A STUDY OF PANSY AND OTHER VIOLA LEAF SPOT DISEASES

by

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A STUDY OF PANSY AND OTHER VIOLA LEAF SPOT DISEASES

INTRODUCTION

History

The earliest known records of leaf spot diseases of pansies and other Violas in Oregon are based on specimens sent to the Oregon State College Experiment Station during the year 1934. Since then many other specimens have been received and both commercial and home growers have asked for aid. The 1934 records contained in the Department of Botany photomicrograph files are herein reviewed because of their historical interest.

A case of leaf spot on pansies from Canby, Ore. contained a fungus which has been identified from photomicrographs as Cercospora violae Sacc. var. minor Rota-Rossi. The following brief description was recorded for this specimen: sporophores arising through the stomata (Plate I, Fig. 1); spots up to two centimeters across, brown on yellowed leaves, not marginate. Spores shown in the illustrations are about 90 x 4.5u, multiseptate, hyaline, cylindrical, and slightly curved (Plate I, Fig. 2).

Another case of Cercospora leaf spot, on violets from Albany, Ore., exhibited a different type of Cercospora spore, which in the photograph appears to belong to Cerco-

spora macrospora Osterw.; for, although certain spores appear rather short for this species, most of them are too broad to belong to any other species of Cercospora described on members of the genus Viola. The general shape of the spores conforms to that of C. macrospora.

A third case in 1934, representing violets from Glenada, Ore., seems to have been caused by a species of Ramularia, possibly Ramularia deflectens Bres. However, the data are insufficient for a positive determination.

In 1937 badly spotted pansy plants were found at Seaside, Oregon, and a specimen from this case was sent to Washington, D. C., where it was tentatively identified as Ramularia agrestis Sacc. Another type of leaf spot became very troublesome the same year at the Oregon State College greenhouses, where it has persisted up to the present time. Mr. John Pryor began investigations of this problem in 1937, but left the College before his work had progressed very far. Within the last two years numerous cases of leaf-spotted pansies have been observed in Oregon and Washington.

Economic Importance

Leaf spot diseases have become so serious on the Oregon coast that outdoor pansy cultures are frequently failures. The severity of the trouble in that region is

attributed to excessive moisture in the form of fog, rain, or dew. However, the drier climate of the Willamette valley does not offer sufficient protection, a fact proved by several recent failures in commercial plantings. Many plants have been ruined before they reached blooming size. The importance of pansy leaf spots from the economic stand-point is considered more fully under the headings of the various diseases.

Purpose and Method of Study

This investigation was begun in 1939 with a threefold object in mind: (1) to determine which fungi are chiefly responsible for the destructive pansy leaf diseases in Oregon, (2) to study carefully the more important pathogens discovered, and (3) to thoroughly examine the available literature on leaf diseases of Violas in order to facilitate future diagnoses.

Specimens of diseased plants have been collected or have been sent from various localities of Oregon and Washington. Diseased leaves have been examined microscopically and hundreds of cultures have been made. The pathogenicity of ten different species of fungi has been tested from pure culture, but only two proved very important. The others are thought to be mostly secondary invaders, although there is inconclusive evidence that some of them

under favorable conditions may become weak parasites. The available literature on Viola leaf diseases has been systematically studied and used in the compilation of tables included in this paper. Descriptions of most of the species of fungi reported on leaves of Violas have been collected and filed, but in order to avoid excessive bulkiness most of these descriptions are omitted and only the references are cited in the check list prepared as Table 4.

IMPORTANT PANSY LEAF SPOT DISEASES IN OREGON

I. CERCOSPORA BLACK-SPOT

Importance

Pansies infected by Cercospora black-spot have been observed at several points in the Willamette valley, but those grown in cold frames at the Oregon State College greenhouses have been most carefully studied. Attempts to produce flowering pansies in these cold frames during the last few years have resulted in 50 to 100 per cent loss of plants by spring. Although plants were not completely killed the leaves in many cases became badly diseased and died before reaching maturity. Such plants were seriously undernourished and seldom produced any blossoms. Transplanting to the cold frames usually has been done in September, when the plants were about six weeks old. It

has been found that those which escape infection until late winter or early spring are not likely to be seriously damaged, although the leaves may show considerable spotting; but the plants which become diseased during early fall prove worthless (Plate II, Fig. 2). Original centers of infection spread rapidly with the onset of cool, damp weather, involving nearly all the plants by spring.

Distribution

Cercospora black-spot is known to occur in both North America and Europe. On the Pacific Coast it has been reported from Alaska (8), and has been observed in the Willamette valley of Oregon from Portland to Corvallis. The probability is that it is much more widespread, but no extensive survey has been made to determine the limits of distribution. It is known to be prevalent in Switzerland, where it was originally described (34), and is almost certainly found in adjacent countries. A Cercospora leaf spot disease, apparently this one, was reported from Denmark (45) in 1929.

Literature

The literature concerning this disease is very limited, but the original paper by Osterwalder (34) is excellent. Other known references are cited in Table 4, but

all good descriptions appear to have been published in German.

Symptoms

The first symptom of this disease is generally the appearance on the leaves, stipules, or bracts, of small brown points, about 0.5 mm. in diameter, surrounded by a narrow translucent band, which by transmitted light appears as a yellowish-green halo. These spots enlarge rapidly and may become a centimeter or more in diameter under conditions optimum for growth of the fungus, but under ordinary circumstances attain a breadth of only a few millimeters. In many cases spots coalesce or infect a large vein and thus destroy considerable portions of the leaf. After the first few days a spot frequently exhibits a purplish border in reflected light, and as it increases in size may show a marked zonation, or "bull's-eye" effect, with considerable clearing of the leaf tissue (Plate II, Fig. 1). It is thought that much of this clearing may be due to the invasion of the dead tissue by secondary organisms. Other species of fungi have been observed to be present in all such cases examined microscopically, as have yeasts and bacteria; but, although certain of these have been isolated they have not been carefully studied. It is notable that certain rapidly growing

Cercospora spots may retain their green color, and that in these spots but few secondary invaders are to be found. Spots of this type with little clearing or zonation are more common under very humid conditions, and may be produced artificially by inoculation with pure culture mycelium on floating leaves. Under extremely humid conditions white aerial mycelium and spores lend a grayish, moldy appearance to the centers of old spots on both sides of the leaves. In a drier environment, however, the centers may become parchment-like and may drop out before any spores are produced. Spotted leaves often die prematurely, so that early infection may result in practically complete defoliation of the plant (Plate II, Fig. 2). Young leaves only one-half inch across may become spotted, but smaller ones are usually entirely free from disease. The stems themselves do not appear to be directly affected.

Etiology

Causal fungus.-- Careful examinations, together with isolations and inoculation experiments, have proved the cause of this disease to be Cercospora macrospora Osterw., an imperfect fungus described by Osterwalder (34), a Swiss phytopathologist, in 1924. No significant variation has been detected between the fungus causing Cercospora spot of pansies here and that described from Switzerland.

C. macrospora differs markedly from all other members of the genus Cercospora known to occur on Viola species (Table 1). No perfect stage has been established for this species.

Morphology.--Hyphae may be present in any or in all cells of diseased tissue, but detailed studies of fresh material and stained paraffin sections indicate they are most numerous in vascular tissue (Plate IV, Fig. 2) and in epidermal cells. Most hyphae are found within the leaf under ordinary conditions, but when subjected to excessive rainfall, extended foggy periods, or a nearly saturated atmosphere they may break through the leaf epidermis and form a cobwebby covering over the dead leaf tissue in the center of the spot. Erect filaments as much as 2 mm. long have been produced in moist chambers. Hyphae within the leaf tissue soon become more or less darkened, but aerial ones appear to remain hyaline. Those in the epidermis grow predominantly parallel to the leaf surface, but regardless of their positions all are septate, moderately branched, and may vary in width from 3-10u or more.

The disruption of the vascular system in the leaf by fungous invasion is an interesting phenomenon of this disease. Extensive invasion of the scalariform vessels in the veins of the leaf (Plate IV, Fig. 2) results in

serious disruption of the water supply to those portions served by the injured veins. In some cases thick-walled, bead-like cells, known as gemmae, appear to be forming within the vessels. It is thought that C. macrospora lives through unfavorable periods mainly in the form of gemmae.

Conidiophores are 5-50 x 4-8u, continuous or septate, straight or geniculately bent (Plate III, Fig. 2), hyaline to pale brown, and usually simple. They arise in a very irregular manner through the epidermal cells or through the stomata in the half-rotted portion of the leaf spot; and, although pairs or groups of three together are not uncommon, large numbers of conidiophores from tuberculate stromata are rarely seen. A few conidiophores have been found attached to specialized ampulliform cells within the leaf epidermis (Plate III, Fig. 2). Young conidiophores bear a single apical conidium, but older ones occasionally may have several attached. A long conidiophore often bears alternately or spirally arranged scars from conidia which were formed near the apex and pushed to one side as the conidiophore elongated.

Conidia are produced mostly on conidiophores arising from internal mycelium, but may be formed occasionally on aerial hyphae. Young spores originate as small clavate, rarely fusiform, buds at the tips of conidiophores.

Mature spores (Plate III, Fig. 1) are 6-16 septate, range from 80 to 350u long and from 6 to 11.5u wide, are consistently aciculate obclavate, either nearly straight or decidedly curved, and remain almost hyaline until they germinate or become very old. Although young spores appear only slightly granular older ones become filled with irregularly distributed guttulae of various sizes. Very old or germinated spores which have turned dark brown or even black are sometimes found, but are exceptional on leaf spot tissues. The long, slender, septate, terminal portion comprises from one-third to one-half the entire spore length. Under favorable conditions each conidium may form a long, threadlike papilla from one side of its basal cell. It is possible that this papilla, which is often septate and may reach a length of 30-50u, is important in spore detachment, for it invariably grows toward the leaf surface at an angle of about 30° from the extended axis of the spore.

Mature spores will germinate in distilled water on a glass slide in less than twenty-four hours. Germination may take place from one or from several cells, but frequently occurs by transformation of the hairlike portion and papilla into growing hyphae. Rapidly elongating germ tubes soon produce an anastomosed mass of hyphae in which it is hard to distinguish the original spore.

Growth in Culture.--Successful leaf tissue cultures of C. macrospora are easily made on potato-dextrose agar or other agar media. Rapidly growing hyphal tips may be removed easily from these original cultures and transferred to a sterile nutrient medium in order to obtain pure cultures of the fungus. At room temperature on potato-dextrose agar in Petri dishes the mycelium reaches a diameter of 70 mm. in ten days (Plate V, Fig. 2). Growth continues at about the same rate until the medium is entirely covered. On potato-dextrose agar hyphae in contact with the substratum turn black within a few days and become bulb-shaped or bead-like gemmae (Plate IV, Fig. 1), while aerial hyphae remain hyaline, and appear white. On Cook's agar the rate of growth is approximately the same, but a thick, white or cream-colored mat of aerial mycelium is formed, giving the fungus a very different appearance. About ten days are required for hyphae submerged in Cook's agar to begin gemma formation, so that even the lower side of the culture retains its light color for several days before changing very gradually to various shades of tan, brown, and finally to black.

No cultures of C. macrospora have been observed to produce spores under average conditions. Adequate sporulation in cultures for purposes of identification and inoculation was obtained by adding 5 cc. of sterilized,

distilled, water to each Petri dish culture at least twelve days old. Cultures treated in this manner and kept at outdoor temperatures fluctuating between 0° and 20° C. produced thousands of spores near the outer margins in three or four days. Spores obtained by this technique appear to be exactly like those found on naturally infected leaves.

Inoculation.--Several methods have been used to inoculate pansies. Spore suspensions from pure cultures of C. macrospora were sprayed onto healthy leaves floating on water, and onto healthy, vigorous plants. Bits of mycelium were also placed on floating leaves and on potted plants.

Infection became apparent on all inoculated floating leaves between two and four days after inoculation. However, the results of inoculation of entire plants were determined largely by prevailing external conditions. For example, within a few days symptoms appeared on all inoculated plants kept in a nearly saturated atmosphere, but those left in a dry place immediately after inoculation developed no leaf spots. In fact, plants diseased by artificial inoculation sometimes recovered entirely when kept away from excessive moisture for about two weeks.

Dissemination

Dissemination of C. macrospora spores and gemmae is brought about by splashing water, and probably to some extent by air currents. Heavy showers readily scatter spores from diseased leaves for a distance of several feet. It is apparent that Osterwalder's statement (34) that initial infection may be started by gemmae from rotted pansy tissue is a valid one for bits of debris in the soil are splattered by raindrops against the lower surfaces of leaves and are not easily removed by wind or rain. Living gemmae or spores which happen to be in this debris find excellent conditions for germination and growth. This method of infection and spread has been observed at the Oregon State College greenhouse cold frames where the top-soil is replaced with fresh dirt before pansies are transplanted from the seed beds. In these cold frames centers of infection may be noted soon after the cool fall rains begin, and in most cases originate near the edge of the frame. It is probable, therefore, that inoculum is splashed to the young plants from the unsterilized frames or from the soil surrounding them.

Control

There is no cure known for Cercospora black-spot after it becomes well established. Therefore it is sug-

gested that control efforts be directed mainly toward prevention of the disease by following certain precautions. (1) Change the site of the pansy beds each year; or, if that is not feasible, carefully replace the top soil with uncontaminated dirt and sterilize the surrounding area for a distance of several feet. Osterwalder (34) recommends the application of powdered calcium hydrate two weeks before sowing. (2) Since a lapse of several days occurs between infection and spore production it is possible to check or halt the spread of the disease by carefully removing and destroying all spotted leaves or by roguing out and destroying the affected plants before the fungus has time to sporulate. (3) Never overcrowd the plants. Crowding provides ideal conditions for the spread of this fungous disease. (4) Avoid watering plants near nightfall or confining them closely under glass while they are wet. (5) Be careful not to introduce disease by placing slightly spotted plants near healthy ones.

II. PHOMA LEAF SPOT AND STEM CANKER

Importance

Usually this disease starts rather slowly, but when favorable conditions occur it kills entire plants or stunts them so badly they are worthless. During late winter or spring large plants of blooming size may be

TABLE 1. *Cercospora* Species Reported on Violas[1]

Species	Year Described	Locality	Conidiophores[2]	Conidia[2]
*violae Sacc.	1876	N. Italy	30-35 x 4, simple, fuscous.	150-200 x 3.5, multiseptate, hyaline, wand-shaped.
violae-silvaticae Oud.	1890	Holland	Erect, cylindrical, short, few-septate.	45-70 x 4-5, 3-7 septate, hyaline, cylindrical, crooked, blunt at tip.
*violae-tricoloris B. & Cav.	1892	Italy	60-100 long, cylindrical, crooked, septate, olivaceous, arising from subepidermal stroma.	100-200 x 3-4, multiseptate, club-shaped, light-yellowish.
violae Sacc. var. minor Rota-Rossi	1907	N. Italy		50-90 x 4-5.
murina Ell. & K.	1884	Kansas	75-100 x 3-4, brown, septate, branched	25-35 x 4-5, 3-septate, brownish, oblong-cylindric.
granuliformis E. & H.	1885	Iowa	15-25 x 3, brown to black, continuous, almost straight, tufted.	17-85 x 2.5-3, 1-3-septate, brownish, straight, cylindrical.

TABLE 1. *Cercospora* Species Reported on Violas (Cont.)

Species	Year Described	Locality	Conidiophores	Conidia
ii Trail	1889	Scotland	30-40 x 4-5, erect continuous.	20-60 x 5-7, 3-6-septate, straight or curved, cylindrical, drawn out.
lilacina Bres.	1892	Saxony	Very long, 4-6 wide, creeping, branched, septate, cespitose.	50-75 x 5-6.5, 1-8-septate, yellowish-hyaline, cylindrical, curved, both ends tapering.
macrospora Osterw.	1924	Switz.	40-93 x 4.6, hyaline, cylindrical, not tufted, continuous or septate.	82-356 x 10-11.6, 6-14-septate, hyaline, old spores blackish, tapered.

* Indicates species on pansies.
1 Material in this table has been compiled from original descriptions or from accurate copies of them when possible. References are cited in Table 4.
2 Measurements are in microns.

TABLE 2. *Phoma* Species Reported on Violas[1]

Species	Year Described	Locality	Pycnidia[2]	Conidia[2]
violae West.	1867	Belgium	globose, aggregated; ostiole papillate, shining, deciduous.	Very thin ovoid, biguttulate, hyaline.
**violae-tricoloris* Died.	1904	Germany	Gregarious, lenticular to globose, brownish, prominent black ostiole erumpent, 60-105 diam.	10 x 2.5, biguttulate, hyaline, cylindrical, both ends rounded.
**violicola* Sydow	1899	Germany	150-210 diam., minute, scattered, subglobose, black, protruding through epidermal covering.	10-14 x 2-3, oblong, continuous, hyaline, both ends rounded.
Kuhniana Oertel	1907	Germany	Scattered, globose, parenchymatous, no ostiole, leathery, dark brown, 300-500 diam.	5-7 x 1-1.5, cylindrical, obtuse, hyaline, non-guttulate.

* Indicates species on pansies.
1 Material in this table has been compiled from the original descriptions or from accurate copies of them when possible. References are cited in Table 4.
2 Measurements are in microns.

attacked and killed within a few weeks. The leaf spot itself is not often serious, but the cankers quickly rot the stems when warm, moist weather prevails for a week or more.

Distribution

Phoma leaf spot and stem canker has been observed only on pansies near Corvallis, but it is known to have been brought here on living plants about four years ago. Very little is known concerning the distribution of this trouble, except that it has been present in Germany for many years and probably occurs in Massachusetts (54).

Literature

Literature concerning this disease is confined to a description of the causal fungus by Sydow (51) and to copies of this description by other authors. A pansy leaf spot and branch canker associated with a species of Phoma was reported by Boyd (54) in 1937 from Massachusetts, but no detailed description was given. It seems probable that very little has been written about this disease.

Symptoms

All green portions of the plant are susceptible to attack, but the first symptoms develop as small spots,

usually less than 5 mm. in diameter, on the leaf blades. Each spot has a dark center surrounded by a narrow purple ring which in transmitted light appears as a pale-green halo. As a spot enlarges the dead, brittle tissue often becomes zonate, light brown or gray-colored, and dotted on the upper or on both sides with minute black pycnidia (Plate VI, Fig. 2). However, the presence of tiny black specks in a gray leaf spot is not proof that the spot is caused by Phoma, for there are many saprophytic and parasitic species of the genus Phyllosticta which also form pycnidia on pansy leaves. This Phoma species, however, does not confine itself to leaves. It attacks all leaf veins which it encounters and follows them down the petiole to the branch or stem (Plate VI, Fig. 1). Numerous pycnidia are produced on stem cankers as soon as the outer tissues of the stem are dead. Infected stems turn dark or purple, but are not always killed outright. If a stem becomes diseased in the fall it may live throughout the winter. Such stems almost invariably are stunted and become partially defoliated. Infected plants often may be distinguished at considerable distance by their yellowed, sickly appearance.

Etiology

Causal Fungus.--The cause of this leaf spot and stem

has been determined by isolation and inoculation to be Phoma violicola Sydow (51). The description written by Sydow in 1899 is very brief, but agrees closely with the characteristics given below. The fact that P. violicola originally was described on Viola altaica instead of on V. tricolor is probably not significant, for many fungi, including species of Phyllosticta and Phoma, are not specific for a single species of Viola (Table 4). The main characteristics of Phoma species known to occur on species of Viola are given in Table 2.

Morphology.--Hyphae are dark or hyaline, 2.5-4.5u in diameter, septate, considerably branched, and are found mostly within the host tissue.

Scattered pycnidia 100-220u in diameter may form in the stem cankers and on both surfaces of diseased leaf tissue, but are less numerous on the under surfaces of the leaf spots than in other positions. Most pycnidia are at first globose, but as they mature they become slightly flattened or flask-shaped. Each one develops a prominent, black, papillate ostiole which breaks through the epidermis (Plate VII, Fig. 1). The black pycnidial wall is composed of small, closely fitted, parenchymatous cells, usually two layers thick.

Hyaline, oblong, straight or slightly curved, mostly 2-guttulate spores (Plate VII, Fig. 2) are formed in great

abundance within the pycnidia. Upon contact with water the contents of a mature pycnidium ooze through the ostiole in a long gelatinous cirrus. This process sometimes continues for a period of more than five minutes.

Growth in Culture.--Phoma violicola grows much more slowly than Cercospora macrospora in culture (Plate V, Fig. 1). Hyphal tips of P. violicola grown in pure culture on potato-dextrose agar in Petri dishes produce colonies which average 15 mm. across and 3 mm. thick in 10 days, and which attain a breadth of 30 mm. in 18 days. Except for small amounts of the uppermost aerial hyphae and the growing tips the entire mycelium is black. Most of the numerous branches are both septate and slightly constricted near their junctions with parent hyphae. The formation of pycnidia usually occurs at the surface of the medium under the thick mycelium, but occasionally may take place considerably beneath the surface of the agar. Small black rhizomorphs and gray sclerotial protuberances have been observed in old cultures, but no perfect stage has been discovered.

Inoculation.--Spore suspension sprayed on pansy leaves floating on water produced visible infection in four days. A few pycnidia were produced within ten days after inoculation by this method. Spore suspension

sprayed on entire plants also produced the disease when the plants were kept in a moist chamber for several days. P. violicola has been reisolated from spots formed on inoculated plants.

Dissemination

Rain appears to be the dominant factor involved in the spread of this disease, but the nature of the fungus suggests that air currents and cultural methods should not be overlooked as probable agents of dissemination. It was found that spores in pycnidia on the dried stem of a plant which had been dead for nine months were extruded normally when placed in water. Most of these spores germinated in water on a slide in less than twenty-four hours (Plate VII, Fig. 3). It is obvious, therefore, that the slightest amount of diseased material left near a planting of pansies might become the source of disease as soon as the pycnidia had absorbed sufficient moisture to permit spore expulsion.

Control

Because this disease affects the branches and stems in addition to the leaves it usually is advisable to destroy completely all infected plants; however, the removal of diseased leaves may be effective if done before

the fungus reaches the stem or sporulates. It has been proved that spores may live in dead pansy stems for many months. Therefore whenever the disease occurs all pansy debris must be destroyed and the plot moved to a different location the following season. No chemical control has been tested.

III. RAMULARIA BROWN-SPOT

Importance

Ramularia brown-spot is a very serious pansy disease along the moist, temperate Oregon coastline, where infected plants generally suffer almost complete defoliation. Home growers near the beaches report that they are unable to rear any healthy pansies, and that the few plants which succeed in blooming are badly spotted and unattractive.

Distribution

Ramularia brown-spot has been found in great abundance on pansies along the northern half of the Oregon coast, and was collected by Dr. F. P. McWhorter at Roy, Wash. in April, 1940. It probably occurs in the Willamette valley, but no serious cases have been reported from that area. This leaf spot has been reported from many European countries (38, 8:469). Flachs (20) states that

the disease occurs on both Viola altaica and V. tricolor in Germany.

Literature

The first description of the fungus causing this disease was written by Saccardo in 1882. The original material was found on pansies (Viola tricolor var. arvensis) in northern Italy. Since 1882 additional information concerning Ramularia agrestis has appeared in mycological literature, but no record of any detailed study was found. A few references are cited in Table 4.

Symptoms

Ramularia brown-spot first develops in the form of circular to elliptical spots visible on both sides of the leaves. Usually these spots, 1-5 mm. in diameter, have dark centers surrounded by a gray-colored ring of dead, brittle tissue. Outside this ring there is a brown or purple-colored band which appears watersoaked when viewed by transmitted light. The centers of leaf-spots, especially the lower surfaces, usually are covered by conidiophores and spores which produce a white, powdery effect. Habits of diseased material may be seen in Plate VIII, Figs. 1 and 2. Plants growing for several months under excessively moist conditions become almost completely de-

foliated and retain only rosettes of small leaves at the tips of abnormally long stems or branches. Such plants seldom bloom. Any green part of the plant may be attacked, but the stems are seldom seriously injured.

Symptoms vary on different leaves, probably due to environmental and host factors. The subject of variation is discussed more fully on page 26.

Etiology

Causal fungus.--The correct species name of the parasite causing this disease was difficult to determine because of the great variability among conidiophores from different plants or from different leaves of the same plant. After this variation had been carefully studied it was decided that the fungus constantly associated with this leaf spot is Ramularia agrestis Sacc. However, more than 100 attempts to grow R. agrestis in culture were failures. Both leaf tissue and spore dilutions were tried on potato-dextrose agar, Cook's agar, and corn meal agar. It is probable, though, that other methods may prove more satisfactory. Regardless of the lack of experimental proof, there appears little doubt that R. agrestis is responsible for the disease; for, under microscopical examination, it is the only organism always seen in this type of leaf spot. It is also noteworthy that the coastal

climatic zone where R. agrestis attacks pansies corresponds to that where R. vallisumbrosae Cav. has been many times the limiting factor for successful culture of Narcissus.

Variation.--Much variation occurs in the structure of the conidiophores and in the general appearance of the leaf spots. Such variations when associated with certain species of fungi are considered of no importance; however, in this case they appear more significant because R. agrestis conidiophores were described by Saccardo (39, 4: 202) as continuous. The Oregon specimens had some groups of conidiophores with no septa above the stromata, and others which were definitely septate. However, very few septa have been distinguished except in material treated by the paraffin method. Since the material examined by Saccardo probably had not been treated in this manner there is little reason to believe that the conidiophores were much different from those examined here.

Conidiophores were described in the literature as unbranched. This condition prevailed in most water mounts, but in old spots on dead or dying leaves from very damp situations long, branched conidiophores were sometimes observed. It is well known, also, that the moisture conditions which obtain during a sporulation period may

affect materially the length and formation of both conidiophores and conidia.

Conidiophores of R. agrestis, according to Saccardo, are 50u long by 3u wide. Since it is hard to believe that no variation in size exists, it is probable that these figures represent average dimensions of whatever material was examined. German authors (21) (38, 8:469) describe conidiophores as being 35-60 x 3-4.5u. These last dimensions agree very favorably with those on most of the material studied here.

Mounts of Oregon specimens taken from leaves grown in shaded situations usually contained the longest conidiophores. On the other hand, mounts prepared from diseased plants which had been kept indoors for ten days after the formation of the spots either had no conidiophores or contained short ones averaging less than 40u. Conidiophores examined were 15-150 x 3-4.5u, mostly 15-90 x 3-4.5u.

Spore sizes are 15-48 x 5-11u, mostly 17-35 x 6-7u. Spore sizes given by Saccardo are 25-30 x 4.5-5.5; those by German authors are 15-32 x 4-7u.

Certain Ramularia species on Violas (Table 3) are so similar that they probably should be grouped together as a single species. R. agrestis, however, is a valid name; and has been determined as the proper species name of the material examined, because most of this material differed

only slightly from the descriptions by German writers.

Variation in size and color of leaf spots is a phenomenon not confined to this disease. It has been observed in other leaf spot diseases of pansies and is supposedly related to physiological conditions of the leaf and to temperature and relative humidity of the atmosphere. The fact that some leaf spots are large and pale-green while others are small and brown colored or olivaceous does not indicate different forms of the pathogenic organism, for in many cases the characteristics of the pathogens have been observed to be identical.

Morphology.--Hyphae are 3-5u in diameter, septate, distinctly nucleate, and somewhat branched. They are formed principally within host tissue.

Conidiophores vary from 15-150u (mostly 15-90u) in length, and from 3-4.5u in width. They are somewhat flexuose, nodulose, or denticulate (Plate IX, Figs. 2 and 3), continuous or occasionally septate, and mostly unbranched. Prominent scars of shed conidia remain on conidiophores which elongate after the first conidial formation. Conidiophores are fasciculate, arising from parenchymatous, subepidermal stromata 50-150u across. The average diameter of stromata at the point of emergence from the stomata is approximately 30u.

Conidia are produced singly at the apices of conidiophores (Plate IX, Fig. 4). They are 15-48 x 5-11u (mostly 17-35 x 6-7u), hyaline, septate, and smooth. There is usually only one cross-wall, but in some mature spores there are two or three. Old spores may be slightly constricted at the septa, and may contain several conspicuous oil droplets (Plate IX, Fig. 1) and nuclei. Germination usually occurs at the ends of the spore (Plate IX, Fig. 1).

Dissemination

Slugs, mites, and aphids are common garden pests throughout the mild winters of the coast region and are potential factors in spore dissemination of fungous leaf spots. In the case of R. agrestis germinated spores have been observed adhering to the bodies of mites feeding on pansy leaves. Infection of pansy seed capsules is common, so seed transmission is likely. Winter gales and rains also facilitate the dissemination of Ramularia brown-spot.

Control

No control has been proved for this disease, but sanitation and proper cultural methods undoubtedly would help, especially in isolated plots or gardens. Van Keulen (56) recommends setting out plants about May 1 in Holland, where the climate is similar to that of the Oregon coast.

Flachs (21) advises the use of a copper-containing fungicide.

KEY TO IMPORTANT LEAF SPOT DISEASES OF PANSIES IN OREGON

Disease symptoms not confined to leaves and leaflike parts. Minute pycnidia produced in lesions. . . . . *Phoma* leaf spot and stem canker.

Disease symptoms mostly confined to spots on leaves or leaflike structures. No pycnidia produced in lesions. .

Spots often developing "bull's-eye" effect (Plate II, Fig. 1). Sometimes appearing moldy, but never with white powdery centers. . . . *Cercospora* black-spot.

Spots usually small and without "bull's-eyes"; usually developing small, white, powdery areas in centers, especially on the lower surfaces. . . . . *Ramularia* brown-spot.

SUMMARY

(1) Three important fungous leaf spot diseases of pansies in western Oregon have been shown to be caused by *Cercospora macrospora*, *Phoma violicola*, and *Ramularia agrestis*.

(2) *Cercospora macrospora* causes much spotting and decay of leaf tissues and has become the limiting factor in the production of pansies at the Oregon State College greenhouses. Moist weather facilitates the spread of this disease and increases its severity. Control involves both sanitary precautions and cultural practices.

(3) Phoma violicola produces leaf spots and stem cankers which usually kill the plants or stunt them badly. This fungus survives in pycnidia on old stem cankers, and should therefore be controlled by sanitary measures and crop rotation.

(4) Ramularia agrestis causes spotting and almost complete defoliation of pansies. Plants growing within a few miles of the sea are most seriously affected, probably due to the high humidity. No control for this disease has been proved.

(5) Methods for distinguishing these various diseases have been devised and the characteristics of the causal organisms described and illustrated.

(6) The distribution of other Viola pathogens has been tabulated for American and foreign habitats.

TABLE 3. *Ramularia* Species Reported on Violas[1]

Species	Year Described	Locality	Conidiophores[2]	Conidia[2]
*lactea (Desm.) Sacc.	(1849) 1881	France	30-60 x 2-4, fasciculate from the stomata, somewhat crooked, hyaline, amphigenous.	7-20 x 2-3, usually one- (rarely two-) celled, sometimes catenate; fusiform or cylindrical, hyaline; ends blunt.
*lactea (Desm.) Sacc. var. violae-tricoloris Thum.	1875	Bohemia	Similar to lactea.	Shorter than lactea, septate.
violae Trail	1889	Scotland	20-25 x 3-4, 1-septate, chiefly hypophyllous, erect, subclavate.	10-16 x 2-3, continuous, finally 1-septate, fusiform to cylindrical, ends rounded, hyaline, straight, catenate.
*agrestis Sacc.	1882	N. Italy	50 x 3, fasciculate, tufts gregarious, chiefly hypophyllous, continuous, simple, hyaline.	25-30 x 4.5-5.5, 1- (rarely 3-) septate, both ends rounded, cylindrical, hyaline.
*deflectens Bres.	1896	Saxony	100-200 x 4, densely tufted, hypophyllous, branched, septate, hyaline.	18-40 x 5-7, 1-4-septate, cylindrical, clavate, somewhat crooked.

TABLE 3. *Ramularia* Species Reported on Violas (Cont.)

Species	Year Described	Locality	Conidiophores[2]	Conidia[2]
biflorae P. Magn.	1905	Austria	20-25 (rarely 40) x 4, hyaline, fasciculate from the stomata, continuous, erect or spreading, simple, tufts very small and scattered, hypophyllous.	23-30 x 3.5-4, continuous or two-celled, acute to obtuse, hyaline, spindle-shaped.
ionophila J. J. Davis	1915	Wisconsin	25-55 x 3-4, hyaline, straight or bent, continuous, fasciculate from stromatic base, hypophyllous.	18-45 x 3-4, 1-3-septate, hyaline, cylindrical, straight.
acutata Bon.		Europe		

* Indicates species on pansies.
1 Material in this table has been compiled from the original descriptions or from accurate copies of them when possible. References are cited in Table 4.
2 Measurements are in microns.

TABLE 4. Check List of Fungi Reported as Causes of *Viola* Leaf Diseases

Fungus	Year[1]	Distribution	Hosts[2]	Literature[2]
Aecidium (see *Puccinia* and *Uromyces*).				
Aecidium banaticum Bubak	1936	Jugoslavia	83	(24)
" *Petersii* B. & C.		N.A.	19,52	(39, 14:372)(39, 7:780)(43)
Allodus (see *Puccinia*).				
Alternaria violae G. & D.	1900	Conn., N.J., N.Y., Pa., Tex., G.Br.	16,17,45,83	(2)(10)(11)(14)(15)(21)(39, 16:1080)(43)(47)(58)
Ascochyta violae Sacc. & Speg.	1879	Pa., G.Br., Italy	2,17,22,45, 59,83	(11)(21)(35)(38, 6:668)(39, 3:397)(43)
" *violae-hirtae* Bubak	1903	Jugoslavia	5,48,89	(35)(39,18:337)
" *violicola* McAlp.	1904	Alaska, Australia	2,45,83	(8)(35)(39, 18:336)
Asterina stictica Berk.		Patagonia	90	(39,9:393)
" *violae* P. Henn.	1902	Japan	76,91	(35)(39,17:876)
Asteroma latebrarum Grogn.	1863	Europe	83,84	(35)(39,3:212)
" *violae* DC.	1815	Europe	7	(35)
Bremiella (see *Peronospora*).				
Caeoma (see *Puccinia* and *Uromyces*).				

TABLE 4. Check List of Fungi Reported as Causes of *Viola* Leaf Diseases (Cont.)

Fungus	Year	Distribution	Hosts	Literature
Cercospora granuliformis E. & Holw.	1885	Ia., N.J., Kans., S.D.	8,17,49,51, 59,70,75,77	(17)(39,4:434) (41)(43)(53)
" *ii* Trail	1889	Scotland	50	(35)(39,10:620) (48)
" *lilacina* Bres.	1892	Germany Holland	50	(5)(35)(38, 9:121)(39,11:625) (48)
" *macrospora* Osterw.	1924	Alaska, Ore., Switz., Den.?	83	(8)(25)(34)(43) (44)(45)
" *murina* Ell. & Kell.	1884	Kansas	17,59	(11)(18)(39, 4:434)(43)
" *violae* Sacc.	1876	General U.S., Austria, Bul., Eng., Germany, Italy, Holland, Switzerland	2,5,8,15,16, 17,45,48,51, 83,86,89	(2)(3)(9)(10) (11)(15)(16)(18) (21)(22)(25)(26) (29)(30)(31)(32) (34)(35)(38, 9:121)(39,4:434) (41)(43)(46)(58)
" *violae* Sacc. var. *minor* Rota-Rossi	1907	Italy		(39,22:1416)
" *violae-silvaticae* Oudem.	1890	Holland	76	(34)(35)(38, 9:122)
" *violae-tricoloris* B. & C.	1892	Italy, Spain	83	(21)(34)(35)(38, 9:122)(39,10: 620)(48)
Cladosporium herbarum Lk.	1816	General		(21)(38,8:800)

TABLE 4. Check List of Fungi Reported as Causes of *Viola* Leaf Diseases (Cont.)

Fungus	Year	Distribution	Hosts	Literature
Colletotrichum violae-rotundifoliae Pk.	1914	Ind., Tex.	17	(1)(43)(58)
" *violae tricoloris* R.E. Sm.	1899	Conn., Del., Mass., N.J., N.Y., Tex.	16,45,83	(2)(10)(15)(16)(21)(26)(35)(39,16:1006)(41)(43)(46)(49)
" *violarum* J.J. Davis		N.A.	22	(43)
Cryptostictis violae Tehon & Daniels	1925	Ill.		(25)(43)(52)
Cylindrosporium violae Sacc.	1897	Italy	12	(35)(39,14:1032)(43)
Dicaeoma (see *Puccinia*).				
Entyloma anzianum Pass.		Italy	7	(35)(39,7:494)(48)
Gloeosporium violae Berk. & Br.	1878	Miss., N.J., G.Br.	2,45	(2)(11)(19)(21)(30)(35)(39,3:701)(43)(46)
" *violicolum* Syd.	1899	Germany	4	(35)(39,16:996)
Hendersonia triseptata Da Ca.	1910	Portugal	2	(35)(39,22:1060)(48)
Illosporium maculicolum Sacc.	1879	Italy	2,45	(21)(35)(38,9:466)(39,4:659)

TABLE 4. Check List of Fungi Reported as Causes of *Viola* Leaf Diseases (Cont.)

Fungus	Year	Distribution	Hosts	Literature
Illosporium vagum Sacc.		Siberia	93	(39,10:711)
Laestadia violae (Lib.) Sacc.	1882	Belgium	2,45	(35)(39,1:431) (48)
Macrosporium commune Rabenh.	1870	Europe	2	(35)(38,9:225) (39,4:524)
" *violae* Poll.	1897	Italy	2,45	(21)(35)(38,9: 246)(39,14:1094) (46)
Marsonia violae (Pass.) Sacc.	1884	New England	7,17,45,75	(21)(35)(38,7: 611)(39,3:770) (43)(46)(47)
Micropuccinia (see *Puccinia*).				
Mycosphaerella violae A. Pot.	1910	Russia	5,89	(35)(39,22:122) (39,24:892)(48)
Myrothecium roridum Tode	1790	General		(37)(38,9:623) (39,4:750)
Nigredo (see *Uromyces*).				
Oidium acutatum Bon.	1861	Germany	45	(39,4:45)
" *erysiphoides* Fr.	1832	General	16	(35)(38,8:79) (39,4:41)
" *violae* Pass.	1878	Italy, Portugal	83	(21)(35)(38, 8:85)(39,4:43)

TABLE 4. Check List of Fungi Reported as Causes of *Viola* Leaf Diseases (Cont.)

Fungus	Year	Distribution	Hosts	Literature
Ovularia acutata Bonord.	1861	Den., Germany, Sweden	2,10,12,45, 83	(21)(35)(38, 8:249)(39,4:142) (48)
Peronospora effusa (Grev.) Rab.	1880	Europe		(46)
" *megasperma* Berl.		U.S	61,84	(11)(35)(39, 14:458)(43)
" *violae* De Bary	1864	Ill., Miss., N.J., G. Br.	2,6,7,16,45, 61,64,83,97	(2)(11)(21)(30) (35)(39,7:251) (43)(46)(48)
Phoma Kuhniana Oertel	1907	Germany	2,45	(35)(37)(39, 22:872)
" *violae* West.	1867	Belgium	12	(35)(38,6:156) (39,3:145)
" *violae-tricoloris* Died.	1904	Germany	83	(13)(35)(39, 18:253)
" *violicola* Syd.	1899	Mass.?, Germ.	4,83	(35)(39,16:857) (51)(54)
Phyllactinia corylea (Pers.) Karst.		N.A.	29	(43)(46)
Phyllosticta libertiae Sacc.	1886	France, Belgium	2,45	(11)(21)(35) (39,10:126)
" *libertiana* Sacc. & March.	1885	Belg., France, G.Br., Italy	2,7,45	(21)(35)(39,10: 127)(48)
" *Rafinesquii* H.W. Anderson		N.A.	61	(43)

TABLE 4. Check List of Fungi Reported as Causes of *Viola* Leaf Diseases (Cont.)

Fungus	Year	Distribution	Hosts	Literature
Phyllosticta tricoloris Sacc.	1879	Russia, Italy	45,83	(35)(38,6:156) (39,3:38)(48)
" *violae* Desm.	1847	General	2,5,7,17,45, 59,61,76,83	(2)(10)(11)(21) (26)(30)(31)(32) (35)(36)(39,3: 38)(41)(42)(43) (46)
" *violae-caninae* Allescher	1901	Belgium		(35)(38,6:156)
Plasmopara (see *Peronospora*)				
Pleospora americana E. & Ev.	1895	N.A.	83	(43)
Puccinia aegra Grove	1883	G.Br.	16	(11)
" *alpina* Fckl.	1873	Finl., Germ., It., Switz.	7,9,11	(11)(35)(43)
" *americana* Langerh.	1895	N.A.	83	(4)(43)
" *canadensis* Arth.	1904	Alta., B.C.	46	(23)(43)
" *cingens* Bom. & Rous.	1900	Chile		(39,16:276)(48)
" *densa* Diet. & Holw.	1897	Wash.	24	(4)(39,14:294) (43)
" *depauperans* (Vize)Syd.		G.Br.	16,35,83,88, 94	(35) (39,7:614) (48)
" *effusa* Diet. & Holw.	1895	Wash., Ore., Cal.	1,32,43,44, 55,60,69	(4)(23)(39,14: 294)(43)
" *ellisiana* Thuem.	1878	U.S. (east of Rocky Mts.), West Indies	8,9,17,21-23, 28,30,34,42, 43,49,51-53, 58,59,65,70, 75,77,83,85	(2)(4)(43)

TABLE 4. Check List of Fungi Reported as Causes of Viola Leaf Diseases (Cont.)

Fungus	Year	Distribution	Hosts	Literature
Puccinia Fergussoni B. & Br.	1875	N.W. Amer., Europe, Japan	8,26,31,37, 42,50,81	(4)(11)(35)(43)
" hastata Cke.	1875	U.S.	26,58	(11)(43)
" hederaceae McAlp.	1906	Austral., Tas.	27,95	(39,21:617)
" Mariae-Wilsoni (Arth. & Fromme) Barthol.		N.A.	51	(43)
" ornatula Holw.	1907	B.C.	2,9,11,24, 67	(4)(23)(39,21: 617)(43)
" Rubelii Volkart	1912		54	(39,23:785)
" violae (Schum.) DC.	1815	General	1,2,5,6,8-20, 22-26,28-33, 37-44,47-54, 56-59,62,64- 80,83,86,87, 89,92	(2)(4)(11)(21) (23)(35)(39, 7:609)(42)(43) (46)
" violae-glabellae Miura	1913	Japan	24	(39,23:785)(48)
" violarum Lk.	1825	N.A.	59	(43)
Ramularia acutata Bon.		Europe	12,64,76,82	(48)
" agrestis Sacc.	1882	Europe, Ore., Wash.	4,83,84	(20)(21)(34)(35) (38,8:469)(39, 4:202)(44)(48) (58)
" biflorae Magn.	1905	Austria	7	(35)(38,8:470) (39,22:1313)(48)
" deflectens Bres.	1896	Den., Eng., Germany, Russia	83,84	(5)(6)(35)(38, 8:469)(39,14: 1059)
" ionophila J.J. Davis	1915	Alaska, Wis.	11,44	(7)(12)(43)

TABLE 4. Check List of Fungi Reported as Causes of *Viola* Leaf Diseases (Cont.)

Fungus	Year	Distribution	Hosts	Literature
Ramularia lactea (Desm.) Sacc.	1849	Colo., Mont., Argentina, Europe	2,5,12,36, 38,45,50,76, 78,82,83,84, 89,96	(8)(11)(20)(21) (34)(35)(36)(38, 8:468)(39,4:201) (44)(46)(48)(56)
" *lactea* (Desm.) Sacc. var. *violae-tricol-oris* Thum.	1875	Bohemia	83	(39,4:202)
" *violae* Trail	1889	Scotland	76	(35)(38,8:470) (39,10:555)
Septoria australiae McAlp.	1903	Australia	95	(39,18:378)(48)
" *cercosperma* Rostr.	1883	N.A.	8,12	(43)
" *hyalina* Ell. &Ev.	1894	Mass., Mich., W.Va.	8,30,50,58	(38,6:876)(39, 11:538)(43)
" *violae* West.		Mass., Wis., Europe	2,7,11,12, 15,17,26,30, 50,54,58,59, 70,74,76,82	(26)(27)(35)(38, 6:876)(39,3:518) (43)
" *violae* West. var. *ogliocarpa* Pk.		N.A.	8	(43)
" *violae* West. var. *rostrata* Van Hook		Indiana	65	(55)
" *violae-palustris* Died.		Austria, Eng.	50	(48)
" *violicola* Sacc.	1884	Germ., G.Br., Switzerland	7	(35)(38,6:876) (39,3:519)(48)
Sphaceloma violae Jenkins	1935	Eastern U.S., S.Afr., N.S.W.	27,45,52,83	(28)

Sphaerella (see *Mycosphaerella*).

TABLE 4. Check List of Fungi Reported as Causes of *Viola* Leaf Diseases (Cont.)

Fungus	Year	Distribution	Hosts	Literature
Sphaerotheca castagnei Lev.	1851	Europe, Asia, N.A.		(39,1:4)
" *humuli* (DC.) Burr.	1887	Wash., Cal.	8,11,12,17, 60,63,83	(35)(43)(46)
" *humuli* var. *fuliginea* (Schl.) Sal.	1900	Minn., Wash.	16,17,83	(2)(43)(46)
Synchytrium alpinum Thomas	1889	It., Switz.	3,7	(35)(39,9:357)(48)
" *aureum* Schrt.	1870	N.A.	5,7,12,15,48, 59,76,83	(35)(43)
" *galii* Rytz.	1907	Switzerland	10	(35)(39,21:841)
" *globosum* Schrt.	1870	N.A.	2,12,64,76, 78	(35)(43)
" *saxifrageae* Rytz.	1906	Switzerland	7	(35)(39,21:842)
Uredo (see *Puccinia*).				
Uredo alpestris Schrt.	1875	Austria, Jap., Switzerland	7	(39,7:840)(48)
Urocystis kmetiana Magn.	1859	Europe, N.A.	61,63	(35)(43)(46)
" *violae* (Sow.) Fisch. Wald.	1877	Can., Den., Eng., Fr., G.Br., It., U.S.	2,5,12,16, 33,45,64,76, 83,	(21)(35)(43) (46)(47)(48)
Uromyces andropogonis Tracy	1893	Eastern U.S.	17,23,30,43, 51-53,58,70, 77,79,83,89	(4)(35)(39,11: 182)(43)

TABLE 4. Check List of Fungi Report as Causes of *Viola* Leaf Diseases (Cont.)

Fungus	Year	Distribution	Hosts	Literature
Uromyces pedatatus Sheldon		N.A.	30,52,58 70,83	(43)
Vermicularia concentrica Pk. & Clinton		N.A.	66	(43)
" *herbarum* West.			2,45	(35)(39,13:1315) (39,3:226)
" *Peckii* Sacc.		N.A.	17,66	(39,3:232)(43)
" *Peckii* var. *violae-rotundifolae* Sacc.	1884	N.A.	66	(39,3:232)(43)
" *violae* Ell. & Ev.		N.A.	17	(43)
" *violae rotundifolae* (Sacc.) House		N.A.	17,22,66	(43)
Volutella violae Stoneman	1898	N.A.	17	(39,16:1096)(43) (50)
Zygodesmus albidus Ell. & Halsted		N.A.	45	(21)(30)(43)(46)

1 Year of original published description, if known.
2 Listed according to numbered hosts on the next page. Blank indicates species indetermined.
3 Not intended as a complete bibliography. Numbers refer to "Literature Cited". Volume and page numbers are given for references 38 and 39.

Viola Species Listed in Table 4 as Hosts

(1) affinis Le Conte
(2) alba Bess.
(3) alpina Jacq.
(4) altaica Pall.
(5) ambigua Koch
(6) arenaria DC.
(7) biflora L.
(8) blanda Willd.
(9) brittoniana Pollard
(10) calcarata L.
(11) canadensis L.
(12) canina L.
(13) cognata Greene
(14) collina Bess.
(15) conspersa Reichenb
(16) cornuta L.
(17) cucullata Ait.
(18) cucullata var. prionosepala (Gr.) Brain.
(19) delphinifolia Nutt.
(20) elatior Tr.
(21) emarginata Le Conte
(22) eriocarpa S.
(23) fimbriatula J.E. Sm.
(24) glabella Nutt.
(25) Grahami Benth.
(26) hastata Michx.
(27) hederacea Labill
(28) hirsutula Brainerd
(29) labradorica Schrank
(30) lanceolata L.
(31) Langsdorfii Fisch.
(32) lobata Benth.
(33) longipes Nutt.
(34) Lunellii Greene
(35) lutea Smith
(36) macedonica ?
(37) Macloskeyi F.E. Lloyd
(38) mirabilis L.
(39) missouriensis Green
(40) monticola Rydb.
(41) nannei Polak
(42) nephrophylla Greene
(43) Nuttallii Pursh
(44) ocellata Torr. & Gr.
(45) odorata L.
(46) orbiculata Geyer
(47) Painteri Rose & House
(48) pallens (Banks) Brain.
(49) palmata L.
(50) palustris L.
(51) papilionacea Pursh
(52) pedata L.
(53) pedatifida G. Don.
(54) pinnata L.
(55) praemorsa Dougl.
(56) pratensis M. & K.
(57) pratincola Greene
(58) primulifolia L.
(59) pubescens Ait.
(60) purpurea Kellogg
(61) Rafinesquii Greene
(62) renifolia Gray
(63) retusa Greene
(64) riviniana Reichenb.
(65) rostrata Pursh
(66) rotundifolia Michx.
(67) rugulosa Greene
(68) ruppii All.
(69) Rydbergii Greene
(70) sagittata Ait.
(71) sciaphila Koch
(72) scopulorum (Gray) Greene
(73) Selkirkii Pursh
(74) sepincola Jord.
(75) septentrionalis Greene
(76) silvatica Tr.
(77) sororia Willd.
(78) stagnina Kit.
(79) striata Ait.
(80) stricta (Hornem.?)
(81) suecica ?
(82) sylvestris Reichenb.
(83) tricolor L.
(84) tricolor v. arvensis Murr.
(85) triloba S.
(86) villosa Walt.
(87) vittata Greene
(88) Willkommii
(89) hirta L.
(90) tridentata Sm.
(91) sylvestris v. grypoceratis
(92) epipsila Ledeb.
(93) uniflora Vand.
(94) imprimis
(95) betonicifolia Sm.
(96) austriaca A. Kern.
(97) tenella Rafin.

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PLATE I

Fig. 1. Cercospora violae var. minor Rota-Rossi. Conidiophores emerged from stoma. x640.

Fib. 2. Cercospora violae var. minor Rota-Rossi. Mature spore. x640.

PLATE I

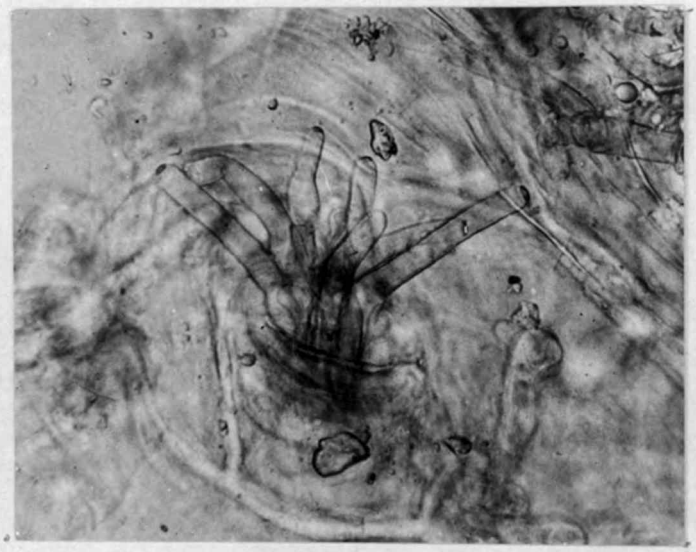

Fig. 1

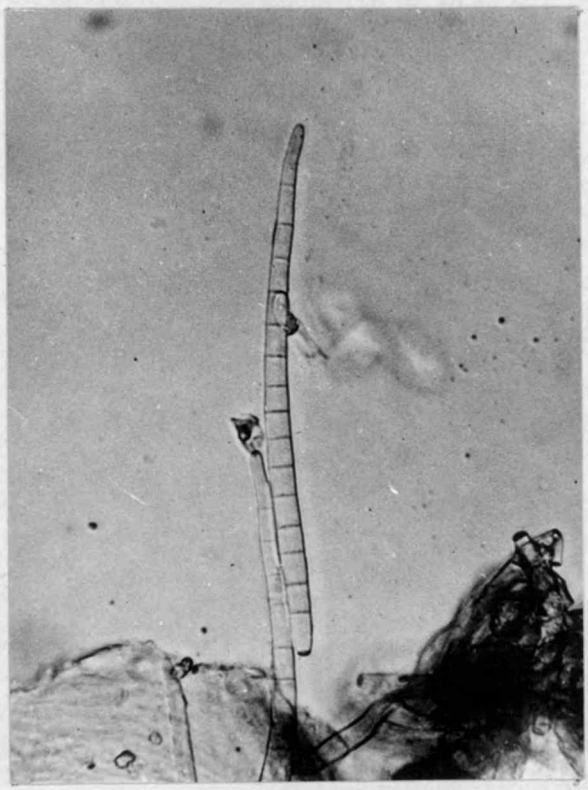

Fig. 2

PLATE II

Fig. 1. Habit of pansy leaves diseased with Cercospora macrospora Osterw.

Fig. 2. Six-months pansies infected with Cercospora macrospora Osterw. All plants grew in the same cold frame under identical conditions, and all are the same age. Plants became infected at different ages.

PLATE II

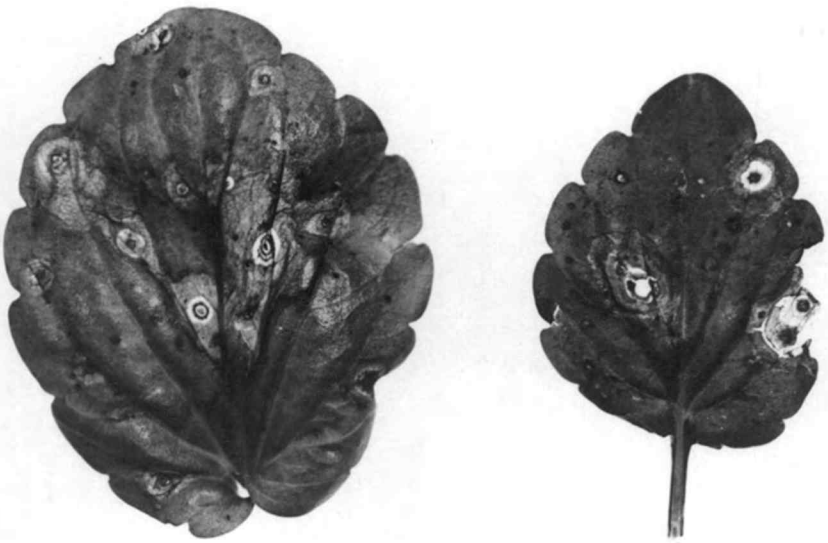

Fig. 1

Fig. 2

PLATE III

Fig. 1. Cercospora macrospora spores. Note hyaline basal appendage. x500.

Fig. 2. Cercospora macrospora. Conidiophores, with attached spores, arising from specialized ampulliform cells. x400.

PLATE III

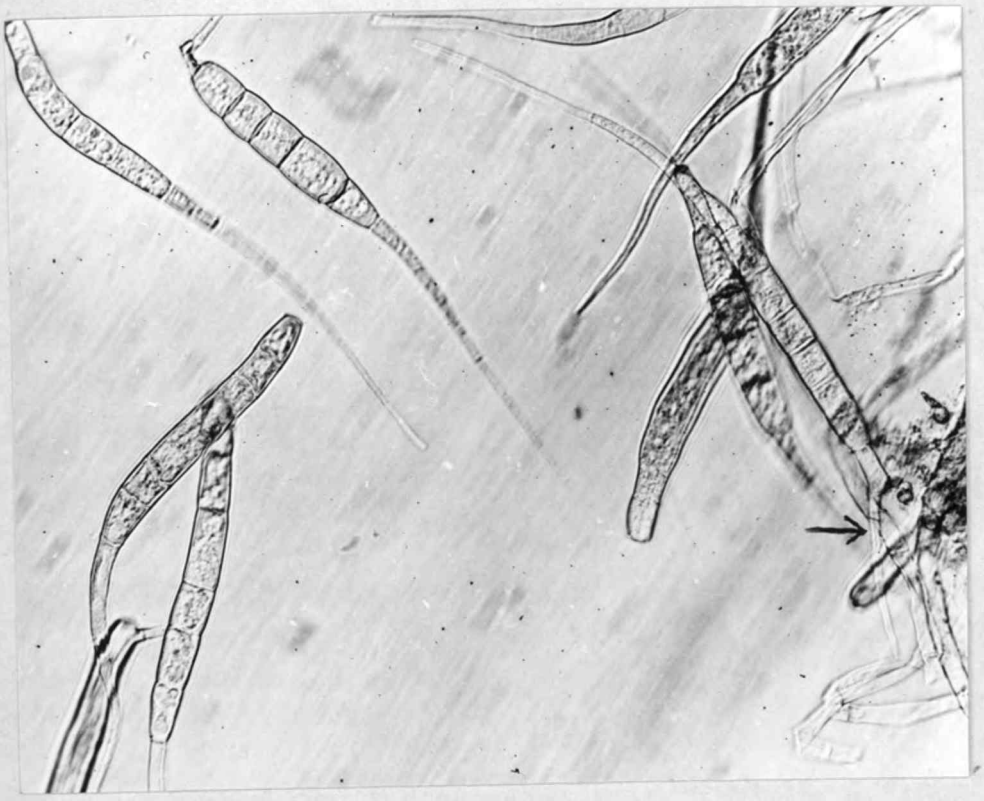

Fig. 1

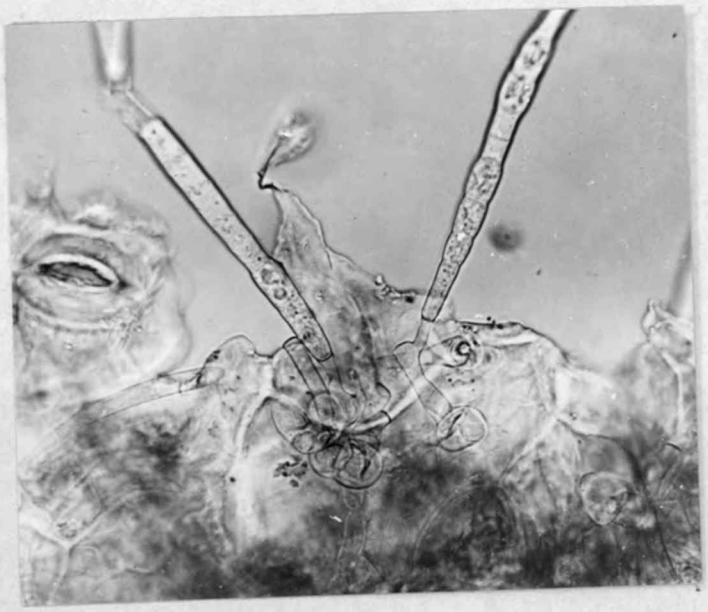

Fig. 2

PLATE IV

Fig. 1. Cercospora macrospora. Gemmae formed in old culture on potato-dextrose agar. x400.

Fig. 2. Cercospora macrospora. Hyphae in scalariform vessel of pansy leaf. x400.

PLATE IV

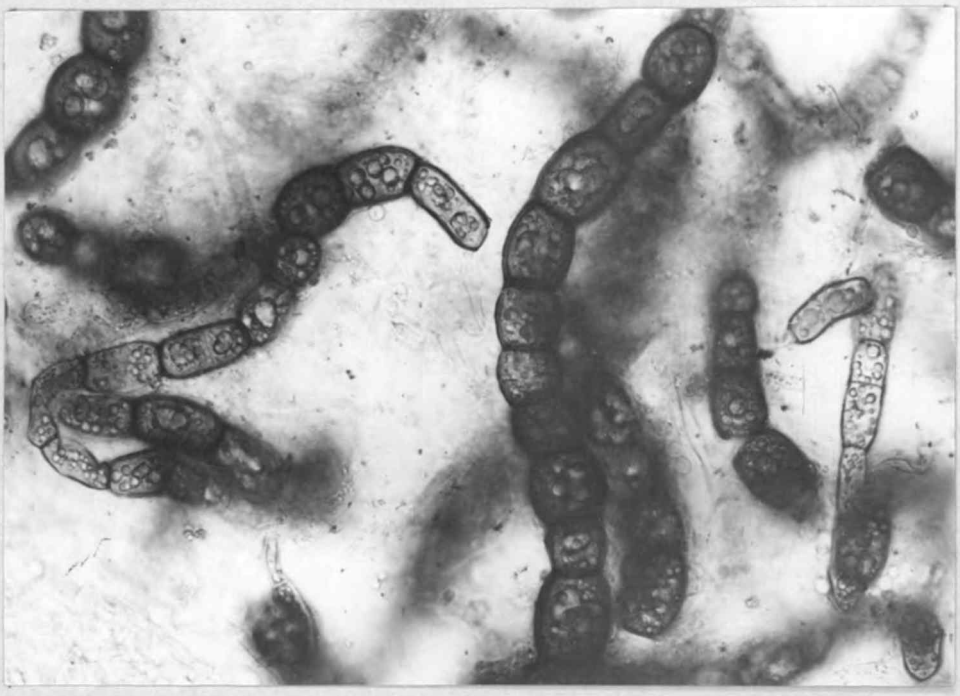

Fig. 1

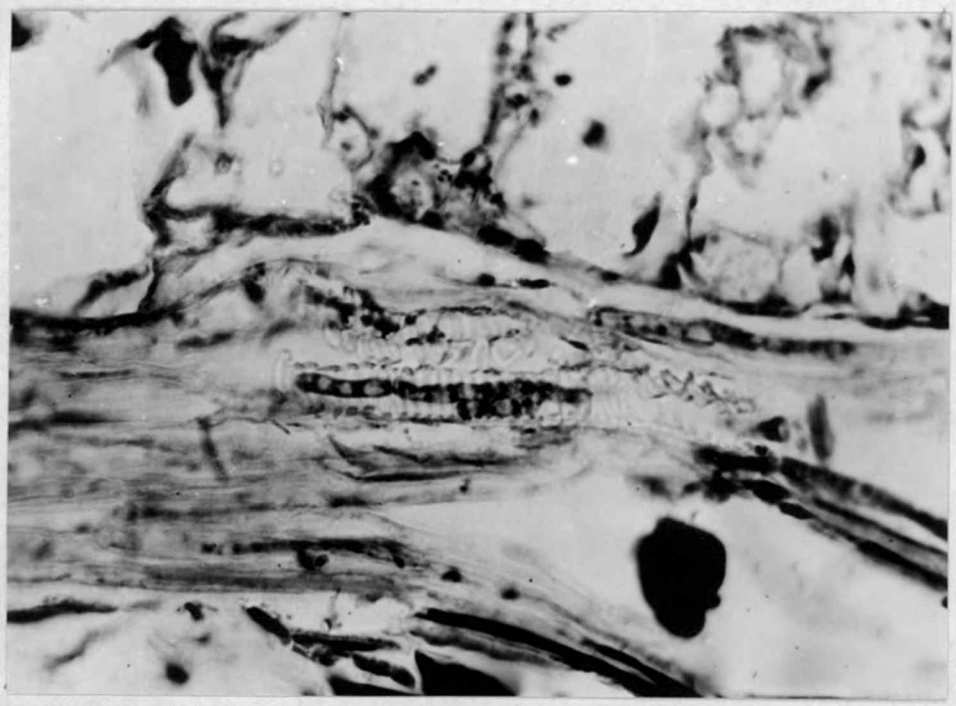

Fig. 2

PLATE V

Comparison of growth of *Phoma violicola* and *Cercospora macrospora* on potato-dextrose agar. Each culture is ten days old. Fig. 1 is *P. violicola*. Fig. 2 is *C. macrospora*.

PLATE V

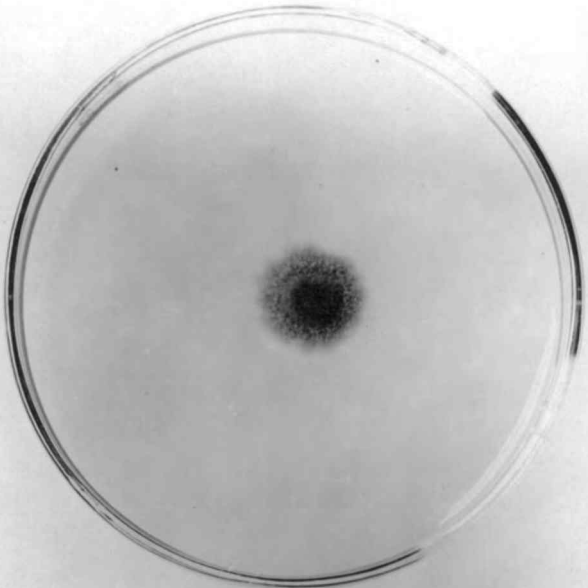

Fig. 1

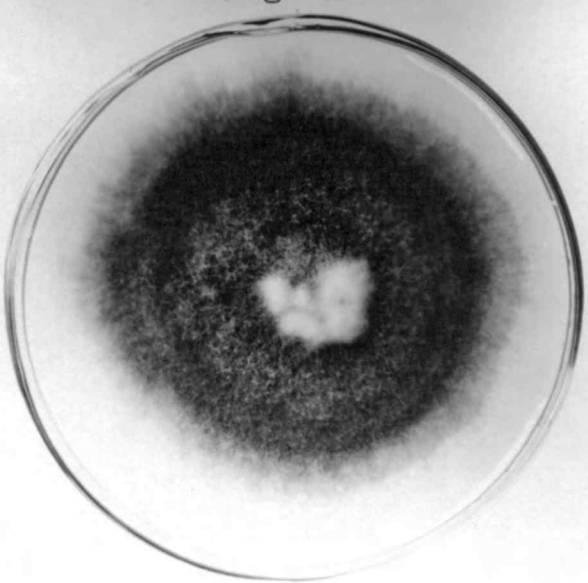

Fig. 2

PLATE VI

Fig. 1. Habit of pansy plant diseased with *Phoma violicola*. Note stem canker. Disease originated in the leaf at upper left.

Fig. 2. Habit of pansy leaves diseased with *Phoma violicola*. Note pycnidia in leaf at upper left.

PLATE VI

Fig. 1

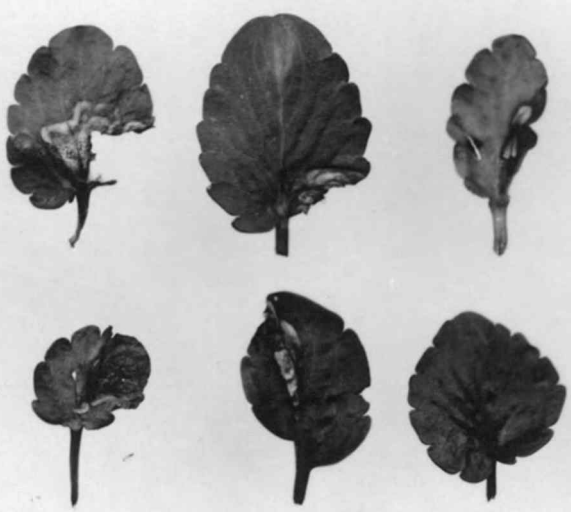

Fig. 2

PLATE VII

Fig. 1. Phoma violicola. Mature pycnidium in pansy stem. x430.

Fig. 2. Phoma violicola. Mature spores. x1300.

Fig. 3. Phoma violicola. Spores from old dead pansy stem. When mounted in water these germinated as shown in this illustration. x500.

PLATE VII

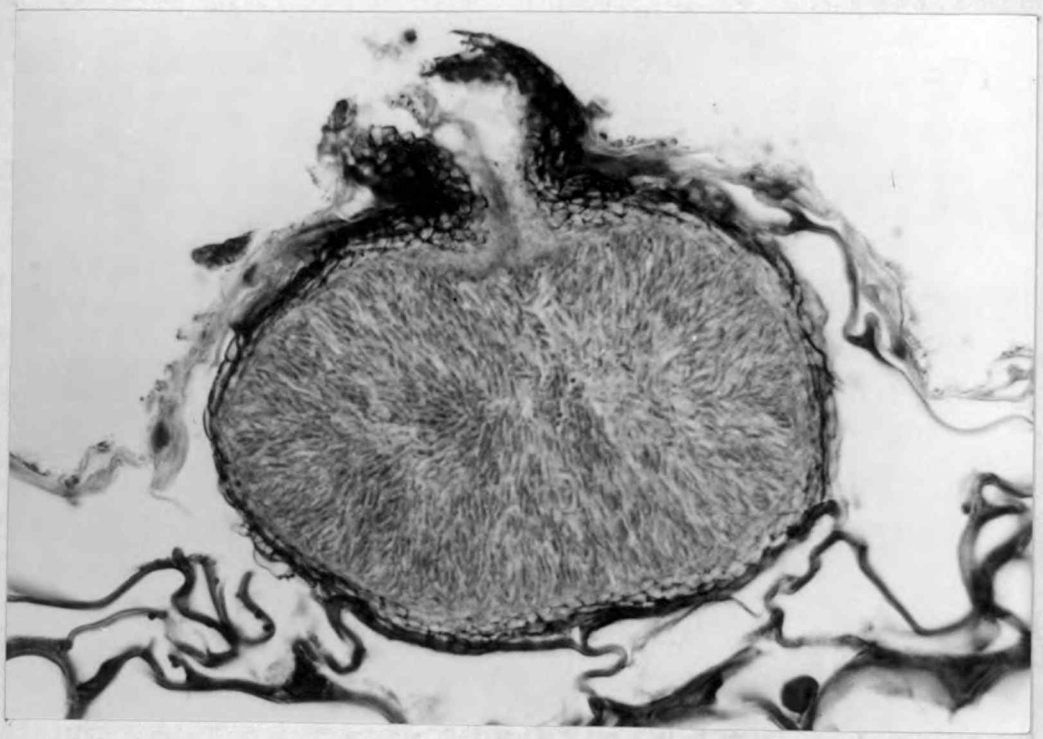

Fig. 1

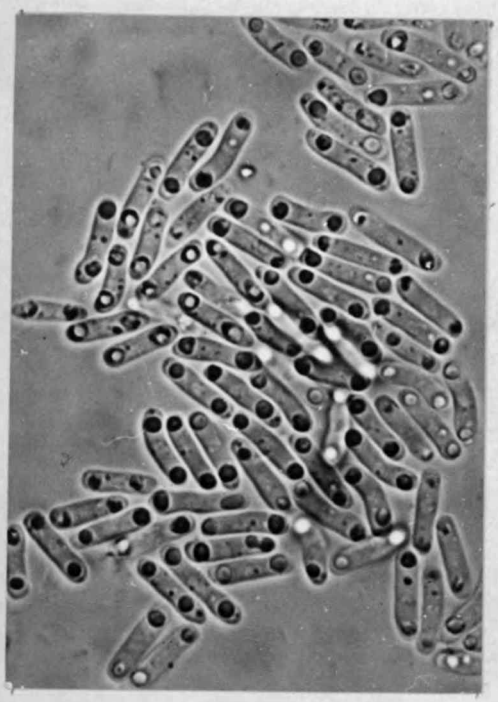

Fig. 2

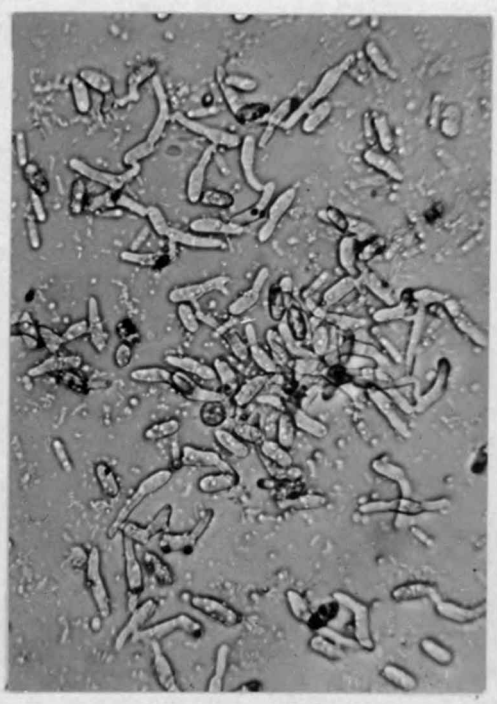

Fig. 3

PLATE VIII

Fig. 1. Habit of pansies diseased with Ramularia agrestis in garden at South Beach, Ore.

Fig. 2. Habit of pansy leaf diseased with Ramularia agrestis. x2.

PLATE VIII

Fig. 1

Fig. 2

PLATE IX

Fig. 1. Ramularia agrestis. Germinating spores. x570.

Fig. 2. Ramularia agrestis. Group of conidiophores emerged from stoma. x400.

Fig. 3. Ramularia agrestis. Dioxan mount. Note old conidiophore with conidial scars. x500.

Fig. 4. Ramularia agrestis. Conidia attached to young conidiophores. x450.

PLATE IX

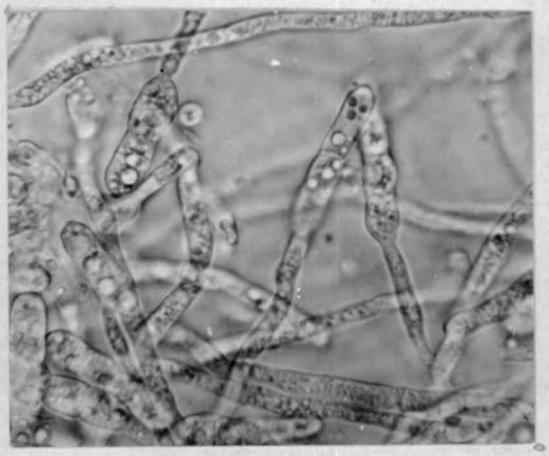

Fig. 1

Fig. 2

Fig. 3

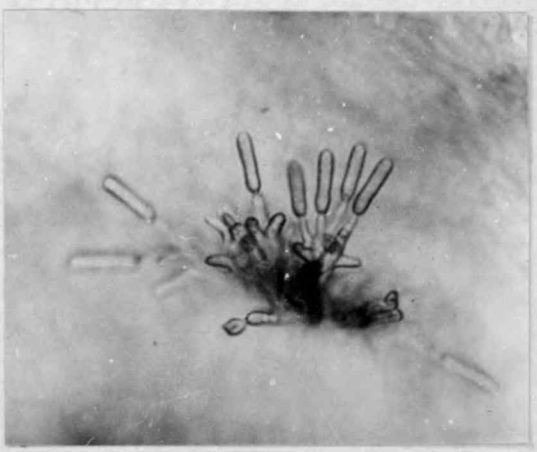

Fig. 4