]

Most smuts are upon unimportant, uncultivated plants. Some of them, such as the *corn* smut, *onion* smut, and the smuts of *wheat, oats, rye, barley* attack plants of high economic value and cause great damage. The common corn smut develops upon almost any part of the corn plant, but is usually most conspicuous upon the ear and tassel. Onion smut grows upon the leaves, often in the bulb; rye smut in the stem; that of oats, wheat, and barley in the ovary, the grain. Another smut of corn growing upon the tassel is less widely known.

It is evident that to know precisely at what parts and at what periods the various crop plants are open to infection is of utmost importance in looking to the prevention of the smuts. It was early proved that *oats* are susceptible to infection only in the very young periods of their development. Kuehn and Wolff held opposing views as to whether it is the young stem or the first leaf sheath that is susceptible. The very exact work of Brefeld settled this point beyond all controversy. He also proved that corn is susceptible to infection on all young, tender, growing parts, and recently Maddox, Brefeld, and others have shown that in the case of the *loose smut of wheat* and the *barley smut* infection occurs while the plant is in bloom, this infection affecting the seeds and resulting in smutted plants in the crop raised from such infected seeds.

It is upon these facts that our present modes of prevention are based. The treatment for oat smut is such as to kill the spores adhering to the grain and thus prevent in-

[1] Clinton, G. P., Proc. Boston Soc. Nat. Hist. *31*, 334, 1904.

fection during the period of susceptibility, *i.e.*, the very young seedling condition. The same treatment is effec-

FIG. 138. — Oat plants, smutted and healthy; note difference in height. Original.

tive for the stinking smut of wheat. The loose smut of wheat gaining entrance to the plant before the grain is harvested cannot be prevented by such means without danger to the seed, but can be prevented by the use of clean, uninfected seed. Corn, being susceptible at all ages of its growth, cannot be protected by seed treatment.

Owing to their great damage and conspicuousness, smuts have attracted attention from very early times, and many references to them are found in ancient writings. Probably not until 1791, however, was their true nature as vegetable parasites recognized. Many were the means that were suggested for the prevention of these pests: placing laurel branches in the field, change of seed, avoidance of manures, thorough screening, soaking in brine, etc.

Preventive treatments. — The only one of the early treatments that has proved its value and remained in common use is that of soaking the seed in copper sulphate (bluestone), first tried by Tessier in 1789, after he, in 1786, and Young, in 1787, had tested numerous chemicals. His test was without results, since during that season neither treated nor untreated wheat was smutted. Prévost of France in 1807 was the first to publish an account of the successful use of bluestone for wheat smut. He recommended a solution of about 6 per cent strength, and the remedy was, and is still, widely used. Solutions varying in strength have been employed, one half per cent being most highly recommended. In 1873 Dreisch improved the bluestone treatment by using limewater to follow the bluestone; thus, to a large extent, diminishing the amount of seed killed by the treatment.

Jensen, a Dane, in 1887 and 1888 reported excellent results with oat, barley, and wheat smuts from dipping the seed in hot water. Untreated seed gave 36 per cent of smut. One fourth per cent of bluestone gave one half per cent smut. Warm water, 133° F. for five minutes, gave no smut. Kellerman and Swingle soon afterward introduced this last treatment into this country.

In 1888 the germicidal action of formalin was discovered and this substance was used as a preventive for oat smut by Bolley of North Dakota during the three years preceding 1897.

The Sar treatment was first announced by Swingle in 1898.[1]

The use of the various smut remedies is usually attended by an increase in vigor of the plants, and by an increase in yield in excess of that due simply to the elimination of the smutted grains. The reason for this has not been fully explained, but it may be due to elimination of the fungus from plants which otherwise would have to resist it throughout a portion of their growth period in order to overcome it and to eventually bear grains. An excellent account of the early history of smuts in general may be found in the Report of the Kansas Agricultural Experiment Station for 1889, and a comprehensive article upon corn smut in the Twelfth Report of the Indiana Agricultural Experiment Station.

Cereal Rusts in General

The rusts constitute a complex, intricate, difficult, but interesting group of diseases. It is said that the "average annual loss from rust throughout the United States far

[1] Swingle, W. T., U.S. Dept. Agr. Farmers' Bul. 75, p. 15.

exceeds that due to any other enemy, insect or fungous, and often equals those from all others combined."[1]

The rust of wheat alone is estimated by Bolley to cause an average loss in the United States of $20,000,000, while Galloway placed the loss in 1891 at $67,000,000.

The rusts in their most complete form exhibit three distinct stages (cf. asparagus): the spring stage, or cluster cup, consists of a group or cluster of very minute, cup-like, spore-bearing regions, sori. These cups are sunken in the tissue of the host, often with their rims only protruding. The second stage, summer stage, also called the *uredo* stage, is of entirely different appearance, consisting usually of elongated sori, bearing a mass of spores the color of iron rust or verging towards orange or yellow. These spore masses are at first covered by the epidermis of the host, but this covering eventually ruptures, disclosing the usually dusty or pulverulent mass of spores, surrounded by a fringe of the remaining epidermis. The third stage, winter stage, or teleutospore, consists of sori almost exactly like those of the uredo stage except that the spores within are usually darker in color and in a compact, cushion-like mass, therefore lending to the sorus a considerable alteration in aspect. The sorus is often identical in the two latter stages, a uredosorus gradually changing as the season advances into a teleutosorus.

These three stages have in general three separate functions. The function of the teleutospores is to live over winter or over the long resting period of the fungus. They are essentially long-lived and hardy. The cluster-cup

[1] Carleton, M. A., U.S. Dept. Agr. Div. Veg. Phys. & Path. Bul. 16, p. 19, September 27, 1899.

spores are to multiply and spread infection, especially in the earliest part of the season. The uredospores are to continue the multiplication and infection throughout the growing season of the host. The last two forms of spores are in general comparatively short-lived. If the host plant remains alive over winter, as is the case with winter wheat, the fungus, south of the fortieth parallel, may continue to grow and produce summer spores all winter, and the need of the other two forms is lessened. Even in colder climates the uredospores of some rusts live over winter and start infection in the spring.

In the case of some rusts these three forms are all present and are known to man. In the case of other rusts one stage or even two stages may be either unknown or may not exist at all. When all three stages do exist, the spring stage is often upon some host other than that bearing the uredo and teleuto stages. Thus the spring stage of the wheat rust is upon the barberry; of corn upon oxalis; of oats upon buckthorn.

That some intimate relation existed between the barberry bush and the wheat rust was believed very early in the eighteenth century, and in 1760 Massachusetts passed a law placing a ban upon the barberry. In 1818 Schroeter, a Danish school-teacher, published many observations concerning the relation of the cluster cup upon the barberry and the rust of grains. This relation was finally definitely proved by DeBary in 1864, who, by sowing the teleutospores from the wheat upon the barberry, produced the cluster cups.

All cereal rusts multiply much more rapidly in damp than in dry weather, and the most destructive rusts are worse upon late crops. There is no evidence that these maladies can be carried by seed from rusted plants, though such seeds should not be used for seed purposes, since they do not have stored nourishment sufficient to give the seedling a vigorous start.

Great difference in rust resistance has been shown; thus one variety was so badly affected as to yield only $2\frac{5}{6}$ bushels per acre, while a resistant variety under the same conditions gave $38\frac{1}{2}$ bushels.[1]

The greatest hope lies in the use of varieties which can resist the disease. A number of varieties of the different kinds of grain are now known which possess sufficient resistance to give good yields even when the rust is in its worst epidemic form. Since serious epidemics of rust must be looked forward to with certainty, the item of rust resistance must have due weight in the selection of the variety to be grown.

Several varieties of oats, among them Texas and Georgia Rust Proof, are known to possess valuable, though not complete, resistance to the oat rust when grown in the Southern States, though the same resistance is not maintained under the different climatic influences of the North.

Early maturity in oats is of especial value in that it enables the plant to evade the heaviest part of the rust attack. Good drainage conduces to plants of more resistance to rust, as does also good preparation of the seed bed and extermination of weeds. Drilled wheat is better lighted and better ventilated and resists rust better than wheat that is broadcast.

Wild grasses that harbor rusts identical with the rusts

[1] Carleton, M. A., U.S. Dept. Agr. Div. Veg. Phys. & Path. Bul. 16.

of crop plants, such as wild meadow oat grass, orchard grass, wild wheat grasses, quack grass, wild rye grasses, etc., may propagate the fungus and increase infection. If such grasses are rusted, they should be burned, plowed under, or avoided in the location of the grain fields.

While sprays of various kinds may be effective in checking the spread of rusts, the use of such means of prevention is impracticable, owing to the nature of growth of the crop, and the difficulty and expense of the application. Moreover the question of use of such treatment is complicated by the different kinds of rusts to be met and by their different behavior in different seasons.

Anthracnose of Cereals

Anthracnose (*Colletotrichum cereale* Manns[1]). — Upon many cereals and forage crops, as rye, wheat, oats, orchard grass, timothy, red top, and blue grass, occurs a blight, resulting in shriveling of the grain and spotting of the leaves and stalks. The fungus is marked by small, black acervuli, located upon the spikes, stems, and sheaths, and the chief attack is made as the plants approach maturity.

For more complete discussion, see **rye.**

Special Diseases of Cereals

BARLEY

Loose smut (*Ustilago nuda* (Jens.) Kell. & Sw.). — This disease, previously thought insignificant, seems to be increasing in importance. It now often causes losses in Wisconsin and Minnesota of from 5 to 10 per cent of the crop,

[1] Sci. n. s. *29*, 915, June 4, 1909.

and is present to some extent in most fields of this country, though often unnoticed on account of the early season of

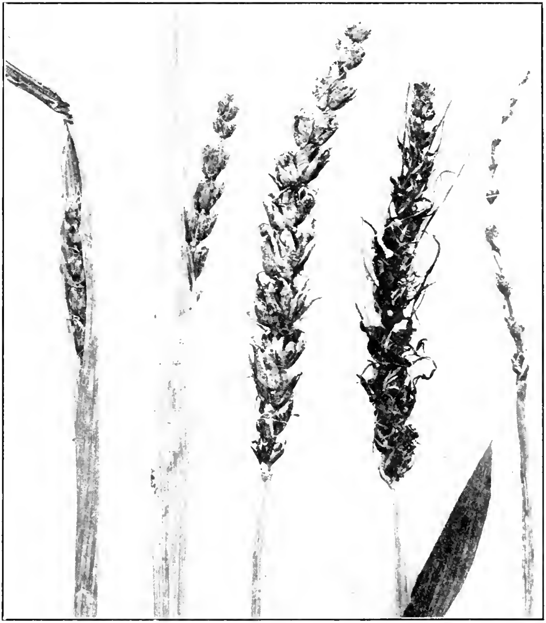


FIG. 139. — Loose smut of barley in various stages of development. After Johnson.

its development, and its absence at harvest time. Every spikelet of the smutted head is usually affected and entirely changed into smut, the central stalk of the head alone escaping. Adjacent leaves are also occasionally smutted.

The smut masses, when they first appear, are covered by a white or gray membrane which soon ruptures, loosing the powdery olive-brown mass of spores, which soon blow away. This character enables one to distinguish this with ease from the covered smut. Smutted plants head early, the smut reaching its maximum at flowering time, though scattered heads of smut may appear at other dates. The smutted heads stand high on especially tall stalks, which affords excellent wind distribution of the spores to the surrounding blossoms. The fungus reaching the blossoms gains such foothold upon the developing grain that its use as seed, without treatment, insures a smutted seedling as offspring. In the plant developing from such an infected seedling the disease does not show externally until the ripening of the smut at the next blossoming season.

The life history of this smut is thus similar to that of wheat loose smut, and the same treatment, *i.e.*, rouging, combined with a modified Jensen hot-water treatment, is effective, preventing all the smut. See p. 372.

Covered smut (*Ustilago Hordei* (Pers.) Kell. & Sw.). — In the covered smut, the smut masses occupying the place of the grains and glumes are at first covered by a membrane composed of the outer surface of the glumes of the spikelet. This membrane retains the spores for some time after harvest. The spores, as seen *en masse*, after the rupture of this cover are very dark to purplish black, with no tint of olive.

The treatment given for oat smut applies here.

Ergot. See **rye.**

Black stem rust (*Puccinia graminis* Pers.). — Identical with that on wheat, this rust can be readily transferred from either host to the other. See **wheat.**

Scab (*Gibberella*). See **wheat.**

Yellow leaf disease (*Helminthosporium gramineum* Rbh.). — This leaf blight was discovered in America by Pammel in 1890. It is characterized by longitudinal, yellowish green spots in parallel rows upon the leaves. The plants die prematurely, and the yield is thus reduced.

Helminthosporiose (*Helminthosporium sativum* Pamm., King, & Bakke). — First known in 1907, this disease has been observed in Iowa, South Dakota, Minnesota, and Saskatchewan.[1]

It occurs as brownish, circular or somewhat elongated, dark spots which soon cause the leaves to turn brown. It also occurs upon sheaths, glumes, spikelets, and grain. The straw at harvest is dull brown and lacks strength.

Powdery mildew. See **wheat.**

BROOM CORN

Kernel smut (*Sphacelotheca Sorghi* (Link) Clinton). — This fungous disease of broom corn and sorghum is indicated by the presence of irregular elongated branches of very inferior value. The branches are further damaged by the blackening occasioned by the loose spores. The seeds are, of course, destroyed. Of the fields examined by Clinton in Illinois[2] few showed over 1 per cent of the stalks infected, though sometimes parts of a field bore as high as 20

[1] Pammel, King, and Bakke, Am. Phytopath. Soc., 1st Ann. Meeting, December 31, 1909.

[2] Clinton, G. P., Ill. Agr. Exp. Sta. Bul. 47, March, 1897.

per cent of infected stalks. Infection can occur only upon very young plants. Between the times of infection and the appearance of the smut masses in the panicle no signs of the disease are seen without the aid of the microscope.

The smut can be prevented by the use of clean seed, obtained either from clean fields or by disinfecting the seed by the hot water (135° F. for 10 to 15 minutes) or formalin methods, as given for oats.

Head smut. See **sorghum.**

CORN

Smut (*Ustilago Zeæ* (Beckm.) Ung.). — Corn smut is well known to every farmer, occurring everywhere the corn plant is grown, as black, pulverulent masses most conspicuous upon the ear and tassel. The damage done by it is estimated at 1 per cent of the ears. To this should be added perhaps 1 per cent more to cover the loss in vigor that is sustained by the plant. Under exceptional conditions the damage may exceed these figures. Thus in Iowa a loss of two thirds of the crop was at one time reported.

Corn smut is first mentioned in literature in 1754, and the first American record is that of its collection in North Carolina in 1822. Experiments looking to its prevention were made as early as 1760. The disease may attack any part of the plant at any age, — leaves, stalks, aërial roots, ears, tassels, — provided only that they be still in tender growing condition, not mature and hard.

The first symptom is a pale, glistening, swollen area covered with a white membrane, which soon appears black owing to the maturation of the spores within. The membrane eventually bursts, loosening a powdery, dry, black mass of spores through which fibrous veins of the corn plant still penetrate. It has been conclusively demonstrated that the causal fungus is not conveyed to the new crop in the seed, as is the case with so many other smuts, and that therefore no form of seed treatment is of value for its prevention. The sowing of seed covered with smut spores does not result in any more smut than does the use of uninfected seed.

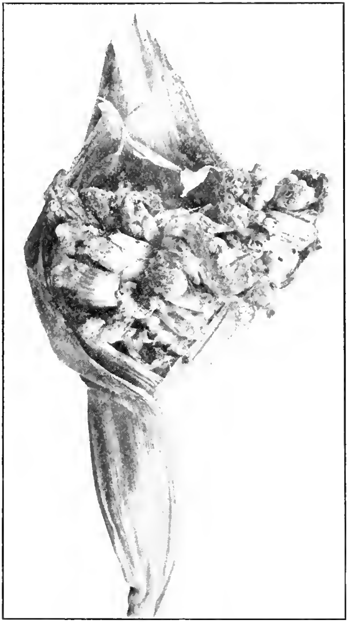


Fig. 140. — Corn smut upon the ear. Original.

It has been clearly shown that infection is produced by the spores which, under suitable conditions of moisture, fall upon any tender part of the corn plant. The silks furnish the requisite conditions, and it is through them that ear infection occurs.

The sheaths of the leaves hold water, and inclosing as they do the tender growing portion of the stem, are admirably

FIG. 141.—Smut upon sweet corn tassels. After Jackson.

suited to infection. Other portions of the plant are less suited to the requirements of the fungus and are not so often attacked. Since infection cannot occur without moisture, weather conditions are of predominating influence.

The longer the crop grows, the longer the period of susceptibility is maintained. Thus a late-planted crop in Indiana showed half as much infection as a crop which was planted earlier, chiefly because it was exposed to contagion only about half as long. Moisture and richness of soil predispose to disease by increasing growth and giving a greater number of susceptible points of attack. Corn thickly planted is more liable to infection because ventilation is restricted, and thus a more humid atmosphere is created around the plants.

It has been shown that corn smut can be reduced some 16 to 72 per cent by spraying with Bordeaux mixture, but the saving does not warrant the expense. The only practical method is to go through the field several times during the season and cut out and burn all the developing smut masses that can be seen, to thus destroy the spores and prevent the continued spread of the disease. Professor Bessey says: "The cost per annum of gathering and burning the smutted ears ought not to exceed ten or fifteen cents per acre. A smart boy carrying a bag slung over his shoulder ought to be able to earn good wages in smutting corn at ten cents per acre." This practice continued yearly would result in continued diminution of smut. Whether it will be profitable or not depends upon the amount of smut usually found in any given community. The use of the silo in which the smut spores are destroyed tends to lessen the amount of smut. The smut fungus can live and even increase in manure. Therefore live smut spores may infect the manure pile and thereby increase the disease in fields to which such manure is applied. The smut itself, contrary to popular belief, is poisonous only under very rare and exceptional conditions, so rare as to be practically negligible.

Head smut (*Sphacelotheca Reiliana* (Kuehn) Clinton). — This smut, identical with that of sorghum, occasionally occurs upon corn and is somewhat more injurious than the usual corn smut.

Corn Ear Rots

Four types of ear rot due to four distinct diseases are described below. In the aggregate the loss from these is enormous, constituting as it does 10 per cent or more of a crop worth annually more than $125,000,000. The infection resulting in this loss comes from definite species of fungi, and is not comparable to ordinary molding of dead organic matter by fungi of varying kind. These corn ear rots are true definite diseases. Ninety per cent of these rots is caused by one species of fungus alone, and its vulnerable points of attack are known.

Dry rot (*Diplodia Zeæ* (Schw.) Lev.) and (*Diplodia macrospora* Earle). — This is one of the very widespread dry ear rots of corn variously known to growers as mold, mildew, rot, dry rot, etc. Suspicion has been recently cast upon it as the cause of pellagra.[1]

Though the disease is really present soon after silking, and even much earlier from root infection, it is not usually recognized until husking, when a whitish covering of the kernels within the husk is noted. This white mycelium also forms dense masses between the individual grains, among the husks, and over the cob. The grains on the

[1] Smith, E. F., and Hedges, Florence, Sci. n. s. *30*, 60, July 9, 1909.

Fig. 142. — Young ear of corn inoculated in the silk with diplodia. After Burrill & Barrett.

affected ear are shrunken, loosely attached, light in weight, and darker in color and more brittle than those of a healthy ear. Upon breaking open an ear, very small black pycnidia may be seen embedded in the white masses of mycelium, especially at the bases of the kernels. Diseased ears left in the field may develop these pycnidia in such abundance as to make the grains black.

Much of the food value of the corn is lost, owing to the consumption of starch within the grain, as well as to the prevention of starch storage. The germinating power of the grain is also lost.

Upon the stalks the fungus first appears as very small dark specks under the rind, near the nodes, and at broken places, usually in over-wintered stalks. Stalks nearly three years old have been found bearing pycnidia. Although the green stalks are not naturally susceptible, the shanks are particularly so.

The causal fungus gains entrance to the ears from infected stalks which bear them, and these are infected from the soil through the roots. Ears are also infected through the silks by wind-borne spores, which come, in part, from diseased ears, but more largely from diseased stalks left in the field.

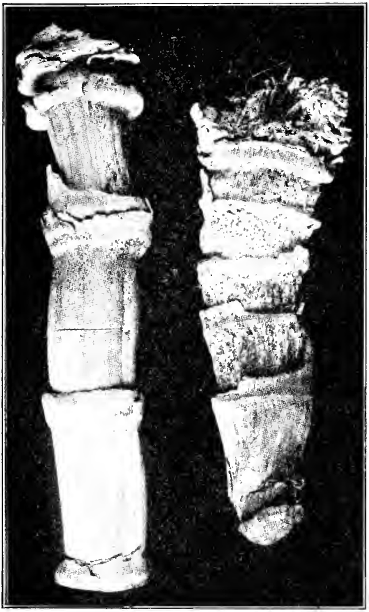


FIG. 143. — Diplodia on old shanks. After Burrill & Barrett.

Any method of reducing the amount of infective trash, particularly old stalks near or in the fields, aids in control

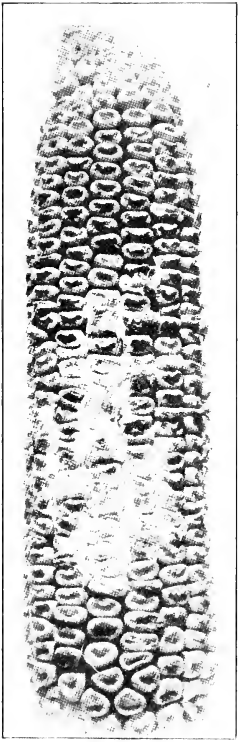


Fig. 144. — Corn mold caused by Fusarium. After Burrill & Barrett.

of this pest. Practically, this means to take out of the field and destroy all rot-infected ears and to cut infected stalks low and haul them away or burn them. It is still better to practice such rotation that corn will not follow corn within two years. Badly infected fields or spots in fields should never be planted to corn without rotation.

Dry rot, fusariose (*Fusarium*). — Upon the ears this disease appears as a dense, felted, white mycelium, extending between the kernels to the cob. The kernels are killed and their starch partly consumed.

A second fusarium disease is characterized by a deep pink to red color noted on the ear when the husks are removed. The kernels are brittle and the starchy portion powdery.

A third fusarium disease causes less complete destruction of the ear than the preceding; often only a few scattered kernels are affected. The mycelium is white and sparse.

Blight (*Bacterium sp.*). — This disease was under the observation of Professor Burrill of Illinois for some time prior to 1889 and was described by him in that year.

It shows chiefly as a dwarfed condition which may occur upon plants scattered throughout the field or more often upon plants in certain spots in the field, such sick spots varying in size from a few rods to an acre or more. The affected plants appear abnormally slender, finally cease growing, turn yellow, and most of them die. In rare instances they may recover.

The lowest roots of diseased plants, in some cases comprising half of the root system, are dead or dying. The stalk near the base, when split lengthwise, shows a uniform dark color which also appears in the upper nodes in lesser degree. The internodes show no disease symptoms. Upon the surface of the stem base are brownish, corroded spots, diffuse or definitely bordered, and accompanied frequently by masses of rather firm semi-transparent jelly.

The leaf sheaths show watery brown or red specks or larger irregular patches. Upon the insides of the sheaths these spots are more conspicuous and larger, and are coated with a gelatinous substance.

The ears are sometimes affected in plants which are taken with the disease so late as to allow ears to form. All parts of the ear appear wilted and gelatinous coated, and the silk rotten, though not ill scented.

Wilt, pseudomonose (*Pseudomonas Stewarti* E. F. Smith). — This corn wilt was first described by F. C. Stewart[1] as prevalent in nearly all parts of Long Island upon many different varieties of sweet corn. In some cases the entire crop was ruined, and 20 to 40 per cent of loss was frequent, though in the majority of cases the loss was so slight as to pass without notice.

The diseased plants wilt and dry up much as though for want of water, yet in soil that is amply water supplied. While the wilting is most liable to occur at flowering time, it may appear at any stage of growth when the plants are 25 cm. or more in height. In mild cases the lower leaves wilt first, while in severe cases all wilt at one time. The death of the plant may come in four days after the first signs of disease show, or may be delayed a month, possibly with recovery and relapse intervening.

The roots remain normal, but the veins in the stems appear as yellow streaks, in older cases black, instead of their normal color. Such stems, if cut crosswise, shortly exude a yellow, viscid drop at the ends of the veins. This is the most distinctive character, and infallibly indicates the presence of the wilt. Death is caused by the plugging of the water passages with this viscid substance, which consists mainly of bacteria.

In the fields the diseased plants are scattered unevenly, young and old stages and healthy plants together, health and disease even in the same hill; yet there appears to be no direct plant-to-plant infection, nor any of that centrifugal spreading from a diseased center that is so noticeable in most wilt or soil diseases.

The causal organism is found in the seed from affected

[1] Stewart, F. C., N.Y. (Geneva) Agr. Exp. Sta. Bul. 130, December, 1897.

plants, and it has been proved experimentally that such seed carries the disease to the offspring.[1]

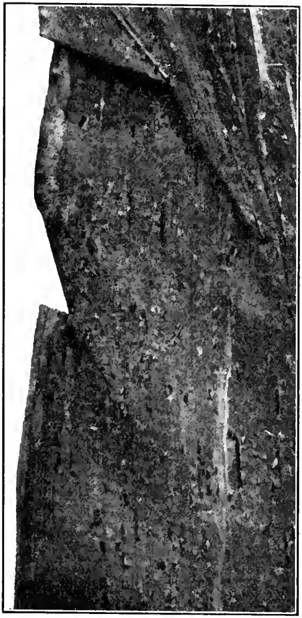


Fig. 145. — Portion of corn leaf showing sori of rust. Original.

As a preventive measure resistant varieties should be selected for planting, and all seed from plants which are at all diseased should be avoided. The disease may be carried from one locality to another by any of the means suggested under soil diseases, and especially by manure infected with stalks of diseased plants.

Rust (*Puccinia Sorghi* Schw.). — Corn rust seems to have taken its place in literature in 1815. It is of comparatively slight harm, since it does not usually develop early in the season, though in exceptionally favorable climatic conditions it may develop early upon young plants. Its injury is then greater. The loss is en-

[1] Smith, E. F., Sci. n. s. *30*, 223.

tirely in destruction of green tissues and impairment of starch-making power.

The sori, confined almost entirely to the leaves, are those characteristic of the rusts, the brown summer spores appearing first in linear sori, and the black winter spores coming later in the season. The cluster-cup stage is found upon the wood sorrel (Oxalis).

Yellow leaf disease, helminthosporiose (*Helminthosporium inconspicuum* C. & Ell.). — This blight gives a somewhat frost-bitten appearance to the plants, producing also a thin olive-green mold upon the lower sides of the leaves. Sometimes only the tips of the leaves are affected, but usually whole leaves die.

The disease produces elongated yellowish spots limited by the veins. The spots are sometimes covered with dark-colored spores. The disease is confined almost entirely to late-planted corn, and is prevalent during its early growth, though it has never been reported upon seedlings.

It is known to cause much loss in Delaware, New York,[1] and Connecticut,[2] and is of widespread occurrence in the United States.

Sclerosporose (*Sclerospora macrospora* Sacc.). — This causes considerable injury to corn in Italy. It has been collected in the United States, but has not been serious. The tassel is chiefly affected.

MILLET

Piriculariose (*Piricularia grisea* (Cke.) Sacc.). — Upon the lower leaves the disease occurs as a spot which is

[1] Stewart, F. C., N.Y. (Geneva) Agr. Exp. Sta. Rpt. *15*, 452.

[2] Conn. State Agr. Exp. Sta. Rpt. *13*, 171, 1889.

at first dark purple or reddish and elongated, parallel with the length of the leaf. Later the center turns black and finally straw-colored, bordered by a black ring which merges into reddish purple at its outer edge.[1] Badly diseased leaves turn yellow and dry and shrivel from the tip toward the base, lessening the fodder value and seed yield of the plant.

Smut (*Ustilago Crameri* Koern.). — This smut infects the individual flowers, destroying the lower parts of the glumes. It has been noted in Ohio, Minnesota, Connecticut, Illinois, Indiana, Iowa, Maine, Michigan, North Dakota, and South Dakota.

The formalin treatment as recommended for oat smut is applicable.

OAT

Loose smut (*Ustilago Avenæ* (Pers.) Jens.). — Under the name "smut," "blackheads," etc., this disease is known wherever oats are grown. Grain and more or less of the chaff are replaced by a powdery black mass, which shatters out as it ripens, leaving later only the naked branches of the panicle.

Fig. 146. — Leaf spot of millet due to piriculariose. After Jackson.

[1] Jackson, Del. Agr. Exp. Sta. Bul. 83, December, 1908.

FIG. 147. — Smut (*Ustilago avenæ*) on oats. After Jackson.

Usually all the spikelets of a head and all the heads of the affected plant are smutted. There is considerable difference in the resistance offered by different varieties, but in view of the perfect protection afforded by proper treatment this is of little significance.

The damage caused by smut is usually underrated. In 1884 Arthur[1] in New York by actual count found the oat smut to constitute from 8.5 to 10 per cent of the ordinary crop. By actual count of nearly 11,000 heads Plumb[2] in 1886 determined the amount of smut to be 8.4 per cent; in some fields he found as high as 20, 28, and even 30 per cent. Kellerman and Swingle,[3] counting smutted heads

[1] Arthur, J. C., N.Y. (Geneva) Agr. Exp. Sta. Rpt. 3, p. 382, 1884.

[2] Plumb, C. S., N.Y. (Geneva) Agr. Exp. Sta. Rpt. 5.

[3] Kellerman, W. A., and Swingle, W. T., Kans. Agr. Exp. Sta. Rpt., p. 213, 1889.

in Kansas, found different fields to have 8, 15.3, and 18.3 per cent of smut, while single portions of a field showed as high as 39 per cent. The annual loss in this country is somewhere between $10,000,000 and $20,000,000.

The reasons for underestimation of oat smut are the dwarfing of many of the affected plants: which thus remain unnoticed by a casual glance over the field, and the fact that many smutted panicles remain invisible unless unrolled from their enveloping leaves.

It was proved as early as 1858 that infection can occur only upon the very young oat plant: that older plants are immune. It was later determined by Brefeld that the plants are immune after the leaves have protruded 1 cm. beyond the leaf sheath. From this it follows that the chief (and as other experiments have demonstrated practically the only) infection comes from smut spores which are upon the seeds when they are planted. These sprout, producing sporidia which infect the young plant. The fungus develops in these plants throughout the season without conspicuous effect until, at blossoming time, the fungus seeks the ovaries and the glumes and appears again as the familiar black spore masses.

Any treatment which kills the spores upon the seed without materially injuring the seed itself results in a clean crop.

The bluestone treatment so widely used to prevent wheat smut, however, is not advisable for oats, since its use is attended with too much danger to the germinating power of the oat seed. The hot-water treatment as applied to wheat for loose smut, using a temperature of 132°–133° F. for ten minutes, 130° F. for fifteen minutes, or 145° F. for not more than five minutes, may be employed with perfect efficiency; but since the formalin or Sar treatments are thoroughly satisfactory and much easier of application, the latter are preferable. The formalin treatment may be made as follows: —

Formalin can be purchased from a druggist at a cost of from seventy-five to ninety cents per pound, much cheaper if purchased in quantity. One pound is sufficient to treat forty-five to fifty bushels of grain. It should be used at the rate of one ounce to three gallons of water, and in general, one gallon of mixture suffices to treat one bushel of grain.

Spread the grain in a thin layer on a smooth barn floor, canvas, or upon hard ground, and sprinkle with the diluted formalin, using either a spraying machine or a watering pot. Sprinkle so as to thoroughly and evenly wet the grain with the mixture. Then shovel the grain over thoroughly a few times to insure even distribution of the solution and thorough wetting of all the seeds, and cover the pile with canvas, carpets, blankets, or bagging, to keep the fumes of the formalin within. The pile should stand from six to twelve hours in this way. The seed may then be readily dried by mixing with air-slaked lime, and the lime may be removed by the fanning mill, or the lime may be omitted and the grain dried by spreading it out in layers about 5 cm. thick and stirring it frequently. The seed is then ready to sow. It may be stored, but in so doing it is liable to renewed smut infection, unless all bags, bins, etc., with which it comes in contact are also disinfected with a thorough application of the formalin solution. The drill that is used should also be disinfected either with formalin or by a thorough dusting with dry lime.

On a large scale oats have been treated by the formalin method at the rate of 500 bushels an hour, by throwing the formalin solution, by means of a steam pump, against the grain as it fell through elevators arranged with deflectors so as to give proper mixing.

The Sar (sulphur, alkali, resin) solution has the advantage that the necessary ingredients can be procured at

Fig. 148. — Outfit and mat for preparing Sar solution. After Swingle.

places where it might be difficult to buy formalin; otherwise formalin is preferable.

To make the Sar treatment, take one half pound of ordinary resin and powder it finely, then mix thoroughly with 15 pounds of ordinary flowers of sulphur. When thoroughly mixed add, little by little, about six quarts of water, stirring all the time. At first the mass crumbles when stirred, but when the right amount of water has been added, the sulphur and resin make a stiff paste, which does not crumble or flow. Too much water must not be added. This paste should be made in the bottom of a barrel or large keg *holding at least six times the bulk occupied by the paste, and preferably more.*

Now pour out ten pounds of granulated caustic soda (concentrated 98 per cent lye or caustic potash) and throw it on top of the sulphur-resin paste and stir rapidly and thoroughly with a flat paddle. In a few minutes the paste begins to turn a reddish brown and slowly liquefies and in a few seconds turns into a deep brown liquid and boils violently. It should be stirred all the time, and after a minute or so it will cease boiling. Hot water should then be added slowly with stirring until the solution is brought up to a six-gallon mark previously made on the inside of the barrel.

This constitutes the stock Sar solution. It should be allowed to stand a few moments, until any dirt or uncombined sulphur has settled to the bottom, and then dipped off and stored in jugs, tightly corked. The mixture can be preserved for months without deterioration. Only a few ounces of the sulphur will remain in the barrel if the solution has been properly prepared.

One fourth of the above formula can be made in a candy pail as shown in Fig. 148. This gives $1\frac{1}{2}$ gallons of stock solution, or enough for 75 gallons of the solution ready for use, in which the grain is soaked for two hours.

The oats or wheat should first be thrown into water, and any smut balls which float should be skimmed off, stirring the grain to be sure that all the smut balls come to the top. The water may then be drained off and the grain treated with well-shaken Sar solution, 1 quart to 50 gallons of water. This should be stirred well in a barrel, then poured over the grain until it is covered several inches deep, stirring so that all the kernels are wetted. The grain should be left from ten to fifteen hours in the solution and stirred several times during the treatment. It may then be spread and dried.

For large amounts of seed it is better to use a much stronger solution and for a shorter time (1 gallon of stock solution to 50 gallons of water for two hours).

Fig. 149. — Smut (*Ustilago levis*) on oats. After Jackson.

Covered smut, ustilagose (*Ustilago levis* (Kell. & Sw.) Magn.). — This differs from the loose smut in the less complete destruction of the flowers and in its less dusty spore masses, which are also blacker than in the loose smut. The smut masses are usually limited to the parts within the flowering glume and the palet or to the bases of these.

The treatment is that given for *Ustilago Avenæ.*

Black stem rust (*Puccinia graminis* Pers.). — The black stem rust on oats shows but slight differences from the black stem rust of wheat, but that it is at least racially distinct is indicated by the fact that proof by inter-inoculation has not been adduced and that a field of one of these crops may be badly affected by its fungus, while adjacent fields of the other crop show no rust or indication of infection such as they might be supposed to do were the two rusts identical.

More common and more injurious than the black stem rust of wheat, it constitutes *the* destructive oat rust, totally destroying thousands of acres of oats almost yearly. As with the wheat black stem rust, its attacks are epidemic, fluctuating greatly in abundance and destructiveness from year to year. It is usually more common in the northern states than in the South.

Crown rust (*Puccinia rhamni* (Pers.) Wett.). — This rust is found only upon the various species of oats, and in the teleutospore stage clearly differs, even to the naked eye, from the other oat rust mentioned above, though in the uredospore stage such separation is extremely difficult without microscopic examination.

It occurs upon oats in practically all fields and is more common than its more destructive relative, the black stem rust. Like the wheat orange leaf rust the damage done is not serious, or very rarely so.

The cluster-cup stage of this rust is known to grow upon the common buckthorn (*Rhamnus cathartica*) and the lance-leaved buckthorn (*Rhamnus lanceolatus*). The stage most conspicuous is the uredo, which forms numerous orange sori upon the leaves. Later the black teleutosori appear under the epidermis as long streaks which, unlike most rusts, do not rupture the epidermis.

Marked varietal resistance is shown. In California black oats are reputed to be less subject to rust than white oats. In the North, the White Russian is said to be resistant, while in the South, the Texas Rust Proof resists attack.

Scab. See **wheat**.

Phyllostictose (*Phyllosticta sp.*). — Browned or reddened leaves with the black pycnidia profuse upon the affected surfaces, sometimes so abundant as to lend a blackish hue to the leaf, comprise the diagnostic symptoms of this malady. Eventually the leaves are killed.

Pseudomonose (*Pseudomonas Avenæ* Manns). — A disease prevalent throughout the entire Eastern and Central States was attributed to bacteria by Galloway and Southworth in 1890.[1] It appeared when the plants were only about 10 cm. high, first causing the leaves to turn brown and die at the tips, then throughout their length. The affected plants revived, but were so reduced in vigor as to prevent effective stooling, and a loss of 35 to 75 per cent of the crop followed.

The disease has recently been carefully investigated by Manns,[2] who claims that it is caused by the symbiotic action of two species of bacteria, a pseudomonas and a bacillus.

Manns describes the disease as follows: —

The preliminary effect is yellowing of the leaf, beginning either as small, round lesions on the blade, or as long, streak-like lesions extending throughout the blade and even the whole length of the culm and blades. Occasionally it begins at the tips and works back into the culm; again the upper leaves often break down through a weakened condition of the plant from defoliation below.

The ultimate symptoms, wherever the disease has made much progress, are partial or general collapse of the leaves, which take on a mottled to almost red color.

It prevails from New England to Georgia, and from the Atlantic to Indiana and Illinois. The damage in Ohio has

[1] Galloway, B. T., and Southworth, E. A., Jour. Mycol. *6*, 72.

[2] Manns, T. F., Ohio Agr. Exp. Sta. Bul. 210, October, 1909.

been estimated at from 14 to 37 per cent of the crop. Rain and moisture favor it.

When very prevalent, the soil may become infected as in typical soil diseases. The only hope seems to rest in resistant strains.

Anthracnose (*Colletotrichum cereale* Manns). — The effect of this disease upon oats is similar to that described for rye.

Yellow leaf disease (*Helminthosporium inconspicuum* C. & Ell. *var. brittanicum* Grove). — Oat leaves with this disease turn yellow and pale and develop dark brown spore-bearing spots. Little is known as to its severity or prevention.

Powdery mildew. See **wheat.**

RICE

Blast, rotten neck (*Piricularia Oryzæ* Cav.). — This is a world-wide rice disease which in Italy is controlled by the use of resistant varieties. It has probably been present for many years in American rice sections, but did not become of serious economic importance until about 1895. What seems to be the same disease occurs upon crab grass, and apparently infection may come from this host. It is reported from South Carolina and Louisiana, also from Texas, where it has been serious. The disease occurs upon upland as well as irrigated fields.

The most characteristic symptom consists of lesions at the sheath nodes just over the joints of the stem, at the region where the stem comes to be the axis of the head (the " neck region ") and at the points where the blades of the leaves join their sheaths,[1] appearing first as very small,

[1] Fulton, H. R., La. Agr. Exp. Sta. Bul. 105, April, 1908.

water-soaked sunken spots on the node of the sheath. Spots upon the neck are not water-soaked, and the skin does not rupture until the head breaks off. Later the spot becomes brownish or black, and similar discoloration runs upward and downward. The affected stem tissue gradually extends laterally, shrinks, and dies, cutting into or through the joint, which results in an open wound. The region above the wound becomes pale and dies.

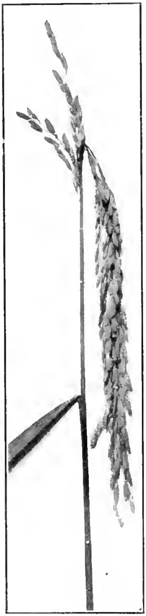


Fig. 150. — Rice blast. After Fulton.

Upon young plants leaf spots occur, first brown with ashen center, later coalescing and taking the whole leaf. If the attack is early, the grain does not fill at all; if late, it may partially fill. The dead portion of the plant may bleach or darken according to subsequent surroundings, resulting in great variety of appearances in the later stages of the disease. In 70 per cent of the cases examined by Metcalf[1] the lowest joint of the rachis was affected, and in consequence the heads broke off at this place. This gives rise to the common name "rotton neck," but since the character is not universal, the name is not an appropriate one.

The chief damage results from the failure of the grain to fill on the diseased stalks. An early attack may render a

[1] Metcalf, Haven, S.C. Agr. Exp. Sta. Bul. 121, May, 1906.

crop unworthy of harvesting. Plants attacked later yield some grains which are of poor, light quality, easily broken or blown away, and consequently largely lost in milling and threshing. The variation in size of the grain also largely depreciates the quality. Many of the heads, especially the heavier ones, fall off, and some fields show at least one third of the crop thus left upon the ground.

FIG. 151. — Rice showing "green smut." After Fulton.

The Rice Committee of the Agricultural Society in South Carolina, March, 1904, estimated the loss, up to that time, to be very nearly $1,000,000. Depreciation in land values, necessitating abandonment of land, is a not insignificant item of charge against this disease.

While the disease can be stopped by spraying with 5–5–50 Bordeaux mixture, this course is not practicable with such a crop as rice. The chief hope lies in the use of resistant varieties. Withholding nitrogenous fertilizers and removal of infective trash by burning are good sanitary measures.

Green smut (*Ustilaginoidea virens* (Cke.) Tak.). — This grain disease, though partaking of the appearance of a true smut, is in reality more closely related to the ergot of rye. The grains, usually only a few in each head, become enlarged, spherical, 5 mm. or more thick, and coated with a dark green powder. Sometimes a yellow color prevails instead of the green. In section the interior is seen to be filled with a compact white mass, bordered by a brownish yellow zone, then by the green coating. Though the disease has been known in Louisiana for ten or more years, and is there present to some extent in most fields, it is not considered serious, since rarely more than 0.25 per cent of the heads, and only a few grains per head, are affected.

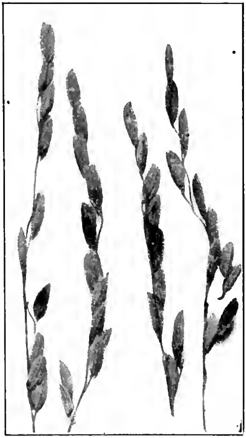


Fig. 152. — Rice showing black smut. After Fulton.

Black smut (*Tilletia horrida* Tak.). — A smut upon rice received by Anderson [1] from Georgetown, S.C., in 1898, was reported as darkening flour made from rice from affected fields. Many heads bore as much as 25 per cent of smutted grains. In Louisiana it is also reported, but not usually in amounts to cause much loss.

This smut was probably imported from Japan in infected seed, but due to the immediate action of Anderson and Walker the pest seems to have been completely stamped out in South Carolina within the first few years after its advent. No reports whatever of its presence there have been made since 1903.

[1] Anderson, A. P., S.C. Agr. Exp. Sta. Bul. 41, March, 1899.

The smut closely resembles the stinking smut of wheat. The affected ovaries or grains are transformed into stum masses which remain within the glumes, and so resemble the normal grains as to often be mistaken for them. The fungous mycelium grows within the stem tissue of the diseased plant, and, as is the case with wheat bunt, infection probably occurs in the seedling stage, and the fungus remains un-

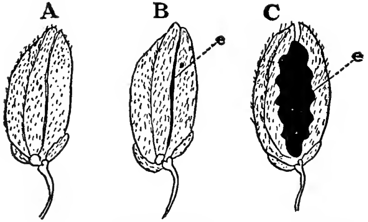


FIG. 153. — Three rice spikelets; *A*, normal; *B*, smutted; *C*, glumes partly torn away exposing the spore mass. After Anderson.

noticed until its presence is disclosed in the place of the grain, as a black spore mass.

The disease can be controlled, should it again appear, by the methods which stamped it out in South Carolina; that is, by floating out and removing the light and smutted seeds in cold water, then soaking the seed for twenty-four hours in liver of sulphur, 1½ pounds in 25 gallons of water, or by employing a 2 per cent solution and soaking the seed only two hours.

Damping off. — Two forms of damping off of seedlings are known: —

1. Rice, not covered, but simply flooded with water, frequently shows soft rot of the shoot in very young seedlings.

2. Covered rice often shows damping-off spots just above the surface of the ground.

The causes of these rots have not been fully studied, but they are probably due to fungi or bacteria or both.

Spotted blight (*Macrosporium sp.*). — Small black spots of mold upon poorly filled grains sometimes occur, occasionally affecting field areas of considerable size. Though this disease has been reported from South Carolina, North Carolina, Georgia, Alabama, Louisiana, and Texas, it is not seriously destructive.

Speck, pip (*Saprophytic fungi and bacteria*). — The grain in some instances bears one or more discolored, often sunken, circular areas, 1–3 mm. in diameter, bounded by dark margins with the centers gray or pale buff in color, and often with a minute dark spot in the very center. In other cases the grain is shriveled and distorted without any definite spot. The interiors of the grains are chalky and brittle, and of such inferior quality as to be largely depreciated in value. Not infrequently 10 to 25 per cent of the grain is affected, and in some cases nearly 100 per cent. Their germinating power is much reduced.

The disease is caused by the invasion of saprophytic fungi or bacteria into wounds caused by sucking bugs. Methods to control these insects have not been thoroughly worked out.

Rust (*Physiological*). — The leaves die gradually, beginning with the tips of the lower ones. Red spots and streaks usually appear before the leaves lose their green color. The plants are dwarfed, the roots poorly developed, and the heads small and light.

RYE

Ergot (*Claviceps purpurea* (Fr.) Tul.). — Ergot is widely known as a black or purplish body, several times larger than the seed of the affected plant, which displaces the ovary or grain. Ergot occurs commonly upon rye and wheat, and upon many other species of grass, as wheat grass, wild ryes, bluejoint, Kentucky blue grass, Canada blue grass, red top, timothy, and rye grass. Of the last named, one farmer reports 1000 tons of hay so badly affected as to be worthless.

This disease is caused by the attack of a fungus upon the ovary while the plant is in bloom. The fungus invades and consumes the ovary and replaces it with the ergot, which consists of a dense mass of tangled, interwoven mycelium, a sclerotium. Ergots, when mature and under suitable conditions, germinate, sending forth several stalks each, with club-shaped, knobbed tops. From these the spores issue to infect susceptible plants then in blossom. For some days the fungus spreads from blossom to blossom by means of other spores, and each infected ovary results in another ergot.

Loss to the grain and the damage to the plant are slight. Chief injury from ergot arises from its effect upon the cattle which eat ergotized grain or graze upon badly infected grass. The effects appear in the spring; animals become emaciated and rough haired as the result of continuous feeding of ergot through the winter. Continued symptoms of ergot poisoning are tardy circulation in the extremities, gangrenous sores upon the teats or mouth, and sloughing off of parts of the tail, ears, or hoofs. Abortion may also follow as an additional effect.

Fields should be examined for the presence of ergot. If large quantities be found, the grass should not be used for hay or pasture. Ergot can be lessened by cutting susceptible grasses about flowering time, thus checking the spread of the fungus. Badly infected hay lands should be burned over to destroy sclerotia; roadside grasses should be cut often enough to prevent the formation of ergot, and seed should be examined to prevent the spread of ergot through this means.

Black stem rust (*Puccinia graminis* Pers.). — This rust is perhaps identical with the black stem rust of wheat, and the description given in that connection applies here.

Orange leaf rust (*Puccinia rubego-vera* (DC.) Wint.). — This rust bears a very close resemblance to the rust of similar name upon wheat, but in careful inoculation experiments it has been impossible to infect one of these hosts from the other. It is invariably present where rye is grown and is particularly abundant in the Southern States, though notwithstanding its universal presence it is not destructive. The uredo mycelium remains alive and continues to produce spores over winter in the leaf in the South, as it probably does in colder climates as well. It is possible that it is in this way carried from season to season by volunteer rye in the fields. The cluster-cup stage occurs upon a member of

FIG. 154. — Leaf of rye showing orange leaf rust. Original.

Fig. 155. — Head of rye attacked by anthracnose. After Manns.

the Borage family, but has never been found occurring naturally in America.

Smut (*Urocystis occulta* (Wallr.) Reb.). — Unlike most of the cereal smuts, this affects the stems and leaves, not the floral parts. It may be recognized by the usual dusty black spores, which occur especially at the joints. While this disease does not directly attack the grain, it does diminish the yield by weakening the plant. It has not as yet been seriously destructive in this country.

Anthracnose (*Colletotrichum cereale* Manns). — A serious disease of cereals and other grasses, chiefly rye, wheat, oats, timothy, blue grass, red top, and orchard grass, was discovered by Selby and Manns[1] in 1908 and described in 1909.

It seems to be a destructive pest of very general dis-

[1] Selby, A. D., and Manns, T. F., Ohio Agr. Exp. Sta. Bul. 203, April, 1909.

tribution, being found in all the fields examined in Ohio. In one field it is estimated to have reduced the yield from 75 bushels to 25 bushels, and it is assigned as a prominent cause of shriveling, such as is often attributed to rust, as well as of whitening and blighting of plants preceding ripening. Upon the heads the disease resembles scab, with the exception that no rose-colored coating is present; instead black acervuli are found upon close examination. Parts of the head above the points of attack die. The portion of the head that is killed is a total loss, and the general decrease in vigor of the plant results in shriveled light grains. Upon stalks and leaf sheaths, beginning at the ground and extending over several internodes, the acervuli may be so numerous as to cause blackening.

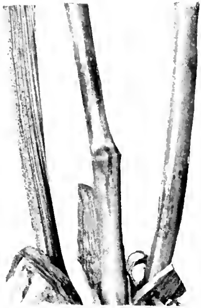


Fig. 156. — Basal portion of rye plant showing anthracnose upon stem and leaf sheath. After Manns.

Fig. 157. — Normal rye kernels and shriveled ones due to anthracnose. After Manns.

Treatment is not yet known.

Scab. See **wheat.**

Powdery mildew. See **wheat.**

SORGHUM

Blight (*Bacillus sorghi* Burr). — This blight was studied by Burrill in 1883 and described in 1887. It prevails upon sorghum, broom corn, Kaffir corn, and Milo maize, and has been noted in Illinois, Kentucky, Iowa, Louisiana, Ohio, Michigan, Nebraska, West Virginia, and District of Columbia, often in serious form. The chief character is irregular-shaped, elongated blotches of red, at first faint orange, upon the leaves and leaf sheaths, sometimes limited by the veins, and always more conspicuous on the inner than the outer sides. Smaller patches later blend into larger ones, and the affected parts die and finally turn black. The lower sides of diseased spots upon the leaves often bear red incrustations, resulting from the drying of the ooze from within. The roots show the same discoloration, and the outer parts of the rootlets die and become loose. If only slightly diseased, the plants may attain normal size.

Badly diseased roots are evidenced by the yellowed tops and other signs of malnutrition. In advanced stages the roots give such poor anchorage that the plants may be easily pulled from the ground.

Infected stalks should be burned and such rotation followed as to relieve the infected soil of susceptible crops for several years.

Kernel smut (*Sphacelotheca Sorghi* (Lk.) Clinton). — This smut infests the individual grains of the panicle, while the head as a whole remains nearly normal in appearance. The smutted grains are at first covered by a white, later gray, membrane. This membrane in time becomes broken by the winter exposure and frees the dark-colored spores.

The disease was reported by Kellerman in 1891 as limited to sorghum grown from imported seed. It was then known in District of Columbia, Wisconsin, New York, Nebraska, and Kansas. It is widespread in Europe, Africa, and Asia, and was probably imported into the United States upon diseased seed. It was first recorded in the United States in 1884, and is now found in almost all places where sorghum is grown.

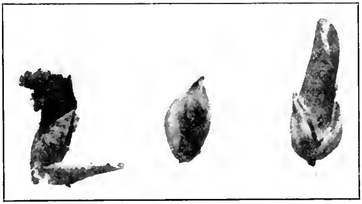


Fig. 158. — Three views of sorghum kernel smut. Original.

According to Clinton's estimates it may prevail upon from 4 to 32 per cent of the plants. The same investigator found that the yield in juice was lessened about 30 per cent, owing to the smaller size of the smutted plants.

As with oats, this smut can gain entrance to the host only during the very young seedling state, before the plants appear above ground. The mycelium of the causal fungus grows through the plant until flowering time without any symptoms of its presence. At blossoming time the fungus seeks the ovary, destroys it, and becomes evident as smut.

Disinfection of the seed is an efficient remedy. The seed should be soaked in formalin, 1 pound to 30 gallons, for two hours, or sprayed with the same solution and piled overnight, as described for oats. The hot-water treatment, 134° to 142 ° F. for 10 to 12 minutes, or the usual bluestone treatment, may be used if preferred.[1]

Head smut (*Sphacelotheca Reiliana* (Kuehn) Clinton). — Instead of involving the grains singly, as in the kernel smut, the head as a whole is affected. A white membrane is at first present, but this later breaks open, exposing the pulverulent spore mass. Rarely a portion only of the head is smutted. The spores soon weather away, leaving behind only the veins of the part involved. This disease was first noted in Egypt in 1868, and is known in abundance in America only in the Texas Panhandle.

The treatments suggested for the kernel smut are of no avail in this case. The only remedy known is to avoid infected seed.

Anthracnose (*Colletotrichum falcatum* Went.). — This was first found in America upon sorghum in North Carolina, where it did considerable damage. It has since been reported from Louisiana. It is worse upon the lower leaves. The spots have a very definite gray or tan-colored center which is surrounded by a dark, reddish brown ring, outside of which is the ordinary green of the healthy leaf. As the spots age they frequently grow together and form one large oblong area, sometimes several centimeters long. At a late period in the development of the disease the centers of the spots are occupied by small black specks, the black acervuli of the causal fungus.

[1] Freeman, E. M., and Umberger, H. J. C., U.S. Dept. Agr. Bur. Plant Indus. Circ. 8, January 27, 1910.

TEOSINTE

Smut. See corn.
Rust. See corn.

WHEAT

Black stem rust (*Puccinia graminis* Pers.). — Though in earlier years this rust was thought to grow indiscriminately upon a great variety of grasses, recent thorough study has shown that what was formerly regarded as one species is in reality a number of races or varieties grouped under one name. The variety now under discussion is known to grow upon barley and wheat and upon several species of Elymus and Agropyrum and other genera of wild grasses.

It is one of the most serious of the rusts, though fortunately not so universally present as the orange leaf rust, and causes more damage in the Central States than any other rust except the oat black stem rust. The damage done fluctuates largely. In some years it is very large, in others comparatively slight. In 1904, a year of especially severe attack, the direct loss in yield was placed at 30,000,000 bushels in the Northwestern States, in addition to the loss in grade of the grain that was harvested. Total loss of the crop often results in Kentucky, Indiana, Texas, Michigan, and Ohio.

Its spring or cluster-cup stage is upon the barberry, where swollen spots are produced upon the leaves, fruit, or young stems. These spots upon one side bear the cups in abundance and upon the other side appear as pale circular regions.

Upon the wheat the rust shows first its uredosori, which come later than the uredosori of the orange leaf rust, and are of more brownish tinge. The sori are most common upon the stems and leaf sheaths, more rare upon the leaf blade. As with some of the other cereal rusts, the uredospores may remain viable over winter, and thus perpetuate the rust, even without the aid of other forms of spores.

Following upon this stage the black teleutosori appear upon the stems and leaf sheaths, constituting the most conspicuous and predominating symptom.

The damage by this disease is due to the inroads of the fungus upon the green leaf tissue, destroying the starch-producing power, diminishing the vigor of the plant, and showing its effects finally in the shrunken, shriveled grain.

Since this rust usually appears late in the season, the varieties of wheat that mature early are likely to escape its attack to a greater extent than those varieties which are late in maturing. For a similar reason any climatic conditions which conduce to slow growth and late maturing of the crop favor the rust. Speaking of the resistance of the durum wheats, Carleton[1] says: —

"Numerous reports indicate that the loss to the wheat crop by rust amounted to as much as 50 or 60 per cent over large areas in North Dakota, South Dakota, and Minnesota (in 1904), while in all cases the loss to durum wheat through the same source seldom reached more than 10 per cent, being usually 3 to 5 per cent, and sometimes nothing. Conservative estimates have given the decrease in the entire production of wheat in the three states mentioned at from 25,000,000 to 40,000,000 bushels, or a loss in the farm value of the wheat of at least $25,000,000. There is little doubt that if all wheat grown in these three states during 1904 had

[1] Carleton, M. A., U.S. Dept. Agr. Farmers' Bul. 219.

been durum wheat, this loss would have been entirely avoided."

Orange leaf rust (*Puccinia triticina* Eriks.). — This is the most common and widely distributed of all rusts of the United States. It is said by Carleton that it is not only never absent from the wheat fields throughout the year, but that it is sometimes abundant even in dry seasons. Though it is so abundant, its inroads upon the crop are not usually serious, and in no case on record has it caused shriveling of the grain such as is common from the black stem rust.

The most conspicuous feature of this rust is the abundant, orange-colored sori upon the leaves, especially upon their lower surfaces. The grayish black teleutosori are neither so prominent nor so abundant as in the black stem rust. Both of these rusts possess the uredo stage, and it is difficult for any but the expert to distinguish them apart in this condition.

As with the rye orange leaf rust, this fungus also can winter its live uredo mycelium and continue to bear uredospores throughout the year, spending its entire existence, if necessary, in this one stage upon the single species of host.

While no variety of wheat is entirely proof against it, large difference is shown in this respect, some varieties presenting high resistance, even under most adverse conditions. Early maturity is an important factor in evading rust.

The following standard varieties are recommended by Carleton as possessing considerable resistance to the orange leaf rust in every part of the country — " Winter wheats: Turkey, Mennonite, Pringles No. 5, Rieti, Odessa, Pringles

Defiance. Spring wheats: Haynes Blue Stem, Saskatchewan Fife.

"The following varieties seem to be resistant, but have not yet been well established as such: Theiss, Oregon Club, Senora, Diehl Mediterranean, Fulcaster, Arnolds Hybrid, California Spring.

"Some of the hardy prolific sorts not yet well known in this country, but likely to be more or less rust-resistant after thorough acclimation and selection, are — Winter wheats: Prolifero, Banatka, Red Winter, Nashi, Tangarotto, Bearded Winter, Winter Ghirka, Budapest, Crimean, Yx, Bellevue, Talavera. Spring wheats: Alsace, Spring Ghirka.

"Two varieties which are quite susceptible to rust, but which usually ripen early enough to escape the worst effects of it, are: Early May and Zimmerman.

"Some others not quite so well known, but probably worthy of trial as rust-escaping sorts, are — Early Baart, Allora Spring, Kathia, Roseworthy, Japanese No. 2, Yemide, Canning Downs.

"These last varieties are not likely to withstand very severe winters, and are therefore best adapted to southern districts, where they may perhaps in time become acclimated. Yemide and Kathia are probably the most hardy of the six. Canning Downs winterkilled in one trial, even in Mississippi."

Stinking smut (*Tilletia foetans* (B. & C.) Trel., *Tilletia Tritici* (Bjerk.) Wint.). — This smut (for practical purposes the two may be considered as one) is readily distinguished from the loose smut by the fact that it attacks only the grain, not the inclosing chaff. The head therefore remains of much more nearly normal appearance, and it is often not until the glumes have been opened, and their contents examined, that the presence of the smut mass is detected, covered with its membrane, and resembling the wheat grain in size and shape. It may be recognized by an expert observer by its peculiar, disagreeable, penetrating odor, and by the deeper green color of the diseased heads. The smut masses are often so firm as to remain unbroken through threshing, but they may be recognized among the grains by their darker color, greater plumpness, absence of groove and germ, and finally by crushing them and liberating the black spores.

The disease is particularly destructive in that its presence signifies not only loss of grain due to replacement by smut, but also loss in value to the good wheat, which may be largely depreciated in price by the presence of the bunt. Often bunted wheat is worthless for milling purposes and even for cattle food. Bunt constitutes for these reasons one of the worst smuts in the world. Strong fanning removes part of the smutted grains, but troublesome washing processes must be used to remove them all, and even then the results are not entirely satisfactory.

Many smut spores naturally find lodgment upon the surfaces of healthy grains from smutted fields, or they may be carried from farm to farm upon the threshing machine. Upon planting such seed the following season these spores are ready to attack the seedling grain plant. The fungus, after gaining entrance into the seedling, grows with it throughout the season, and appears again at harvest time as spore masses within the chaff. Affected plants are usually smutted in every head and every grain in the head.

The seedling age, like that of the oat, is the only age susceptible to smut infection. Treatment of seed wheat with formalin, as recommended for oats, is complete in its efficiency and trifling in cost. If formalin is not obtainable, immersion for twelve hours in one half per cent solution of copper sulphate (2 pounds to 50 gallons of water), then in milk of lime (2 pounds of lime to 20 gallons of water), for five minutes is recommended. The use of the lime cannot be omitted without endangering the germinating power of the seed. There is but little choice between these two treatments for wheat, though the formalin is perhaps safer in its effect upon the germinating power of the seed, especially if the lime is not used with the bluestone. The hot-water treatment, see p. 372, is serviceable but more laborious than either of the others. In any of these methods the seed must be dried, and the drill disinfected. See p. 346.

Loose smut (*Ustilago Tritici* (Pers.) Jens.). — Like the loose smut of barley, this smut seems to be increasing in importance. In some regions it prevails to a greater extent than the bunt, causing at times a loss of more than half the crop. It may be readily distinguished from stinking smut of wheat by the fact that the spore masses involve the whole spikelet, which becomes dry and powdery and falls away; also by its much earlier appearance in the field, *i.e.*, at flowering time. The spore masses are dark, olive-black, and are produced exclusively in the spikelets. The bearded spring wheats seem to be more susceptible than the blue-stem varieties, but the smut is common on all varieties.

From the studies of Maddox, 1896, in Tasmania, Wakagwa in Japan, Brefeld in Germany, and others, it is known that with the loose smuts of wheat and barley, totally unlike the bunt of wheat and the loose smut of oats, infection occurs exclusively at blossoming time; that at all other times the plants are immune. Smut spores from near-by smutted heads are blown into the wheat or barley flowers. Infection follows. The fungus then lies dormant in the grain until the seed sprouts. If the grain ripening from such infected flowers be used for seed, the fungus develops in the seedling, and an infected plant, producing smut but no grain, results, though no external symptom of the disease appears until blossoming time. Conversely, if seed resulting from blossoms which were not infected be used, plants free from smut will be raised.

The remedy in this case, therefore, lies in the use of uninfected seed. To obtain such seed grain must be secured from a mother field in which there is no loose smut, or if this is not practicable, seed grain must be raised under such conditions as will afford clean seed.

It has been found that while formalin, as a seed treatment, is ineffective against barley and wheat loose smuts, the Jensen hot-water treatment, in modified form, is effective, and it could be used directly as a preventive, were it not that it is too difficult of manipulation to be applicable to large quantities, and that its use seriously endangers germination of the seed unless applied with great care.

Rouging, or weeding out all diseased plants from the crop that is to be used for seed, diminishes the smut largely, but does not entirely eliminate it.

A practicable, effective means, which results in complete and inexpensive eradication of this smut, consists of a combination of the seed plat with the Jensen hot-water treatment. The directions for proceeding, drawn from Freeman and Johnson,[1] are as follows: —

A good, clean, well-cultivated piece of land should be selected for raising seed. The plat should be large enough to provide at least twice as much grain as will be necessary for farm seed the following year in order to allow for loss in cleaning and selecting. This seed plat should not lie near fields of smutted crops of the same cereals, nor should it be so located that the prevailing winds at flowering time can carry spores to the seed plant from a neighboring field of the same grain. This isolation is absolutely necessary. A strip of wood, a cornfield, or a large meadow is a valuable protection.

After seed for the plat has been cleaned by the best fanning and sifting, it must be treated by the Jensen method. The clean seed should be soaked for from five to seven hours in water at ordinary room temperature, 17° to 22° C. (63° to 72° F.), then placed in small, loose sacks or wire baskets, containing not more than one half peck each, and drained for a short time. The seed must be treated in small lots in order that all of the grain may quickly and uniformly reach the desired temperature. "Two tubs or vats of water should be provided. In one tub (No. 2) the exact temperature required should be maintained. The other tub (No. 1) is used for bringing the grain to the temperature of the treatment, so as not to lower the temperature in tub No. 2. Galvanized iron tubs of 20 to 40 gallons capacity, and kerosene or gasoline double-burner stoves, are convenient.

[1] Freeman, E. M., and Johnson, E. C., U.S. Dept. Agr. Bur. Plant Indus. 152, July 12, 1909.

The drained sacks or baskets of seed should be plunged into tub No. 1 for a minute, then transferred to tub No. 2, and kept agitated while immersed at temperatures and for the periods specified below, the temperatures mentioned being

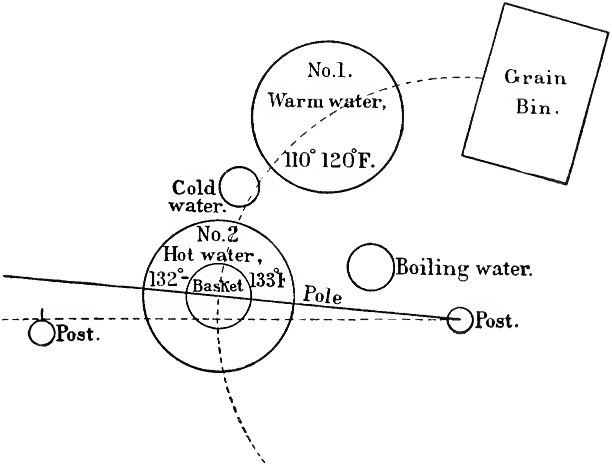


Fig. 159. — Diagram showing a convenient arrangement of utensils for the Jensen hot-water treatment. After Swingle.

maintained as nearly as possible: For barley, 15 minutes at 52° C. (125.6° F.). For wheat, 10 minutes at 54° C. (129.2° F.). In treating barley, if the temperature should rise above 52° C. (125.6° F.), the time of immersion must be reduced to ten minutes at 53° C. (127.4° F.), or five minutes at 54° C. (129.2° F.). Above 54° C. (129.2° F.) there is no safe margin. If the temperature falls slightly below 52° C. (125.6° F.), the time of treatment should be increased in proportion. A temperature lower than 51° C. (123.8° F.) is not effective. In treating wheat, if the temperature should rise above 54° C. (129.2° F.) or fall below 52° C. (125.6° F.), the time for immersion must be diminished or increased accordingly. Under no circumstances should a temperature of more than 55° C. (131° F.) be allowed. Temperatures below 51° C. (123.8° F.) are ineffective." A reliable thermometer is necessary, since the use of an inaccurate instrument may result in injury to the germinating power of the grain or in failure to prevent the smut.

Two men working together can easily treat one bushel of grain an hour, or enough seed in one day to sow a seed plat of from 6 to 10 acres. The seed may be dried by spreading it out in thin layers not over 5 cm. in depth on a clean granary floor or on canvas, and shoveling or raking it from time to time. It should not be allowed to sprout. Care must be taken to prevent freezing of the grain when it is moist, as this will impair germination.

Seed treated as indicated may be planted as soon as it is sufficiently dry to run freely through the drills, making allowance for the swollen seed. Before sowing, the seed should be tested for germinating power, and a corresponding increase in the rate of seeding be made.

The seed plat may be maintained from year to year, or as long as any smut is present in the grain fields. Seed obtained from the treated seed plat does not have to be treated the following year.

Anthracnose (*Colletotrichum cereale* Manns). — This anthracnose seems to prevail on wheat as extensively as upon rye. Upon wheat the head or parts of it are not destroyed, as in the case of rye, but general weakness of the plant and light shriveled grain follows the attack.

Powdery mildew (*Erysiphe graminis DC.*). — The usual characters of the powdery mildews are exhibited: a whitish,

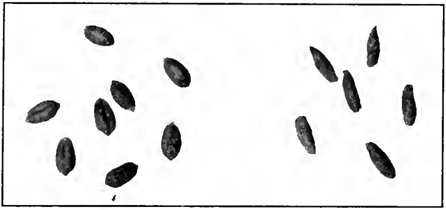


Fig. 160. — Normal wheat kernels and shriveled kernels due to anthracnose. After Manns.

flour-like coating in irregular circular spots upon the leaves and other plant parts. This mildew, together with the mildew of oats, rye, and barley, bears the same specific name, but upon each of these crops the form is so specialized as not to transfer readily, if at all, to the other crop plant. Thus from the plant disease viewpoint there are practically four distinct kinds of mildew, although indistinguishable to the eye. The form upon wheat grows upon all species of Triticum.

In damp, shaded spots the mildew is sometimes quite injurious, though it is rarely so over any considerable area. The conditions favoring the disease should be avoided.

Leptosphæriose (*Leptosphæria tritici* Pass.). — In Nebraska, Heald[1] reported a disease in which the lower leaves were killed early in the season, and the whole field was pale in color. The loss was not large.

Septoriose (*Septoria sp.*). — Septoriose has been noted by Selby[2] as small, dark spots upon the chaff of certain varieties of wheat. No damage was mentioned.

b a

FIG. 161. — Wheat kernels; *a*, normal; b, shrunken and killed by scab. After Manns.

Scab (*Gibberella Saubinetii* (Mont.) Sacc.). — This scab, first described in 1884 in England, seems to be quite generally distributed in America, and is sometimes, though not usually, the cause of considerable loss. Under conditions favorable to the disease the loss may reach 10 per cent. It appears only upon the heads when about half ripe, as yellow or pink incrustations on the spikelets, on the bases of the glumes, or covering the rachis. The affected spikelets ripen prematurely and turn yellow before the normal parts

[1] Heald, F. D., Neb. Agr. Exp. Sta. Rpt. *19*, 46, 1906.

[2] Selby, A. D., Ohio Agr. Exp. Sta. Bul. 97, December 1898.

do. After ripening of the head, the diseased parts appear shrunken. The grain itself is hollow, shrunken, covered with a thick-felted mycelium, and is incapable of germination.

Only a few spikelets upon the head may be affected, these occupying any position, — basal, terminal, or intermediate, — or the whole head may be diseased. The loss occurs in injury to the quality of the grain and diminution in quantity.

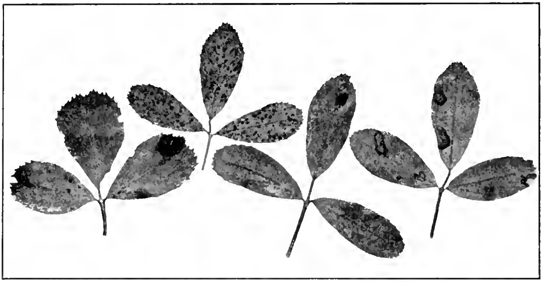
Selby has recently shown that seedlings in the field are often killed by this disease, which is carried over in the seed. In this way as high as 5.9 per cent of death in seedlings has been caused, and it is doubtless chiefly in this manner that the fungus is carried from crop to crop.

FORAGE CROPS

ALFALFA

Leaf spot (*Pseudopeziza Medicaginis* (Lib.). Sacc.). — No other disease of alfalfa is so widely, even universally, present as is this leaf spot. It constitutes the most important, in most sections the only really important, disease of this crop. It seems to be always, everywhere, under all conditions, present to some extent, and it often becomes of serious importance through the decrease in vigor which it causes, and by the loss in hay brought about by the shedding of the leaves. Pammel in Iowa in 1891 estimated the loss in some fields at 50 per cent. It was first described in Europe in 1832, and noted in the United States in 1875.

The leaves first show small brown to black spots, irregular or circular, which extend through the leaf and are thus visible from both sides. They are about 1–2 mm. in diameter, and are not sharply bordered, but shade off gradually into the surrounding tissue. With a hand lens very small, spore-bearing organs may be seen in the centers of the older spots, first as shiny amber-colored elevations. These elevations soon crack open and expose very small,



1 2 3 4

FIG. 162. — Four alfalfa leaf spots; 1, ascochytose; 2, pseudopezizose; 3, cercosporose; 4, stagonosporose. After Stewart and others.

disk or cup shaped sporiferous bodies, which remain surrounded by portions of the ruptured epidermis. Badly diseased leaves usually turn yellow and fall off. Spots upon the stems show the same general character as those upon the leaves.

The lower leaves, and the leaves of older plants, are most subject to the leaf spot. Plants late in the season, as of the second and third cuttings, suffer much more than earlier in the season. These crops, especially if allowed to stand a little too long before cutting in a dry season, may be badly spotted, and the loss in hay, through falling of the leaves, may be considerable. The vigor of the plants is also seriously impaired, both by the loss of green tissue of the leaves that persist, and by the loss of leaves that fall. The plants are never killed by this disease, though young fields which have not yet become well established may be ruined.

The leaf spot attacks yellow trefoil, and a disease which is perhaps identical with it is found upon red clover.

Its mode of dissemination is unknown, but infection through seed is probably one method. Notwithstanding this fact, seed treatment would probably be without avail as a preventive.

The only practicable treatment is to mow down badly diseased plants with the hope that the new shoots which spring forth may overcome the disease. If the disease appears just before cutting time, the mowing should be hastened a few days in order to avoid loss from leaf shedding.

Sclerotiniose, wilt (*Sclerotinia Trifoliorum* Eriks.).—This wilt, which in some respects resembles lettuce sclerotiniose and which may be caused by the same fungus which causes that disease, has been noted in several widely separated sections of the United States.

It kills the plants, and under favorable weather conditions, the chief factor of which is a humid atmosphere, it may extend from plant to plant and cause large sick areas in the field.

Sick plants may show a variety of symptoms. Sometimes the leaves droop, and become matted together in a sodden mass at the base of the plant, and overgrown with a white cotton-like mass of mycelium, in which black sclerotia, similar to those described under lettuce, are found.

At other times the stems may be the point of attack, showing dead brown sections covered with the mycelium and bearing sclerotia. Upon splitting a stem open the central part may be found full of mycelium and with occasional sclerotia about the size of a grain of wheat. The white mycelium and sclerotia are absolutely diagnostic.

Under unfavorable weather conditions the disease may die out and fail to reappear, but if the weather is favorable to it, the wilt may reappear year after year with increased vigor and involving larger and larger areas.

Stewart, French, and Wilson[1] reported large areas where 50 per cent of the stalks were killed, though later the field recovered entirely.

If the disease becomes troublesome, rotation of crops seems to be the only recourse.

Root rot, wilt, fusariose (*Fusarium sp.*). — The first sympton of this wilt is a yellowing of the outer leaves which gradually spreads until all of the leaves and stems become discolored, wilt, and die. This rot is said to be quite generally destructive in Arizona. It is a soil disease, and its general characters are those indicated on p. 63.

Root rot, rhizoctoniose (*Rhizoctonia Medicaginis* DC.). — Similar to the effects of rhizoctoniose upon so many other hosts, the disease consists primarily of a root rot in which the diseased parts are coated with matted strands of the fungous mycelium, usually brownish red or violet in color, accompanied by sclerotia. The tops of plants so diseased turn yellow and die.

The very aggressive fungus migrates through or over the

[1] Stewart, F. C., French, G. T., and Wilson, J. K., N.Y. (Geneva) Agr. Exp. Sta. Bul. 305, November, 1908.

soil to adjoining plants, and the affected spot in the field thus enlarges, sometimes at a rate of 7 m. radially per year. Though long known in Europe, it has not yet appeared in many parts of America.

Rhizoctoniose is a typical soil disease and is kept alive in the soil by its sclerotia, which may live at least two or three years. The general suggestions given under soil diseases apply.

Texas root rot (*Ozonium omnivorum* Shear.). — This rot is the same that affects the cotton so disastrously, and which is discussed fully under cotton diseases. It is a soil disease which in its general characters is the same as those shown upon cotton, and the treatment applied to cotton is the only one to be recommended for alfalfa. It has been very destructive in Texas since 1892.

Anthracnose (*Colletotrichum Trifolii* Bain). — Alfalfa anthracnose was first mentioned in 1905[1] by Bain and Essary, who stated that it was abundant in Tennessee in 1906 and was one of the chief causes of alfalfa failures in that state. It has also been noted in destructive form in Virginia and New York. It appears as elliptical, sunken spots, 5–6 mm. long, upon the stems. The spots are gray and have dark acervuli scattered over them. Where the disease becomes aggressive, dead or withered stalks or plants are seen scattered over the field. These stalks arise from diseased crowns, which are characterized by blackening of the woody parts, below the point where the diseased stalks are attacked. The only remedy seems to be the use of resistant varieties.

Ascochytose (*Ascochyta Medicaginis* Bres.). — This leaf

[1] Bain, S. McC., and Essary, S. H., Sci. n. s. *22*, 503, October 20, 1905.

spot has been noted in North Carolina, and what is probably the same disease, also in New York.

The spots are irregularly circular except where they occur on the edge of the leaf, light brown in color, and bear small black dots. The disease is not important.

Cercosporose (*Cercospora Medicaginis* Ell. & Ev.).—This disease appeared in Delaware in 1889 and has also been noted in New York and New Jersey.

The leaf spots are nearly circular, smoky brown to black, from 0.5–1 mm. in diameter, and show equally well from either surface of the leaf. They have no well-defined borders, but shade into the surrounding healthy tissue. Affected leaves turn yellow and die.

Pseudomonose (*Pseudomonas Medicaginis* Sackett).—From Colorado Paddock,[1] in 1906, described a severe disease of alfalfa which has been noted for several successive years.

It is due to bacteria[2] and in its early stages produces a watery, semitransparent, yellowish to olive-green appearance along one side of the stem of the plant. The plants are at first weak, and light colored, then discolored or blackened on the stems. Drops of thick fluid ooze from the stems and dry upon them, giving a glistening appearance as if they were varnished. The chief damage is to the first cutting, though in subsequent years the plants may die from decay of the crown, or roots, or from loss of nutrition. Infection seems to be chiefly through rifts in the epidermis due to frost, and is caused by wind-borne bacteria.

[1] Paddock, W., Col. Agr. Exp. Sta. Press Bul. 28, November, 1906.

[2] Sackett, W. G., Soc. Am. Bact., Boston meeting, December, 1909. Also Colo. Agr. Exp. Sta. B. 158, 1910.

Downy mildew (*Peronospora Trifoliorum* DeBy.). — Downy mildew, which is a serious pest in Europe, has been reported in America from Colorado, Kansas, New York, and North Carolina, though it has not yet been destructive in this country. The affected parts of the leaf turn yellowish gray to purple, and are frequently curled. The leaves, as seen from below, are coated with the downy fuzz, violet when old, characteristic of this class of diseases.

Rust (*Uromyces striatus* Schroet.). — The true rust of alfalfa may be recognized by the typical rust sori, which are, in this case, chiefly upon the lower sides of the leaves. It is not usually serious.

Glœosporiose (*Glœosporium Medicaginis* Ell. & Kell.). — Black, rather prominent acervuli appear chiefly upon the lower surfaces of leaf spots. The lower leaves often turn yellow and die.

Seed mold (*Alternaria sp.*). — Brown, dead, shriveled seeds are often noted in samples of alfalfa seed. Such seeds, if planted, develop, apparently from within, a dense black mold due to a species of alternaria.

The economic importance of this condition is not known.

Damping off (*Rhizoctonia sp.* and *Pythium DeBaryanum* Hesse). — The damping off of alfalfa is chiefly caused by the two fungi above named. Damping off is discussed in general on p. 60.

It has been known to affect alfalfa seedlings in the greenhouse, and it may occur to some extent in the field, especially the form caused by rhizoctonia.

Stagonosporose (*Stagonospora carpathica* Baeuml.). — This in no case destructive leaf spot has been noted only in New York, and is described as follows by Stewart,

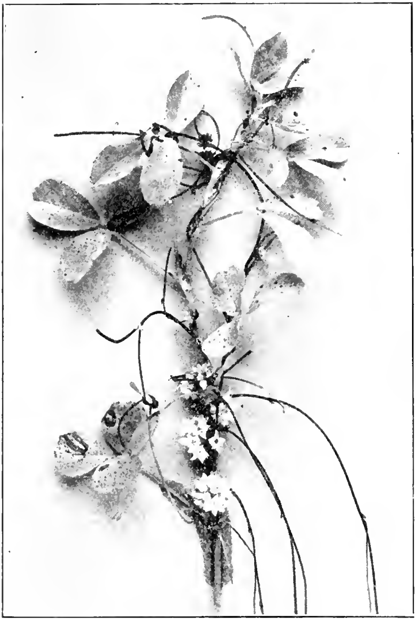


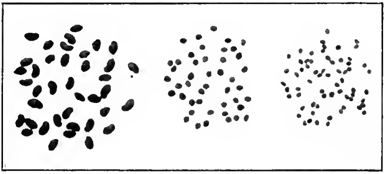
FIG. 163. — Alfalfa plant and dodder. After Stewart and others.

French and Wilson[1]: Unlike the ascochyta leaf spot, this disease attacks chiefly green leaves in the upper part of the plant. The spots are circular, 1–3 mm. in diameter, and usually light brown with a narrow border of dark

[1] Stewart, French and Wilson, l.c.

brown. Each spot bears several light brown pycnidia visible on both surfaces of the leaf.

Dodder (*Cuscuta*). — Dodder, or love vine, is a parasitic flowering plant. It consists of yellow, threadlike stems which coil closely around the alfalfa stems, and take nourishment from them. It reproduces by seed, and the seed may readily pass with alfalfa seed unless very carefully in-



1 2 3

FIG. 164. — 1, Alfalfa seed; 2, seed of large seeded dodder; 3, seed of small seeded dodder, natural size. After Stewart and others.

spected. The parasite is absolutely ruinous to the portions of the field that are infected by it, and, since it spreads rapidly, it is a very serious enemy.

Badly infected fields should be plowed up. If fields are infected in only a few spots, these spots may be dug over or burned over before the dodder ripens its seed, using kerosene and straw to insure heat sufficient to kill every infected plant, and a margin of a few feet entirely around the infected spot.

BLUEGRASS

Rust (*Puccinia Poarum* Niels). — The uredo of this rust takes even greater prominence than does the uredo of most other rusts; indeed other forms of spores are almost entirely absent in most parts of the country, throwing the burden of perpetuation of the species entirely upon the uredo mycelium and its spores. This stage is known to be perennial as far north as Washington, DC., and Lincoln, Neb.

The rust is very destructive, and seems to be limited to this one host.

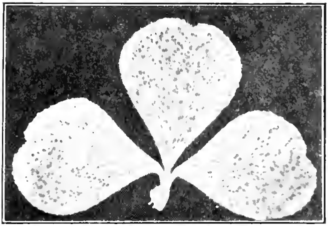


FIG. 165. — Clover leaf showing spots of black mold. Original.

Smut. See **timothy.**

Anthracnose. See **rye.**

CLOVER

Black mold (*Phyllachora Trifolii* (Pers.) Fckl.). — Common red clover, crimson clover, white clover, alsike clover, and several other related plants are affected by this mold.

The chief symptoms are pale spots upon the upper sides of the leaves accompanied by black dots on the lower sides. These spots at first glance so strongly resemble the sori of the rusts as to lead the disease to be mistaken for a rust by the casual observer.

Though the disease is often of considerable damage, no treatment is known.

Sclerotiniose, wilt (*Sclerotinia Trifoliorum* Eriks.). — This wilt is possibly identical with the wilt of alfalfa. In any event it resembles it very closely. It was first noted in America, in Delaware, by Chester in 1889, later in New Jersey by Halsted.

The affected plants wilt and rot to the ground, and white mats of mycelial threads, and later black sclerotia, are found upon or within the dead stems. Sclerotia are especially abundant at the bases of the sick stems. Disk-like bodies, similar to those described in connection with lettuce sclerotiniose, develop from the sclerotium and bear spores which spread the infection.

While this malady has been very destructive in Europe upon several varieties of clover, it has not yet attained wide distribution in America, though it has appeared in a serious way in a few fields.

It is exceedingly difficult to eradicate when it has once gained foothold, and the European recommendation is to avoid planting the affected fields to susceptible crops.

Rust (*Uromyces Trifolii* (Hedw. f.) Lév.). — The clover rust is most injurious to the second crop, to which it may cause a damage of 20 per cent or even 50 per cent if conditions favorable to the disease — damp, cool weather — obtain.

This rust, long known in Europe, whence it is probably adventive, was first reported in America in 1884. At the present time it is found upon red, white, crimson, and alsike clovers over a large part of the United States.

It is one of the true rusts, and on the white clover possesses all of the three stages, cluster cup, summer or uredo, and winter or teleuto spores. It attacks all green parts of the plant. The most conspicuous and destructive stage is the uredo, which is marked by an abundance of circular or elongated chestnut-brown powdery sori. These may be few and scattered, but more often they are quite abundant, nearly covering the leaf. If abundant, the leaf turns black, dies, and shrivels. The rust is conveyed from plant to plant throughout the summer by spores of this stage.

The teleutospores may appear in the same sori with the uredospores or in separate sori, and in either event come

FIG. 166. — Clover leaf showing sori of rust. Original.

later in the season. They are recognized by their darker brown color. The cluster-cup stage, which is less abundant and less injurious than the other stages, may often pass unnoticed. It appears first as pale swollen regions upon the leaf or petiole. These regions soon show the characteristic cups with orange-colored spores. The cluster-cup stage, though not known on red clover, predominates in the early spring, upon many other varieties; but the uredo stage soon gains the ascendancy over it. All three forms may be produced side by side, to some extent, throughout the summer.

Hibernation probably occurs in two ways, by the teleutospores and by the mycelium, which may remain alive in the affected parts over winter.

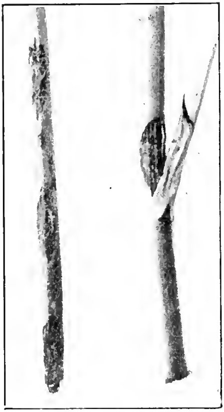


FIG. 167. — Anthracnose on red clover stem and petiole. After Jackson.

Anthracnose (*Colletotrichum Trifolii* Bain). — This anthracnose is now known in Tennessee, Ohio, West Virginia, Arkansas, Kentucky, and Delaware. It is first found chiefly upon the leaf stalks, later upon the stems, near the surface of the ground and just below the flower clusters, as elongated sunken spots, which result eventually in the death of the whole plant. It frequently causes great loss, and is said by Bain to be the most serious plant disease in Tennessee. The same disease occurs upon alfalfa, but alsike clover is nearly immune. The greatest hope lies in the breeding of resistant varieties.

Anthracnose (*Glœosporium caulivorum* Kirchner). — Long, brown to black, sunken spots upon stems and petioles, causing death of the more distal parts, are diagnostic characters of this anthracnose, which was first reported in the United States by Sheldon in 1906, and has since been noted as serious in a number of states.

Leaf spot (*Pseudopeziza Trifolii* (Biv. Bernh.) Fckl.). — Perhaps identical with the similar disease of alfalfa, this occasionally causes considerably damage.

Macrosporiose (*Macrosporium sarciniæforme* Cav.). — This widely distributed black mold is a common cause of leaf spots.

Scab (*Gibberella Saubinetii* (Mont.) Sacc.). — This parasite of grains is also known to cause depressed oblong spots upon clover. See **wheat**.

Broom rape (*Orobanche minor.* L.). — The parasite which causes this disease is very similar to that upon tobacco. See p. 307. Orobanche has also been noted upon pelargonium, tomato, coleus, and several other plants.

Dodder. See **alfalfa**.

CRAB GRASS

Piriculariose (*Piricularia Oryzæ* Cav.). — This is probably identical with rice blast. See p. 352.

COWPEA

Wilt, fusariose (*Fusarium vasinfectum* Atk.) — This disease is closely like fusariose of cotton, okra, and watermelon, though the disease is not communicable from one of these plants to the other.

It first appears when the plants are about six weeks old.[1] Up to this time they will grow well and appear healthy. Scattered plants then begin to drop their leaves, the lower ones falling first. Growth is checked, and the stem shows

[1] Orton, W. A., U.S. Dept. Agr. Bur. Plant Indus. Bul. 17, April, 1902.

a faint reddish brown tinge. After the leaves have fallen the stem dies and becomes covered with a light pink coating of the spores of the wilt fungus. The spread of the disease is more gradual and less conspicuous in the early part of the season, but after the peas begin to set fruit they succumb rapidly, and a field that in July may promise a fine crop may be entirely dead before September without having matured a pod. The disease usually appears in spots, like the cotton wilt, and these diseased areas spread until they may cover a whole field.

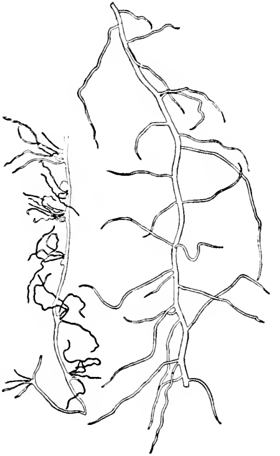


Fig. 168. — Roots of diseased cowpea at left; healthy roots on the right. After Orton.

In moderate cases, or where the varieties planted are less subject to the disease, only the weaker plants are killed, while the rest are dwarfed and their yield reduced. Careful examination of the roots shows that many of the small lateral roots are dead, small tufts of roots marking the points of infection. Fig. 168. This tufting of the rootlets is similar to that produced on cotton by the cotton wilt fungus.

In all cases the veins of the stem are brown, and the dis-

Fig. 169. — Cowpea wilt on the right; the resistant variety, Iron cowpea, on the left. After Orton.

ease may be clearly distinguished by cutting across the stem and observing whether the color of the wood is normal. This discoloration, which may often be seen through the translucent stem of the cowpea, is characteristic of this class of diseases. The name "wilt" is somewhat mislead-

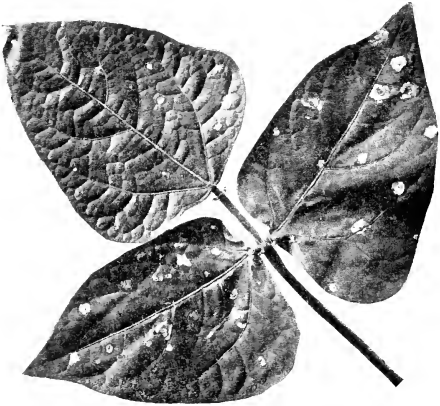


FIG. 170. — Cowpea leaf spot (amerosporiose). Original.

ing, as the leaves usually drop off before there is any conspicuous wilting.

The causal fungus is carried by the plow and cultivator, as evidenced by the spread of the disease lengthwise of a field, and by cattle, in cases where they pass through an infected field on their way to pasture. It may also be carried by drainage water, and by other of the ways suggested under soil diseases. The disease is now known in most of the Southern States from North Carolina to Florida, and west to Texas, and is yearly noted in new localities.

Owing to the all-important position the cowpea occupies in southern agriculture as a nitrogen crop, where the best rotation demands its frequent recurrence upon the same soil, the disease is of peculiar moment.

FIG. 171. — Cowpea leaflet spotted with powdery mildew. Original.

No remedy is known except the use of the iron cowpea,' the resistance of which was noted by Mr. T. S. Williams of South Carolina in 1900, and further tested by W. A. Orton of the United States Department of Agriculture.

Leaf spot (*Amerosporium œconomicum* Ell. & Tracy). — This disease is readily distinguished from cercosporose by the fact that the spots are circular, are of shiny whiteness, and are studded all over with little black pycnidia, smaller than an ordinary pinhole. Fig. 170. The disease is often abundant, but is usually not so serious as cercosporose.

Powdery mildew (*Erysiphe polygoni* DC.). — The white spots of this mildew are strictly circular when young, but as they enlarge they coalesce and cover the whole upper surface of the leaves with a white powder.

The disease is very widespread, but even in the worst seasons does not do much injury.

Angular leaf spot (*Cercospora cruenta* Sacc.). — The angular leaf spots of this disease are a familiar sight in most cowpea fields. They are of various colors above, chiefly reddish, and are gray to purplish or slate-colored below.

Fig. 172. — Leaflet of cowpea showing cercosporose spots. Original.

The damage is rarely very great. In some instances the attack may proceed to the stems, where, especially at the base, it may cause cracking and result in such lowering of the vigor of the plant as to cause shedding of leaves and failure to properly fill the pods. The loss of leaves is of course serious to the hay value of the crop.

JAPAN CLOVER

Powdery mildew (*Microsphæra diffusa* C. & Peck). — The usual characters of the powdery mildews distinguish this disease sufficiently. The injury to this valuable southern forage plant, while considerable, is never sufficient to call for treatment.

ORCHARD GRASS

Scolecotrichose (*Scolecotrichum graminis*, Fckl.). — In times of severe drought elongated dead spots may appear upon orchard grass, most conspicuous upon the lower outer leaves. Following these comes the death of the leaf, sometimes starting at the leaf tips and reaching to the base. In conditions favorable to the disease whole plants are involved. The spots, before they become confluent, are of quite characteristic appearance: large, dark brown to purplish brown. When old, they usually show at their centers spots of gray or white, and these spots may be marked with very small black pycnidia arranged in rows lengthwise of the leaf.

Black stem rust (*Puccinia graminis* Pers.). — This rust is identical with the oat rust caused by *Puccinia graminis*, and it may be conveyed from either of these hosts to the other.

Rust (*Puccinia Rhamni* (Pers.). Wett.). — It is probable that orchard grass can act as host for this species, which has been described under **oats.**

Anthracnose. See **rye.**

QUACK GRASS

Smut. See **timothy.**

Smut, urocystose (*Urocystis Agropyri* (Preuss.) Schroet.). — This smut resembles the above closely in the general appearance of its sori, though microscopically its characters are quite different; its spores show a more reddish hue.

RED TOP

Black stem rust (*Puccinia graminis*, Pers.). — The rust is identical with that upon wheat and oats, though infection does not readily occur from one host to the other.

Smut (*Ustilago striæformis* (Westend.) Niessl.). — This is the smut described under **timothy.** It has been known to affect 30 per cent of the plants, and to reduce the seed yield from 300 hundredweight to 70 hundredweight.

Anthracnose. See **rye.**

TALL OAT GRASS

Smut (*Ustilago perennans* Rostr.). — This smut closely resembles that of oats, though the flower parts are not so completely destroyed as is the case in oat smut. The disease is perennial in its perennial host, and smutted plants bear smut, year after year.

TIMOTHY

Smut (*Ustilago striæformis* (Westend.) Niessl.). — This smut occurs chiefly upon the leaves, more rarely upon other parts of timothy, as well as upon some species of Agrostis, Poa, and Elymus. The spore masses form long black lines upon the leaf, and by merging and rupturing reduce the leaf to a torn, blackened state. The affected plants are weakened, small, and often fail to make seed. The disease perenniates with the host. Infection probably occurs through the seed.

Rust (*Puccinia graminis* Pers.). — This rust in general resembles the black rust of the grains. It was first reported in 1882 and has of recent years increased rapidly. It does not seem to be communicable to other grasses.

Anthracnose. See **rye.**

VETCH

Spot (*Protocoronospora nigricans* Atk. & Edg.). — Upon the stems, leaves, and bracts of vetch very characteristic, long, narrow, or elliptical spots are formed, frequently with a dull, purple border, and usually with a white center. When on the pods, they are obliquely situated. When old, they appear as black, oblique lines.

No serious damage has been reported.

FIBER PLANTS

COTTON

Wilt, fusariose (*Fusarium vasinfectum* Atk.). — The cotton wilt, now widely distributed and yearly preëmpting more territory, is caused by a fungus that plugs the water ducts in the veins of the stem and cuts off the water supply to the parts above, always reducing the vigor of the plants and usually resulting in speedy death.

Soil which produces a sick crop one year is so infested with the causal fungus as to insure reappearance of the disease in more extensive areas in subsequent croppings with the susceptible plant. The destruction of this form of disease, which takes not only the crop, but in part the usefulness of the soil as well, cannot be estimated. Its injury can only be realized by those who have experienced its effects.

Wilt has long been known by southern cotton planters, and is now prevalent in many sections of Alabama, Arkansas, North Carolina, South Carolina, Georgia, Louisiana, and probably throughout the whole cotton belt. Many foreign countries also record it.

The first appearance of the wilt is a yellowing of the lower leaves at the edges or between the main ribs, which portions may become almost white; later they turn brown and die. A single leaf often presents the three conditions, green (healthy), yellow (sick), and brown (dead), side by side in bands, parallel to the main ribs and radiating from the leaf stem. The dead parts may break away, leaving the leaf ragged. The upper leaves follow rapidly over the course of the lower leaves. The leaves as soon as badly affected fall away, leaving only a bare stalk. In mild cases,

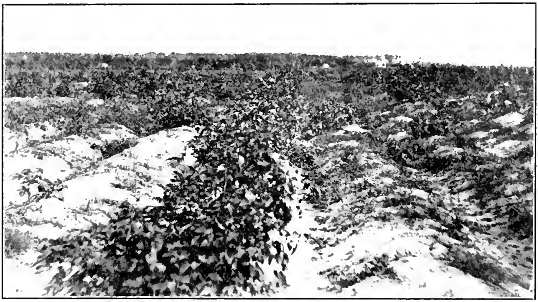


FIG. 173.—A variety of cotton resistant to the wilt; note the complete failure of the other varieties. After Orton.

where the disease runs its course more slowly, the intervals between the different stages are more prolonged. In light sand the disease may progress very rapidly and may consist of only two stages, the sudden wilted condition followed by speedy death. The final diagnostic symptom of the disease, however, as in the case of many other wilts, is the darkening of the affected veins, which change from the normal white to light brown or black. Though in most cases the plant dies, occasionally one revives and seems to outgrow the disease. In such plants relapses may follow, showing somewhat different symptoms, among them decay of the boll, and a different sequence of color changes.

Rotation of crops should be practiced and the diseased plants should be pulled and burned to check the spread of the disease in the soil, and in general the recommendations given under soil diseases should be followed. The ultimate solution of the question must be in the employment of resistant varieties. One such, a long-staple cotton, has been bred up by the United States Department of Agriculture.

Anthracnose (*Glomerella gossypii* (South.) Edg.). — The causal fungus of this disease was first described in 1890. The disease is very destructive in some localities and prevails throughout a large portion of the cotton belt. In central Georgia it is said to destroy about 22 per cent of the crop yearly, sometimes more; while to the state as a whole the loss is put at 17 per cent or approximately $14,750,000.

It is most conspicuous upon the bolls, where it produces unsightly ulcers, at first black, and later bearing a coat of pink. The ulcers have dark brown to black, watery borders and vary in diameter from a few millimeters to covering the whole boll. When small, the spots are reddish and slightly depressed. Attacks upon young bolls stop their growth and induce premature ripening and imperfect opening, or the bolls may die and decay without opening at all. In such bolls the fungus is found upon the lint and seed within. Upon the stems the fungus is limited mainly to injured parts, leaf scars, etc., and to very young, tender plants, causing damping off. Here it is accompanied by reddening and by shrinkage in longitudinal lines. This disease upon young plants usually follows the use of diseased seed. Upon old stems it causes blighting of the bark, which becomes reddish brown and dies.

Upon the leaves as upon the stems the attack is mainly limited to injured or weak parts. The seed leaves, being in a state of weakness, are especially susceptible to the fungus, which develops here with characters very similar to those of the stem and the boll. The leaves sometimes have a scalded look, assume a yellowish or leaden green color, and wither and die, much as though frosted.

There is abundant evidence that the disease is largely carried from year to year in the seed. Therefore, only seed from entirely healthy fields and seed that has been ginned where only healthy cotton has been ginned should be used. No mode of seed treatment has proved reliable.

Texas root rot (*Ozonium omnivorum* Shear.). — The first technical description of this disease was given by Pammel in 1888. It has since been the subject of many papers, and is known to occur in very destructive form in Texas, Oklahoma, New Mexico, and Arizona, though it has not yet been found east of Texas.[1] The estimated loss from ozoniose in 1906 in Texas was about $3,000,000. Some planters regard it as a worse enemy than the boll weevil.

In this disease a few of the plants may wilt and dry up in a day. This usually occurs at or before blossoming, occasionally upon plants only a few inches high. Later, many plants suffer similar fate, resulting in irregular spots of disease in the field, marked by the presence of numerous standing, dead plants. The plants succumb with especial

[1] Shear, C. L., and Miles, Geo. F., U.S. Dept. Agr. Bur. Plant Indus. Bul. 102, Part V, September 9, 1907.

rapidity on hot days following rain, not so rapidly in continuous dry weather. Especially after a rain, living plants surrounded by dead ones may show symptoms of the disease in the form of dense sterile mycelium upon the tap root. All diseased plants have diseased roots marked by injured rootlets and shrunken tap roots, accompanied by depressed spots which are at first bordered by red discoloration. The causal fungus is also apparent here, at first as a white mold which later turns brown or yellow and is finally accompanied by wart-like sclerotia. Enlargements, from which new roots are put forth, often occur near the soil surface. Even the lint of the diseased plants is affected, the fibers being wider and larger, and the spirals fewer and more uneven, than upon healthy plants. The disease is truly of the soil, and the diseased soil centers enlarge yearly as in other soil diseases. It is subject to the modes of dissemination suggested on page 65.

Especial precautions should be exercised against the use, for the purpose of legume inoculation, of soil which may possibly be infested with the disease. This warning is particularly necessary in view of the fact that alfalfa is affected by the same disease, and the causal fungus is now present in many alfalfa fields.

As to treatment, rotation with immune crops in conjunction with deep fall plowing is recommended. Shear and Miles[1] say: "Rotation with immune crops at Terrell, Tex., resulted as follows: 1904, planted to cotton, about 95 per cent of which was killed by root rot; 1905, planted to

[1] Shear, C. L., and Miles, Geo. F., U.S. Dept. Agr. Bur. Plant Indus. Circ. 9, June 19, 1908.

corn; 1906, planted to wheat, followed by sorghum the same season; 1907, cotton again planted, with the result that, as nearly as could be estimated, less than 5 per cent of the cotton was dead at the close of the season.

"Land badly infected with the root rot was plowed seven to nine inches deep November 11, 1906, at Petty, Tex. In experiment No. 1 the deep-plowed plat showed 42.75 per cent less dead plants than the adjoining check plat which received the customary tillage. In experiment No. 2 the deep-plowed plat showed 43 per cent less dead plants than the adjoining check plat, and in both cases a much larger amount of cotton was produced on the dead plants on the treated plats, because these plants did not die until later than those on the untreated plats, and therefore had greater opportunity to mature their bolls."

Frosty mildew (*Ramularia areola* Atk.). — This leaf spot is limited sharply by the smaller veins, and bears upon the lower surface numerous colorless spores upon colorless hyphæ, thus lending a frosted appearance. Seen from above, the spots are light yellow or of a paler green than the normal leaf tissue. Widespread, though not especially destructive, it does not usually attract the attention of the planter.

Leaf blight (*Mycosphærella gossypina* Atk.). — The fungus which causes this disease was first described from Carolinian specimens in 1883, at which time its presence was recognized in South Carolina, Georgia, and Florida. The disease prevails in all cotton sections of the United States, appearing first in damp localities upon the lower leaves, and with the progress of the season spotting all the leaves more or less. The leaf spots appear at first as small red dots, which finally, as they enlarge, bear brown or white centers with a characteristic red border. A copious development of dark hyphæ upon the centers later gives them a blackish hue, and an abundance of white spores gives these hyphæ a white coating. The old diseased centers of the spots are brittle and frequently break away, leaving perforations. The disease is widespread but unimportant, since it is largely limited to weakened tissues, especially to spots produced by cotton mosaic.

Bacteriose (*Bacterium malvacearum* E. F. Smith). — Widespread but seldom abundant enough to attract attention, the diseased areas appear as angular spots bounded by the veins and of a watery appearance. They may be scattered over the leaf, or they may be nearly contiguous and later become confluent, resulting in irregular dead patches. Frequently they are most numerous adjacent to the main ribs, and result in long, irregular, dead, black regions. The dead tissue is brittle and often falls away, causing holes or ragged edges. Badly affected leaves fall early.

Boll rot. — This rot in wet seasons may cause the loss of nearly all of the crop. It sometimes begins as small, black or dark brown spots upon the young seed and lint, especially near the base of the boll, and thence invades the whole boll, showing itself externally only when nearly all of the inner part of the boll has decayed. If it begins later, only a few seeds and their lint may rot, and the remainder of the boll may ripen and be harvested. The cause and remedies are not known. The disease may be of bacterial origin.

Damping off (*Pythium DeBaryanum* and other fungi). — Young cotton plants may suffer the characteristic soft rot of damping off.

Sore shin, rhizoctoniose (*Rhizoctonia sp.*). — Primarily this is an ulcerous wound upon the stem near the ground, accompanied by reddening or browning of the leaves. If the ulcer enters deep into the stem, so as to interfere with the ascending sap, it may cause death, though this is usually prevented by healing of the wound before the disease has progressed too far. The disease is often caused by the attack of rhizoctonia, especially in tissues predisposed to such attack by weakness.

Harrowing, to aid in drying the surface soil, to some extent prevents the attack and development of this fungus. A similar disease may also result from purely mechanical injuries caused by tools.

Mosaic, yellow leaf blight, black rust (*Physiological*). — The first signs of this disease are yellowish spots which give the leaf a checkered appearance. The discoloration occurs first in small areas, which are roughly rectangular owing to limitation by the veins, and which are situated at points most remote from the main feeding veins. In later stages these weakened areas may be overgrown by various saprophytic fungi. Usually the centers of these spots soon turn brown, and the brown part enlarges and shows a series of concentric markings. If very dark-colored fungi grow upon these spots, they soon become black-coated and take the popular name "black rust."

Kainit, used as fertilizer, often reduces the damage from mosaic.

Red leaf blight (*Physiological*). — This reddening, resembling autumnal coloration, occurs most frequently toward the season's end and is most common upon poor soil. It is due chiefly to lack of nourishment.

Attacks of the mite cause a similar appearance.

Shedding (*Physiological*). — This occurs chiefly following extremes of either dry or wet weather or following a change from one extreme to the other.

FLAX

Wilt, fusariose (*Fusarium lini* Bolley). — A condition of soil known as "flax sick" has prevailed in many sections of the country to such an extent as to cause the abandonment of flax as a crop. This is notably true of Iowa, Minnesota, North and South Dakota. On such soils flax plants are attacked at any age, and die early or late according to the time and intensity of the attack.[1] Many of the plants in an aggravated attack are killed before they appear above the surface of the ground. Such field spots become centers of disease; they enlarge throughout the summer, and new plants sicken, wilt, and die around their margins, finally giving the entire field a spotted appearance. Young plants wilt suddenly and dry up, or decay if the weather is moist. Older woody plants become sickly and weak, turn yellow, wilt at the top, and die slowly. Such plants are easily pulled up, owing to their decayed root system.

Most of the roots of diseased plants are dead and have a characteristic ashen-gray color. If the plant is attacked late in the season, this gray color may be limited to one side only of the taproot. In such cases the leaves and branches on the affected side are blighted. If the disease is sowed with the seed upon healthy soil, only a few plants may be attacked during the first year, and such plants may be very

[1] Bolley, H. L., N.Dak. Agr. Exp. Sta. Bul. 50, December, 1901.

unevenly scattered throughout the field and escape notice until late in the season.

If the weather favor the disease, each new area of infection may increase sufficiently to reach plants in several adjacent drill rows. These infection areas are nearly always circular, and enlarge each year that flax is grown thereon. A diseased spot 1–2 m. in diameter the first year may become 2–3 m. the second year. Thus only a few years are required for the disease to gain complete possession of a field. The disease not only persists in a field not sown to flax, but the disease areas may even enlarge when no flax is present. When soil is once infected, no way is known to render it suitable for flax again.

This is essentially a soil disease, and it is spread in the ways suggested under soil diseases, notably by soil particles, drainage water, and especially diseased flax straw which may get into the manure. The chief agent of dissemination, however, is the seed. In threshing, the spores of the causal fungus, which are abundant upon the dead straw, find lodgment upon the seed, especially if it be moist.

To prevent carrying the disease to land yet uninfected, all seed should be disinfected in the following manner: —

Use formaldehyde at the rate of 1 pound to 40 or 45 gallons of water. Spread the seed upon a tight floor or upon a canvas and sprinkle or spray upon it a small amount of the liquid. Shovel, hoe, or rake the grain over rapidly. Repeat this spraying, shoveling, and raking until all of the seeds are evenly moistened, yet not wet enough to mat or gum together. Continue to stir the grain, so that the mass may become dry as soon as possible. Avoid any excess of moisture. If flax seeds are dipped in the solution or are allowed to become wet enough to soften the coats so that they stick together, they will be considerably injured or even killed.

The solution recommended is strong enough to kill all seeds if they are made thoroughly wet or are allowed to stay quite damp for some hours. Less than one half gallon of solution is required to treat one bushel of seed. It is well also to burn all the infected straw and to avoid planting too deep.

By continued selection of seed from resistant plants Bolley [1] has developed a variety which is resistant to the wilt.

Alternariose (*Alternaria sp.*). — This is said by Bolley to cause destruction of young plants in damp soil.

Colletotrichose (*Colletotrichum sp.*). — This has been mentioned by Bolley as very destructive to young plants.

Rust (*Melampsora lini* (DC.) Tul.). — This rust shows sori characteristic of the rusts. Upon the leaves in early season they are yellow or orange. Later black sori appear, chiefly upon the stems. Badly affected plants turn brown and die earlier than plants not rusted. Large injury is not usual, though in 1904 and 1905 considerable damage was reported from North Dakota.

[1] Bolley, H. L., N.Dak. Agr. Exp. Sta. Bul. 50, December, 1901.

TREES AND TIMBER[1]

General Diseases

DECAY IN LIVE TREES

Wood decay is always caused by fungi (perhaps rarely aided by bacteria) whose mycelium penetrates through or between the wood cells, producing enzymes which soften the cells or disintegrate the middle layer between cells, thus destroying stability of the aggregate as by the crumbling of the plaster or the brick of a wall. Within the tree this disintegration may occur either to the heartwood or to the sapwood, or to both.

The life of a tree may be much reduced by decay of the heartwood, the main mechanical support. Decay of the sapwood further hastens death by interfering with the rise of the sap.

Upon the living tree the natural protection against fungous invasion is the bark, consisting of cells with specially resistant walls; cutinized or supplied with resin, gum, or other repellents. Moreover, the dead bark is not generally nutritious and does not offer attractive invitation to the fungus. The protection thus constituted is normally ample; but in case of removal of the natural protection and exposure of either sapwood or heartwood, especially the latter, the path is open, and it is through wounds offering such exposure

[1] The facts concerning tree and timber rots are drawn largely from the writings of von Schrenk and his associates.

that rot usually begins in standing timber. Such rots might therefore be appropriately termed "wound decays."

FIG. 174. — Fomes igniarius upon live beech tree. After Atkinson.

The fungi which cause these decays are, in the main, the larger fungi whose fructification is of the toadstool type (Fig. 184). After the decay within is well under way the spore-bearing toadstools appear upon the surface of the diseased parts, and are quite generally recognized by lumbermen as a sign of rottenness within.

Fig. 175. — Stump of limb improperly removed. After Ind. Agr. Exp. Sta.

A branch, broken or sawed off, split by wind, bruised by a falling tree, gnawed by animals, pecked by birds, eaten by insects, or wounded in some other way, may result in the exposure of heart or sap wood to the fungous spore. From this point of invasion the rot spreads in every direction. When the rot reaches the trunk, it spreads upward and downward and into all branches to which it has access. Thus trees, hollow with rot, may trace their downfall to infection of some small branch months or even years earlier.

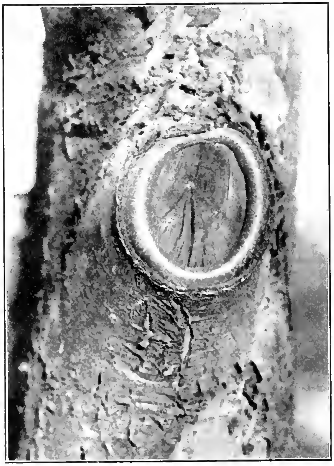


Fig. 176. — Wound of properly removed limb beginning to heal over. Ind. Agr. Exp. Sta.

Care should be exercised in felling trees to avoid injuring other trees, and in case of pruning-wounds to apply some antiseptic to the exposed wound to prevent the effective germination of spores upon its surface. Suitable antiseptics are tar or paint.

Old, diseased trees should be cut to prevent spread of infection to other trees. Excision of the infected tissue can be practiced in case of especially valuable trees.

The fungi which cause these decays are manifold. In some cases one species of fungus grows upon many different kinds of wood. Other fungi are more particular as to their food supply and are found upon fewer hosts. They chiefly belong to two kinds: one bearing its spores upon gills, Fig. 184; the other with its spores borne in pores, Fig. 211.

FIG. 177. — Wound of properly removed limb nicely healed over. After Ind. Agr. Exp. Sta.

Still others bear their spores upon spines. In describing the fructification of the causal fungi for recognition purposes it is necessary to note especially the *stalk*, or *stipe*, and the *cap* or *pileus*, Fig. 184. A cap with no stalk is "sessile."

Prominent among the rots are these following: —

Heart rot (*Trametes pini* (Brot.) Fr.). — In the North this rot affects all conifers, invading first the heartwood, very rarely the sapwood. The wood is not wholly destroyed by the fungus; but series of small holes with silvery lining are noted in early stages. In spruce the color of the wood itself is changed to a light purplish gray, later to a reddish brown netted with small black lines. Small patches of white follow, which later develop into holes, arranged in series to correspond with the annual rings, and as the disease progresses result in a series of vacant spaces separated only by plates. In tamarack the decay finally destroys the plates, reducing the whole wood mass to mere fiber.

The sporophores may consist of either brackets or of extended sheets with shallow, pit-like pores on the underside. They are cinnamon-brown on the lower surface and much fissured and broken on the black, charcoal-like upper surface.

White heart rot (*Fomes igniarius* (L.) Fr.). — This is the most important and widespread of the heart rots, and the one which has the widest range of host plants. It is known in Alaska, Canada, the United States, and in South America to Patagonia, growing upon beech, aspen, willow, mountain maple, hornbeam, white elm, sugar maple, red maple, silver maple, striped maple, yellow birch, butternut, black walnut, oaks, apple, and hickory. The amount of damage done by it is beyond estimation. In many cases almost the entire timber stand is ruined. Actual count has shown 90 to 95 per cent of otherwise marketable trees valueless.

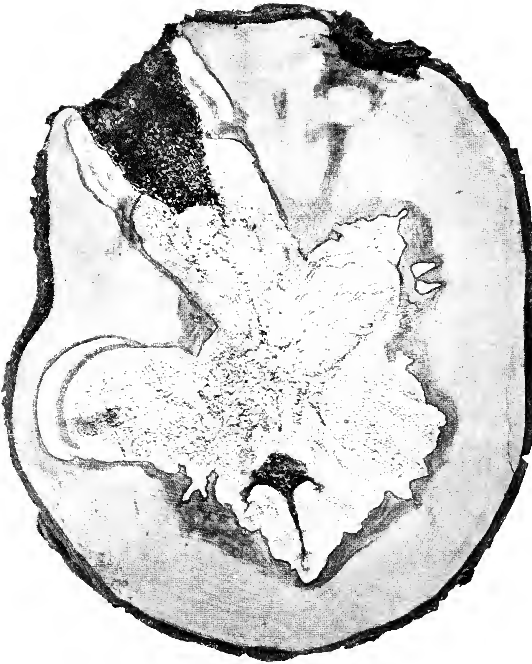


FIG. 178. — Fomes igniarius upon maple. After von Schrenk.

The rot, while chiefly of the heartwood, may, when started, encroach upon the sapwood, even to the youngest layers, and death may result by weakening the tree to the breaking point.

The causal fungus enters through wounds, particularly broken stubs, and usually produces its sporophore at these points after the rot has extended a meter or so in both directions from the infection point. The first sure external sign of the disease is the presence of the sporophores, although sounding with the ax may sometimes be relied upon.

The sporophores, numbering sometimes as many as twelve on a tree, are shelving, hoof-shaped bodies from 25 to 30 cm. wide. The upper surface is brown, in later stages black, hard, smooth, concentrically marked with age, finally seamed and cracked. The pores are in layers, approximately annual, and may be 50 or even 80 in number. The lower surface is gray to red-brown.

The trunk in cross section shows rot at the center; the wood becomes soft and pulpy. The decayed region is irregular in outline and bounded by narrow black layers. The tree is rarely hollow, but remains filled with the decayed wood. Young trees which have no dead branches to admit the fungus are usually immune.

Infective material should be burned, wounds avoided, and excision practiced in case of valuable trees.

Red heart rot (*Polyporus sulphureus* (Bull.) Fr.). — The conifers, also oak, cherry, chestnut, maple, walnut, butternut, alder, locust, apple, pear, and many other trees are affected. It is very widely distributed and destructive.

The many-pored edible sporophores consist of a series of overlapping shelves, two to twenty, or possibly more, with the upper surface in early stages a bright orange-red; later they are sulphur-yellow both above and below. The

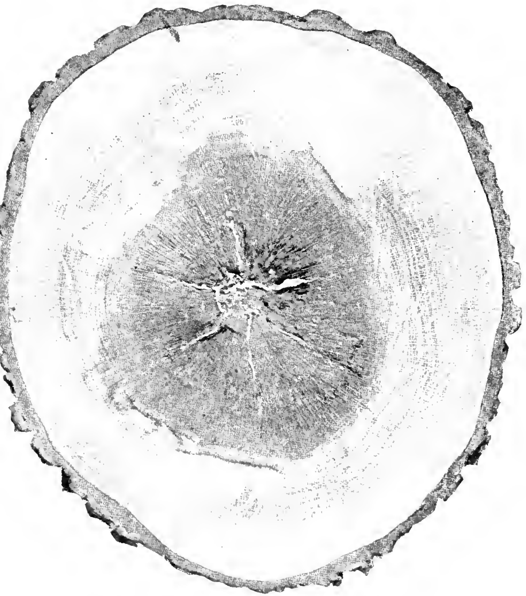


FIG. 179. — Polyporus sulphureus showing effect upon wood of oak tree. After von Schrenk.

upper surface when bruised is brown. The sporophore is soft and fleshy when young, growing harder with age until at maturity it is brittle. This fungus abounds on knots and stumps.

The rotted wood resembles a red-brown charcoal and bears concentric and radial cracks due to shrinkage following the decay. In these cracks are large sheets of fungous wefts.

Diseased trees should be cut and burned to prevent infection.

Piped rot (*Fungus sp.*). — The oak, chestnut, beech, and birch are susceptible to this rot. The sporiferous stage of the causal fungus has not been recognized. The rot, limited to the heartwood, is characterized by irregular, small, pocketlike patches of white fiber.[1] These regions first appear in the wood as small, lenticular areas which increase, coalesce, and change into small pockets. These frequently become filled with a dark, red-brown mycelium. The speckled character of the wood is a distinctive mark.

Heart rot (*Fomes nigricans* Fr.). — The birch, willow, and aspen, from Maine to Oregon, are affected.

The rotted heartwood is reddish brown and very soft and spongy. The disease eventually progresses into the sapwood, reaches the bark, and kills the tree.

The pore-bearing sporophores are few, hoof-shaped, large, 25–30 cm. wide, and woody, much like those of *Fomes igniarius*.

White rot (*Hydnum erinaceus* Bull.). — Although upon many species, oaks are chiefly affected. The rotten wood is soft and wet and with numerous holes full of light yellow floccose mycelium. The fleshy sporophores are white,

[1] Von Schrenk, H., U.S. Dept. Agr. Bur. Plant Indus. Bul. 149.

1 to 25–30 cm. in diameter, nearly spherical, and consist chiefly of immense numbers of white spines upon whose surfaces the spores are borne.

Heart rot (*Fomes fulvus* Fr.). — In Missouri and Arkansas this heart rot is found upon the river birch and a number of other trees. The wood is brown, and crumbles on crushing. It extends from 3–4 m. above and below the sporophores. These are pore-bearing, triangular in section. The upper surface is very hard and bears fine, irregular fissures parallel to the edge. When mature, the upper surface is red-brown. The pores are barely visible without a hand lens.

Rot (*Polyporus subacidus* Peck). — This is a rot of dead logs as well as living trees, which often enters through the roots.

The decayed wood is moist, spongy, and bears cavities of various size and shape lined with a tough mycelial felt, which is yellow inside. In early stages the wood is black-spotted. The black spots later give way to larger white spots surrounded by a straw-colored frayed region. The sporophores are sheet-like and bear shallow, straw-yellow pores.

Soft rot (*Polyporus obtusus* Berk.). — The black oaks (*Q. Marylandica* and *Q. velutina*) are chiefly affected by this rot, which is found in Missouri, Arkansas, Iowa, Tennessee, Mississippi, New Jersey, and Maryland.

The causal fungus enters through the burrows of a wood borer. The heartwood turns light yellow, then white, and becomes brittle. Strings and sheets of white mycelium are found in the wood. Death results either from diminution of water supply or from breaking of the trunk.

Heart rot (*Fomes Everhartii* Ell. & Galloway). — This rot closely resembles that caused by *Fomes igniarius*.

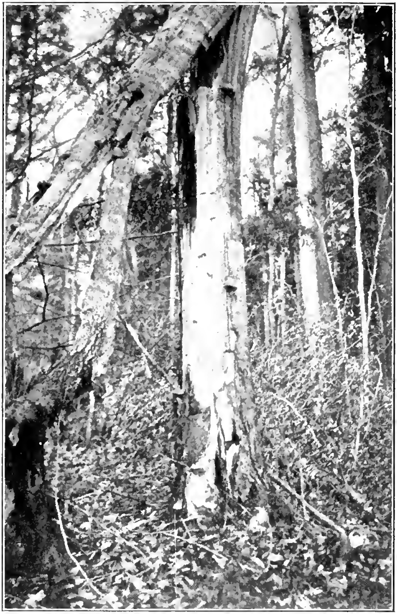


Fig. 180. — Tree weakened by Fomes fomentarius. After Atkinson.

Large, rusty-brown, woody sporophores, red-brown below, grow from wounds and bear very small pores.

White rot (*Polyporus squamosus* (Huds.) Fr.). — In Europe this rot affects several species of maples, the pear, oak, elm, walnut, linden, willow, ash, birch, beech, and horse-chestnut. In America it has been reported from Minnesota. The wood becomes unusually white and bears scattered series of white lines.

The nearly circular fruiting bodies are stalked and often attain a diameter of 15 cm. When young, they are soft, but later become very tough. The upper surface is scaly and rough.

Fig. 181. — Fomes fomentarius showing hoof-shaped sporophore. After Atkinson.

Sapwood rot (*Fomes fomentarius* (L.) Fr.). — This rot abounds throughout the northern part of the United States, as one of the most common diseases of deciduous trees, chiefly affecting the beech, white, paper, and yellow birches.

Decay begins in the outer sapwood and proceeds inward. The wood is marked by irregular black lines, the boundaries between diseased and normal wood. When wholly rotten, the wood is soft and spongy and light yellow in color.

The pore-bearing sporophores are hoof-shaped, smooth above, and concentrically ridged and gray. Below they are red-brown.

Fig. 182. — Fomes applanatus upon trunk of dead tree. After Freeman.

Rot (*Fomes applanatus* (Pers.) Wallr.). — The shelving, pore-bearing sporophores are very large, woody, and grayish to brown above, and are commonly found on dead wood, more rarely upon live trees.

Rot (*Polyporus pinicola* (Schwartz) Fr.). — The causal fungus is of world-wide distribution upon conifers, especially spruce, pine, fir, and hemlock. It occurs also upon birches and other deciduous trees. Entrance is made through wounds of any kind. The rotted wood is brittle, cracked, and permeated by numerous sheets of mycelium. In early stages of decay it passes through red-brown to dark-brown, then small, white areas of numerous shapes and irregu-

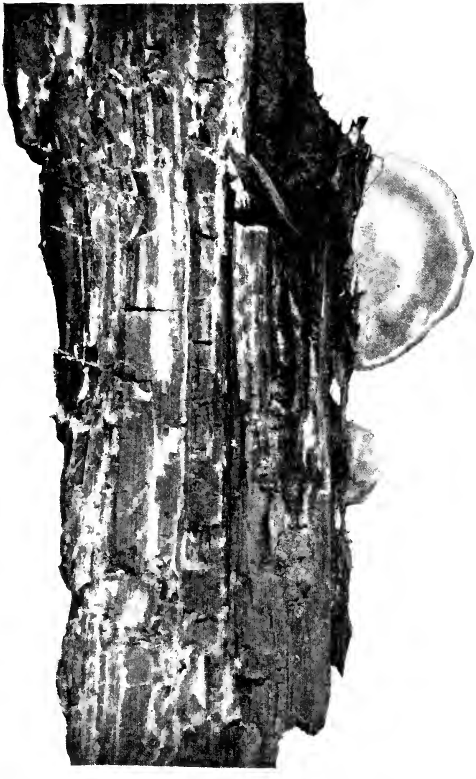


FIG. 183. — Fruiting body of Polyporus pinicola upon log rotted by the fungus. After von Schrenk.

larly scattered appear. The sporophores vary from 2.5–30 cm., averaging 10–15 cm., are bracket-shaped and lobed. The young lobes are bright red to pale yellow, old ones dark red-brown. The lower surface is pale and smooth; watery when bruised.

Canker (*Nummularia* and *Nectria cinnabarina* (Tode) Fr.). — The cankers caused by these fungi occur either upon branches or roots and may be found upon nearly all species of deciduous trees of which they are wound parasites. The spores are borne on soft, bright red knobs, or in another form in pear-shaped perithecia. Infective material should be burned.

ROOT ROTS

Fungi similar to these already considered may also attack the roots of trees and thus cause death without any previous rotting of the trunk wood. Prominent among such diseases are the following: —

Armillariose (*Armillaria mellea* Vahl). — The fungus usually enters the root through wounds, and grows in the cambium, through which it spreads until it encircles the tree. As its growth proceeds the layers adjacent to the cambium become dry, and the top of the tree is killed by stoppage of its water supply. A characteristic accompaniment is the profuse development of string-like, hard, black mycelial strands which permeate the soil near the base of the affected tree. From the mycelium around the base of the tree rise the numerous white-gilled, honey-colored sporophores, their viscid tops flecked with white; the stems swollen and with a ring (annulus).

This disease may spread for long distances through the soil by means of the fine roots and infect neighboring trees. Upon newly cleared land diseased roots of forest trees may be a source of infection to fruit trees subsequently grown thereon.

Polyporose (*Polyporus versicolor*). See p. 429.

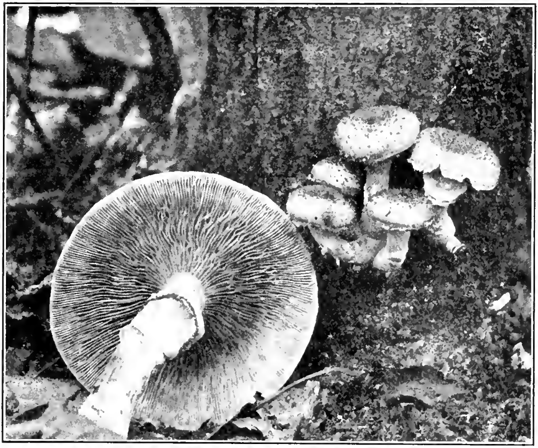


Fig. 184. — Armillaria mellea attacking a tree. After Freeman.

Red rot (*Fomes annosus* Fr.). — Though not very destructive in this country, this fungus has been found on many of the pines, where it brings about a red rot of the root system, which ultimately results in the death of an affected tree. The fruiting bodies form small, cup-shaped or irregular masses on the roots or around the base of the trunk. The fungus has also been found growing on trees many years after they had died. Neighboring trees

Fig. 185. — Log rotted by Polyporus Schweinitzii. After von Schrenk.

generally become infected from a diseased tree, through the small fibrous roots.

Root rot (*Polyporus Schweinitzii* Fr.). — A destructive root rot of spruce, fir, arbor vitæ, and pine, by weakening the root or trunk, leads to the overthrow of the tree by wind.

The point of attack is always the root, through the heart of which invasion is made into the trunk. This often leads to one-sided decay of the trunk's heartwood. The wood is rendered very brittle, yellow, and later of cheesy character, so that it can readily be cut cross grain when wet or reduced to a powder when dry.

The pore-bearing sporophores, which appear in July or August, are from 10–35 cm. across, growing either from the roots or the trunk. If from the trunk, they are sessile; from the roots, stalked. The fresh spore layer is rose-colored, and turns dark red if bruised.

This disease is very common throughout northern forests. In Europe, where it is greatly dreaded, it is customary to prevent its spread by trenching. Groups of infected trees and trees near them may be cut to advantage to protect other trees.

Root rot, ozoniose (*Ozonium omnivorum* Shear). — Elm, basswood, oak, cottonwood, mesquite, china tree, mulberry, apple, and pear are affected by this rot, which has been described and discussed on page 401.

Root rot, dematophorose (*Dematophora necatrix* Hartig). — A disease described on page 172 affects a large number of species of trees, among them mulberry, fig, apple, pear, and cherry, as well as many wild species.

Thelephorose (*Thelephora galactina* Fr.). — Noted in the Ozarks primarily upon the oak, but attacking fruit trees as well, this rot much resembles dematophorose.

DECAY OF DEAD TREES OR DEAD PARTS

While decay of dead trees cannot be regarded strictly as a condition of disease, but rather as a post-mortem change, a word is due to it on account of its vast importance, involving, as it does, all structural wood. The fact that the railroads use more than 110,000,000 ties annually, and that the number of posts in use is approximately

FIG. 186. — Dry rot fungus (Merulius lacrymans); on the right the mycelium is visible as white strings. After Freeman.

4,000,000,000, necessitating an annual replacement of some 500,000,000 in the United States, indicates the enormous money values involved.

This kind of decay is brought about by agencies similar, sometimes identical, with those causing rot in living trees, It can be prevented by impregnating the wood with various antiseptics, as creosote or zinc chloride.[1]

A few of the chief causes of the decay of dead wood are as follows: —

Polyporose (*Polyporus pinicola*). See p. 422.

Dry rot, meruliose (*Merulius lacrymans* (Jcq.) Fr.). — One of the most common and destructive of all the rots of structural timber, this renders the wood spongy and brownish. If very moist, a profuse superficial pure white mycelium may develop, at first loosely, later in dense sheets or strands. The sporophores are flat, at first white, later red, and still later yellow-brown. The spore-bearing surface carries shallow pores penned between folds and wrinkles.

Sap rot (*Polystictis versicolor* (L.) Fr.). — In addition to its parasitic life upon the chestnut and catalpa, this fungus grows as a saprophyte upon all kinds of deciduous woods, and is "regarded as the most serious of all wood-rotting fungi which attack the dead wood of broad-leaf trees.[2] It destroys probably 75 per cent or more of the broad-leaf species of timber used for tie purposes." "Whenever broad-leaf species of wood are used for fencing for posts or poles, or for any purpose where they come in contact with the soil, they are sure to be attacked sooner or later by *Polystictis versicolor*."

Polyporose (*Polyporus pergamenus* Fr.). — This fungus is similar to *Polystictis versicolor*, and of great importance, appearing upon cut timber or on large wounded surfaces

[1] For details see Sherfesee, W. F., Bul. 78, Forestry Service, November 11, 1909.

[2] Von Schrenk, H., and Spaulding, Perley, U.S. Dept. Agr. Bur. Plant Indus. Bul. 149.

of standing trees, especially following fires. It is found throughout the United States on all deciduous woods.

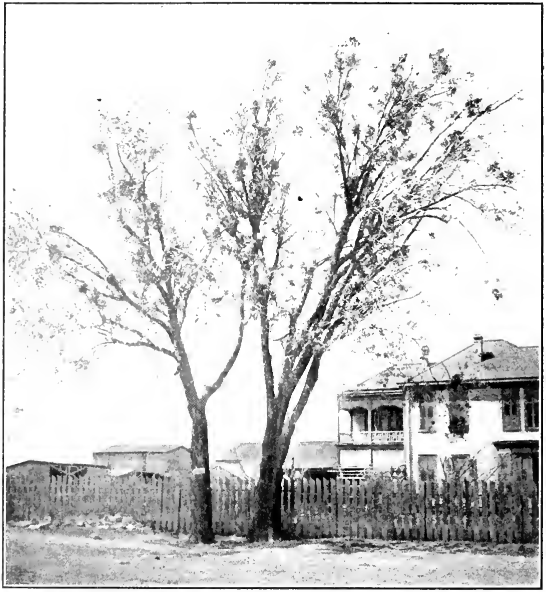


FIG. 187. — Trees infested with mistletoe. Courtesy of the School of Botany of the University of Texas.

Very numerous genera and species of fungi other than those mentioned above can also bring about similar changes.

Mistletoe (*Phoradendron flavescens* Nutt). — While not generally considered a pest, this parasite under favorable weather conditions may become so, especially upon trees in lawns and parks. It usually attacks the smaller branches of the trees, and thus cuts off the nourishment from their tips and eventually causes this portion to die. The general effect is to spoil the beauty of the tree. About thirty different kinds of trees are attacked, and the parasite can be carried easily from one host to another.

To destroy mistletoe the infected branches should all be cut from the trees and no berries allowed to mature, thus preventing dissemination of the pest by birds.

Special Hosts

ASH

White rot (*Polyporus fraxinophilus* Peck). — In Missouri, Nebraska, and Kansas in some localities this disease affects 90 per cent of the trees. It prevails in the Mississippi valley and east to the Atlantic. The heartwood first darkens, and later becomes soft, pulpy, and yellowish. The shelving, pored sporophores, 5–10 cm. long and nearly triangular in section, are numerous, chiefly near stubs or wounds, appearing soon after infection. The old upper surface is brown or black, and very hard. Trees of any age are susceptible, but those over 10 cm. in diameter are most subject to attack. Diseased trees should be cut down, or excision practiced, and the hole filled with tar.

Rust (*Puccinia fraxini* (Link) Arthur). — This is a rust which may be recognized by the orange-colored cluster cups upon the much-swollen parts of the leaves and petioles of nearly all species of ash. The winter condition is found upon marsh grass, Spartina.

The injury is not usually large, but in seasons favorable to the disease defoliation may result. Diseased leaves should be collected and burned.

Phyllostictose (*Phyllosticta viridis* Ell. & Kell.). — Brown spots, 5–10 mm. in diameter, with conspicuous yellow borders and minute black pycnidia, appear upon the leaflets. Defoliation may result.

Leaf spots. — Leaf spots due to several species of fungi are frequently seen, but not in destructive form. Among the causal fungi are: Glœosporium, Shæropsis, Septoria.

BIRCH

Sapwood rot (*Polyporus betulinus* Fr.). — Several species of birch are affected by this rot, which is of wide distribution in the northern United States. The fungus enters the sapwood from the bark through wounds or through the lenticels, and progresses inward. The yellowish, cracked, diseased wood crumbles when fully decayed.

Rust (*Melampsora betulina* (Pers.) Tul.). — This is much like the willow rust. See p. 450.

BUTTERNUT

Glœosporiose (*Glœosporium juglandis* (Lib.) Mont.). — The affected leaflets bear circular dead spots, indefinitely bordered, and defoliation results. The disease spreads very rapidly throughout the tree, and to other trees.

CATALPA

Leaf spot (*Phyllosticta Catalpæ* Ell. & Mart.). — Affected leaves bear round brown spots, often with a yellow-gray border. The spots, from 3–6 mm. in diameter, often coalesce to form large blotches which are fragile, sometimes dropping from the leaf. Young leaves develop poorly and are deformed, while severe infection may cause complete defoliation of the tree.

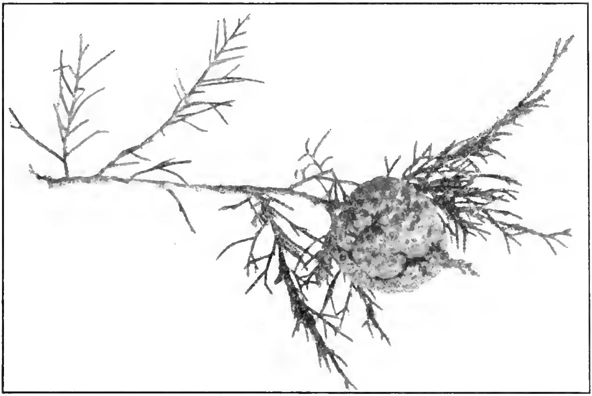


FIG. 188. — "Cedar apple," gall of the rust fungus. Original.

Macrosporiose (*Macrosporium Catalpæ* Ell. & Mart.). — This spot is scarcely distinguishable from phyllostictose except through the absence of pycnidia and the presence of a scant quantity of black mold.

Powdery mildew, microsphærose (*Microsphæra vaccinii* (Schw.) Salm.). — This shows the usual powdery spots with black perithecia.

Rhizoctoniose. See p. 61.

Soft heart rot (*Polystictis versicolor* (L.) Fr.). — The wood at the center of the tree is discolored and disintegrated, becoming eventually straw-colored and soft.

Fig. 189. — Cross cut of cedar log showing effect of Polyporus **juniperinus.** After von Schrenk.

The sporophores appear near the wound which afforded entrance. They are sessile, grouped, soft hairy above with alternate bands of light and dark color. When old, they are tough with edges curled in. See also p. 429.

CEDAR, RED

Rust (*Gymnosporangium*, various species). — The "cedar apples," familiar upon the red cedar, are usually of but small significance to the cedar tree itself unless exceptionally abundant. See **apple rust**.

Fig. 190. — Longitudinal section of cedar showing effect of *Polyporus juniperinus*. After von Schrenk.

White rot (*Polyporus juniperinus* v. Schrenk). — In this disease long holes appear in the heartwood, extending longitudinally with a partition of sound wood between. These cavities may eventually unite to form tubes throughout the tree. The wood between one cavity and the next is not the normal red, but is somewhat browned, and the holes themselves are coated with a brilliant white lining. The holes, partially filled with a velvety reddish-yellow mycelium, may be from 4–9 cm. long. The pore-bearing sporophore is hard and woody, rough above, later fissured, yellow-brown at the margin, later deep brown. The pore layer is yellow to brown.

Red rot, pecky cedar (*Polyporus carneus* Nees).—Though more common than white rot, this has been found in Missouri, Arkansas, Kentucky, Tennessee, Virginia, New York, and Mississippi.

The wood is full of pockets of brown, brittle wood, varying from a centimeter to a meter or so in length. The sporophore, formed in the cavities under dead branches, is from 0.5–35 cm. in length by 1 cm. wide. The pore-bearing layer is flesh colored.

These two diseases of the cedar taken together have been estimated to cause 60 per cent loss in some localities. Since they are caused by wound parasites, the removal of diseased trees and the destruction of sporophores is recommended.

CHESTNUT

Bark disease[1] (*Diaporthe parasitica* Murrill).—First noted in 1904 by Murrill in New York, this disease is now known in New York, New Jersey, Delaware, Connecticut, Rhode Island, Maryland, and Virginia, and is rapidly spreading in every direction. In Brooklyn 16,695 trees were killed on 350 acres, and the loss in and about

[1] Metcalf, H., and Collins, J. F., U.S. Dept. Agr. Bur. Plant Indus. Bul. 141.

New York City is placed at five to ten million dollars. The chinquepin and chestnut alone are susceptible. The attack is made upon the bark through wounds, but twigs and leaves are not directly affected. From the point of attack it spreads in all directions until the diseased parts meet on

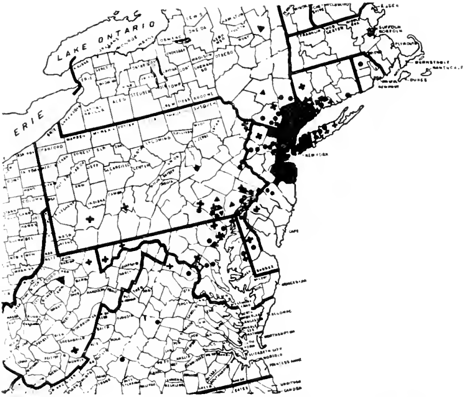


Fig. 191. — Map showing the distribution of the chestnut bark disease: black shows area of severe infection; round dots, presence of disease prior to 1909; + indicates the spread of the disease during 1909. After Metcalf.

the opposite side of branch, thus girdling the twig. Dead, discolored, sunken patches with numerous yellow, orange, or reddish-brown pustules are produced; spores are extruded in greenish or yellow horns. The appearance of the fungus upon the trunk indicates speedy death, but if small branches are first diseased, the tree may live for a few years.

Infection is supposed to be spread through nursery stock, and when once established, no means of stopping it is known. Only preventive measures can be taken, such as destruction of diseased trees by fire, careful inspection of all nursery stock, and excision in the case of isolated trees which are considered valuable enough to justify this mode of treatment.

Septoriose (*Septoria ochroleuca* B. & C.). — Small dead spots 3 mm. in diameter are produced upon the leaves, and premature defoliation results, injuring the beauty of the tree.

Anthracnose, leaf spot (*Marsonia ochroleuca* B. & C.). — The characters of this disease are small bleached areas with spore pustules in them. It has been quite injurious to nursery varieties.

Bordeaux mixture is advised.

Monochetiose (*Monochetia pacyspora* Bubák). — This leaf spot is very abundant in forests, and causes much loss of vigor to the tree. It is recognized as large, 1–5 cm. circular spots with irregular concentric marking. No treatment is possible in forests, but isolated trees can be protected by spraying.

COTTONWOOD

Rust (*Melampsora*). — In general this resembles the willow rust. See p. 450.

ELM

Leaf spot, dothidellose (*Dothidella ulmea* (Schw.) Ell. & Ev.). — The leaf spots are 1–3 mm. in diameter, and in each spot is a cluster of small, black, rounded, slightly elevated perithecia, the cluster surrounded by a border of dead tissue. Premature defoliation results. The disease is very abundant in all parts of the United States. Infected materials should be burned in the fall.

Powdery mildew, uncinulose. See **oak.**

Powdery mildew, phyllactinose. See **oak.**

FILBERT. See **hazel.**

FIR

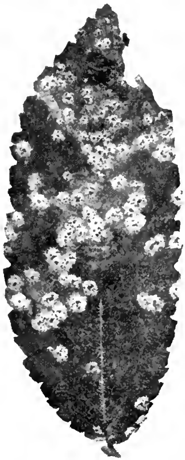


FIG. 192. — Elm leaf-spot. After Heald.

Rust (*Aecidium elatinum* Alb. & Schw.). — This cluster-cup fungus has been noted in Minnesota.[1] It produces bushy distortions, "witches' brooms," by causing profuse branching of the affected part of the tree. These abnormal branches soon lose their leaves, and cluster cups are produced upon them. The brooms are perennial and increase in size each year, in some cases largely covering a whole tree with the brooms. In such cases the trees are stunted and may even be killed. Infection may be reduced by destruction of the spore-bearing branches.

Canker (*Dasyscypha resinaria* (Ckle. & Phill.) Rehm). — Swollen cankers occur in the stems and branches, even girdling the main trunk and killing the tree. After the

[1] Freeman, E. M., Minn. Plant Dis., p. 277.

branch is dead the causal fungus fruits in small disks, orange-colored within, about 4–6 mm. wide and high.

HAZEL

Black knot (*Cryptosporella anomala* (Peck) Sacc.). —In 1892 Halsted noted black knot as destructive to several hundred trees in New Jersey, and in 1893 Humphry[1] described the same disease as upon hazel canes in Massachusetts. It is characterized by numerous small elliptical, warty emergences upon the bark of the diseased branches. The diseased portions are sunken, owing to the contraction of the inner bark to a mere line. The girdling produced results in death of the affected canes and general injury similar to that produced by plum knot. Affected branches should be cut and burned.

HORSE-CHESTNUT

Leaf spot, phyllostictose (*Phyllosticta sphæropsidea* Ell. & Ev.). — Unsightly spots upon the leaflets and premature defoliation render this the most conspicuous disease of this tree. The brown spots are at first circular, but as they enlarge are limited by the larger ribs, thus becoming nearly rectangular. Pycnidia may be seen with a lens. This is a decided nursery pest.

Five applications of Bordeaux mixture have much reduced the spotting.

LINDEN

Leaf spot, cercosporose (*Cercospora microsora* Sacc.). — Small circular or large irregular dead spots of the leaf

[1] Humphry, J. E., Mass. (Amherst) Agr. Exp. Sta. Rpt. 10, January, 1893.

indicate the presence of this disease. It has been reported as destructive in Massachusetts, New Jersey, and New York. Two sprayings in Massachusetts resulted in longer retention of the foliage and lessened infection. It was estimated that two sprayings will give a gain of from 2 to 5 per cent in growth and development.

LOCUST

Heart rot (*Fomes rimosus* Berk.). — From Massachusetts to New Mexico, over the entire black locust territory, this heart rot prevails. It is a yellow rot extending from the center outward in radial lines through the medullary rays; the hard flinty wood is reduced to a soft yellow cheesy mass, spongy when wet. The pore-bearing, shelving, hoof-shaped sporophores develop chiefly from the burrows of the locust borers or from stubs. The young portions are light brown; older parts, dark to black and fissured. The lower side is dull red-brown.

The rot ceases with the death of the tree, and posts made from diseased wood do not continue to rot.

LOCUST, HONEY

Leaf spot (*Leptostroma hypophylla* B. & Rav.). — The leaflets become covered with small black specks; some turn yellow and fall.

MAGNOLIA

Colletotrichose (*Colletotrichum sp.*). — Circular dead spots are produced upon the leaves and upon the young branches, killing the foliage and twigs.

MAPLE

Leaf spot, phyllostictose (*Phyllosticta acericola* C. & E.).— A large proportion of the leaf may become involved, causing premature defoliation which materially lessens the

Fig. 193. — Maple tar spot. After Heald.

value of the tree for ornament or shade. The silver maples are especially susceptible, and their sale has thereby been reduced. The leaf spot was first noted in 1874 and is distributed throughout the United States. The blackish, subcircular spots as they enlarge change to brown and later to dirty white in the center with black borders. Small black pycnidia may be seen in the central regions of the mature spots, which are from 10–14 mm. in diameter.

Burning diseased leaves is recommended, accompanied by use of Bordeaux mixture when economy allows.

Tar spot, rhytismose (*Rhytisma acerinum* (Pers.) Fr.). — Thick, shining, irregular black spots 1–1.5 cm. across appear on the leaves in late summer and cause them to fall prematurely, thus weakening the tree. Considerable damage is often done to nursery stock.

The leaves should be raked together and burned in the fall.

Leaf spot, rhytismose (*Rhytisma punctatum* (Pers.) Fr.). — In this leaf spot the causal fungus forms several small black dots upon the leaves as contrasted with the one large black blotch of the tar spot.

Anthracnose, glœosporiose (*Glœosporium apocryptum* Ell. & Ev.). — Nursery maples have been seriously injured by this anthracnose. The tips of leaves of pruned twigs turn yellow, then blacken and die as though frosted. Young leaves and shoots are killed and by their death induce abnormal branching, resulting in a compact "head." The disease seems limited to young trees.

Bordeaux mixture is advised, three or more sprayings.

Powdery mildews. See **Oak.**

MULBERRY

Bacteriose (*Bacterium mori* Boy. & Lamb.). — Upon the leaf small reddish brown[1] spots, pellucid when moist, are produced. The twigs and even entire trees are stunted and

[1] Conn. Agr. Exp. Sta. Rpt. 1904, p. 319.

yellowed. Cankers may almost or quite girdle the stem, the diseased area becoming dark. Prune as for blight of pear.

OAK

Leaf curl, taphrinose (*Taphrina cærulescens* (Desm. & M.) Tul.). — Though close kin to the peach curl, only a small proportion of each leaf in spots 1–2 cm. in diameter is involved. Defoliation may result in extreme cases, and continued disease each year may cause death. Affected leaves should be burned and the tree sprayed as for peach curl if the tree value warrants it.

Powdery mildews, microsphærose (*Microsphæra*).— These appear late and do little harm except upon nursery stock.

Flowers of sulphur or Bordeaux mixture are useful.

OSAGE ORANGE

Rust (*Physopella Fici* (Cast.) Arthur). — The sori which are scattered thickly over large areas of the lower side of the leaf are small, 0.1–0.3 mm. in diameter and are pale cinnamon-brown. This is known from South Carolina to Texas.

PECAN

Scab, fusicladiose (*Fusicladium effusum* Wint.). — Twigs, leaves, and nuts are affected in the Southern States,[1] particularly Florida, Louisiana, Georgia, Oklahoma, and Texas. Upon leaves and petioles dead spots, distortion, and defoliation are caused. The new growth of twig is often killed, but the greatest injury is to the nuts.

[1] Orton, W. A., Sci. n. s. *21*, 503, March 31, 1905.

Spraying has proved effective.

Microsphærose (*Microsphæra alni* Wallr.). — Certain years in the South the pecan crop has been practically destroyed by this mildew. It is recognized as a flour-like, white coating particularly damaging over the young nuts.

Spraying with Bordeaux mixture before the fungus appears is effective. Burning of infected fall refuse is also helpful.

PINE

Bluing (*Ceratostomella pilifera* (Fr.) Wint.). — The characteristic symptom, bluing of the sapwood, begins in August and September after the trees have been attacked by beetles.[1] The blue color starts near the base of the tree and gradually spreads upward until the entire sapwood is blue. The cause is the presence of the mycelium of the above-named fungus, which gains entrance through openings made by the beetle and is initiated by spores carried by the beetle.

Blue wood is as strong as normal green wood, is tougher, and when dry, it will last as long; but when wet, it rots rapidly.

Hypodermose (*Hypoderma Desmazieri* Duby). — The needles die from the tips toward the bases, becoming first reddish, then gray. Black lines which extend lengthwise of the leaves are the ascus-bearing organs.

Premature defoliation results.

Leaf blight, twig blight (*Lophodermium brachysporum* Rostr.). — In Maine the leaf blight has been noted as

[1] von Schrenk, H., U.S. Dept. Agr. Bur. Plant Indus. Bul. 36.

destructive to a considerable number of small trees and injuring the lower branches of large trees; serious damage from it, however, is not common.

Fusariose, damping off (*Fusarium sp.*). — The general characters are these mentioned under damping off. It is serious in Vermont, New York, Missouri, and probably in many other states, killing the seedlings in nurseries as soon as they appear above ground.

The beds should be given all ventilation possible. A top-dressing of sterilized sand sprinkled over the beds immediately after germination resulted in 30 per cent of disease against 42 per cent in the untreated part. Perhaps the best results have been attained by the use of copper sulphate 1 pound and lime 10 pounds,[1] and by sulphuric acid 1 ounce to 1 gallon of water, either of these applied to the soil of the seed bed before planting and again after the plants are up.

Rust, peridermiose (*Peridermium Cerebrum* Peck of *Cronartium Quercus*). — Swollen areas occur upon the branches and young stems which are gradually killed. The gall-like growth sheds an abundance of orange-colored spores each spring. In some sections it kills many trees, chiefly by its interference with the sap current. The swellings are perennial and may last for many years. One stage of this rust occurs upon the oaks.

Peridermiose (*Peridermium acicolum* Und. & Earle, of *Coleosporium solidaginis* (Schw.) Thüm.).—Another species of Peridermium of no special significance occurs upon leaves, producing small, sac-like, tubular outgrowths which contain

[1] Spaulding, Perley, U.S. Dept. Agr. Bur. Plant Indus. Circ. 4, April, 1908.

the spores. This is the cluster-cup stage of a rust which appears later in the season upon goldenrods and asters.

Red rot[1] (*Polyporus ponderosus* von Schrenk). — Upon dead trees this rot starts just under the bark, usually near the tree top, often following "bluing." The wood is at first wet and soggy, but soon becomes brittle, so that it crumbles readily. The cracks become filled with felted fungous threads. The sporophores first appear as fleshy knots, soon red, which widen to pore-bearing shelves.

Cladosporiose blight (*Cladosporium herbarum* (Pers.) Link). — The terminal leaflets die and curl and the tip of the stem is killed. Dark patches of hyphæ appear upon the dead parts.

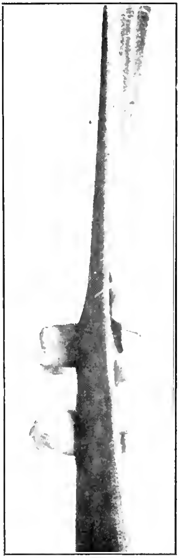


FIG. 194. — Pine needle bearing cluster cup of rust, enlarged. After Clinton.

POPLAR

Rust (*Melampsora populina* (Jcq.) Lév.). — This is similar to willow rust. See p. 450.

Powdery mildew, uncinulose. See **willow.**

Leaf blight, marsoniose (*Marsonia Populi* (Lib.) Sacc.). — Primary infection occurs upon the leaves, resulting in small, 3–8 mm., circular, black dead spots which are quite definitely bordered. As the leaves die, patches

[1] von Schrenk, H., U.S. Dept. Agr. Bur. Plant Indus. Bul. 36, 1903.

upon the stems also turn black and die. Infection proceeds to the supporting twigs and may result in dead patches of bark upon quite large shoots.

Cutting and burning infected twigs is advised.

SASSAFRAS

Heart rot (*Fomes Ribis* (Schum.) Fr.). — Spaulding in 1907[1] described this rot as a serious injury to sassafras in Missouri. It is also found upon stems and roots of various shrubby plants, as rose, currant. By means of a wound the attack is made upon exposed heartwood, proceeding slowly into the sapwood. The sassafras is thus immune until it reaches an age bearing heartwood. The decaying wood is abnormally light in color and slightly reddish, and the affected region is bounded by a narrow black zone. Trees sometimes die from the attack.

The causal fungus has been reported in America from Kansas, Missouri, New York, and New Jersey.

SYCAMORE

Gnomoniose (*Glœosporium nervisequum* (Fckl.) Sacc. of *Gnomonia veneta* (Sacc. & Speg.) Kleb.). — First noted in 1848, this anthracnose is very widely distributed from New Jersey to California and Mississippi. In extreme cases it may so weaken the trees as to cause their death. The scorched appearance of the leaves and defoliation render the trees unsightly. Just before they become full-grown the leaves give the first indication of the attack. Beginning near the veins or ribs or upon the petiole, the disease

[1] Spaulding, Perley, Sci. n. s. *26*, 479.

causes a stoppage of the water supply to the more distant portions of the leaf, resulting in dead areas.

Dead twigs should be pruned out, and infected material collected and burned. Spraying with Bordeaux mixture may be practiced if the expense is warranted.

Powdery mildew. See **oak.**

BLACK WALNUT

Anthracnose, Gnomoniose (*Marsonia juglandis* (Lib.) Sacc. of *Gnomonia leptostyla* (Fries) Ces. & d. Not.).—Conspicuous brown spots, 2–4 mm. in diameter, appear upon the leaflets, which soon yellow and fall. Upon the lower sides of the leaf spots are small, concentrically arranged, black acervuli.

The disease has been troublesome in Delaware, Iowa, Maryland, and West Virginia.

Fig. 195.—Walnut twig blighted by bacteria. After R. E. Smith.

WALNUT, ENGLISH

Pseudomonose, blight (*Pseudomonas juglandis* Pierce[1]).—Up to the present time this disease has occurred only

[1] Pierce, N. B., Bot. Gaz. *31*, 273.

upon the Pacific coast, where it often causes a loss of 50 per cent of the crop.

It may be recognized as black cankered spots upon the young nuts, which fall prematurely, or by similar spots upon the young green shoots. In seasons favorable to blight much of the terminal growth is killed and the succeeding crop is thereby reduced.

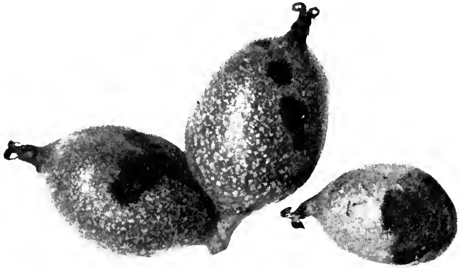


Fig. 196. — Bacterial blight of walnuts. After R. E. Smith.

Two treatments with Bordeaux mixture, after thorough removal of diseased parts, have been known to prevent 50 per cent of the loss.[1] The second spraying should be given when the nuts are firmly set. Care should be taken to select resistant trees for propagation.

WILLOW

Tar spot (*Rhytismose*). See **maple.**

Rust (*Melampsora saliciscapræ* (Pers.) Wint.). — Of tree rusts this is one of the most abundant, occurring as

[1] U.S. Dept. Agr. Yearbook, p. 98, 1904.

dusty yellow sori upon the lower leaf surfaces. Young trees are sometimes somewhat injured by it, and the trees are rendered unsightly, especially by the defoliation that is induced. In the latter part of the season the winter sori appear as reddish brown to black, waxy or crusty spots.

A similar rust is common upon cottonwood, Balm of Gilead, poplar.

Powdery mildew. See **oak.**

Powdery mildew, uncinulose (*Uncinula Salicis* (DC.) Wint.). — A characteristic white flour-like growth appears upon the leaves, usually upon both sides. In later stages small black perithecia are seen upon the white background.

ORNAMENTAL PLANTS

VARIEGATED PLANTS, IN GENERAL

In variegated plants the non-green parts of a leaf afford less resistance to disease than do the green parts of the same leaf. It thus happens that many diseases occur upon the variegated species that are not found upon the usual green species. Variegated Aspidistra, Pelargonium, Alternanthra, Abutelon, Ageratum, Aralia, Begonia, Centaurea, Coleus, Croton, Cyclamen, Dieffenbachia, Dracæna, Euonymus, Ficus, Fraxinus, Funkia, Hedera, Hibiscus, Hydrangea, Impatiens, Maranta, Nepeta, Nerium, Pittosporium, Ptychosperma, Sambucus, Solanum, Sarracenia, Spiræa, Vinca are subject to disease caused by various species of Colletotrichum, Ascochyta, Phyllosticta, Glœosporium, Leptosphæria, Cercospora, Septoria, Coryneum, Coniothyrium, Læstadia, and Diplodia.

The number of these diseases is so large that separate discussion cannot be given to them. The grower should recognize, however, the special weakness of this type of plant and compensate for it by special care as to hygienic surroundings, clean-culture methods, and liberal use of protective sprays when acervuli, pycnidia, or molds indicate the presence of a fungus.

ASTER, CHINA

Wilt, stem rot, fusariose[1] (*Fusarium sp.*). — The wilt, mentioned as early as 1896 by Galloway, has since been reported from Massachusetts and Colorado, and is probably the most important disease of the China aster. The time of transplanting the beds and blossoming time are most susceptible periods, though the wilt is present to some extent at other times.

The most conspicuous symptom is the sudden death of the plants, with all portions of the stem except the wood rotted at the ground line. Close observation earlier shows the leaves upon one side of the plant, particularly the lower leaves, yellowed and wilted, and the youngest leaves to be smaller than normal. The wilting effect may sometimes be found first on one side only of one of the lower leaves. Plants attacked early may die, or in milder cases may survive to produce a few small blooms. If the symptoms first show at blooming time, their sequence is the same.

The roots in early stages appear healthy, but the stem near the ground, in longitudinal section, shows darkening of the outer wood, local at first upon the affected side, but

[1] Smith, R. E., Mass. Agr. Exp. Sta. Bul. 79, February, 1902.

extending rapidly in all directions. Eventually the discoloration extends into the bark, which rots away.

In the seed bed the same disease may occur as damping off. See p. 60. It seems that the original infection always occurs in the seed bed, not in the open.

Plants started in the open are not susceptible. If it is necessary to start them under glass, too thick sowing should be avoided, and they should be ventilated thoroughly. Soil that is known to be infected should not be used. The disease may be prevented by avoidance of the conditions that favor damping off.

Rhizoctoniose. See **carnation.**

Rust (*Colæosporium sonchi* (Pers.) Lév.). — Orange-red sori, waxy in consistency, are produced in great numbers upon the leaves, which when badly affected curl and die and thus bring about the death of the plant.

BALM, SILVER

Rust (*Puccinia Menthæ* Pers.). — Some thirty species of members of the mint family, including peppermint, thyme, catnip, monarda, are affected by this rust. It is recognized by its sori, which are at first cinnamon-colored, later chestnut-brown. Badly diseased leaves curl and die.

Infected refuse should be burned.

BLETIA

Colletotrichose (*Colletotrichum Bletiæ* Halst.). — The leaves of this orchid are frequently disfigured by very dark, almost black spots. In late stages the dead tissue falls away, leaving merely shreds of veins traversing the place of disease.

The tips of the leaves are often frayed.

Volutellose (*Volutella concentrica* Halst.). — Numerous lemon-colored acervuli surrounded by concentric bluish rings render these spots different from those above described.

CALLA

Soft rot,[1] bacillose (*Bacillus aroideæ* Townsend). — A large annual loss and frequently the abandonment of calla growing is due to this disease, which is known throughout the United States, and which is perhaps identical with the carrot soft rot.[2]

The affected plants rot off near the soil surface, and the rot progresses from this point up into the leaves or down into the corm. Usually the rot first shows at the top of the corm, but in some instances it is seen first at the edge of a petiole, or on the corm below ground.

In section the diseased portion is brown, soft, and watery. Leaves whose bases are diseased become pale at the edges, then brown. Similar changes occur in spots on the leaf, and the whole leaf eventually dies, or the rot may progress so rapidly that the leaf falls before losing its green color. The flower or its stalk are similarly diseased. Through the corm the roots are reached. Here the skin is unaffected and remains as a parchment-like tube filled with the creamy residue of decay. Rot of the bulb may be arrested by unfavorable conditions and show only as dark sunken spots.

[1] Townsend, C. O., U.S. Dept. Agr. Bur. Plant Indus. Bul. 60, June, 1904.

[2] Harding, H. A., Jones, L. R., and Morse, W. J., N.Y. (Geneva) Agr. Exp. Sta. Tech. Bul. 11.

The course of the disease extends from a few days to several weeks, or the disease may lie dormant for months, even from season to season. Such cases of dormant disease carry the infection to the succeeding crop and in commercial corms from country to country. The rot spreads rapidly from plant to plant by way of the diseased roots and through the soil itself. The causal bacillus remains in the soil and may attack healthy corms planted therein at later periods.

No known treatment of diseased plants is practicable. Infection of soil may be prevented by careful inspection of all corms so as to avoid diseased ones. It is best to test commercial corms in pots to be assured of their healthfulness before putting them in the beds. All soil from badly infected beds should be disinfected or removed and fresh soil supplied.

Phyllostictose (*Phyllosticta Richardiæ* Halst.). — Blighted leaves bear large ashen spots upon which are numerous minute dark pycnidia.

Cercosporose (*Cercospora Richardiæcola* Atk.). — This was first mentioned by Atkinson in 1891 as occurring in Alabama. The edges of the leaves turn black in circular spots.

CARNATION

Rust (*Uromyces caryophyllinus* (Schrk.) Schroet.). — The carnation rust was first described in 1789 in Germany and was noted in the United States by Arthur[1] in 1891, then evidently a quite recent importation from the mother country. It rapidly became widespread through sale of infected plants and cuttings and was soon present in almost all green-

[1] Arthur, J. C., Bot. Gaz. 1891.

houses. Though widely known in Europe, it did not seem to be especially destructive there; but upon entrance into America its character changed to that of an aggressive pest, and ruin was brought to the beds in many greenhouses. The entire contents of large houses valued at thousands of dollars was in many instances utterly lost. After a short period of extreme destructiveness, which was at its height about 1893, the vigor of the attack waned, until to-day the pest does only a small fraction of the damage that was commonly due to it in the early years of its invasion, though it is still one of the serious carnation diseases.

The rust is easily recognized by the sori; in this case full of brown spores which may be rubbed out as a dark dry powder. The sori, at first covered by the white epidermis, are 1–2 mm. in diameter, round or elongated in the direction of the length of the stem or leaf. When very numerous, the affected part is slightly bleached or yellowed and appears swollen, owing to the much-ruptured epidermis. The mycelium of the causal fungus is usually general throughout affected plants, but may, in case of new infection, be limited to the immediate region of the sorus.

There is much difference in varietal resistance, a fact that should receive due weight in the selection of varieties for culture. The William Scott is highly resistant. Uncle John, Daybreak, Silver Spray, and Jacqueminot are susceptible.

Cuttings should never be taken from diseased stock. If there is doubt as to the absence of superficial spores, it is well to dip the cuttings in potassium sulphide, one ounce to one gallon. A weekly protective spray of copper sulphate, one pound to twenty-five gallons, throughout the life of the plant is also recommended. The leaves should be kept as free from moisture as possible by free ventilation, and still better by subirrigation.

Fumigation of the houses in the fall before the introduction of the plants serves to lessen infection from old spores.

Septoriose (*Septoria Dianthi* Desm.). — The spots of this disease — usually upon the leaves, sometimes upon the stems — are circular or oblong, blanched or pinkish, and purple bordered. Numerous small black pycnidia lie in the central region. The disease is especially abundant upon the lower portion of the leaves and the sheaths. The diseased part often becomes contracted, which results in bending and curling of the leaves. Surface watering of the plants or humid atmosphere tend to increase the trouble.

Vermiculariose (*Vermicularia subeffigurata* Schw.). — The bases of the leaves or the stems are usually the points of attack. Black spore-bearing bodies appear in abundance. Spraying with ammoniacal copper carbonate has given good results.

Alternariose (*Alternaria Dianthi*[1] S. & H.). — This leaf and stem disease has been reported as quite troublesome in Connecticut, Pennsylvania, District of Columbia, and North Carolina. It consists of spots mostly upon the leaves, sometimes upon the stems, especially at the nodes. These are strikingly characteristic, of ashen whiteness, with the centers occupied by an often scanty, though sometimes profuse, black fungous growth. The diseased spot is dry, somewhat shrunken, thinner than healthy portions of the leaf, approximately circular, though often

[1] Stevens, F. L., and Hall, J. G., Bot. Gaz. 47, 1909.

somewhat elongated in the direction of the longitudinal axis of the leaf (Fig. 197). When at the node, the disease usually involves the bases of both of the leaves, as well as the stem between them. As these nodal spots age, the disease penetrates through the stem, killing its tissue, which shrinks somewhat and becomes soft and disintegrated, resulting in the death of the more distal portions of the plant.

FIG. 197. — Carnation leaf showing spot caused by *Alternaria Dianthi*. Original.

A striking feature is the tendency of this disease to infect to a large degree one variety, the Mrs. Thomas W. Lawson, to the exemption of others.

Fusariose, of stems, stem rot, wilt, die back (*Fusarium sp.*). — Described in 1897 by Stergis, this rot occurs chiefly upon the stems[1] and larger branches, discoloring the wood and killing the bark, but rarely causing soft rot. The diseased plants die gradually with yellowing and drying of the foliage, much as though due to insufficient water supply.

When practicable, beds should be disinfected and new uninfected stock introduced. The disease when first introduced upon a few plants can be stopped by the immediate removal and destruction by fire of the diseased plants.

Fusariose, of leaves, leaf spot (*Fusarium sp.*). — This is a secondary disease following primary lesions of the rust. The spots as described by Stewart[2] vary from 3–25 mm. in

[1] Stewart, F. C., Bot. Gaz. *27*, 129, February, 1899.

[2] Stewart, F. C., N.Y. (Geneva) Agr. Exp. Sta. Bul. 164, 1899.

length; are elliptical in outline; covered with a pinkish gray mold; irregularly dotted near the center with light yellow spore masses. This is not common and may be prevented by avoidance of the rust.

Fig. 198. — Carnation fusariose following rust. After Stewart.

Volutellose (*Volutella Dianthi* Atk.). — The affected parts are pale and studded with minute black acervuli. This disease is of greatest injury in the cutting bench.

Heterosporiose, leaf mold (*Heterosporium echinulatum* (Berk.) Cke.). — Circular spots, 1–4 mm. in diameter, bearing more or less concentric zones of dark mold, appear upon the leaves, especially the younger ones, also upon the stems and sometimes upon the calyx. When upon the calyx, deformation of the flower results. In some instances the whole top of a plant becomes moldy.

Infected refuse and leaves should be burned and Bordeaux mixture employed as a spray.

Bacterial spot (*Bacteria*). — The spots of the leaves and stems are described by Woods[1] as small, usually surrounded by a narrow water-soaked area, while the center is commonly slightly brown. As the spots grow larger they resemble septoriose spots with the exception of the water-soaked margin. Later they dry and collapse. Badly diseased leaves wither. In some cases nearly all the leaves on many of the stems are so badly diseased as to be hopeless.

This trouble can be checked by removing and burning all diseased leaves, then spraying with formalin, 1 part to

[1] Woods, A. F., Sci. n. s. *18*, 537, October 23, 1903.

500. This should be done before noon, so that the plants may dry before night.

Botryose (*Botrytis sp.*). — A brown mold similar to that upon lettuce sometimes attacks the carnation bud, rotting it before it opens.

The only remedy available is to burn all infected refuse and to give thorough ventilation.

Bud rot, sporotrichose (*Sporotrichum anthophilum* Peck). — In this malady some buds never open, others fail to expand to perfect flowers, still others deviate only slightly from the normal. Badly affected flowers, if not picked, wither and turn brown, — first the petals, then the sepals. All parts of the flower within the calyx are eventually affected with a rot, and in some cases, though not always, hyphæ of the causal fungus may be seen with the naked eye. Mites are usually present, but they are not the true cause of the disease.

Neglect is among the prominent predisposing causes, especially the presence of too much water in the soil or air, and the accumulation of débris, leaves, trimmings, and other organic matter on the benches.

The Lawson and Queen Louise are mentioned as especially susceptible.[1]

The disease may cause considerable damage; thus a daily loss of from $1.50 to $2 is recorded in one small house. Since the buds only are affected, not the plants themselves, no permanent injury is done, and clean culture, destruction of all refuse which might harbor the fungus, maintenance of the moisture at the minimum, and the picking and burning of all infected buds will soon bring relief.

[1] Heald, F. D., Neb. Agr. Exp. Sta. Bul. 103.

Rhizoctoniose, stem rot (*Rhizoctonia sp.*). — The plants suddenly wilt, dry, and die, while the outer portion of the stem becomes soft and rotten. Sclerotia as described for the potato are present. For further discussion of stem rot, see p. 61.

CHRYSANTHEMUM

Septoriose, leaf spot (*Septoria chrysanthemi* Allesch.). — Large brown to black blotches, often irregularly circular and of indefinite border, appear upon the leaves. These enlarge and coalesce to involve the whole leaf, which withers, dies, and falls away.

The lower leaves are first affected, but in later stages all the leaves of the plant may be badly spotted, and practically complete defoliation may result. Cuttings from infected stock should be avoided. All diseased foliage should be picked, collected, and burned, and the remaining foliage should be sprayed with Bordeaux mixture with soap added sufficient to form a suds to increase its adhesive power. Five or six sprays during the season are usually sufficient.[1]

Phyllostictose (*Phyllosticta sp.*). — This disease, first described in 1893, is very similar to the above, except that the spots are more regularly circular, are purplish brown, and with a distinct border. Pycnidia which may often be seen with the naked eye are present.

Rust (*Puccinia chrysanthemi* Roze). — Apparently a native of Japan, the rust was introduced into England (1895) and Europe through commercial agencies,[2] and similarly into the United States, where it was first noted

[1] Beach, S. A., N.Y. (Geneva) Agr. Exp. Sta. Rpt. 1892, p. 557.

[2] Arthur, J. C., Ind. Agr. Exp. Sta. Bul. 85, p. 150, October, 1900.

in 1896 in Massachusetts. It was rapidly spread throughout this country by diseased stock, and is now known in nearly all localities where the chrysanthemum is cultivated. The loss occasioned by the diminution in vigor of the plant and consequent imperfection of blooms is large.

FIG. 199.— Chrysanthemum leaf showing rust sori. Original.

The sori, 2–3 mm. in diameter, which are diagnostic, first appear as small blisters covered by the epidermis. The rupture of this covering discloses a dark brown mass of spores. The sori are usually very numerous upon the lower leaf surface, less abundant above, and the spores as liberated form dusty coatings upon the leaves. Badly affected leaves curl, shrivel, and die. The plants are dwarfed and fail to produce flowers of value.

All new stock introduced to the houses should be carefully inspected and all diseased stock destroyed by fire. New stock should be isolated and watched for a month or more to be sure that no rust develops. If disease appears, all affected leaves should be picked and burned with precautions to avoid scattering the spores. If the rust continues to appear, all aboveground parts must be destroyed by fire at the end of the season, and plants for the next year raised in uncontaminated soil and house.

Ascochytose, ray blight (*Ascochyta chrysanthemi* Stevens). — In this disease, described by Stevens[1] as doing considerable damage in North Carolina, the ray flowers are blighted, resulting in imperfect opening of the buds. Thorough spraying with Bordeaux mixture from the beginning of the season until blossoming, accompanied by destruction of infected refuse, has proved a satisfactory treatment.

Fig. 200. — Chrysanthemum blossom distorted with ray blight. Original.

Powdery mildew (*Oidium chrysanthemi* Rbh. of *Erysiphe cichoracearum* DC.). — This mildew occurs as white, flour-like spots upon the green parts of the plant. It is not often serious, but if it should be, can probably readily be controlled by the means suggested for grape oidiose.

Cylindrosporiose (*Cylindrosporium chrysanthemi* Ell. & Dearn). — First described in 1893, this closely resembles septoriose, though it develops somewhat more rapidly and is consequently more injurious. Often the leaves die and flowers fail to form. Treatment is the same as for septoriose.

[1] Stevens, F. L., Bot. Gaz. *44*, 241, October, 1907.

Pseudomonose, tumor, gall (*Pseudomonas tumefaciens* Smith & Townsend). — Galls upon the stems of this plant have been proved by Smith and Townsend[1] to be due to a species of Pseudomonas. Treatment has not yet been discussed.

CLEMATIS

Phomose (*Phoma sp.*). — Plants affected with this disease were first noted in 1883.[2] They showed roots which were rotted for several centimeters distant from the stem. Minute black pycnidia occurred upon the affected parts.

COREOPSIS

Rhizoctonia. See p. 61.

COSMOS

Phlyctænose (*Phlyctæna sp.*). — The first indication of disease is seen in brown discoloration of the stem or branches, the attack often, though not always, occurring at a wound. The diseased branches at the point of attack are weak and frequently break off. Minute pycnidia are present in the diseased parts.

CYCLAMEN

Phomose (*Phoma cyclameneæ* Halst.). — A disease of the foliage which sometimes causes almost entire loss of the crop is marked by large, dark, irregularly shaped spots upon the leaf. These spots later dry, turn lighter in color, and show a series of concentric light and dark

[1] Smith, E. F., and Townsend, C. O., Centbl. Bakt. 22, 89, December, 1907.

[2] Arthur, J. C., N.Y. (Geneva) Agr. Exp. Sta. Rpt. 3, p. 383, 1884.

bands, at the same time becoming brittle and often breaking away. Diseased leaves should be burned and the plants sprayed with Bordeaux mixture or ammoniacal copper carbonate.

Glomerellose (*Glomerella rufomaculans* (Berk.) Spaul. & von Schrenk *var. cyclaminis* Patt. & Ch.).[1] — The spots on the leaves are circular, watery, with definite borders. Black hairy acervuli are often present in great numbers.

DAHLIA

Powdery mildew (*Oidium* of *Erysiphe communis* Wallr.). — This powdery mildew is quite common, affecting particularly the lower leaves late in the season.

Phomose (*Phoma Dahliæ* Berk.). — The stems of the flowers are the chief seats of attack. The flowers are small and are often dropped before opening.

DRACÆNA

Phyllostictose (*Phyllosticta maculicola* Halst.). — This may be recognized as small, brown, somewhat angular spots on the leaves, each spot surrounded by a rather wide yellow border. Minute pycnidia are present.

FERNS

Phyllostictose, blight (*Phyllosticta pteridis* Halst.). — The tender growing tips of ferns are subject to blight, and blighted spots may also occur lower upon the leaf. The brown dead tips and leaf spots bear minute pycnidia. Blighted parts should be cut away and burned and the

[1] Patterson, Mrs. Flora, and Charles, Vera K., U.S. Dept. Agr. Bur. Plant Indus. Bul. 171.

remaining foliage sprayed with Bordeaux mixture. The disease is strictly local, and close attention will stop its spread, even after it has attained considerable foothold.

Completoriose (*Completoria complens* Lohde). — Upon sporelings (prothallia of aspidium and pteris) this disease is first shown by a yellow or yellow-brown color, as seen in mass. Under a hand lens the abnormal color is seen as spots, varying from green to yellowish brown and later to black. In later stages disintegration of the affected cells gives the prothallia a ragged appearance.

GOLDEN GLOW

Powdery mildew (*Erysiphe cichoracearum* DC.). — This is a characteristic powdery mildew.

HOLLYHOCK

Rust (*Puccinia Malvacearum* Mont.). — This rust, native to Chili, was introduced into France about 1868. It spread rapidly over all Europe, from whence it came to the United States about 1886 upon infected seed. It was rapidly disseminated throughout this country, and is now known from Maine to Louisiana, in many places rendering the plants unsightly. It is easily recognized by its yellow to brown sori, each sorus considerably raised above the surface of the leaf or stem as a small, wartlike protuberance. Badly rusted leaves, or even whole plants, wither and die as though blighted. In mild cases the leaves remain green and the plant may bloom.

It is recommended to sponge the diseased parts with permanganate of potash: two tablespoonfuls of saturated solution diluted with one quart of water.

Cercosporose (*Cercospora althæina* Sacc.). — Upon the leaves and other green parts of the hollyhock, velvet leaf, and mallow rather large, dark, angular spots are produced in abundance, each spot with a dark border and an ashen center upon which numerous black hyphæ may be seen. Badly diseased leaves fall, and by midsummer only dead, leafless stalks may remain. Even in mild cases, by decreasing the amount of green surface, the spots both injure the appearance of the plant and lessen productiveness.

Spraying with Bordeaux mixture or ammoniacal copper carbonate at intervals of about ten days is thoroughly effective.

Phyllostictose (*Phyllosticta althæina* Sacc.). — This pest, long known in Europe, is recognized as large, brown, circular spots, 1–2 cm. or more in diameter, upon the leaves. The centers are brittle and usually break away irregularly.

Colletotrichose, anthracnose (*Colletotrichum Malvarum* (Br. & Casp.) South.). — Since about 1885, this disease has been noticed in destructive form in greenhouses, particularly in the propagating beds; in some cases to such serious extent as to nearly prohibit commercial culture of the hollyhock.

It occurs upon any green part of the plant. On the leaves it forms brown spots and causes withering. When upon young succulent petioles or stems, collapse of the parts beyond follows. If the parts be older, sunken spots varying from light yellow to black are produced.

The plants should be sprayed with Bordeaux mixture as soon as the first leaves appear and every second day thereafter.

HYDRANGEA

Phyllostictose (*Phyllosticta Hydrangeæ* Ell. & Ev.). — Large rusty brown blotches occur upon the leaves, in some cases to such extent that the tops of the plants must be cut away, to the entire destruction of their decorative value.

Cercosporose (*Cercospora sp.*). — Small, round or angular white spots with a very small amount of dark hyphal growth in the centers are common upon this plant. The spots are definite and are bordered by a narrow reddish purple line.

IVY (Hedera)

Vermiculariose (*Vermicularia trichella* Fr.). — This blight usually begins midway between base and apex of the leaf, and is especially common upon the white portions of the variegated varieties. The diseased portions turn black, and small black acervuli appear.

LILAC

Powdery mildew (*Microsphæra alni* Wallr.). — The characteristic spots of the powdery mildew, white and flour-like, are frequent upon the lilac. Black perithecia are abundant late in the season.

LILY

Botryose (*Botrytis sp.*). — This exceedingly destructive mold of the lily was noted about 1885, and was first closely studied by Ward[1] in 1888. It makes its appear-

[1] Ward, H. M., Ann. Bot. II, No. 7, November, 1888.

ance in the spring as small, orange-colored spots upon the leaves and buds. These enlarge, and later become coated with a light brown, dusty, fuzzy mold which destroys the leaves and blossoms, often leaving only the naked stalks standing.

Sclerotia much like those described under lettuce sclerotiniose appear in association with the decay in its late stages. Their subsequent history is like that of lettuce sclerotia.

MIGNONETTE

Cercosporose (*Cercospora Resedæ* Fckl.). — This disease occasionally ruins the greenhouse crop. The spots are at first minute, pale, with brownish or yellowish borders, or they spread over the leaf as a reddish discoloration. In late stages they are uniform brown, with dark hyphæ scattered over the central portions. The dead areas enlarge irregularly, and the leaves finally curl and die.

Bordeaux mixture or ammoniacal copper carbonate, used once a week, have proved effective remedies.

NASTURTIUM

Pseudomonose (*Pseudomonas sp.*). — In this disease the leaves are wilted and bear water-soaked spots 3–5 mm. in diameter or larger.

Alternariose (*Alternaria* of *Pleospora Tropæoli* Halst.). — The leaves which are affected turn light green, later yellow, and still later are covered with a black mold.

Damping off (*Colletotrichum sp.*). — Damping off due to a species of colletotrichum is common in the cutting bed. The diseased parts bear numerous black acervuli.

OLEANDER

Bacillose, knot, gall (*Bacillus*). — This disease both upon leaves and stems appears to be identical with that upon the olive.[1] Smith of California believes it to be caused by the same germ as that upon the olive, while E. F. Smith thinks it is different.

ORCHIDS

Botryose (*Botrytis vulgaris* Fr.). — The plants are often rendered unsightly and the flowers valueless by straw-colored spots. They are at first very minute, but enlarge rapidly and involve large areas. A gray mold similar to that found upon the lily appears later.

All infected refuse should be burned.

PALM

Colletotrichose (*Colletotrichum sp.*). — Palms often die and turn black at the tips of the leaf segments, or similar spots may appear upon other parts of the leaf. These spots near their edges have a watery appearance. When they become dry, purplish acervuli appear. Upon seedlings the disease is particularly troublesome, resulting in failure of the leaves to unfold.

The blighted parts should be cut away and burned and the remaining foliage sprayed at least once each week with Bordeaux mixture or ammoniacal copper carbonate.

PANSY

Colletotrichose (*Colletotrichum violæ-tricoloris* R. E. Smith). — This blight has been noted in many states. It is

[1] Smith, C. O., Bot. Gaz. *42*, 301, October, 1906.

characterized by the appearance of dead, black-bordered spots on the leaves and petals,[1] thus disfiguring the flowers, and affecting the production of seed, or even bringing premature death to the plant.

Thorough and frequent spraying with Bordeaux mixture is advocated.

Fusariose (*Fusarium violæ* Wolf[2]).—This was noted as of economic importance in Nebraska, where it caused sudden dying of the plants, apparently healthy plants becoming dry and dead in a few days. Slight sunken areas were evident on the stems just above the ground, and the roots were reduced to mere stumps.

Rust (*Puccinia Violæ* (Schüm.) DC.).—One of the most common of pansy diseases is this true rust which affects all aerial parts of the plant. It is recognized by its sori.

Downey mildew. See **violet.**

PEONY

Botryose (*Botrytis peoniæ* Oud.).—This mold was first noted in 1897 in Europe. It has since been mentioned[3] in Canada, Massachusetts, Rhode Island, Pennsylvania, and Maryland as causing serious loss.

The plants are attached almost as soon as they appear above ground, and ashen gray spots are produced both upon the bud, scales, and stems. Brown mold similar to that described for lettuce often, but not always, develops

[1] Smith, R. E., Bot. Gaz. *27*, 203, March, 1899.

[2] Wolf, F. A., Mycologia *2*, 19, January, 1910.

[3] Patterson, Mrs. Flora, and Charles, Vera K., U.S. Dept. Agr. Bur. Plant Indus. Bul. 171.

upon the affected parts. Numerous greenish black, flat sclerotia, 1–1½ mm. in diameter, are formed in the stems.

Dead leaf and stem remains should be removed from the peonies before they are set in the ground. Bordeaux mixture may be used after the plants appear in the spring. Infected beds should be steamed.

PINK

Rust (*Puccinia Arenariæ* (Schüm.) Schroet.). — This rust was described in 1803 by Schumacher. It is quite common upon various members of the pink family, as chickweeds, corn cockle, bouncing bet, etc. The sori are large raised blisters arranged in characteristic concentric circles.

Diseased plants should be burned.

PRIMROSE

Phyllostictose (*Phyllosticta primulicola* Desm.). — Large, circular, brown dead spots are produced upon the leaves. Minute dark pycnidia may be seen.

Ascochytose (*Ascochyta primulæ* Trail). — Well-defined oval spots, resembling those of phyllostictose, are formed. These two diseases cannot be distinguished without the aid of the microscope.

Ramulariose (*Ramularia primulæ* Thuem.). — In this disease the blotches are yellow with centers of ashen whiteness. No pycnidia are present, but instead a gray coating of mold.

Colletotrichose (*Colletotrichum primulæ* Halst.). — In this blight the leaf as a whole is more involved than in the above diseases, and definite spots are more rare. Dark acervuli are present.

Botryose (*Botrytis vulgaris* Fr.).— This occurs upon leaves and flowers much as upon lettuce.

Bordeaux mixture is useful with all of these Primrose diseases.

PRIVET

Glœosporiose, anthracnose (*Glœosporium cingulatum*[1] Atk.). — Twig blight superficially resembling that of the pear is a character of this disease in its later stages, terminal parts of the twigs 2–5 cm. long being affected. The line of separation between diseased and healthy tissue is a sharp one through shrinking and depression of the diseased part. In early stages depressed oblong diseased spots, at first very minute, are seen upon the bark. These spots enlarge, eventually girdle the twig, and cause the death of the distal part. Minute black elevated acervuli, visible to the naked eye, are scattered over the surface of the original disease spots.

Affected branches should be cut well below the disease and burned. A spring spraying, before the buds swell, with any good dormant spray will still further reduce infection.

ROSE

Black spot (*Actinonema Rosæ* (Lib.) Fr.). — Both in and out of doors, this is a widely known and destructive rose disease. It was first described in 1826, and is now known throughout Europe and the United States. It consists of irregular circular or oval indefinitely bordered black spots upon the upper surface of the leaves that are mature or

[1] Atkinson, G. F., N.Y. (Cornell) Agr. Exp. Sta. Bul. 49.

nearly so. The larger spots are a centimeter or more in diameter, and they frequently coalesce so as to nearly cover whole leaflets.

With age the spots turn gray at the centers, at which part the leaf dies. They also become more regular in outline

FIG. 201. — Rose mildew; diseased and healthy shoots. Original.

than in their earlier stages. Portions of the leaflets outside of the area actually spotted often turn yellow, and the diseased leaflets fall off prematurely. Thus the beds beneath diseased plants are often strewn with fallen leaves.

All infective material should be gathered and burned, and both bushes and ground be well cleared of superficial spores by a good dormant spray. Ammoniacal copper carbonate used once each week is effective after the plants are in foliage.

Powdery mildew (*Sphærotheca pannosa* (Wallr.) Lév.). — This is perhaps the most widespread and destructive of all rose diseases both under glass and in the open, being especially destructive to the Rambler varieties. In mild cases it occurs merely as flour-like, dusty white patches upon the leaves. But when present, it usually becomes aggressive, attacking the young leaves and tender shoots, which become dwarfed, curled, reddened, variously deformed (Fig. 201), and covered with the white powder of spores and spore stalks. The vitality of the plant is so lowered by repeated attacks and even by direct attack upon the buds that the plants become worthless.

Indoors sulphur is serviceable. The house should be closed and the sulphur boiled in a kettle for two to three hours twice weekly, or the house may be closed in the morning, the temperature raised to 75° F., and the air well filled with sulphur from bellows. The temperature should then be raised to 85°–90° F., and then allowed to cool gradually.

Either out doors or in, spraying with any good fungicide, as potassium sulphide, 1 ounce to 2 gallons, or Bordeaux mixture, is effective.

Rust (*Phragmidium subcorticum* (Schrank) Wint.). — This true rust is common in Europe, and is found in many parts of the United States from the Atlantic to the Pacific; still it is not a very common pest.

Early in the season orange-yellow sori appear upon the green parts of the plant: on the leaf as small, circular spots; on the stems and petioles often as quite large, powdery masses. Later in the season the color of the sori changes to brick red.

Affected branches should be promptly burned, and all infective material should be burned in the autumn. If the disease reappears, the whole plant should be dug up and burned. In beds where the disease has occurred, a dormant spray should be applied in early spring.

Rust (*Phragmidium speciosum* Fr.). — Though much like the last, this disease is limited to the stems, rarely petioles, in its attack. The sori are irregular and black. Since the causal fungus is perennial in the stems, excision and burning are to be practiced.

Glœsporiose, anthracnose (*Glæosporium Rosæ* Halst.). — This anthracnose is very similar to that of the raspberry. The diseased canes, bearing small, pale leaves, die from the tip backward for 2–3 dm., and red acervuli appear upon them after death. Often the canes become completely defoliated.

Affected plants should be sprayed with Bordeaux mixture or ammoniacal copper carbonate.

Sphærellose (*Mycosphærella rosigena* Ell. & Ev.). — The leaves are marked with gray, irregular, indefinite blotches which bear minute black perithecia in their centers.

Leaf spot, cercosporose (*Cercospora rosæicola* Pass.). — Circular gray spots bordered with dark purple but without pycnidia are present.

Downy mildew (*Peronospora sparsa* Berk.). — This mildew is kin to that of the grape. Its spots are indefinite, and the characteristic downy white to purple coating is noted upon the lower surfaces of the leaves. It is not common in America.

Crown gall. See **peach**.

SEDUM

Septoriose (*Septoria Sedi* Westd.). — Dark, circular blotches appear upon the leaves and result in such defoliation that the stems often become naked nearly to the tips of the branches.

Infected parts should be burned.

Vermiculariose (*Vermicularia Telephii* Karst.). — This disease usually appears first at the point of attachment of the leaves, and later it passes to the stem, causing soft rot and shrinking of the outer parts. After defoliation the disease spreads slowly toward the base of the stem.

Infected parts should be burned.

SNAPDRAGON

Colletotrichose, anthracnose (*Colletotrichum antirrhini* Stew.). — This disease which often ruins the crop is the most destructive of this host, both under glass and in the open. It attacks plants of any age, producing on the stem elliptical sunken spots, 5–8 mm. long, and on the leaves circular dead spots. These are at first dirty white with narrow brown margin; later acervuli appear in the center, at first brown, then black. Diseased plants show numerous dead hanging leaves. The stems or lateral shoots may be girdled, killing the parts beyond.

It is recommended to use only healthy plants for cuttings and to clean up and burn all diseased refuse. The cuttings should be sprayed as soon as well rooted and repeatedly until transplanted. Excess of water should be avoided and thorough ventilation provided.

Phomose (*Phoma sp.*). — This is a disease of succulent shoots, causing several centimeters of the terminal portions to wilt and die.

Bordeaux mixture is recommended.

SPURGE

Glœosporiose (*Glœosporium euphorbiæ* Halst.). — The attack usually begins upon the flower cluster and passes down the stem to the leaves, which then fall away, leaving the naked, blighted branches. The disease often interferes seriously with the ornamental effect of this decorative plant.

SUNFLOWER, ARTICHOKE

Rust (*Puccinia Helianthi* Schw.). — Both wild and cultivated species of sunflowers are often badly rusted. The early sori are yellow to brown, the later black. Badly rusted leaves die, curl, or fall, and much injury follows both to flower and seed.

In the spring the cluster-cup stage is sometimes found upon the same host. There is some doubt as to the ability of the rust upon one species to infect all of the other species of host.

Burning of infected refuse is the only remedy known.

VERBENA

Powdery mildew (*Erysiphe cichoracearum* DC.). — Powdery mildew is quite common upon verbena under glass or in the open.

The use of potassium sulphide, 1 ounce to 3 gallons, twice a week has proved effective.

VIOLET

Alternariose, spot disease[1] (*Alternaria Violæ* Galloway & Dorsett). — This is one of the most widespread and destructive of violet diseases. It attacks the plant at any stage of its growth and upon any green part, but is most destructive upon the foliage. It first appears as small, definite, circular, greenish or yellowish-white spots, varying from mere dots to 1 mm. in diameter. The light center is surrounded by a narrow ring, usually dark brown to black, but turning lighter with age. As the spot enlarges the freshly diseased tissue is usually watery and translucent, and the center changes to yellow or gray-white and may fall out. Frequently by the combined effects of several spots the whole leaf is destroyed. If the air is damp, a thin coating of rusty-colored spores may be seen in the old spots.

Damp, warm, cloudy, summer weather, unclean houses, weak plants, poor stock, poor beds, are predisposing conditions to disease.

The Marie Louise is especially susceptible; the Lady Hume Campbell much more resistant.

To avoid the disease the houses should be kept scrupulously clean, only strong stock used, infected material picked and burned, and insects banished. Close attention must also be given to ventilation, heating, shading, and watering. The soil should be removed each season and every means used to produce strong resistant plants.

Cercosporose, leaf spot (*Cercospora Violæ* Sacc.). — Large dead ashen gray definite spots are produced upon

[1] Dorsett, P. H., U.S. Dept. Agr. Div. Veg. Phys. & Path. 23, November, 1900.

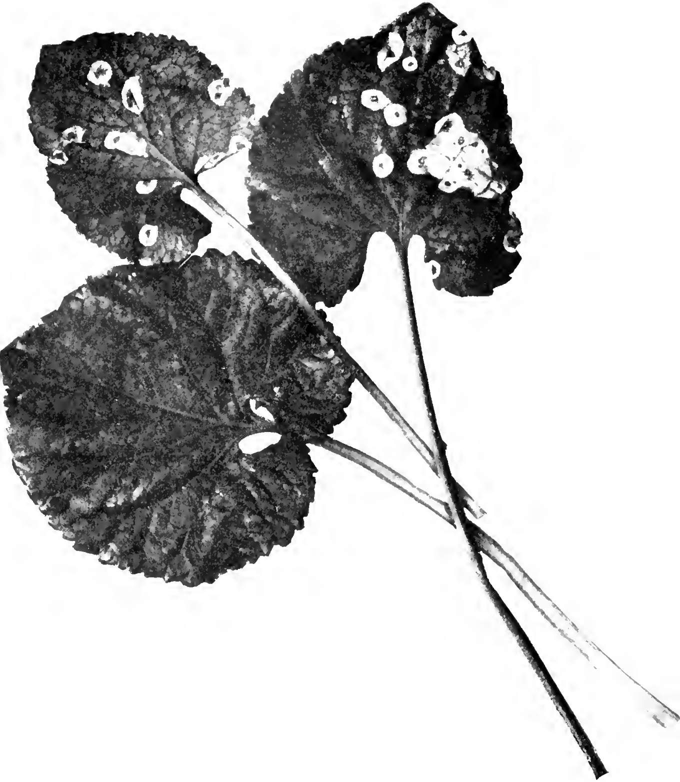


Fig. 202. — Violet leaves, healthy and affected by alternariose. After Dorsett.

the leaves. No pycnidia are present, but the centers of the spots are darkened by the presence of hyphæ.

Phyllostictose (*Phyllosticta Violæ* Desm.). — Straw-colored or white, circular spots about 3 mm. in diameter, similar to the last except for the presence of pycnidia, are produced upon the leaves.

Downy mildew (*Peronospora Violæ* DeBy.). — The downy mildew is in general character like that of the grape. The spots are indefinite, and affected plants droop and die.

Glœosporiose, anthracnose (*Glœosporium Violæ* B. & Br.). — The anthracnose often begins at the edge of the leaf, as an irregular discoloration which extends inward, eventually blighting the whole leaf.

Thielaviose (*Thielavia basicola* (B. & Br.) Zopf.). — Affected plants are stunted and yellow. The underground parts show numerous dark spots of dead tissue which often involve the roots for considerable distances. The disease is the same as that of tobacco.

Marsoniose, leaf spot (*Marsonia Violæ* (Pass.) Sacc.). — This disease seems to be rare. The spots are smaller than with other diseases, usually only 2–3 mm. in diameter, and are reddish. When abundant, they cause yellowing of the intervening tissue and result in serious injury to the leaves.

Rhizoctoniose. See p. 61.

Zygodesmose (*Zygodesmus albidus* Ell. & Halst.). — This mold forms a white, flour-like coat over the leaf.

VIRGINIA CREEPER

Phyllostictose (*Phyllosticta ampelopsidis* E. & M.). — The spots occurring upon the leaves and shoots are identical in appearance with those upon the grape, and the same treatment is recommended.

Powdery mildew. See **grape.**

WATER LILY

Cercosporose (*Cercospora*). — Circular spots, at first pale green, later yellow, and finally brown and dead, are produced upon the leaves. The dead tissue may break away, leaving irregular holes.

Soda Bordeaux mixture is recommended, since it is effective and does not spot the leaves. It is beneficial also in removing undesired algal growth.

APPENDIX

PHYSIOLOGICAL

THE ordinary cultivated plants, all except the mushrooms, absorb water and all needed nutrients, except carbon, through the roots. The absorbing organs are very fine root hairs (Fig. 203), located near the extreme root tip. From the point of absorption the crude foods must be distributed to the plant parts where they are to be utilized; that is, largely to the parts that are growing and to any green part. This necessitates a conducting system which exists in the veins continuous throughout the plant, consisting of microscopic water ducts (Fig. 206) extending through the wood of the root, stem, and leaf. The upward sap current passes through these ducts. A living plant is constantly giving off water, transpiring. The amount is considerable, averaging 75 kilo. daily for a full size beech tree. This water too must rise through the ducts.

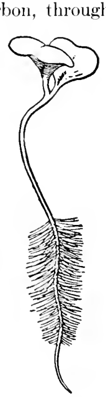


FIG. 203. — Plantlet showing location of root hairs near the root tip.

Any injury of the root hairs retards absorption, and any stoppage or interruption of the ducts in root or stem hinders the rise of sap, and in either case poor nutrition or even wilting may result.

The carbon necessary for the plant is derived from the air, taken in mainly through the stomata (Fig. 205, epidermal pores) and elaborated under the influence of sunlight and by the aid of the green substance (chlorophyll) into sugar or starch, two of the fundamental substances upon which plant growth depends. Any injury or diminution of the green plant part results at once in diminished carbon assimilation (photosynthesis) and as a consequence in lessened growth. Abstraction of elaborated carbon or other useful substances by parasites is of course detrimental. The starch or sugar made in the green parts is needed in any growing part, especially in the roots where none is made. This necessitates rootward conduction, which occurs through the bark or through the bark portion (phloem) of a vein (Fig. 206). Injury to the bark thus results in stoppage of the downward sap movement and in retarded root growth.

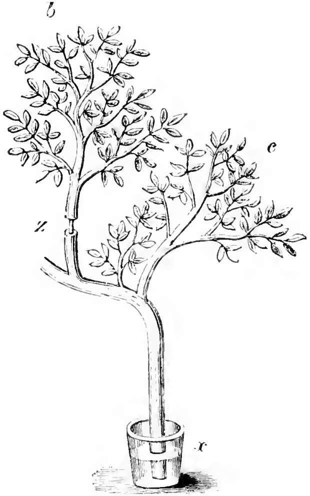


FIG. 204. — Experiment showing ascent of sap current through wood. Bark removed does not cause the leaves to wither beyond. From Strasburger's textbook.

Gaseous absorption (oxygen and carbon dioxide) is chiefly through the stomata of the leaves and enlarged stomata (lenticels) of the bark. Clogging of these openings as by dust, overgrowth by fungi or lichens, etc., interferes with this function.

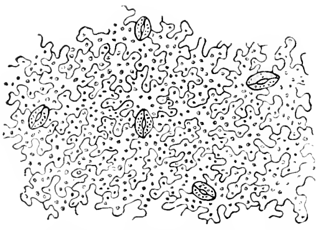


FIG. 205. — Stomata or breathing pores in the epidermis. From Strasburger's textbook.

The chief points of growth are the tips of the roots and branches and the delicate sappy layer between the bark and the wood (cambium, Fig. 206). Injury to any of these stops or deranges growth at the point injured. It is chiefly through derangement of some of these functions, absorption, liquid or gaseous, conduction, photosynthesis, or growth, that disease is caused.

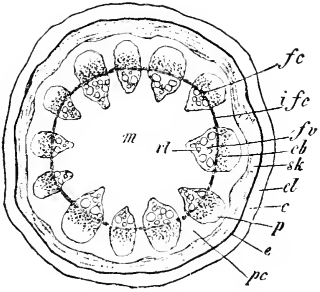


FIG. 206. — Diagram of cross section of stem showing circle of veins. *m*, pith; *i. f. c*, cambium ring. The portion of the vein inside the ring is the wood and contains large ducts. The portion outside of cambium ring is the bark. From Strasburger's textbook.

FUNGI AND BACTERIA

Fungi and bacteria are devoid of chlorophyll, therefore they cannot utilize the carbon of the air and are dependent, for their carbon supply, upon this element as elaborated by some other organism. When they take this food (often other nutrients as well) from living plants or animals, they become parasites, and if

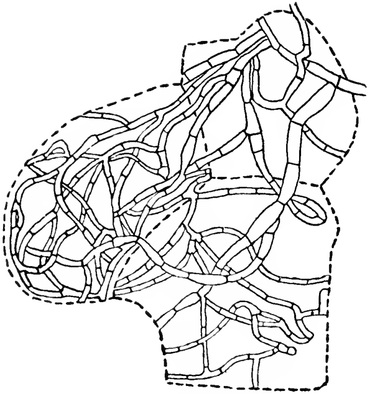


FIG. 207. — Apple cells invaded by the mycelium of Volutella. Original.

their thievery becomes considerable, a condition of disease is produced. By growing in the plant body they may also derange the vital functions in many ways. The fungous plant pathogens usually consist of a threadlike body (the mycelium, Fig. 207), which grows within or upon the plant. Masses of mycelial threads may be large enough to be visible to the naked eye.

The mycelium may propagate only vegetatively, often forming dense masses (sclerotia) (Fig. 208), to tide over unfavorable times, or they may produce reproductive cells (spores) having the function of seeds. The forms of spores and the ways in which they are borne are manifold and serve as the chief means of distinguishing one fungus from another. Some are borne in sacs (asci, Fig. 209); others on basidia (Fig. 210). The asci may be in perithecia (Fig. 209), or uncovered. Basidia are often borne upon the surface of the gills of toadstool-like fungi (Fig. 184), or upon the lining of the pores of similar struc-

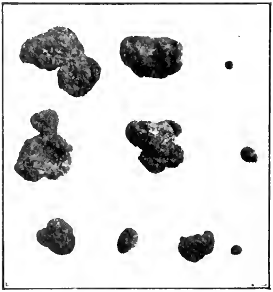


FIG. 208. — Sclerotia of lettuce sclerotiniose, natural size. Original.

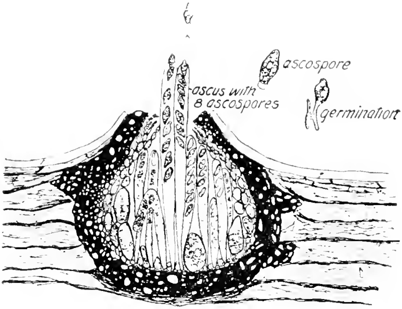


FIG. 209. — Perithecium with asci.

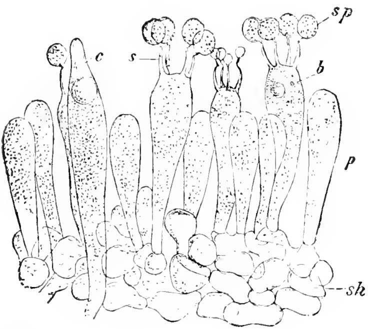


FIG. 210. — Russula rubra. Portion of the hymenium. *sh*, sub-hymenial layer; *b*, basidia; *s*, sterigmata; *sp*, spores; *p*, paraphyses; *c*, a cystid (× 540).

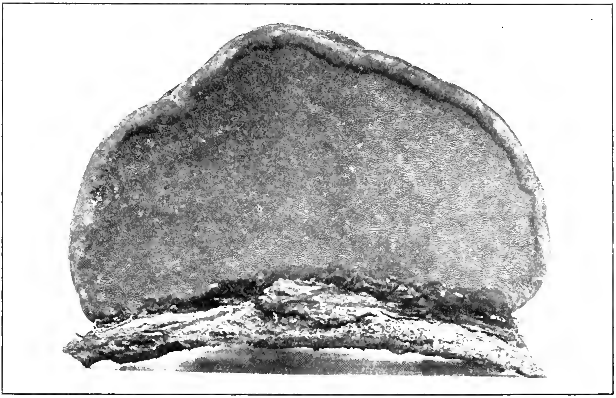


FIG. 211. — Fomes fomentarius; sporophore showing pores. After Atkinson.

tures (Fig. 211). Other spores (conidia) are borne upon the ends of stalks (Fig. 212). These stalks may be uncovered, naked, or they may be inclosed in pycnidia (Fig. 213). Several spore forms may be borne by one and the same fungus. The mode of spore formation, the time and place, are important to

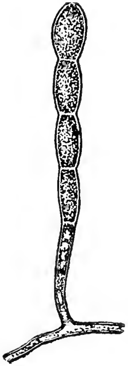


Fig. 212. — Conidia and conidiophore of powdery mildew.

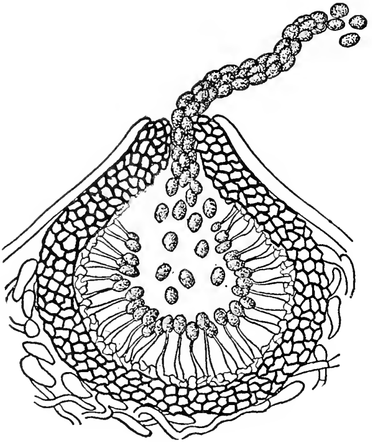


Fig. 213. — A pycnidium. Redrawn after Quartance and Shear.

the pathologist, for they may reveal a vulnerable point of attack in the life history of the parasite.

Bacteria, physiologically, are much like fungi, but their bodies are single-celled and not threadlike (Fig. 214). They are very small, — one of ordinary size is about 0.001 mm. long ($\frac{1}{25000}$ inch); yet they multiply with such rapidity (one produces a progeny of

16,000,000 in 6 or 8 hours under the most favorable conditions) that notwithstanding their minuteness they are formidable foes. They are, of course, invisible to the naked eye except in masses of countless numbers.

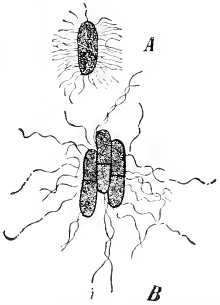
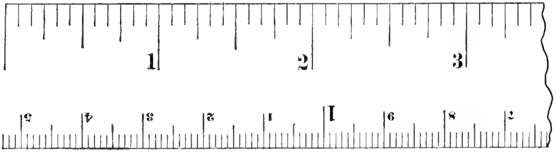
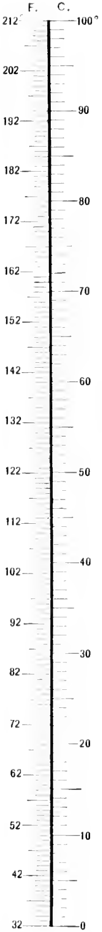


FIG. 214. — Bacillus subtilis. Swarming rods with numerous fine flagella. *A*, after $7\frac{1}{4}$ hrs.; *B*, after $8\frac{3}{4}$ hrs., with fully developed flagella. (After A. Tischer.)

ENGLISH EQUIVALENTS OF METRIC UNITS

1 mm. 0.0394 inch, or approximately $\frac{1}{25}$ inch
1 cm. 0.3937 inch, or approximately $\frac{2}{5}$ inch
1 dm. 3.9370 inches, or approximately 4 inches
1 m. 39.37 inches, or approximately 1 yard





Fahrenheit and Centigrade Thermometer Scales.

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