their habits and determining their natural history we shall at once know which of the old and well tried remedies to adopt.

CHAPTER XVII.

THE FUNGI OF FORAGE PLANTS.

BY WILLIAM TRELEASE, D. SC.

Grasses afford a nidus for the development of a large number of fungi, so that they are a favorite collecting ground with students of these plants; but the greater number of species are found on dry stems and leaves, which they seize upon, as a rule, only after their death, and though the number of truly parasitic species is by no means small, there are but few that seriously injure valuable grasses. The number of noxious species on clovers and other forage plants of the pea-family is also small; hence this chapter includes a few which are of such frequent occurrence as to attract general attention.

For the most part the fungi of forage plants are directly injurious by weakening them and appropriating to themselves the food needed for making a good growth; but they likewise lower the nutritive value of the crop that is produced. In cases where seed is an object, the loss is even greater, since the yield of diseased plants is greatly lessened, while the quality of their seed is always poor. The annual loss in our meadows and pastures due to these causes cannot be stated, from the lack of reliable statistics, but in some seasons a moderate estimate places it in the millions.

Besides these direct injuries to the crops the fungi of grasses are the cause of a very considerable loss to the farmer in another way. Ergot and corn-smut have long been known to possess ac-

tive medicinal and poisonous properties, and it has been demonstrated that abortion and certain diseases of the feet of cattle follow the prolonged use of ergotized hay or pasturage. How many of the smuts and other fungi of grasses possess similar or other detrimental properties is at present merely a matter of conjecture; but some of them occur in sufficient quantity to merit suspicion until they have been shown to be harmless.

SMUTS.

1. **Corn-smut** (*Ustilago zeæ mays, D. C.*). *Order Basidiomycetes. Sub-order Ustilagineae.* Forming galls, often of large size, in the leaves and other parts of Indian corn and teosinte, that are finally transformed into dusty masses of brown spores.

No fungus is more widely distributed or better known than corn-smut. Like other smuts, its germinating spores attack young plants, its mycelium or spawn making its way upward through their growing tissues without producing any evident effect until it prepares to fruit, when it increases and leads to the formation of the smut-galls, that are ultimately filled with myriads of round brown spores, each densely covered by short, sharp spines. These spores, which measure 9-13 micro-millimeters, preserve their power of germination for several years, or, in fresh barnyard manure, etc., they develop at once, multiplying indefinitely by the production of yeast-like secondary spores, each of which has the power of infecting a seedling corn plant.

Gathering and burning the smut-galls and smutty ears, while they are still green, to prevent the accumulation of spores in the soil, rotating the crop when smut has become firmly established in a field; treating seed corn with copperas-water and lime, etc., before planting; and using only old, well-rotted manure or artificial fertilizers, have all been proposed as preventives of smut.

2. **The leaf-smut of Timothy** (*Tilletia striaeformis, Westd.*) Forming black, smutty lines in the leaves of Timothy and other

grasses, which are finally reduced to brown shreds, covered with dusty spores.

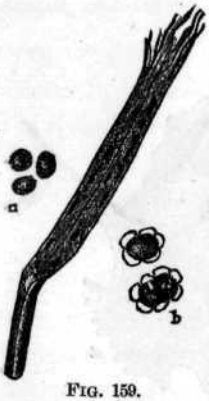

FIG. 159.

The first appearance of this disease is in the formation of lead-colored, thickened lines, about 1-64 in. wide and 1-16 to ¼ in. long, between the nerves of the leaf. The epidermis, which at first covers them and gives them their gray color, soon breaks away, revealing a powdery mass of black-brown spores, which are irregularly rounded or egg-shaped, and closely studded with short spines. They measure 10–12 micro-millimeters, and in their microscopical characters closely resemble the spores of the corn-smut.

Similar black lines are formed in the leaves of species of *Glyceria* by *Ustilago longissima* (Sow.) which has smooth brown spores, 3.5 to 7 micro-millimeters in diameter, and in the leaves of wild rye and other grasses by *Urocystis occulta* (Wall.) the dark brown opaque spores of which measure 10–20 micro-millimeters, and usually occur in clusters of 2–4, closely surrounded by masses of half-round, colorless cells of slightly greater diameter.

Ustilago hypodytes (Schl.) occurs on the stem of quack grass and other species, usually forming black smut masses inside the leaf-sheath, and *U. grandis* (Fr.) causes cat-tail-like swellings on the internodes of the reed.

The fruit of many grasses is replaced by other smut fungi, the number of which is very considerable. The commonest are: *Ustilago panici glauci* (Wall.), very abundant in autumn on pigeon grass; *U. rabenhorstiana* (Kuehn), on crab grasses and sand burs; and *U. segetum*, (P.), in oats, barley, wheat, etc.

Draining the soil well, transferring the crops to new land when they have begun to smut badly, and exercising care with respect to manure are preventive measures.

3 **Grass-rust,** (*Puccinia graminis, P.*) *Order Basidiomycetes. Sub-order Uredineae.*

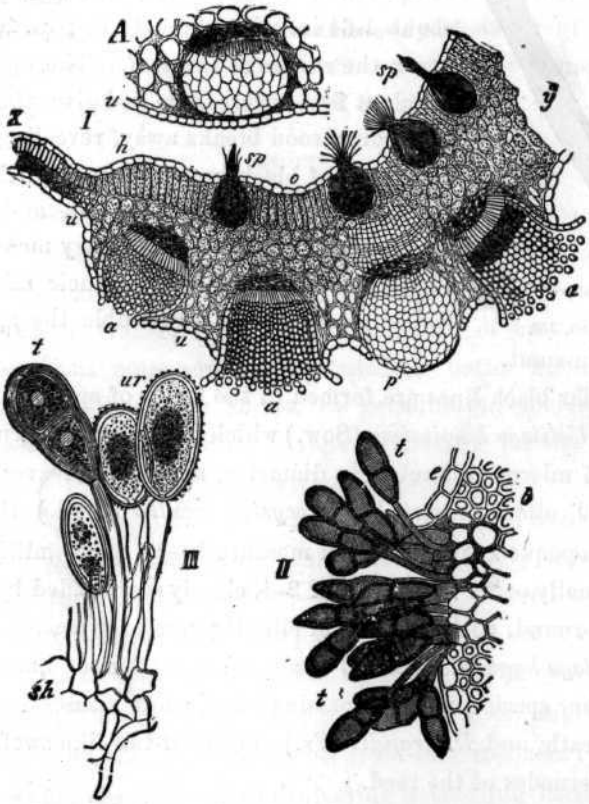

FIG. 160.—Several stages of grass-rust. *A*, young æcidium fruit; *x*, section of Barberry leaf; *a p*, æcidium fruit; *s p*, spermagonia; *II.*, a mass of teleutospores on a leaf of a grass; *III.*, three uredospores, *u r*; with one teleutospore, *t*.—(From DeBarry.)

Forming orange-red, powdery spots and lines on the leaves and stems of cereals and meadow-grasses, that give place later to dead-black velvety lines.

The sheaths and culms of the smaller grasses, especially quack grasses and red-top, are very often attacked by this rust (called mildew and brand in England), which produces the same dis-

astrous effects on them as on wheat. The red rust or uredo state appears from early spring until fall. It consists of microscopic one-celled rough spores, borne on branches of a myceli-

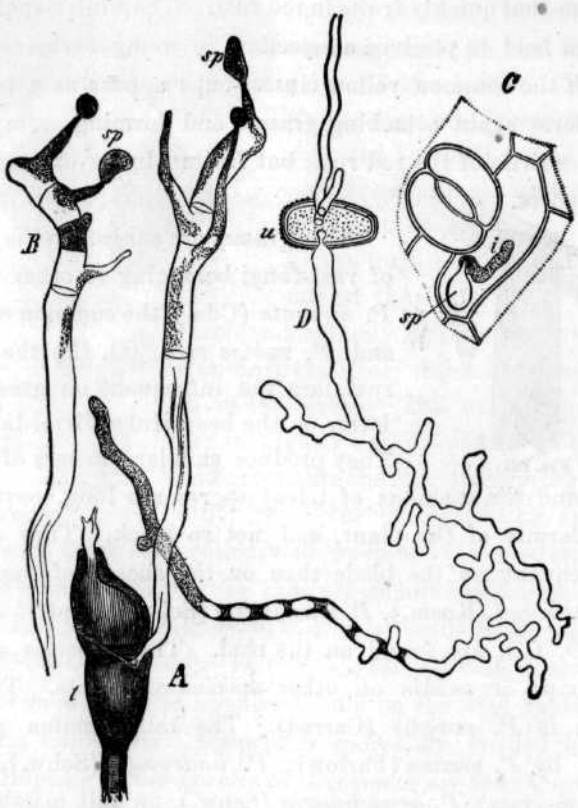

FIG. 161.—Grass-rust. *A*, germinating teleutospore, *t*; B, promycelium, with sporidia; C, *s p*, sporidium, germinating on the lower side of a leaf; *u*, a germinating uredospore.—(From DeBarry.)

um that vegetates within the grass, and only appears on the surface to fruit, which propagate the disease rapidly in damp warm weather. Toward the end of the season the same mycelium bears a second form of fruit—two-celled teleutospores or winter-spores—that form dense elongated black cushions where they break through the epidermis, often covering the greater part of

the dead stem. These spores germinate the next spring, when they produce secondary spores that are said by an English experimenter to infect very young grass leaves, in which they form a mycelium that quickly fruits in red rust. The winter-spores have long been held to produce a mycelium in young barberry leaves, on which the common yellow cluster-cups appear as a result,—their spores again attacking grasses and forming a mycelium that bears little of the red rust, but fruits almost exclusively by winter-spores.

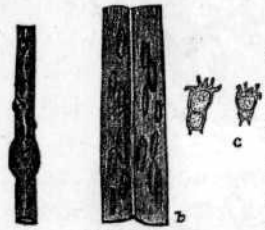

FIG. 162.

Other grasses are subject to the attacks of rust-fungi belonging to other species. *P. coronata* (Cda.), the common oat-rust, and *P. rubigo vera*, (D. C.) the barley-rust, are not infrequent on grasses, the latter on the beautiful squirrel-tail grass. They produce smaller clusters of uredo-spores, and the cushions of teleutospores are long, covered by the epidermis of the plant, and not so black. They are also more frequent on the blade than on the sheath of the leaves. *P. magnusiana* (Koem.), *P. phragmitis* (Schum), and *P. arundinacea* (D. C.), are found on the reed. These species all have cluster-cups or æcidia on other species of plants. The rust of corn is *P. maydis* (Carrad). The tall gramma grass is infested by *P. vexans* (Farlow); *P. andropogi* (Schw.), occurs on broom-grass; *P. arundinariæ* (Schw.), on fall marsh grass; and *P. cynodontis* (Desm.), on Bermuda grass. The common rust of old witch-grass or tickle-grass is *P. emaculata* (Schw.) etc. None of these species are known to produce cluster-cups.

4. **Clover-rust** (*Uromyces trifolii*, A. & S.) Producing minute white cluster-cups, pale brown uredo-pustules and darker brown teleutospore-cushions, 1-64 in. in diameter, on the leaf-stalks and blades of clover, especially white clover.

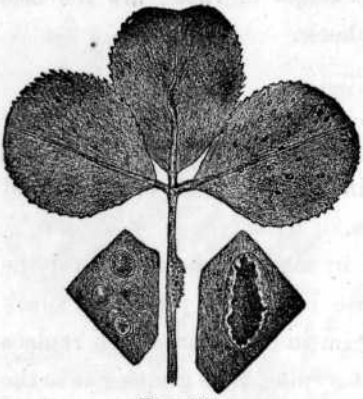

FIG. 163.

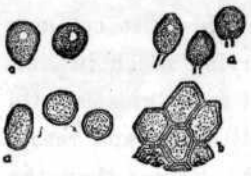

FIG. 164.

The clover-rust bears its cluster-cups on the same plant with the other forms. They appear in early summer, in small clusters, especially on the stalk and veins of the leaves. The later cluster-cups are accompanied or followed by small round or oval pustules of rough brown uredospores, that are partly covered by the torn, lead-colored epidermis of the leaf. Both of these forms immediately reproduce a mycelium, similar to that from which they originated, in other leaves. The winter spores occur in slightly darker clusters in the fall, and germinate the following spring. They differ from the corresponding spores of *Puccinia* in being one-celled, and resemble the uredospores of the same species, except that they are somewhat darker brown, smooth, and often furnished with a blunt point at the end.

U. medicaginis falcatae (D. C.), is a related rust, found in all its stages on alfalfa and none-such, and on the wild rabbit's-foot clover and hop-clover. Its winter spores are striped by longitudinal ridges. Other species of *Uromyces* are found on different grasses. *U. dactylidis* (Otth.) occurs, in Europe, on orchard grass, the taller fescue, etc., and is represented in this country by several forms on a number of grasses. Its cluster-cups are found on the butter-cup. *U. acuminatus* (Arthur) is common on fall-marsh grass; *U. spartinae* (Farlow) on rush-salt grass; and *U. Peckianus* on the smaller salt grass (*Distichlis maritima*). These species are not known to have a cluster-cup stage.

Burning over meadows and fields covered with rusty stubble; a proper succession of crops; and the destruction of plants that

serve as hosts for the cluster-cup stages of rusts, are the best methods of keeping them within check.

ASCOMYCETES.

5. **Ergot.** (*Claviceps*, Sp. *Sclerotium clavus* of authors.) Black, purple or dark gray spurs in the flowers of cereals and of various wild and cultivated grasses.

The officinal ergot, to be found in most rye-fields toward the end of summer, appears in the form of curved purple or black spurs, often an inch long and 3-16 in. in diameter, which replace the grain in one or more flowers of a spike, thus giving rise to the popular name of spurred rye, often applied to it. Spurs of the same nature, but usually shorter and stouter, are also common in the heads of wheat. Similar bodies, varying much in size, shape and color, are found in the flowers of many grasses. On the rush-salt grass they are very long and slender, and rather pale. On wild rice they are short, and even stouter than the spurs of wheat; while on smaller grasses, like red-top, Timothy, blue-grass, etc., they are much smaller, and closely resemble the pellets of mice.

These spurs are the resting form, or sclerotia, of a fungus which appears at the base of the young grain, when the grasses are in bloom. As it grows it gradually takes the place of the grain, the remains of which are pushed up at its end. While young, the fungus gives off a sweetish, ill-smelling fluid, that contains myriads of microscopic spores which are carried from plant to plant by flies, beetles and other insects that feed on the fluid, and so play an important part in spreading the disease. When the spurs have reached their growth they harden, and fall to the ground, where, as a general thing, they remain unchanged till the next spring, when each bears a number of small, stalked,

FIG. 165.—1, 2, 3, 4, Grasses affected with Ergot appearing as black spurs. (From the U. S. Dept. of Agrl.)

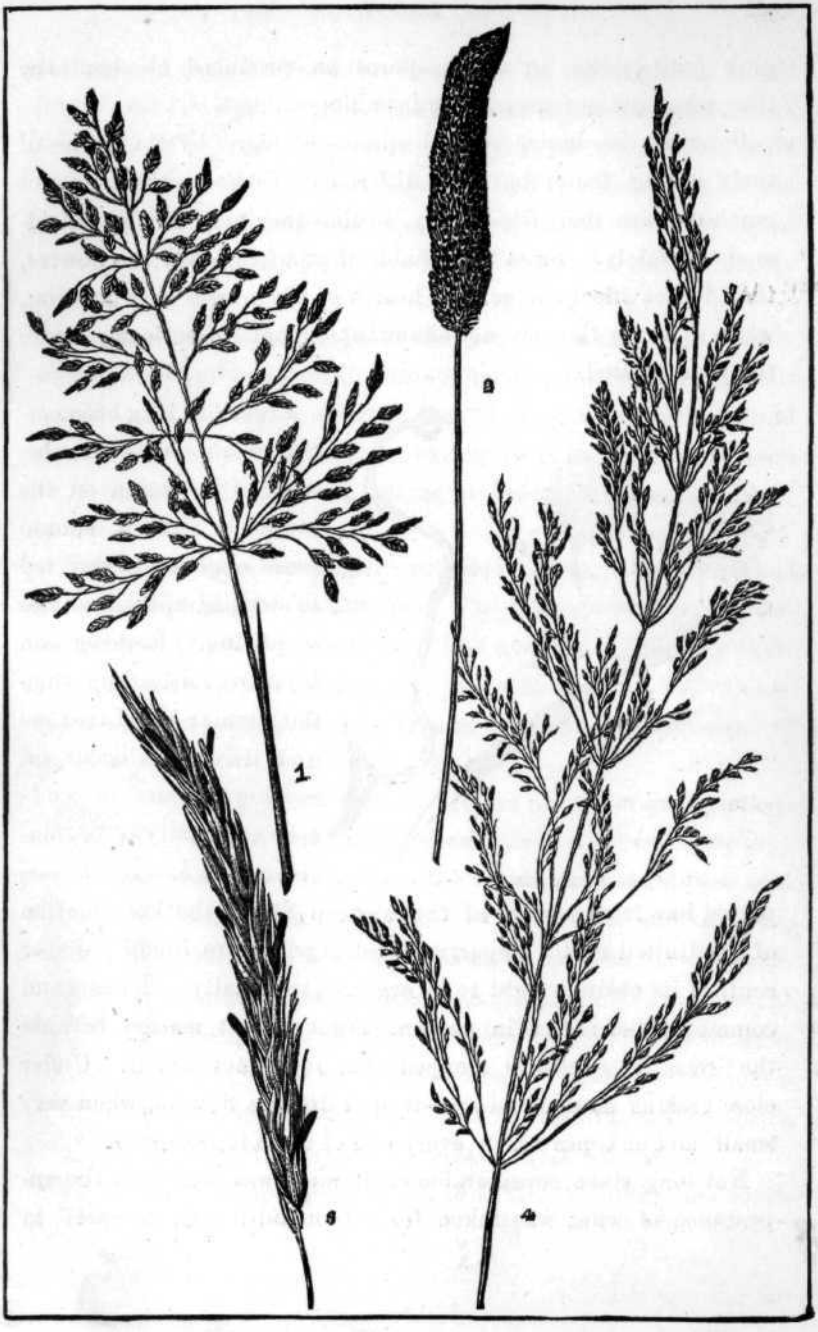

FIG. 165.

pink fruit-bodies, in which spores are produced at about the time when grasses are coming into bloom.

Botanists recognize several species of ergot by the form of their spring fruit; but the differences between them do not much concern their life-history, so that they need not be considered separately. From their habit of attacking only the flowers, they do not affect the general health of the grasses they grow on, while as a rule they are not abundant enough to seriously lessen the yield of seed.

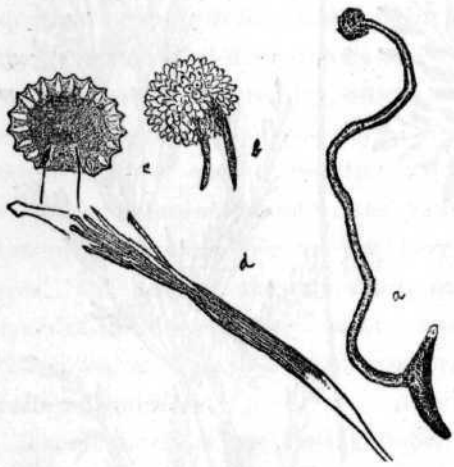

FIG. 166.

Ergot has long been employed in medicine, because of its action on the uterus. That it should cause abortion when fed to stock is, therefore, not surprising. Nothing can be more misleading than the popular belief that ergot does not occur on meadow grasses in sufficient quantity to be dangerous. In examining suspected hay from several of the western States the Veterinarian of the United States Department of Agriculture found 2–6 per cent. of its entire weight to be ergot. An equally erroneous and common belief is that in pastures ergot cannot mature because the grass is so closely cropped that it cannot flower. Under close grazing most grasses produce scattering flowers, when very small, and at times nearly every one of these is ergotized.

Not long since considerable excitement was caused by the appearance of what was taken for "foot-and-mouth disease" in

Kansas and other parts of the West, but on investigation it was found that the sloughing of the hoofs and other symptoms were the result of ergotism, due to the foul hay on which the cattle had been fed. Similar cases have occurred in other parts of the country, and in Europe the use of flour made from ergotized grain has occasionally given rise to epidemics of a similar nature among men.

However it may be as regards abortion, ergot does not usually occur abundantly enough in closely grazed pastures to cause this trouble. It has been suggested that it may be prevented from occurring to a dangerous extent in hay by cutting grass as soon as it comes to bloom, and curing it before the ergot has matured.

Yellowish-white, irregularly rounded bodies, with a checked surface, occurring in the flowers of *Paspalum laeve* are *Spermoedia paspali* (Fr.), the sclerotium of an entirely different fungus.

6. **The cat-tail grass fungus,** (*Epichlöe typhina*, P.) Forming a white or yellow coating around the upper leaf-sheaths of grasses.

FIG. 167.

This pretty fungus is found on rather young plants through the entire open season. The velvety ring which it forms about the sheath consists at first of a loose mycelium, rooted in the tissues of the grass, which bears an abundance of conidia, or summer-spores, by which other plants are infected. As the season goes on this thickens into a yellow or waxy mass, while its surface becomes uneven by the elevation of minute points, each containing, when ripe, a cluster of asci, or spore-sacs, filled with spores.

In Europe, meadow grasses, and especially Timothy, are some-

times extensively attacked by this parasite, but in America it has not been noticed to any great extent on the more valuable species—its presence being possibly overlooked in meadows because concealed by the spreading blades above.

A black fungus related to this, which occurs on grass, is *Hypocrella hypoxylon* (Pk.)

7. **The black-spot disease of grass,** (*Phyllachora graminis*, P.) Coal-black spots usually under 1-32 in. wide, and 1-32–¼ in. long, on the leaves of grasses; especially conspicuous on the upper side.

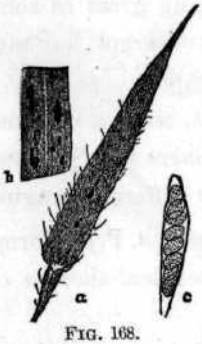

FIG. 168.

This is one of the commonest and most noticeable of grass-diseases, especially toward the end of the season, but does little harm to valuable species. It is most abundant on quack grass, hedgehog grass and the broad-leaved Panicum. The black spots are composed of dense mycelium. In them, usually after the death of the leaf, oval colorless spores are formed in asci. These spores carry the species over the winter. Smaller spores (stylospores) are produced in the same spots earlier, and serve for summer propagation. If the disease should prove troublesome, the grass may be cut early before the fungus develops, and the meadow should be burned over on the approach of cold weather to destroy the forming winter spores. (Fig. 168 illustrates the above species.)

8. **The black-spot disease of clover,** (*Phyllachora trifolli*, P.) On the lower side of clover leaves, forming at first dull-black patches, often ⅛ in. across; later occurring in the form of slightly glossy-black dots, 1.64 in. in diameter, on small whitish or pale-brown spots. (See Fig. 169.)

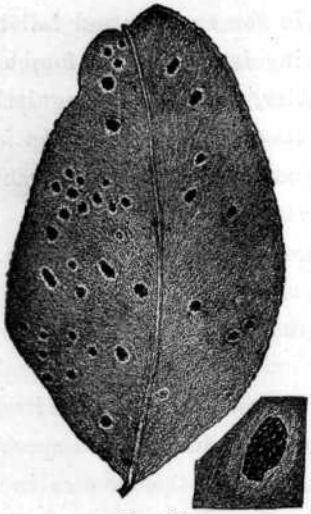

FIG. 169.

In the earlier part of the season small whitish or pale-brown spots appear in the leaf, which contains the mycelium of a fungus. This fruits on the lower surface, producing numerous tufts of necklace-shaped threads, each of which ends in a 2-celled, egg-shaped conidia-spore. These tufts of threads, which, like the spores, are of a deep brown color, are packed so closely together as to completely cover the spots, though under a hand lens they can be distinguished as separate panules. To the naked eye they appear dead-black. Later in the season similar spots are occupied by small, coal-black fruits that contain stylospores. Winter spores, produced in asci, are not known.

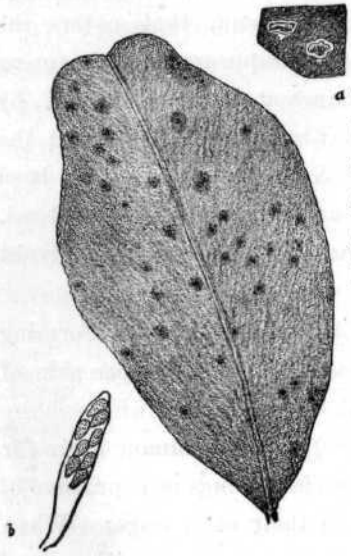

FIG. 170.

The conidial form of this fungus (called *Polythrincium trifolii*) is especially common on white clover, though both forms are at times found abundantly on red clover and other species. Kühn suggests growing grass with the clover as a means of lessening its injury. (See Fig. 170.)

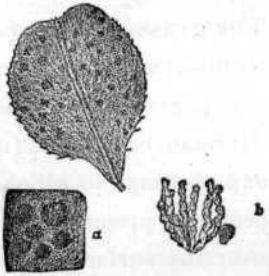

FIG. 171.

Red clover is, also, often marked in the summer and fall by similar but darker brown spots, bearing in the center of each a brown cup, scarcely 1.32 in. in diameter, that opens irregularly at the top and so allows the escape of its spores. This is *Phacidium* (or *Pseudopeziza*) *trifolii*, which at times does considerable damage in Europe. (Consult Fig. 171.)

9. **The violet root-fungus** (*Leptosphæria circinans*, Fcke.) Forming a violet mold on the roots of alfalfa, red clover, etc., which soon rot, the parts above ground turning yellow and dying.

In Europe, Lucerne is subject to a disease that manifests itself by the appearance of yellow spots in the fields. These spread until the entire crop is often affected. The trouble lies in a violet-colored mold that develops on the roots of the plants, spreading from one to another through the soil, and finally producing spores by which it is apparently carried over the winter. This disease has not been recognized yet in the United States, but what is held to be a state of the root fungus—a cobwebby, white mycelium, known as the snow-mold, that covers the ground, leaves, etc., just as the snow disappears in early spring—has been noticed in great abundance at River Falls, Wis., by my friend, Professor King, so that it is not improbable that the parasitic form will soon be found. No remedies for it have been proposed, except digging ditches, as deep as the roots extend, about diseased parts of the field when it first appears to prevent it from spreading.

10. **The grass-mildew,** (*Erysiphe graminis*, D. C.) Forming a pure white, cobwebby or mealy coating on the upper side of the leaves of grasses, especially in the shade

The German equivalent (meal-dew) of our common name for the group of fungi to which this species belongs is expressive of the appearance presented by them in their early stages. When they cover the surface of the plants they grow on with a fine,

white mycelium that bears such numbers of white spores as to suggest a dusting of meal or flour.

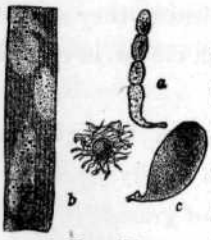

FIG. 172.

This mildew is usually found through the entire open season on grass growing in damp and shaded positions; it is especially abundant on June grass. Its cobwebby mycelium, which does not penetrate the leaves, does not at first appear to injure them but in time they succumb and dry up. Through the summer it spreads by means of its light conidia, that are easily blown about and germinate quickly while fresh, though they are unable to live through the winter. On the dead leaves small, black fruit-bodies, scarcely visible to the naked eye, are formed, in which winter-spores are produced in short-stem asci. (Fig. 172 is the illustration for the grass-mildew.)

Usually grasses do not suffer much from mildew, except in damp and shaded places. Drainage is likely to prove beneficial where it is troublesome.

11. **The sclerotium disease of clover,** (*Peziza cibonoides*, F.) On clover, causing a browning of leaves or stem, which are soon covered in spots by a white mold that ultimately forms solid, wavy, black bodies, often $\frac{1}{2}$ in. long, white within.

In Europe, clovers are occasionally attacked by this fungus, which is very destructive when it occurs. The entire plant becomes filled with a mycelium which soon kills it and afterward breaks through in places, forming black sclerotia on the various parts of the decaying plants as winter approaches. These bodies lie dormant in the soil until the following summer, when they produce fruit-bodies in the form of wavy stems, bearing brown disks or inverted cones, $\frac{1}{16}$ to $\frac{1}{2}$ in. in diameter, on their ends. When these reach the surface they shed their spores and so spread the disease.

Draining the soil well, and especially replacing clover by

wheat, corn, or other crops not attacked by the *Peziza*, are recommended where it appears. As the potato, rape, and hemp sometimes suffer from a similar sclerotium disease, they should not be used in rotation with each other or with clover in case of its appearance.

A large number of fungi are spoken of as imperfect fungi from the resemblance of their fruit to the conidia or stylospores of Ascomycetes. Several of these cause diseases of grasses.

FIG. 173.

The brown-spot disease of pigeon-grass, early spear-grass, and other species, is due to *Septoria graminum*, (Desm.) (Fig. 173), that form a mycelium within the plant, usually killing it in places which turn brown and are finally dotted with the minute black fruit-bodies of the parasite, within which slender colorless spores are produced. In Europe, a similar disease is also caused by a related fungus (*Dilophospora graminis*, Desm.) whose spores differ in having brush-like appendages at their ends. Both are at times destructive, but affect the cereals more than the smaller grasses. *Mastigosporium album*, (Riess), and *Scolecotrichum graminis*, (Fche.), cause diseases of the leaves of grass in Europe; the last named appeared on orchard grass in great abundance about Madison, Wisconsin, in 1886. *Hadrotrichum phragmitis*, (Fche.), forms small, dark-brown pustules on leaves of the reed, resembling those of a rust-fungus, even under a hand-lens. The gray-spot disease of crab-grass is due to *Pyricularia grisea* (Che.), another imperfect form that bears pear-shaped conidia on threads that protrude through the stomata of the gray spots.

Sporobolus indicus, a grass of the Southern States, somewhat esteemed for pasturage while young, is often called "black-seed grass" or "smut-grass" from the fact that its flowering parts are generally covered by the dark-brown fruit of *Helmintho-*

sporium ravenelii, (Curt)., that is often so abundant as to form a dense, spongy mass. Wire grass is subject to similar attacks from *H. nodosum,* (B. & C)., and other species of the same genus occur on different grasses in a similar manner.

PERONOSPOREAE.

FIG. 174.

12. **The grass-peronospora,** (*Peronospora graminicola,* Sacc.) In the leaves of Hungarian grass and pigeon grass, ultimately filling them with a snuff-brown, powdery mass.

Hungarian grass (*Setaria italica*) is sometimes attacked by a parasite clearly related to the notorious potato blight which forms a mycelium in the leaves of the grass in the cells of which it lives. Branches of this emerge sparsely through the stomata and bear colorless conidia which spread the disease. Later in the season these spores are replaced by winter spores (oöspores) that originate on branches of the mycelium within the leaf by a process of fertilization. These spores are contained in thick-walled, brown envelopes, and presumably infect new plants in the spring. So far, this disease has not proved seriously destructive, though the leaves attacked are reduced to mere shreds when the winter spores are ripe. The flower-clusters of pigeon grass are greatly changed by the fungus, according to Dr. Halsted. (See Fig. 174.)

13. **The clover peronospora,** (*Peronospora trifoliorum,* DeBary). A dirty white or purple-brown mold, often completely covering the lower surface of the leaves of clover, alfalfa, none-such, etc. (See Fig. 175.)

FIG. 175.

The life history of this species is quite similar to that of the last, though they differ greatly in appearance. The leaves that it occurs on are paler than the others, and the threads that escape through their stomata and bear conidia are so numerous and bushy as to form a dense coating on their under side. Oöspores are produced in smaller numbers than in the last species, and, as they are thin-walled and nearly colorless, they are only to be found after careful microscopical examination. Another species of the same genus (*P. vicial,* Berk.) is found on the leaves of vetches and of the pea.

14. **The seedling rot,** (*Pythium debaryanum,* Hesse). Causing young plants of clover, millet, corn, and many other species to rot close to the ground.

Several species of *Pythium* attack living plants. The present species is said to be widely distributed in garden soil in Europe and causes serious trouble by attacking seedling plants. It has not been observed in America as yet, but can be recognized, if found, by its effects on the plants, which quickly decay near the ground. They contain a delicate, colorless mycelium that fruits on the surface of the decaying parts, when these are kept damp, producing conidia, swarm-spores, and oöspores.

Fairy-Ring Fungi.—Bright green circles, several feet in diameter, closely surrounded by a narrow strip of dead or dying grass, are frequently seen in lawns or pastures, and are commonly called "fairy-rings." They are caused by several species of

toadstools (the commonest is *Marasmius oreades*) that spread a short distance outward every year, their mycelium destroying the grass in the roots of which it grows, and so causing the brown ring, on which an abundant crop of toad-stool fruits forms in the fall, which by their decay enrich the soil so that it produces a ranker vegetation the next season.

An appearance which may be called false fairy-rings is occasionally produced by *Physarum cinereum*, one of the shine-molds, on the leaves and stems of grasses. This fungus grows unnoticed on decaying matter in the ground, often creeping out in a regular manner from its starting point until a more or less perfect circle six or seven feet in diameter is formed, when it suddenly appears upon the plants it has grown under, and produces its dusty, ash-colored fruit in such abundance as to attract attention from a distance. From its mode of life, it does little if any harm to the grass, further than to make a little of it unpalatable to animals.

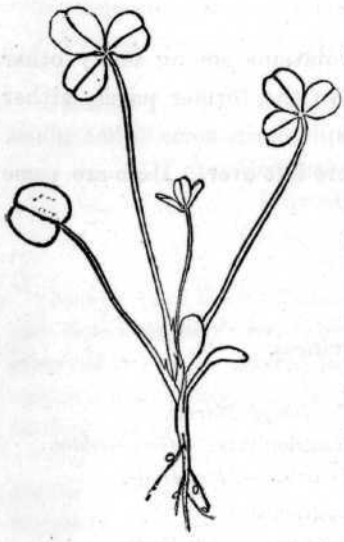

FIG. 175.

In closing this chapter, mention should be made of small, egg-shaped galls that occur on the roots of clover and many other leguminosæ. It has been claimed that they result from the attacks of a little understood parasitic fungus (*Schinzia leguminosarum*, Frank), or from the presence of one of the bacteria, which is apparently the case; but they have been the subject of much controversy. Whatever their true nature may be, they do not appear to be in the least injurious to the plants, and may be found on nearly every clover root examined.