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TIMBER-ROT IN THE PEPPER TREE, SCHINUS MOLLE

By
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*In cooperation with the New Mexico Agricultural Experiment Station and the United States Department of Agriculture, Bureau of Animal Industry.
†In cooperation with United States Department of Agriculture, Bureau of Plant Industry.

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TIMBER-ROT IN THE PEPPER TREE, SCHINUS MOLLE

By
J. G. Brown

THE HOST

The pepper tree, *Schinus molle,* is perhaps the most beautiful tree in the Southwest when it is healthy. Not only is it valuable for shade and as an ornamental, but its gracefully drooping evergreen leaves and clusters of scarlet berries are also used locally and sometimes exported for holiday decoration. Although it is a native of tropical South America, the tree grows in the open in southern Europe as well as in the extreme southern and southwestern parts of the United States. The common name, "pepper tree," is derived from the peppery taste of the pulp of the fruit. Another name, that of mastic tree, comes from the white resin or mastic secreted by the tree and used medicinally in South America. The pepper tree is not a member of the true pepper family, *Piperaceae,* but belongs to the sumac family, *Anacardiaceae.*

Diseased pepper trees are common in Arizona, and the diseased tree is often as ugly in appearance as the healthy tree is beautiful. The tree is seriously injured by two fungal diseases, timber-rot and Texas root-rot, either of which may kill it. Since timber-rot may involve wilting and Texas root-rot always does, the two diseases may be confused without careful observation Two physiological diseases, frost injury and root binding, are common; another, strangulation, frequently kills young trees which are planted in tree-holes excavated in the more impermeable types of caliche soil Frost injury when extensive not only is serious in itself, but usually leads to infection with the timber-rot fungus. Root binding which is common in caliche soils, is accompanied by nanism or dwarfing. This publication deals chiefly with the timber-rot disease.

THE DISEASE

Symptoms.—Timber-rot is to be suspected whenever scattered dead branches are found in the pepper tree. These may occur in any part of the top. Death of a branch may come quickly or slowly. During the hot, dry, early summer a large branch on one side of the tree shows wilted leaves and dies, another follows, until the whole top is dead. Later there may be a rapid growth of young branches from the lower part of the trunk; sometimes only one or two branches grow out. Again large branches having their origin at a distance below the infection in the trunk may remain alive for months or even years after the top is dead (Pl. I, Fig. 2). As contrasted with timber-rot, Texas root-rot usually suddenly affects the whole top of the tree. All the branches show wilted leaves and the tree is soon moribund. In other cases the top dies, but the tree puts out a new growth of basal shoots supported by a new growth of small adventitious roots which grow above the roots which have rotted. Thus is is possible to distinguish between the two fungal disease by superficial observations.

In the case of timber-rot which has progressed for some time, the appearance of the sporophores or "fruiting bodies" of the fungus is a sure means of diagnosis. The sporophores are round, light colored bodies at first (Pl. IV, Figs. 9, 10), which grow out on the trunk of the tree or on a large branch. They appear soon after the summer rains begin in July and grow rapidly into brown, bracket-shaped structures (Pl. V, Fig. 12; Pl. VI, Fig. 15) with many fine pores on the lower surface from which a brown powder, the spores, is shed. By the time that the brackets are produced the tree usually is so badly decayed that little or nothing can be done to save it.

An infected trunk or large branch of the pepper tree, when cut across, shows at first a dark brown discoloration in the medullary region (Pl. II, Fig. 4; Pl. III, Fig. 7). Here the infection travels faster than in the xylem, but eventually the fungal hyphae penetrate peripherally toward the cambium (Pl. II, Fig. 4). The rotted wood is a very light dull brown, but sufficiently discolored to photograph darker than the healthy wood (Pl. III, Figs. 5, 7). Sections of the wood show an abundance of hyphae which penetrate into the cells (Pl. VII, Fig. 17) even in the outer part of the woody cylinder (stele). Although no hyphae were seen in the living elements next to the cambium in the few available sections of that region, the numerous hypertrophies in infected trees and the frequent death of the cortex suggest that the fungus may invade the cambium and the tissues external to it.

The Cause.—Timber-rot of the pepper tree is caused by a fungus which belongs to the *Basidiomycetes* or Club Fungi, to which mushrooms and toadstools also belong. The body of this fungus, like that of most fungi, consists of threads or filaments. The threads are brown in the brackets and more or less colorless in the wood of the tree; they are called hyphae. The hyphae form grayish-white strands under the bark (Pl. III, Fig. 8) at the spot where a bracket grows. They penetrate the wood in all directions, dissolve certain substances from it, and eventually change it into a punky mass which is difficult to cut with an axe. In some of the trees which have been studied, the hpyhae had destroyed all of the wood except a very thin shell immediately underneath the bark (Pl. III, Figs. 5, 6).

The wood of the pepper tree mainly consists of long tubes (tracheae) and elongated overlapping cells with thickened, pitted walls (tracheids) which carry water upward to the green parts to replace the water given off in transpiration. The fungal threads or hyphae previously mentioned clog the cavities of the tracheae (Pl. VIII, Fig. 18) and tracheids. With only a thin shell of functioning wood and many of its tracheae and tracheids clogged by the fungus, insufficient water is drawn upward to replace the water given off. Wilting and the subsequent death of the affected members follow. During the early summer and late fall when the balance between the intake and outgo of water is particularly close, the effect of the disease is marked.

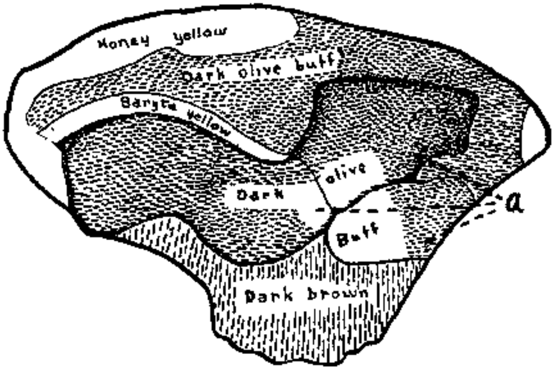


Fig. 13.—Diagram of lower surface of young sporophore.

With the advent of the summer rains, the fungus sends toward the surface of the infected tree many filaments or hyphae which grow out into round, knob-like structures (Pl. IV, Figs. 9, 10; Pl. VI, Fig. 14). These are the young sporophores destined to form the spores which serve the function of seeds. For some reason the first sporophores usually appear at or near the place where the primary infection occurred. Possibly the exhaustion of the food supply stimulates the reproduction of the fungus, and the food is first exhausted in the place where the fungus first starts to grow. Often the young sporophores appear in a cavity left by the decay of an improperly pruned branch or a branch injured in a storm. In color they are light orange citrine* at first; as they develop they may show changes in color (Fig. 13); finally they become brown One or more pearly drops of excreted moisture commonly appear upon their smooth surfaces.

Under favorable conditions of moisture the sporophores grow rapidly Those shown in figure 9 matured in less than 3 weeks from the date of their appearance It has been observed that more sporophores are produced in summers having a normal rainfall than in dry summers During the summer of 1923 the precipitation in inches up to the time that the illustrated sporophores were mature was as follows·

JULY

Day	6	7	12	13	14	15	20	21	22	23	24	27	30	31
Prec.	.10	.32	1.31	.05	T	08	.11	17	04	.12	.03	.10	.07	50

AUGUST

Day	3	5	6	9	10	11
Prec	.25	.20	.13	2 48	.09	.06

Growth of the sporophores is more or less equal at first, except as influenced mechanically by the place in which they develop After a time the lower part of the sporophore grows faster than the upper part and the bracket shape is assumed. Lobing results in sporophores with two or more overlapping shelves (Pl V, Fig. 12), i. e., imbricate, or they may be simple (Pl. VI, Fig. 15).

The sporophores vary considerably in size Measurements of those in a collection of 18 gathered at various times give the following results

Side to side, cm.	Front to back, cm	Thickness, cm
23	17	10
12	9.5	6
21.5	14	9
10.5	7	3.5
9.5	6	4.5
12	6	4.5
10.5	7.5	5
19.5	13.5	13
10	7	6.5
14	7	5

*Ridgway, Robert—Color standards and nomenclature

14	8	3.5
15.5	8	3
16.5	10.5	4
14	8	4
10	6.5	3.5
10	5	2
10	6	2
4.5	4.2	1.5

Although the average size in this collection is 13.1 cm. by 8.8 cm. by 5 cm., the smaller sporophores are much more numerous in the field than the larger ones. The average size of the sporophores as they are encountered probably runs about 10-12 cm. by 4-8 cm. by 1.5 -4 cm.

As the sporophore matures pores form on the under surface, which open into the spore-bearing tubes of the sporophore (Pl. V, Fig. 11; Pl. VI, Fig. 15). There may be one or several areas in which the pores are forming at the same time. These areas are usually somewhat depressed. The pores are four- to six-sided, and circles of the smaller size arranged around a central and larger pore (Pl. VII, Fig. 16) generally can be distinguished. Pores and canals may have a grayish appearance superficially, or they may be brown in color. The pores vary in size from 2 to 4 per millimeter, that is, they are one-half to one-fourth millimeter in diameter.

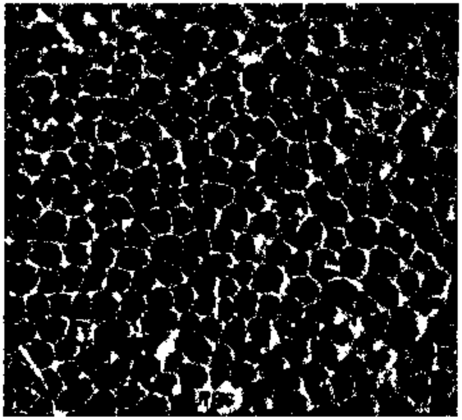


Fig 33.—Photograph showing arrangement and form of mature pores

The tubes into which the pores open and which bear the spores are 3 to 20 millimeters long, the shortest ones being located near the margin. They average approximately 10 millimeters in length. They are angular, round, or oval in cross-section as seen in paraffin sections. More round ones occur in the deeper sections, which suggests that the tubes which are angular near the surface may be rounded farther back where the plectenchyma is less dense. Teeth (Pl. VIII, Fig. 32) are occasionally found. The walls (tramae) between the tubes are the same or nearly the same brown color as the sterile mass above (context).

The spores (Pl. VIII, Fig. 31) are smooth, oval, light brown, and measure 6μ to 7.9μ in length and 4.5μ to 6.9μ in transverse diameter. The average of 25 spores was 5.4μ x 6.9μ. Occasionally spores are found which are slightly flattened on one side. The development of the spores is typical for *Basidiomycetes*. The young basidium shows at first two nuclei (Pl. VIII, Fig 22) which fuse (Pl. VIII, Fig. 23), and the fusion nucleus is followed by two successive divisions (Pl. VIII, Figs. 25, 26). Vacuolization of the cytoplasm at the base of the basidium carries the four nuclei to the region of the sterigmata (Pl. VIII, Figs. 27, 28, 29). Passage of the nuclei through the sterigmata into the spores is probably rapid, since this stage was not found in any of the numerous sections which were prepared. Four spores develop on each basidium (Pl. VIII, Fig. 30).

For the fungus which causes the timber-rot of the pepper tree, the writer suggested the name *Inonotus schini* in 1921.*

Technical Description of the Sporophore.—Sporophore simple or imbricate, ungulate and dimidiate, or irregular; sessile, corky to woody, annual, 4.5 cm.-23 cm. side to side by 4.2 cm.-17 cm. front to back by 1.5 cm.-13 cm. thick; surface smooth, not polished, azonate to obscurely zonate, no conidia found; upper surface snuff-brown, lower surface russet, both darker with age; margin blunt, or thin and sharp, 1 mm.-5 mm. thick; sterile zone 1 mm.-5 mm. broad; context 1 cm.-2 cm. thick, occasionally thicker, obscurely zonate, snuff-brown to vandyke-brown; tubes angular, oval, or round, 2 mm.-20 mm. long; tramae 52 μ-190 μ thick, average 108 μ, sayal brown to snuff-brown, hyphae, 3.8 μ in diameter; hymenium 13 μ thick at time basidiospores are formed; a few teeth present, brown, 6 μ-9 μ by 21 μ-28 μ; pores angular in mature sporophore, 4-6 sided, 2-4 per mm.; spores smooth, oval, light brown, 6 μ-9 μ x 4.5 μ-6.9 μ, average 6.9 μ x 5.4 μ.

CONTROL

Since the fungus which causes timber-rot appears to enter the pepper tree strictly through wounds, proper care of the tree should insure a healthy condition, so far as timber-rot is concerned. The greatest dan-

*Brown, J. G.—Annual Meeting Southwestern Division, A. A. A. S.

ger comes from careless and improper pruning (Pl. VI, Fig. 14), although infection also follows injury from wind storms (Pl. II, Figs. 3, 4) and from frost. In pruning, care should be taken to cut off branches flush with the surface of the member to which they are attached (Pl. VI, Fig. 14,c). An axe should never be used for cutting off branches. A sharp saw is the proper tool. Large branches should be partly cut through from the under side first, then completely severed from the upper side. It is often advisable to support a large branch which is to be cut off by anchoring it from above with a rope or cable. The object of these precautions is to prevent splitting which affords numerous cracks in which the spores of the timber-rot fungus may lodge and grow. Freshly-cut surfaces should be kept painted with a good white lead paint or roofing paint until they are healed over.

Suggestions for the care of the pepper tree after pruning also apply to care after injury from wind and frost. The injured members should be carefully pruned as soon as possible after injury, and the cut surfaces should be painted.

When a pepper tree is extensively infected with the timber-rot fungus its symmetry is destroyed by the death of large branches and as a rule the tree is doomed. However, if the disease starts in a single branch and is recognized in time, the excision of the infected branch followed by the precautions mentioned above may save the tree from further injury. Tree surgery, so-called, has been resorted to in cases of extensive injury, but the task of removing all the decayed and infected tissues is so difficult that the measure is often unsatisfactory. The symmetry of the tree is seldom restored in subsequent growth. Prevention is to be emphasized rather than attempted rejuvenation. Since quick healing of wounds is a factor in the prevention of the timber-rot disease, pepper trees should be carefully cultivated, especially during the dry months of summer. The supply of water and the way in which the water is applied are important factors in the growth of the tree. All the green parts give off or "transpire" water into the air, and the amount lost in this way must be replaced from the soil. Enough water must be supplied to the soil to meet the needs of the tree, besides that lost in direct evaporation from the soil and the water absorbed by lawn grass, weeds, and other plants growing near the tree. At times this may require water at the rate of one or more barrels per day for a large pepper tree.

The manner of applying water is important. Basin irrigation (Pl. I, Fig. 1) is perhaps best in southern Arizona. In order to save time the basin should be large enough to supply an abundance of water without requiring many refillings, unless the water is piped to each tree. A basin

6 feet in diameter and 6 inches deep will hold approximately 105 gallons of water, without making allowance for the space taken up by the tree. A basin of this size is much better than a smaller one. Watering trees by sprinkling is usually unsatisfactory, for only a shallow layer of soil is wetted, roots are developed just below the surface, and as a consequence the tree suffers severely during the dry season.

The frequency of irrigation depends, of course, upon the weather as well as upon the nature of the soil. Pepper trees that have a maximum water content are injured by the low temperatures of the winter months more readily than trees that are watered sparingly at that time of year. It is not uncommon to find in winter a young pepper tree killed by cold standing only a few feet from an unharmed tree. During the winter of 1928-29 this situation was observed several times in Tucson. The tree killed by the cold had been supplied with more water than the surviving one as shown by a drier soil around the roots of the latter. A monthly irrigation in winter is usually sufficient. In summer, however, one heavy irrigation per week may be necessary in order to keep the soil in good tilth. Daily light irrigations are bad for the tree for reasons already stated.

To determine whether the trees are receiving enough water if the tree, itself, does not show drought, it is advisable to use a soil auger or a spade and to test the soil at a depth of at least 1½ or 2 feet below the surface. If the tree is a large one, a foot or more in diameter measured breast-high, one boring should be made 6 or 8 feet from the base of the trunk and another under the tips of the long branches. The soil at the bottom of the boring when squeezed in the hand, should just fall apart when the hand is opened. If it is sticky less water should be applied; if it falls apart easily or runs between the fingers more water should be used. In case the soil feels moist yet the tree does not appear to be growing well and no evidence of a parasite is present, samples of the soil should be sent to the Experiment Station for analysis. When penetration of the soil is slow the surface should be worked to a depth of 6 inches. A mulch of coarse manure or straw applied to the soil during the cooler months of the year, or well-rotted manure applied at any time, conserves the water and helps to prevent rapid changes in the water-content of the soil. This treatment applies also to the basin around the tree, which should be kept free from weeds, well-tilled, and covered with a mulch.

SUMMARY

1. The pepper tree, *Schinus molle*, which is extensively cultivated for shade and as an ornamental in Arizona is frequently destroyed by timber-rot. Symptoms of the disease are described.

2. Timber-rot of the pepper tree is caused by a fungus which belongs to the Class *Basidiomycetes* and the Family *Polyporaceae*. A brief description of the fungus is given. For it the name, *Inonotus schini*, was suggested by the writer in 1921.

3. Suggestions are given for the care of the pepper tree which have to do with the prevention of the timber-rot disease.

DESCRIPTION OF PLATES

PLATE I. The pepper tree, *Schinus molle*.

Fig. 1—Healthy and well cared for.

Fig. 2—Destroyed by the timber-rot fungus.

PLATE II. Branches of the pepper tree injured in a wind storm.

Fig. 3—Seen from the surface.

Fig. 4—The same branches split to show the infected areas.

PLATE III. Fig. 5—Stump of a pepper tree which was almost entirely destroyed by timber-rot. Only a thin shell of functioning wood (a) remains.

Fig. 6—Section of the trunk near the top of the tree whose stump is illustrated in Fig. 5. The functioning wood (a) is sufficient to support one small branch.

Fig. 7—Three sections of a branch which was primarily infected at the base and rotted upward. Just above (c) the decay is spreading toward the base of a twig.

Fig. 8—Inner side of a piece of bark showing strands of hyphae (rhizomorphs) radiating from the site (a) of a sporophore. The semicircle at the top marks the former location of a rotted branch.

PLATE IV. Development of the sporophore of the timber-rot fungus.

Fig. 9—Two young sporophores growing on the trunk of the pepper tree in cavities left by decayed branches. The cavities were approximately 1 foot apart. Upper sporophore, 35 mm. measured vertically; lower sporophore, 21 mm. wide, 18 mm. vertically. Color, light orange-citrine. Photographed July 25, 1923.

Fig. 10—The same sporophores shown in Fig. 9, but 24 hours older. Upper sporophore

50 mm. vertically. 30 mm. wide; lower sporophore 24 mm. vertically and 29 mm. wide. Pores beginning to appear in the lower parts of the sporophores, but too small to show. Conspicuous holes are the work of beetle larvae.

PLATE V. Development of the sporophore of the timber-rot fungus.

Fig. 11—The sporophores shown in Figs. 9 and 10, photographed August 2. Upper sporophore 100 mm. vertically, 90 mm. wide, 50 mm. thick; lower sporophore 60 mm. vertically, 57 mm. wide. Pore-bearing surface (x) of upper sporophore approximately 75 mm. by 50 mm.; that of lower sporophore 35 mm. by 45 mm.

Fig. 12—Sporophores shown in Figs. 9, 10, 11 which have become mature. Upper sterile parts of both sporophores punctured by beetle larvae. Photographed August 13.

Fig. 13—See text.

PLATE VI. Fig. 14—Pepper tree undoubtedly infected as a result of vicious method of pruning. (a) Young sporophore occupying the site of a rotted branch. (b) Branch illustrating the wrong way to prune. (c) Healed scar of a properly pruned branch. (d) Large cavity left by the decay of a branch pruned like the one shown at "b."

Fig. 15—Ungulate type of sporophore developed from the "button" illustrated in Fig. 14.

PLATE VII. Fig. 16—Camera lucida drawing of pores when they first appear. Groups of smaller pores arranged around a larger central one can usually be distinguished. x 82.

Fig. 17—Hyphae of the timber-rot fungus in a section of infected wood. (a) Medullary ray cells. From the medullary ray on the right to that on the left, the hyphae have penetrated through tracheids and wood cells; just above "b" a cross-wall has probably been destroyed. x 1586.

PLATE VIII. Fig. 18—Hyphae in the lumen of a trachea. x 1260.

Fig. 19—Hyphae in a wood cell and medullary ray cells to show the irregular shape of the fungal filaments. x 2667.

Fig. 20—Part of a hypha which has penetrated a cell wall. The penetrating branch is often much slenderer than the part of the hypha from which it arises. x 2667.

Fig. 21—Part of a hypha lying in a medullary ray cell and a tracheid and showing a cell with two nuclei. x 2667.

Figs. 22 to 29—Stages in the development of the basidium. x 2325.

Fig. 22—Binucleate stage of basidium.

Fig. 23—Fusion of the nuclei.

Fig. 24—Fusion nucleus.

Fig. 25—First division of fusion nucleus completed.

Fig. 26—Second division of fusion nucleus completed and sterigmata forming.

Fig. 27—Sterigmata farther advanced

Fig. 28—Vacuolization at the base of the basidium resulting in the upward movement of the nuclei.

Fig. 29—Nuceli at base of sterigmata.

Fig. 30—Basidiospores formed. x 2325.

Fig. 31—Mature basidiospores. x 2667

Fig. 32—Tooth from hymenial layer x 1570

Fig 33—See text

Fig. 2

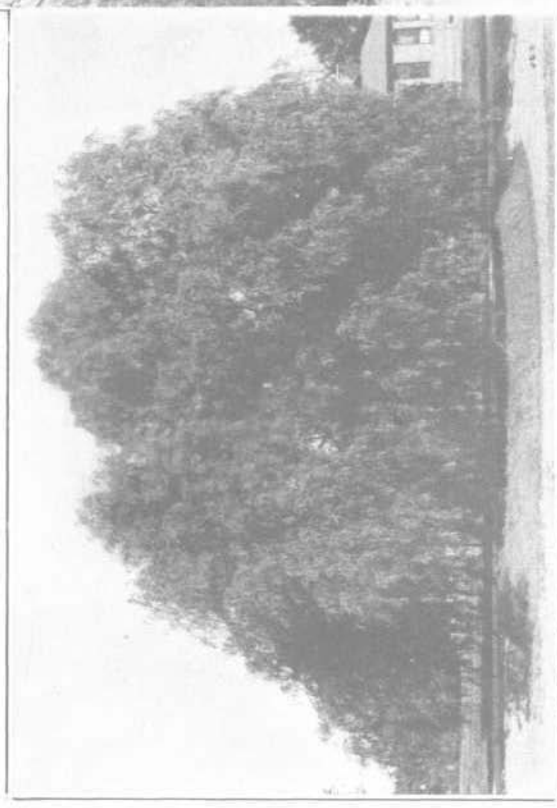


Fig. 1

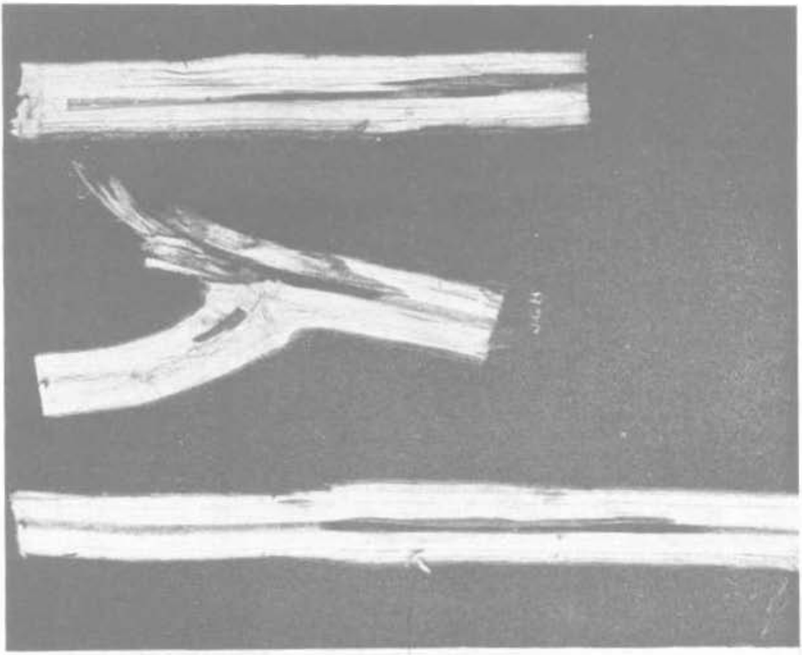


Fig. 4

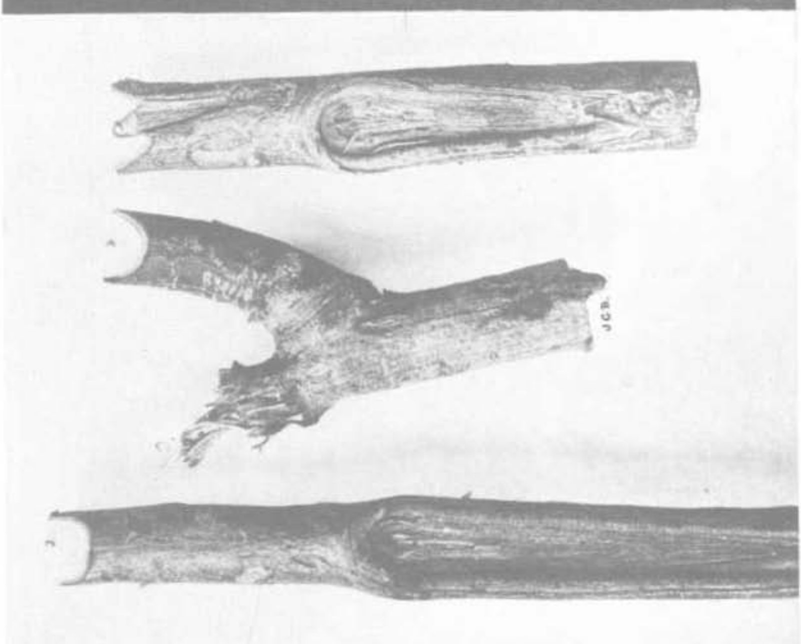
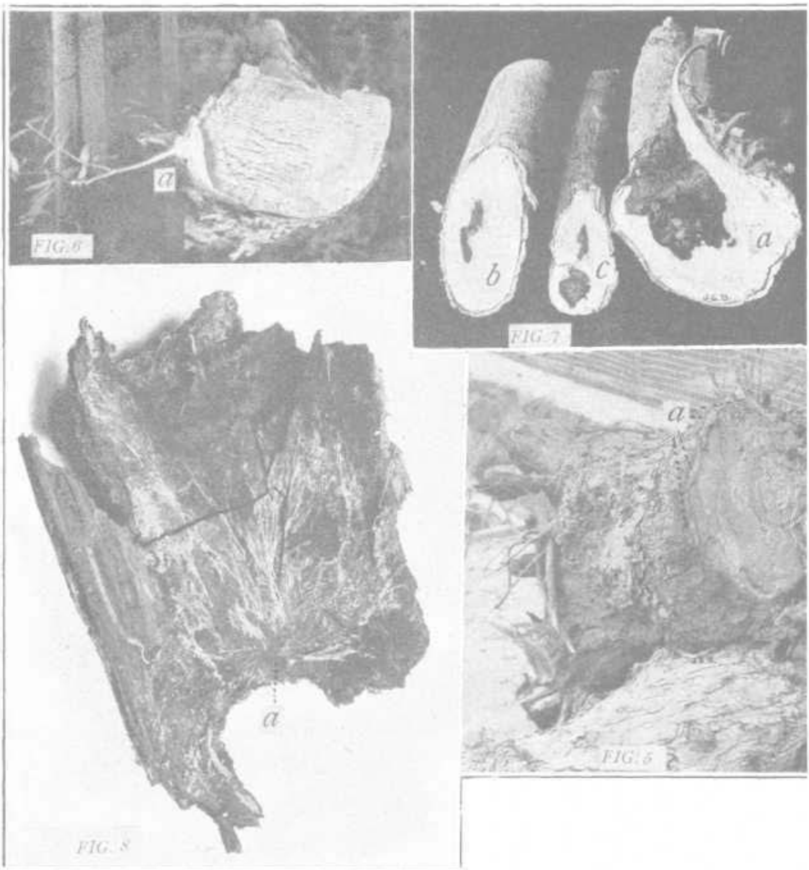


Fig. 3

Plate III



Figs. 5-8

Fig. 10

Fig. 9

Plate V

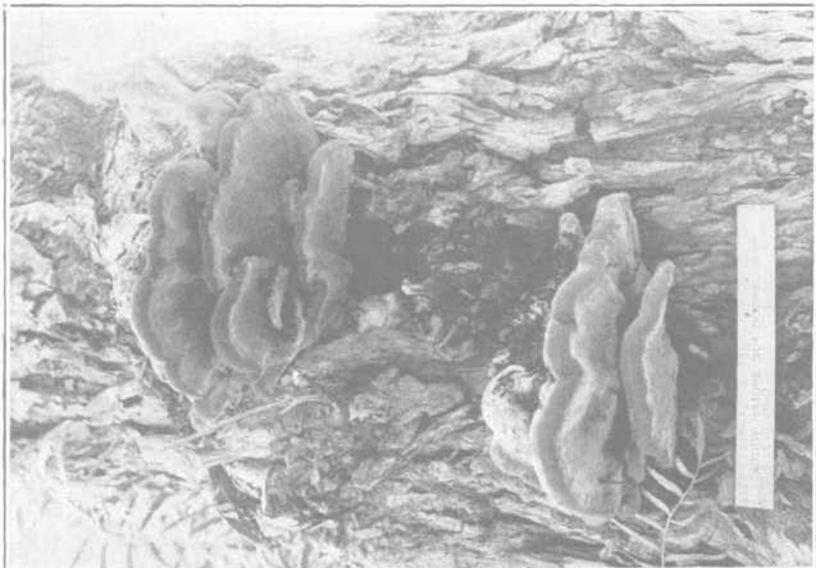


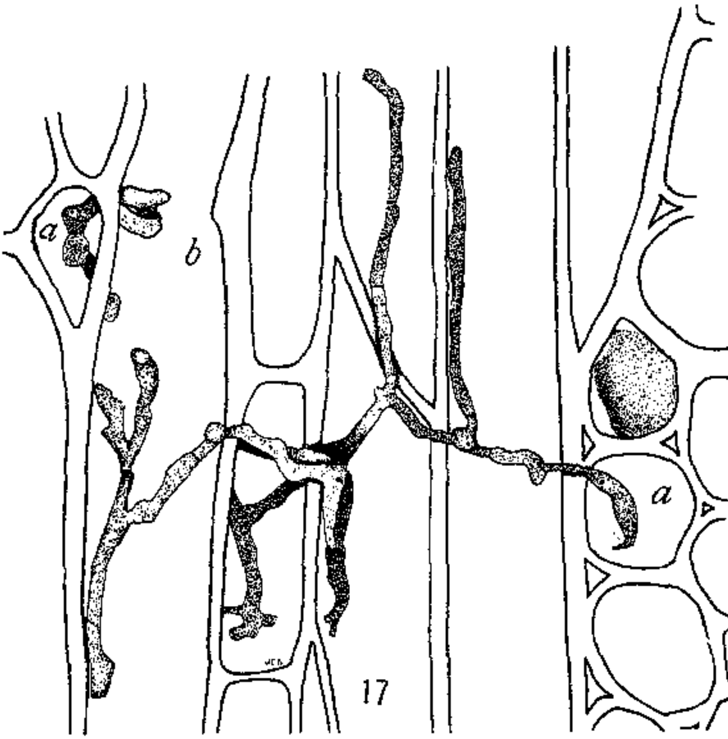
Fig. 12

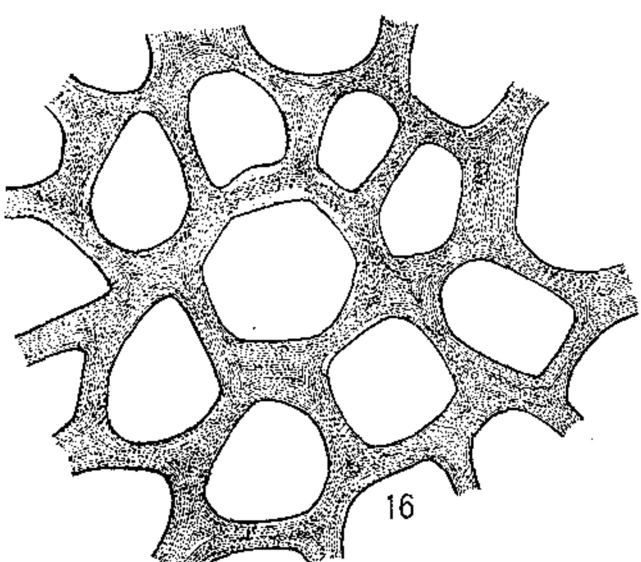
Fig. 11

Plate VI

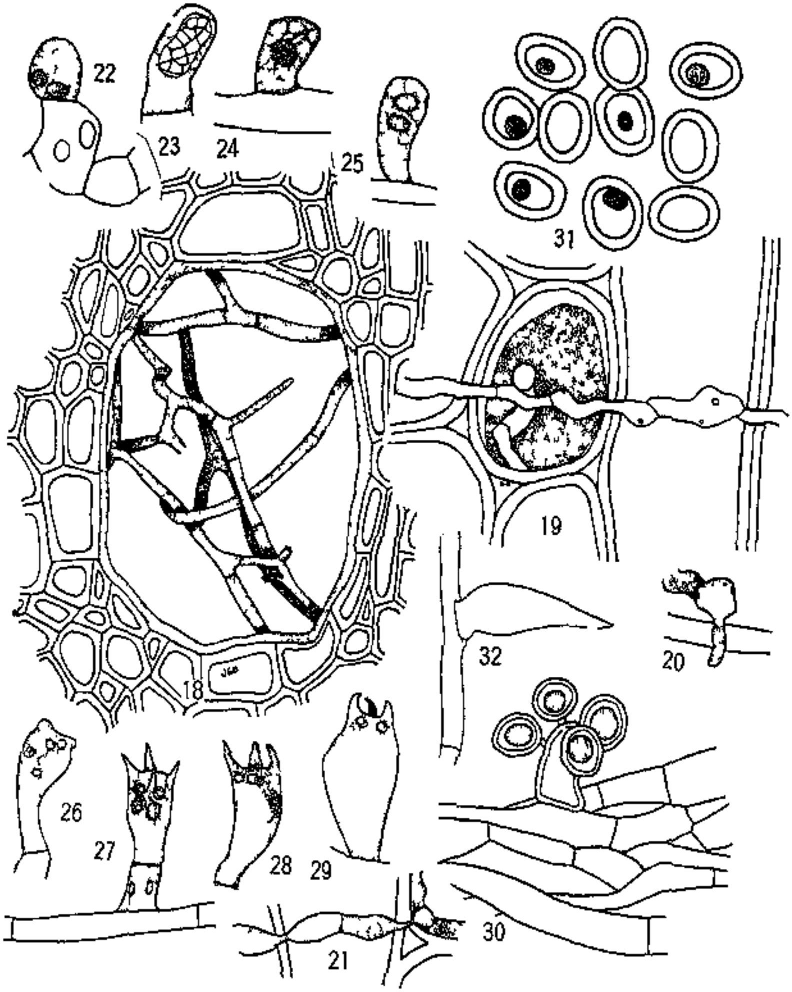
Fig. 15

Fig. 14





Figs. 16, 17



Figs 18-32