United States Department of Agriculture
Bureau of Entomology and Plant Quarantine

April 1, 1940

Foreign Plant Quarantines In-service Training Series. No. 5
(No. 1 is an introductory and explanatory number.)
Prepared by N. Rex Hunt

# SCLEROSPORA SPP. DOWNY MILDEWS OF CORN, SUGARCANE, AND RICE

Quarantines 15, 24, and 55.

Downy mildew diseases due to species of Sclerospora are among those covered by three foreign plant quarantines. Quarantine 15, the sugarcane quarantine, promulgated June 6, 1914, does not name any of the diseases responsible for its promulgation but among the serious foreign diseases of cane which its enforcement tends to keep out are species of Sclerospora. Quarantine 24, the corn disease quarantine, promulgated April 29, 1916, effective on and after July 1, 1916, lists two species of Sclerospora among the diseases responsible for it. Quarantine 55, the seed or paddy rice quarantine, issued July 17, 1923, effective on and after September 1, 1923, starts the list of diseases responsible for its promulgation with a species of Sclerospora.

While much additional information regarding the Sclerosporas has become available since these quarantines were promulgated, there are many unsolved problems in identity, life histories, host ranges, and geographic distribution of these fungi.

Uncertainty as to the identity and relationship of various foreign Sclerosporas is relatively unimportant from the quarantine standpoint at present since we must guard against all of them. But the entry and establishment of a form, the status of which is doubtful, would immediately change the situation. There would be the question of modifying the quarantined area without proper data on which to make such modification. Control measures for the newly introduced pathagen could not be satisfactorily worked out in the absence of full knowledge of its life history, host range, and amenability to various control measures.

## SCLEROSPORA

### Methods of spread.

The genus Sclerospora is in the same subfamily, Peronosporae, as the general Phytophthora, Plasmopara, and Peronospora, all of which cause serious downy mildew diseases of important crops. These fungi get the name "Downy mildews" from the fact that most species produce a downy growth of conidiophores on the surface of affected areas.

The spread of Sclerosporas is accomplished in three principal ways: (1) Local spread during the growing season is usually by means of air borne conidia. These conidia are produced in enormous numbers in some species and may be responsible for rapid spread which will badly damage or ruin a planting within a few days after sporulation starts. These conidia are produced during the night and collapse and die in the morning if not already distributed and established by that time. They are therefore not directly responsible for spread to distant areas. (2) The sexual spores, called oospores, are produced in thick-walled oogonia, are themselves thick-walled, and are capable of remaining viable for years. Many of these oospores may remain in or on the soil to infect succeeding crops. Others become scattered about as spores, oogonia, or in bits of the host tissue, get mixed with seed of the host or of nearby plants and are transported to new localities. (3) Sometimes the fungus is spread in the form of living mycelium. In sugarcane cuttings used as seed pieces this is especially likely to occur. One species is said to be systemic in a perennial wild host. Since the host range of the various species is not well known, others may be systemic in perennial hosts and thus liable to be transported in living parts of such hosts.

For some species of Sclerospora conidia only are known. Where host material is available at all times either as perennials or as successive crops no other stage is needed to maintain the fungus. For other species, conidia are unknown or rare. Such species may spread little during the season but may fill the soil with resting spores and are easily spread to new localities with seed or other plant parts bearing oospores.

Named species on corn, sugarcane, and rice.

Eight named species, some of which may be synonyms, are recognized as infecting corn, or sugarcane, or rice, or some combination of these hosts. In addition there are reports of undetermined species which may add to the list. Notes regarding these species are given in the accompanying work sheets. Attention may be called to the following points:

Two of the eight named species are already established in this country on the mainland. These are S. graminicola, which attacks a variety of hosts including corn, and S. macrospora which attacks a number of hosts including corn and rice and is the species meant to be included in the rice quarantine (No. 55) but misspelled there.

S. graminicola is readily separated from other species because its conidia germinate by producing zoospores instead of germ tubes. Later in the season oogonia are produced on some hosts. As oogonia are seldom produced on corn the fungus probably gained entrance as oospores with seed of some other host.

S. macrospora produces oogonia in great abundance in the leaf tissues of its hosts. Conidia, though reported to occur, are not usually found. It is the only form regularly producing oospores on corn, but has not been reported to occur on corn in the United States.

Of the six named species attacking corn and sugarcane and not known to occur in this country, all produce conidia which germinate by the production of germ tubes. Oogonia have been reported for three of the species--S. miscanthi which occurs on sugarcane, S. sacchari which attacks sugarcane and corn, and S. sorghi which attacks corn. S. miscanthi and S. sacchari are probably disseminated with cane cuttings used as seed pieces and also in the form of oospores while S. sorghi is disseminated as oospores with sorghum or other seed.

Of the three remaining species, S. maydis which attacks corn, may be a strain of S. sorghi; S. philippinensis which attacks corn may be a strain of S. sacchari; and S. spontanea which attacks corn and cane may be a strain of S. miscanthi. It is possible that the four latter species are in reality a single variable species or that further work will show a larger group of related species. Unless oospores are produced their spread would be limited to local distribution as conidia and to transport in living host tissues.

Some of the species of Sclerospora under discussion are separated from others because of different host reactions or different spore measurements. However, many fungi develop strains which prefer certain hosts or certain varieties and it is known that a species of Sclerospora may virtually destroy some varieties of corn and scarcely affect others near by. Spore sizes within a species are variable also. Measurements by different workers vary and in the case of S. sacchari two distinct sets of measurements for the conidia are given in the original description. Whether such variations are due to mixtures of two species, or some of the so-called species are unstable hybrids, or the variations in size depend on host, environment, length of day, methods of collecting and preparing spores for measurement, or other conditions, the variations do occur and add to the difficulty of clearing up the status of Sclerosporas. Cross inoculation data would be very helpful in clarifying the situation.

Foreign species on corn.

On corn conidia are produced in abundance by S. maydis, S. philippinensis, S. sacchari, S. sorghi, and S. spontanea but no oospores are produced and Weston (35, 38) and Palm (17) were unable to demonstrate that the disease was carried over in corn grains in which the tissues had been invaded by mycelium. Hence corn is an important factor in rapid local spread of downy mildews but has not been proved to be important of itself in carrying the disease over from season to season or in carrying the disease from one area to

distant areas. Further work may show that infected grains do carry the disease. Unhusked roasting ears might carry actively sporulating areas for long distances under modern storage conditions. Susceptibility of corn varieties is extremely variable and oospores may be formed in some varieties. Perhaps the most serious risk with corn is the fact that it is often planted in close proximity to hosts on which oospores are produced in abundance, that the corn may become contaminated with such oospores and that if imported and planted the heavy conidia production on corn might serve to spread the disease over large areas and to other hosts before the nature of the disease could be established and eradication effected.

Foreign species on sugarcane.

On sugarcane S. philippinensis and S. spontanea are only known to produce conidia but S. miscanthi and S. sacchari produce oospores. The first two species might be eradicated by use of a short host free period but the two latter species would probably persist in the soil for some time after removal of the host plants if the oospores had been released before removal of all diseased host material.

Infected sugarcane cuttings as used for propagation would be unlikely to show any evidence of such infection. Growing all imported sugarcane under rigid quarantine conditions until found to be disease free eliminates the risk of introducing Sclerosporas with such material.

The seeds of sugarcane might harbor the mycelium or be contaminated with oospores and should be handled with equal care.

Species on rice.

So far as known all Sclerospora downy mildews reported as occurring on rice belong to S. macrospora which is now known to occur in the United States.

Foreign species on other hosts.

The seed of hosts on which oospores of these foreign Sclerospora are produced and of other plants grown near by are likely to be contaminated with oospores. Sorghum is not listed in quarantine No. 24 but oospores of S. sorghi are produced in abundance on it. Spread of this fungus to new areas and continents has probably been accomplished by transport of contaminated sorghum seed in most cases at least.

There are other named species of Sclerospora occurring on grasses in foreign countries which might affect corn or sugarcane or might possibly be identical with undetermined species listed as occurring on corn or sugarcane.

Possible importance of these Sclerosporas in this country.

The Sclerosporas do not seem likely to become outstandingly destructive in this country except in the Mississippi Valley, especially the lower part, or other areas with high humidity during the early part of the growing season. While much of the corn belt may have periods of weather favorable for the development of conidia and the rapid spread of these downy mildews, the fact that some other host would seem to be required to carry the fungus from season to season makes control possible except where such hosts may be perennial or where a continuous succession of hosts is maintained. With sugarcane, losses would probably be severe since resting spores, of some species at least, are produced on cane and conditions in cane fields are likely to favor rapid spread of the downy mildews locally. Establishment of these Sclerosporas in the lower Mississippi Valley on hosts of species infecting corn would provide a reservoir from which air currents could carry infection up the valley to plantings of corn somewhat as wheat rust is carried north, though the delicate structure of the Sclerospora conidia should greatly restrict the length of any one "jump."

While the available information regarding the foreign Sclerospora downy mildews of corn and sugarcane is scattered, incomplete, contradictory and difficult to evaluate, their possible destructiveness, the absence of studies designed to enable prompt and efficacious eradication or control in the event of their introduction, the decided possibility of their entry, and the importance of these and other hosts of the pathogens involved combine to fully warrant continued drastic quarantine measures to prevent the entry and establishment of these foreign downy mildews.

Name of disease: Downy mildew, Green-ear disease.

Name of pathogen: Sclerospora graminicola (Sacc.) Schroet.
Syns. Peronospora graminicola Sacc.
Peronospora setariae Pass.
Protomyces graminicola Sacc., etc.

Hosts: Members of the tribe Paniceae of the family Gramineae, especially. Include Pennisetum typhoideum, Setaria (Chaetochloa) viridis, Chaetochloa spp., Panicum miliaceum, Zea mays, Andropogon halepensis.

Part attacked: Leaves, sheaths, stem above and below the ground level.

Place of origin:

Country of first report:

First report from U. S.: Wisconsin, 1884.

Distribution: Europe, Asia, Africa, North America.

Factors affecting severity: High humidity and moderate temperatures at night when conidia are produced presumably are necessary for maximum production of conidia and local spread. Usually formation of numerous oogonia soon ends production of conidia. Conditions conducive to infection by oospores are not known apparently. Host susceptibility is an important factor in determining relative losses. Association with other hosts may affect the percentage of infection also. In an area where corn was the only host the disease might soon die out entirely.

Methods of spread: Air borne conidia are responsible for local spread during the growing season in Florida (40) Chaetochloa (Setaria) magna but spread from plant to plant during the growing season does not seem to occur in India (5) on Pennisetum typhoideum. The fungus seems to be systemic in C. magna, which is a perennial, and hence might be carried in living plant parts of this host. Oospores are produced in abundance on most hosts and may be blown about or carried by surface water or may get mixed with seed of the host or of nearby plants.

Losses incurred: Apparently losses are not usually severe as to the total crop although individual plants may be a total loss and small areas are sometimes seriously affected. Losses in 15 districts in Manchuria were reported as 10 to 25% on Setaria italica in 1927-29 (28).

Comparative losses: Losses are small everywhere apparently and no comparison is practical on basis of the information noted.

Control methods: Destruction of infected plants, crop rotation, clean seed.

Quarantine action: None.

Description: Symptoms vary with the host, age at time of attack and spore form or forms produced. On corn only the conidial stage is produced, causing discolored areas on the leaves but causing relatively little damage normally. On Pennisetum typhoideum in India (5) the fungus causes "green ear disease" so called because the solid spikate ear is wholly or partly transformed into a loose, green head composed of a mass of small, twisted leaves. Complete sterility of the head may result. Infected young leaves show chlorotic areas or long streaks, conidiophores emerge in masses through the stomata covering the chlorotic areas with whitish downy growth from which the conidia are produced. Conidia germinate by production of zoospores but these do not seem to produce new infections. Later, affected areas on older plants may turn brown, great numbers of brownish oogonia being produced in the tissues. Each oogonium contains an oospore. They are formed in such abundance that the tissue between veins is largely destroyed resulting in the splitting or shredding of affected leaves.

In the case of systemic infections of Chaetochloa magna in Florida (40) a pallid yellowish area is produced at the base of the oldest infected leaf and gets larger on each successive leaf, running out in irregular, jagged extensions toward the tip until the later leaves are yellowish white throughout. Seedlings infected from oospores in the soil presumably develop much as the systemically infected plants but all leaves may be wholly chlorotic practically from the time of emergence. In addition to the systemic infections there are numerous leaf spots on other plants of the host, presumably the result of infection by zoospores. These spots produce some conidia but oogonia do not seem to develop in them and they soon dry up, apparently without producing any oogonia. These spots are never conspicuous.

Conidia 19-31 x 12-21 mu on Pennisetum typhoideum in India according to Butler (5); 11-35 x 10-21 mu, usually 16-22 x 12-16 mu on Setaria viridis in Minnesota and Washington, D. C., according to Weston (39); 13-36.9 x 11-24.9 mu on Chaetochloa (Setaria) magna in Florida according to Weston and Weber (40); 15-28.9 x 13-22.9 mu on Pennisetum typhoideum at

Poona, India, according to Weston and Uppal (42). Mature conidia have a papilla of dehiscence prominent at the apex, germination being by the production and release of 3 to 12 or more zoospores which are irregular kidney shaped with 2 cilia on the concave side, 9-12 mu in diameter when they settle and round up. Oogonia with heavy uneven walls. Oospores 22.5-35 mu averaging 32 mu in diameter according to Butler (5), 19-44.9 mu, 541 of 1000 measured being 31-37 mu and 814 being 29.-38.9 mu according to Weston and Weber (40), 25-46.9 mu in diameter on Setaria italica, Pennisetum typhoideum and S. viridis, 400 measurements on each host but source of material not stated, over half of oospores on each host 33-36.9 mu according to Weston and Uppal (42).

Bibliography: (5, 8, 9, 23, 24, 28, 31, 39, 40, 41, 42.)

Name of disease: Wheat downy mildew.

Name of pathogen: Sclerospora macrospora Sacc.
Syn. Sclerospora oryzae Brizi

Hosts: Wheat and maize especially; also on oats, barley, rice, rye, and wild grasses of the genera Phalaria, phragmites, Glyceria, Agropyron, Lolium, Bromus, Festuca, Holcus, Alopecurus. Not found on corn in the United States but reported on corn in Australia and elsewhere.

Part attacked: Leaves.

Place of origin:

Country of first report: (Described from Australian material on Alopecurus in 1890)

First report from U. S.: California, Tennessee, Kentucky, 1921. (Collected in California in 1919, probably present several years in Tennessee and Kentucky).

Present distribution: Australia, Abyssinia, Bulgaria, Japan, France, Italy, Russia, Spain.

Factors affecting severity: Seems to persist in low bottom lands only and to cause destruction in areas that have been flooded or at least remained wet for some time.

Methods of spread: Since conidia are not produced, usually, spread must depend on dissemination of oospores by air currents, surface water movement, transportation of spore bearing plant parts, etc.

Losses incurred: Severe in low ground, especially flooded areas, very little elsewhere.

Comparative losses: Apparently little loss in U. S., but losses might be heavy any place in temperate zone in low wet ground if susceptible crops were grown on it each year after infection occurred there. Said to have caused considerable damage in Europe at times.

Control: Crop rotation with eradication of all wild hosts nearby should give control, or growth of non-susceptible crops on the low spots at all times.

Quarantine action: The rice disease quarantine, No. 55, is based on this and other diseases, the specific name being misspelled

as S. macrocarpa in the quarantine.

Description: Three types of symptoms on immature wheat were noted by Weston (36): (1) Excessive tillering, all shoots soon withering, browning and dying. (2) Internodes shortened, leaves striped or yellow and fleshy, twisted or curled and held in unnatural positions. (3) Leaves yellowed, thickened and twisted but not so stunted as in (1) and (2). There are also intergradations and combinations of these symptoms.

In maize the disease may be found on plants with twisted and abnormal growth, particularly of the tassel. A more accurate diagnosis is made by examination of apparently infected leaves with a hand lens by transmitted light for the innumerable spores in diseased tissue and pellucid dotted appearance of such tissue.

Conidia rare, said to have been found on Holcus lunatus in Italy (18), papillate, 60-70 x 38-52 mu on short peduncles. Also obtained on infected wheat plant parts in water (19). Germination by production of zoospores. Oospores 60-65 mu in diameter according to Saccardo, caused shredding of barley leaves in California (12) but often remained imbedded in tissues. Some oospores germinated in moist chamber (18) and produced macroconidia which in turn germinated by the production of zoospores. Mature macroconidia are lemon-shaped with the papilla well marked, 75-80 x 55-60 mu.

Bibliography: (12, 18, 19, 29).

Name of disease: Downy mildew.

Name of pathogen: Sclerospora maydis (Rac.) Palm (not Butler)
Syn. Peronospora maydis Raciborski
Sclerospora javanica Palm

Hosts: Zea mays, hybrids of maize and teosinte.

Part attacked: Leaves and other parts above roots.

Origin: Java (?)

Country of first report: Java, 1897.

First report from U. S.: None.

Present distribution: Java, Sumatra, Belgian Congo (1937).

Factors affecting severity: Humid nights as for other downy mildews of maize favor production of conidia and local spread.

Methods of spread: Local spread during the growing season is by conidia, largely air borne. The fungus may be carried over from season to season on a succession of hosts only, as oospores are not known. Unless oospores are formed movement of the disease from one country to another would require transport of living infected plants, so far as we know.

Losses incurred: Severe at times, damage of 30 and 50 percent of the crop in some localities in the Dutch East Indies in 1920 (32).

Comparative losses: Said to be very destructive in Java at times. According to Dr. R. D. Rands (verbal statement) a series of American varieties of maize being grown at the experiment station in Java were naturally attacked and virtually no crop produced on any of them. Javan varieties were not so susceptible. The disease is said to be capable of being very destructive in Belgian Congo where the natives make successive plantings, but the crop has no sale value there, hence the losses are not very important.

Control: Use of resistant varieties, and of a host free season might be effective.

Quarantine action: Under the original name Peronospora maydis Raciborski this is first on the list of diseases responsible for the promulgation of the corn disease quarantine, No. 24.

Description: Symptoms are said to be similar to those of Sclerospora sorghi. According to Steyaert's (24) description of the disease on maize in Belgian Congo the first leaves attacked do not always show the disease in an acute form. By the time the 7th or 8th leaf is produced the severity of the disease is usually manifest. Chlorotic zones start from the base of the leaves and progress to the point. The leaves remain small, narrow, chlorotic and erect while normal leaves fall in curves. The whole plant has the appearance of being weakly and dwarfed. The chlorotic tissues take a greenish yellow tinge or even pure yellow. On plants that have made a normal start the symptoms are not so pronounced. It is, in general, only the bases of the leaves which are attacked.

Long chlorotic striations start from the base of infected leaves and advance along the ribs, often more rapidly along the midrib. These striations later become confluent at the base, brownish, necrotic spots appear and secondary organisms develop.

The tassels may be conspicuously deformed and the ears equally deformed.

In describing the disease in Java, Palm (17) divides the symptoms into three types two of which are similar to those given by Steyaert and a third type in which the disease produces narrow, inconspicuous brown stripes full length of the lowest leaves and growing progressively shorter until only the tips of some of the younger leaves are affected and the top leaves are normal green throughout.

Palm's measurements for the conidia are 19-26 x 15-20 mu while Steyaert's are 17.5-27.5 x 13.75-17.5 mu. Germination is by production of a germ tube.

Oospores are not known. How did it get from the East Indies to Belgian Congo?

Bibliography: (17, 20, 24, 32, 35).

Name of disease: Downy mildew.

Name of pathogen: Sclerospora miscanthi T. Miyake.
Syn. Sclerospora macrospora (?) tentative determination used by T. Miyake (16).

Hosts: Miscanthus (Eulalia) japonicus, M. sinensis, Saccharum officinarum, and S. spontanea.

Part attacked: Leaves.

Place of origin:

Country of first report: Formosa (found in February, 1911).

First report from U. S.:

Distribution: Formosa, (Philippine Islands only place listed by Stevenson and Rands) (23).

Factors affecting severity: No information but might be similar to S. macrospora which it is said to resemble.

Methods of spread: No information.

Losses incurred: Miyake (16) speaking of it in Formosa says its power of spreading is small and the extent of the damage very limited and it only occurs over a small area.

Comparative losses:

Control methods:

Quarantine action: None specifically but would be covered by the general statement used in the sugarcane quarantine, No. 15.

Description: On Miscanthus japonicus (16) the affected leaves split up into threads resembling those of millet affected by S. graminicola. Sugarcane planted following the clearing off of diseased M. sinensis became affected, the leaves stripping and the stems being liable to be broken or bent over at the nodes. Cane is mostly attacked from June to September or October when growing rapidly, especially in poorly prepared fields, according to Miyake's fellow station workers. Conidia were not found for some time after publication of the description but are said to be similar to those of S. sacchari. Whether similar to the long or the short conidia of S. sacchari or both is not stated. (Or is it possible one group belongs to each species?) Oogonia on M. japonicus, 52-73 x 45-69 mu, reddish brown, walls 3.8 mu up to 3 or 4 times that, uneven;

oospores 40-55 mu round, yellow, with a glossy yellow wall 4 mu thick. Weston (41) measured large numbers of the oospores and found most of them were 47-48.9 mu. in diameter.

Bibliography: (16, 23, 41).

Name of disease: Philippine downy mildew of maize.

Name of pathogen: Sclerospora philippinensis Weston
Syns. Sclerospora maydis (Rac.) Butler (not Palm)
Sclerospora indica Butler
Sclerospora maydis Reinking

Hosts: Zea mays, Euchlaena luxurians, Andropogon sorghum.

Part attacked: Leaves and all parts except roots.

Origin:

Country of first report: India, 1912.

First report from U. S.: None.

Present distributions: India, Philippine Islands (1916).

Factors affecting severity: High humidity at night is necessary for maximum production of conidia and of spread of disease in epidemic form.

Methods of spread: Oogonial stage unknown, hence possibility of spread from area to area unknown, except possible transport of diseased fresh host material which might continue to sporulate under favorable conditions. See above also.

Losses incurred: In the Philippines losses of 40 to 60% were frequent in the maize growing areas of Laguna and Batangas. Losses in imported varieties sometimes 100%.

Comparative losses: In India losses appear to be light with only individual plants affected.

Control methods: Where infection is light as in India, destruction of infected plants might be effective. In the Philippines sanitation and crop rotation might be useful in some cases but breeding for resistant varieties should be attempted.

Quarantine action: Partly responsible for promulgation of the corn disease quarantine, No. 24.

Description: Symptoms vary with the age of the corn plant when infected, means of infection, variety, environmental conditions, etc. In general the disease manifests itself by loss of chlorophyll in more or less sharply defined areas of the leaf, by the production of whitish down, mostly on the chlorotic areas and by alterations in normal growth of the

plant. Effects of the disease may show any time from the putting out of the third or fourth leaf until tassel and ear mature.

In young plants two or three narrow longitudinal stripes of pale yellow to whitish color show at the base of the nearly developed second, third, or even fourth leaf in contrast to surrounding normal green. The leaves above these earlier ones are almost wholly chlorotic, remain narrow and become rigid. Stem growth is checked, so plant is more or less dwarfed. The leaf sheaths develop almost full length and hence overlap. The weakened plant may be attacked by secondary parasites and killed or may produce a few grains.

When older plants are infected the oldest leaf to show infection, that is, basal chlorotic stripes, may be the fourth and up to the eighth leaf. The basal discolored areas and the stripes are broader and larger on the oldest leaves infected than on leaves of plants showing the disease early and get progressively worse on the leaves above. In these older plants the shape, size and flexibility of the leaves is not so much altered from normal, but the invasion of the fungus may cause the midribs to become so brittle they break so the leaf hangs straight down along the stem. Reproductive structures of the host show all sorts of malformations. Ear production is delayed.

In later stages of the disease especially in plants less heavily attacked the diseased areas regain most of their color so they can scarcely be distinguished from non-invaded areas.

Susceptibility varies with age but plants with kernels hardening may be attacked through young suckers. In such cases only the lower leaves of the old plant may show narrow pale irregular broken stripes. No conidiophores are produced on these areas.

Conidiophores are not produced on any of the types of infected plants unless conditions are favorable.

The symptoms on teosinte are less marked than on corn, the percentages of infection and loss are less and fewer spores are produced.

In sorghum the percentage of infection is very low but plants are infected when young and soon die, no further infection being noted.

Conidia elongate, variable in size, 17.-52.9 x 11-24.9 mu (37), usually 27-39 x 17-21 mu, hyaline, germinating by production of a germ tube, spores produced at night. Oospores not known.

Bibliography: (6, 23, 24, 30, 35, 37, 38).

Name of disease: Downy mildew of sugarcane.

Name of pathogen: Sclerospora sacchari T. Miyake.

Hosts: Saccharum officinarum, Zea mays, Euchlaena (teosinte).(see (43)

Parts attacked: Leaves and stalks.

Place of origin: New Guinea?

Country of first report: Formosa, found in 1909, description published in 1912. Found on cane recently introduced from Australia.

First report from U. S.:

Distribution: Fiji, Formosa, India, Japan, New Guinea, Philippines, Queensland, Siam. (May have been eradicated from India. An attempt was made to eradicate it in the Philippines.)

Factors affecting severity: Apparently there is only a limited production of conidia on sugarcane but on corn and teosinte conidia are produced in such numbers that it is unsafe to plant them in the neighborhood of sugarcane fields. Humid nights presumably are required for production of conidia, as in other species.

Methods of spread: Local spread during the season is due to air borne conidia presumably as in several other species. At least a part of the distant spread has been due to carriage of the fungus in or on sugarcane cuttings used for seed pieces. The role of oospores and of living mycelium in this carriage is not known.

Losses incurred: No definite data available. Said to be severe on corn and on sugarcane growing near infected corn and teosinte, in Formosa. According to Weston (35) it may attack cane "with violent intensity."

Comparative losses: Apparently the disease is not usually severe on cane in Australia. This may be accounted for by the fact that corn usually does not become infected in Australia. Available data do not permit any authoritative explanation of the extreme differences in behavior of this fungus. (but see (43).

Quarantine action: The corn disease quarantine No. 24 was based on several diseases, this being one of those named.

Description: Based on the translation of Miyake's bulletin (16) by Hiroda & North, on cane when a leaf is affected by this fungous disease it first shows a few yellowish stripes running parallel with the veins. These stripes increase in number until most of the leaf loses its green color and becomes marked here and there by reddish brown spots. At the same time a fluffy growth develops on the under surface of the leaf which becomes dry, yellowish brown and dead. At the last stage of the disease some of the leaves become torn vertically into threads near their tops only. A diseased leaf is likely to be lighter and narrower than a healthy one. Mycelium invades the stems also. On most varieties there are more nodes in diseased canes. Diseased canes are often two or three feet taller than healthy ones and witches' broom-like growth resulting from the disease may weight tops to the ground.

On maize and teosinte leaves show whitish yellow stripes like those in cane, but not so pronounced. Conidia are produced all over the plant instead of being restricted to lower leaf surfaces. Growth was not checked by infection of maize and teosinte but maize ripened and teosinte continued to grow and seemed to outgrow the disease by the end of August. Apparently the teosinte did not show infection until August 10 while the disease swept over the maize field early in July, thus accounting perhaps for difference in behavior on the two hosts.

Oogonia were found in cane in December 1910 but could not be found in either living or dead leaves from April to July of 1911. Oogonia 49-58 x 55-73 mu, oospores 40-50 mu in diameter, wall 3.8-5 mu thick, in tissues of slightly splitting leaves. Conidia 25-41 x 15-23 mu or elongate and 49-54 x 19-23 mu.

It may be noted that Weston (41), when describing S. northi compared it with S. sacchari and stated that the oospores of S. sacchari are usually between 49 and 54.9 mu in diameter and wall 5 to 8 mu thick. He also mentions "..... the oogonial Sclerospora occurring on Saccharum spontaneum L. in the Philippines, a species very similar to S. sacchari but perhaps separate from it."

Subramanian (26) found the conidia 18.5-45.1 x 13.2-26.4 mu the average of 200 spores being 31.5 x 18.8 mu in India on the single sugar cane plant found diseased. These measurements agree reasonably well with the smaller of the two types of conidia mentioned by Miyake.

Bibliography: (2, 3, 10, 14, 16, 23, 26, 27, 35, 41, 43).

Name of disease: Downy mildew of sorghum.

Name of pathogen: Sclerospora sorghi (Kulk.) Weston and Uppal.
Syns. Sclerospora graminicola (Sacc.) Schroet. in part
Sclerospora graminicola var. Andropogonis sorghi Kulk.

Hosts: Andropogon sorghum, Zea mays, Euchlaena mexicana. E. mexicana has been inoculated successfully and it is thought likely a downy mildew found on this host by Butler in 1905 was this species (31).

Part attacked: Leaves.

Place of origin:

Country of first report: India (Bombay and Madras Presidencies), 1907.

First report from U. S.:

Present distribution: India, Egypt, Tanganyika.

Factors affecting severity: According to Butler (5) it was noticed in Madras that the disease is generally (though not always) most severe in the wetter parts of fields. Presumably as in other species of the genus, high humidity at night would be required for production of conidia, but it has not been demonstrated apparently that there is any appreciable spreading of the disease by conidia.

Method of spread: So far as can be determined most of the spread is through distribution of oospores and these are not produced on corn.

Losses incurred: Losses have not been heavy in any case apparently. This may be because infections are so nearly confined to those from oospores, i.e., there is no great amount of spread from plant to plant in the field. This species has been confused with S. graminicola and data relating to it specifically and unmistakably is incomplete. It is possible that with different varieties of its host plants or under more favorable humidity or other conditions it would be more destructive.

Comparison of losses: Data inadequate.

Control: No control measures would be required where corn was the only host grown since oospores are not produced on corn apparently and the disease would not live over from one season to the next. On sorghum, rogueing, resistant varieties and crop rotation should be effective.

Quarantine Action: This fungus would fall under the term "other downy mildews" as used in the corn disease quarantine, No. 24.

Description: According to Butler (5) seedlings of Andropogon sorghum may show the disease very soon after they come up, affected seedlings having pale yellow, narrow leaves, covered on the lower or on both sides with the white downy conidial stage of the fungus. In 5 or 6 weeks white streaks appear on the upper leaves followed by shredding of the tissues which turn brown from oospores produced there. Oospores may form in the upper part of the sheaths also. The diseased seedlings are stunted and produce no ears.

When symptoms do not show on individual plants until they are about two months old, the top leaves and the bases of lower leaves turn white followed by browning when the oospores are produced. On the lower leaves pale yellow patches indicate the presence of the conidial stage. Plants of this type produce stunted ears if any. This is the commonest and most prominent form of the disease.

When symptoms appear on groups of older plants, the disease seems to spread from them, which is not true of the seedlings or of individually infected older plants. On these groups the leaves develop long narrow streaks and patches which turn from pale yellow to orange and then brown. Conidia form on both surfaces especially on the under side but no oospores are produced. The patches appear to spread from the lower to the upper leaves and from the tip to the base of individual leaves. The whole leaf may turn brown but there is no shredding. Normal ears are produced.

Uppal and Desai (31) state that the symptoms and general effects of this downy mildew on the individual plants of sorghum and maize were the same, as observed in the field. When the plants were 5 weeks old, leaves of affected plants were pale yellow and covered with the conidial stage of the fungus. However, the sorghum plants later showed shredding while the corn plants did not. The latter continued to produce conidia instead of changing to the production of oogonia.

Conidia 18-32 x 16-23 mu according to Kulkarni (9, 42), 15-28.9 x 15-26.9 mu according to Weston and Uppal (42), germinating by production of germ tube or hyphae.

Oogonia similar to those of S. graminicola, oospores 25-42.9 mu in diameter, the majority 31-36.9 mu; wall 0.3-4.3 mu, usually 1.1-2.7 mu thick (42).

Unlike S. graminicola the formation of the oogonia chiefly within elongate reddish discolored areas is followed by marked disintegration of the leaf tissue into tangled fibres. This stage does not occur in corn.

Bibliography: (5, 8, 9, 13, 15, 24, 31, 33, 34, 42).

Name of disease: Downy mildew.

Name of pathogen: Sclerospora spontanea Weston.

Hosts: Saccharum spontaneum, Zea mays, Saccharum officinarum and, by inoculation, Euchlaena luxurians, Miscanthus japonicus.

Part attacked: Leaves.

Origin: Philippine Islands.

Country of first report: Philippine Islands, 1921.

First report from U. S.:

Present distribution: Visayan group of the Philippine Islands, Siam.

Factors affecting severity: Not very well known but humid nights would doubtless be necessary for maximum production of conidia as in other species. Host association may be important also. So far as known the disease cannot live over on corn but lives over on the perennial Saccharum spontaneum which is not severely injured. A few conidia from S. spontaneum serve to start the disease on corn on which abundant production of conidia may soon result in an epidemic on the corn. S. spontaneum is said to be susceptible in the seedling stage only.

Methods of spread: Local spread during the growing season is by air borne conidia. There is an undetermined species of Sclerospora which produces abundant oospores on S. spontaneum in the Philippines and which might belong to this fungus. If oospores are produced on this or some other host, they would serve to spread the disease as in other Sclerosporas.

Since the disease persists year after year in clumps of the perennial S. spontaneum, movement of living parts of this host might spread the disease.

Losses incurred: Said to be as destructive on corn as S. philippinensis which causes losses up to 50% or more of the crop. Little damage found on S. spontaneum. Inadequate information with respect to other hosts.

Comparative losses:

Control methods: Since the disease is not carried over on corn apparently, eradication of perennial hosts might eliminate the disease. If oospores produced on other hosts are a stage of this fungus, it might be desirable to rotate crops to

eliminate them from the soil before planting corn on the same land.

Quarantine action: This disease would be included under the term "other downy mildews" as used in the corn disease quarantine, No. 24.

Description: The symptoms and destructiveness of this disease on corn are said to be the same as those of S. philippinensis (35). S. spontaneum is very resistant and even though heavily infected shows only slight striping of the leaves, remains undeformed and is not materially retarded in development. Infected plants tiller and produce dense clumps on which the downy mildew persists year after year.

Conidia 25-64.9 x 11-20.9 mu, usually 39-45 x 15-17 mu (37). Germination by formation of a germ tube.

Oogonia and oospores not known. Oogonia are commonly found in the Philippines on S. spontaneum, officinarum, and Miscanthus japonicus, but have not been connected with conidial forms. The oogonia on all three hosts are so nearly alike that they may belong to one species.

S. spontanea is the first conidial species of Sclerospora to be found on a wild host. Infected plants from which the tops have been removed will produce new growth in which the fungus persists and produces conidia.

Bibliography: (23, 24, 35, 37, 38, 41).

## SCLEROSPORA, UNDETERMINED OR DOUBTFUL SPECIES

Sclerospora sp. on maize in South Africa reported by Storey and McClean. Material of this fungus was examined by Dr. Weston who states in correspondence that it agrees very closely with S. maydis and S. sorghi as they occur on corn. (Bibliography: (1, 4, 7, 24, 25).

"Sclerospora maydis Butler" reported by Lobik as attacking corn in Crimea. The conidial measurements given, 17-28.8 x 11.4-15.2 mu, fit those of S. graminicola and S. maydis (Rac.) Palm fairly well. Presumably it is not P. graminicola because the illustration shows no papillae of dehiscence at the apex of the conidia. S. maydis Butler is now S. philippinensis Weston which has far larger conidia. Bibliography: (11).

Sclerospora sp. was reported on corn and sorghum in Uganda by Small who said the oospores were only half the size of those of the downy mildew in India (S. graminicola and S. sorghi) which would seem to preclude placing the fungus in any species for which the oospores have been described. Oospores were reported as occurring in sorghum but not in corn. Bibliography: (21, 22).

Sclerospora sp. on cultivated sugarcane in Fiji reported by Weston on the basis of correspondence with Mr. D. S. North as apparently distinct from S. sacchari as it does not cause elongation of the shoots, rarely shows conidial stage and produces more oogonia and leaf splitting. Bibliography: (41).

Sclerospora sp. on sugarcane leaves in Formosa, India, Siam Queensland. On Saccharum spontaneum, Philippine Islands, Siam. Listed by Stevenson and Rands (23).

Sclerospora sp. on corn in Tanganyika. S. sorghi is reported on sorghum. The fungus on corn may be that species also. Bibliography: (34).

Sclerospora sp. or spp. on Saccharum spontaneum, S. officinarum, and Miscanthus in the Philippines. Weston (37 p. 680) calls attention to the fact that oogonia on these three hosts, and not yet connected with any conidial form, are so nearly alike they may be one species. However, the oogonia of S. graminicola and S. sorghi are quite similar and it is possible the oogonia of both S. philippinensis and S. spontanea will be found in the undetermined oogonial forms on one or more of these hosts.

Bibliography: (37, these may be included in whole or in part in 23 also.)

Spore measurements of Sclerosporas of corn, sugarcane, and rice.

| Species | Conidia | Oospores |
|---|---|---|
| S. graminicola<br>corn et al | 19 - 31 x 12 - 21 mu--Butler (5)<br>11 - 35 x 10 - 21 mu, usually 16 - 22 x 12 - 16 mu -- Weston (39)<br>15 - 28.9 x 13 - 22.9 mu, usually 17 - 22.9 x 15 - 16.9 mu--Weston and Uppal (42) | 22.5 - 35 mu diameter, average 32 mu--Butler (5)<br>25 - 46.9 mu, mostly 29 - 41 mu -- Weston and Uppal (42) |
| S. macrospora<br>corn, rice, et al | 60 - 70 x 38 - 52 mu--Peglion (18) | 60 - 65 mu diameter --Saccardo |
| S. maydis<br>corn | 19 - 26 x 15 - 20 mu--Palm (17)<br>17.5 - 27.5 x 13.75 - 17.5 mu--Steyaert (24) | |
| S. sorghi<br>corn, et al | 18 - 32 x 16 - 23 mu--Kulkarni (9)<br>15 - 28.9 x 15 - 26.9 mu, usually 19 - 24.9 x 19 - 22.9 mu--Weston and Uppal (42) | 25 - 42.9 mu diameter--Weston and Uppal (42) |
| S. miscanthi<br>sugarcane, et al | Said to be similar to S. sacchari (16) | 40 - 55 mu diameter--Miyake (16)<br>usually 47 - 48.9 mu--Weston (41) |
| S. spontanea<br>(sugarcane, et al) | 25 - 64.9 x 11 - 20.9 mu, usually 39 - 45 x 15 - 17 mu--Weston (37) | |
| S. philippinensis<br>corn, et al | 17 - 52.9 x 11 - 24.9 mu, usually 27 - 39 x 17 - 21 mu--Weston (35)<br>28 - 45 x 16 - 22 mu--Butler (5) | |
| S. sacchari<br>corn, sugarcane | 25 - 41 x 15 - 23 mu or<br>49 - 54 x 19 - 23 mu--Miyake (16)<br>18.5 - 45.1 x 13.2 - 26.4 mu--Subramaniam (26) | 40 - 50 mu diameter, wall 3.8 - 5 mu--Miyake (16)<br>usually 49 - 54.9 mu, wall 5 - 8 mu --Weston (41) |

Bibliography:

(1) Anonymous
1924 Departmental Activities: Botany. - Journ. Dept. Agr. S. Africa 8: 452-454. (Abstr. R.A.M. 4: 24. 1925)
Sclerospora sp. reported for the first time in the Natal coast belt in 1923.

(2) Anonymous
1929 Bureau of Sugar Experiment Stations; - Queensland Agric. Journ. 32: 4-7.
Sclerospora sacchari destructive on some canes. Found in 5 of 71 plantings surveyed in Giru district in April 1929.

(3) Bell, Arthur F.
1929 A Key for the Field Identification of Sugar Cane Diseases.
(See Bul. No. 2, Queensland Bureau of Sugar Exp. Stas., pp. 7-63,
(43) pls. 17.
also) pp. 31-32, Downy Mildew
Alternative names - Leaf stripe, leaf splitting disease, sclerospora disease.
Causal agent - Slerospora sacchari Miy.
Diagnostic characters, transmission & control discussed.

(4) Bottomley, A. M. and Doidge, E. M.
1929 Maize diseases in South Africa. Pan-African Agric. and Veterinary Conf. Pretoria, Aug. 1 - 17, 1929. Agric. Sect. 2: 235-237. (Paper 46).
Sclerospora maydis (Rac.) Butl. of minor importance in the Union. Occurs all along the Natal coast and in isolated localities in the Transvaal. Note. - S. maydis (Rac.) Butler is now a synonym of S. philippinensis Weston, but the identity of the fungus noted is not yet known with certainty.

(5) Butler, E. J.
1918 Fungi and Disease in Plants. 547 pp. 206 figs.
Sclerospora graminicola on Pennisetum typhoideum and S. sorghi (under its synonym S. graminicola var. andropogonis-sorghi) on sorghum discussed rather fully, both fungi and disease symptoms.
Sclerospora philippinensis (under the name S. maydis (Rac.) Butler) on maize is discussed and pictured also.

(6) Butler, E. J.
1913 The downy mildew of maize. Memoirs Dept. Agr. India, Bot. Ser. 5: 275-280, May, 1913.
Sclerospora philippinensis discussed under the name S. maydis (Rac.) Butl. as he thought it the fungus described as Peronospora maydis by Raciborski.

(7) Doidge, E. M. and Bottomley, A. M.
1931 A revised list of plant diseases occurring in South Africa. Mem. Bot. Surv. So. Africa No. 11. 78 pp.

"Sclerospora maydis (Rac.) Butl." on corn along the Natal coast and in the Transvaal. Usually unimportant. (This is the undetermined species discussed by Storey and McLean.)

S. graminicola on Johnson grass, Sudan grass, sorghum, and Sclerospora (?) graminicola on Eragrostis spp.

(8) Jones, G. Howard
1934 or 5 Egyptian plant diseases: a Summary of Research and Control. Tech. and Scientific Service (Mycological Sect.) Bul. No. 146, pt. 2 pp. 9-41, List of Diseases of Crop Plants. (Not dated apparently)

Reports S. graminicola on corn (p. 24) and sorghum (p. 26) but it seems likely S. sorghi is referred to. Eradicated.

(9) Kulkarni, G. S.
1913 Observations on the downy mildew (Sclerospora graminicola (Sacc.) Schroet. of Bajra and Jowar. Mem. Dept. Agric. in India 5: 268-273. 2 pl. May.

Separates form on sorghum as S. graminicola var. Andropogonis sorghi because conidia germinate by production of germ tubes instead of zoospores as in the species proper. Note: Bajra - Pennisetum typhoideum and Jowar - sorghum.

(10) Lee, H. A. and Medalla, M. G.
1921 Leaf Stripe Disease of Sugar-cane in the Philippines. Science, N. S. 54: 274-5.

Sclerospora sacchari found on sugar-cane imported from Formosa. Eradication being attempted.

(11) Lobik, A. I.
1933 Present position of the problem of the diseases and injuries affecting maize in N. Caucasus. Bull. N. Caucasian Inst. for Plant Protection I (VIII) 2. pp. 3-51, 2 pl., bibliog. 1931 (in Russian) (Abstr. R.A.M. 12: 505-6, 1933)

This paper lists Sclerospora maydis Butler as occurring on corn in Crimea, gives the symptoms briefly and the measurements of the conidia, 17-28.8 x 11.4-15.2 mu. Oospores are not mentioned and drawings show no papillae of dehiscence so the species can hardly be S. graminicola but the conidia measurements seem to preclude S. philippinensis of which S. maydis Butler is a synonym.

(12) Mackie, W. W.
1930 Sclerospora macrocarpa in barley. Phytopath. 20: 107. 1930.

Barley in California found infected. Note.- The Erroneous use of macrocarpa for macrospora in the federal quarantine (Rice quarantine No. 55) and elsewhere is unexplained.

(13) McRae, W.
1934 Report of the Imperial Mycologist. - Sci. Repts. Imper. Inst. Agric. Res., Pusa. 1932-33, pp. 134-160.
A Sclerospora agreeing with S. sorghi was found on Panicum trypheron, first report on host.

(14) McRae, W.
1932 Report of the Imperial Mycologist. Imper. Inst. Agric. Res., Pusa. 1930-31, pp. 73-86.
Reports occurrence only, of Sclerospora sacchari on cane, maize, and Euchlaena luxurians in India.

(15) Melchers, L. E.
1931 Downy mildew of Sorghum and maize in Egypt. Phytopath. 21: 239-240. (Feb.) (Abstract in Rev. Appl. Mycol. 10: 449. 1931)
Oospores of Egyptian material (S. sorghi) were studied by Dr. Weston. Variable but most closely resembles specimens from Kirkee, India, rather than from Poona, India, where Kulkarni established this species as a variety of S. graminicola.

(16) Miyake, Tsutome
1912 On a fungus disease of sugar cane caused by a new parasitic fungus, Sclerospora sacchari T. Miy. Bul.Div. Path., Sugar Exp. Sta. Formosa No. 1. 61 pp. Dec. 1911 (Transl. by Mr. Hirode & Dr. D. S. North in Library files). (Bull. printed Mar. 28 and published Mar. 30, 1912).
A copy of the original, in Japanese, and a copy of the translation made from a copy loaned to Dr. Weston by Dr. H. L. Lyon of Hawaii who received it from Dr. North, both are in the U. S. Dept. of Agr. library and were consulted in preparing notes.

Information regarding S. miscanthi is found on p. 21 of the translation and p. 22 has a note said to have been added in July, 1913, saying that the conidial stage had been found recently and closely resembled that of S. sacchari and that the species had been named S. miscanthi T. Miyake.

(17) Palm, Bjorn
1918 Onderzockingen over der omo lyer von de mais. Dept. Landb. Nivj. en Handel (Dutch East Indies), Meded. Lab. Plantenziekten, No. 32, 78 p., 8 pl. English summary, p. 55-57. Literatuurlijst, p. 78.
Describes Sclerospora javanica Palm now a synonym of S. maydis (Rac.) Palm.

(18) Peglion, V.
1930 La formazione dei conidi e la germinazione delle oospore della 'Sclerospora macrospora' Sacc. Bol. R. Staz. Pat. Veg., N. S. 10: 153-164. (Abstract in Rev. Appl. Mycol. 10: 174-5. 1931.)

Symptoms given for disease on wheat and Phragmites communis (said to be a constant source of inoculum). Conidia found on Holcus lunatus are papillate, 60-70 x 38-52 mu on short peduncles from mycelium. Part of oospores germinate after 15-20 days in moist chamber at temperatures not exceeding 18° C. forming a large macroconidium which at maturity is 75-80 x 55-60 mu and usually germinates by production of zoospores.

(19) Peyronel, B.
1929 Gli zoosporangia nella Sclerospora macrospora. Boll. R. Staz. Pat. Veg. N. S. 9: 353-357. (Abstract in Rev. Appl. Mycol. 9: 513, 1930.)

Conidia obtained on bits of infected wheat culms and leaves in water, emerging in groups through stomata the guard cells of which constrict bases making them easily detached. Production of short duration, from very young actively growing mycelium which had not produced zoospores. Conidia germinate by production of zoospores which soon lose cilia and round up. This species unique in the genus in forming its conidiophores in water instead of air.

(20) Raciborski, Maryan
1897 Leijer, Eine Gefahrliche Maiskrankheit. Ber Deut. Bot. Gesell. 15: 475-478. 1897.

Describes Peronospora maydis Rac. now known as Sclerospora maydis (Rac.) Palm.

(21) Small, W.
1922 Ann. Rept. of the Gov't. Mycologist for 1921 in Ann. Rept. Dept. Agric. Uganda for year ending Dec. 31, 1921. pp. 49-57. (Abstract in Rev. Appl. Mycol. 2: 156. 1923.)

On page 52 a downy mildew of sorghum is reported with oospores said to be only half the size of those of the fungus which induces the same disease in India.

(22) Small, W.
1922 Diseases of Cereals in Uganda. Dept. of Agric. Uganda, Circ. No. 8, pp. 1-27.

Sclerospora sp. on sorghum (pp. 5-6) and on corn (pp. 9-10), both conidia and oospores found on sorghum but conidia are not described and it is not stated to be the same species on both hosts. The fungus on corn was not studied, determination being based on symptoms.

(23) Stevenson, John A. and Rands, R. D.
1938 An annotated list of the fungi and bacteria associated with sugarcane and its products. The Hawaiian Planters' Record 42: 247-313. 1938.

Sclerosporas on pp. 304-305, include S. graminicola, S. miscanthi, S. philippinensis, S. sacchari, and S. spontanea, also Sclerospora sp. on leaves of cane in Formosa, India, Siam, Queensland, and on Saccharum spontaneum in Philippine Islands, Siam.

(24) Steyaert, R. L.
1937 Presence du Sclerospora maydis (Rac.) Palm (S. javanica Palm) au Congo belge. Scientific bull. No. 13 of the I.N.E.A.C. (L'Institut National Pour L'Etude Agronomique du Congo Belge.)

Discussion of Sclerospora spp. on corn, additional hosts, distribution, etc., and assignment of downy mildew found in the Belgian Congo to S. maydis, on basis of symptoms measurements, etc. Discussion of other Sclerosporas in Africa.

(25) Storey, H. H. and McClean, A. P. D.
1930 A note upon the conidial Sclerospora of maize in South Africa. Phytopath. 20: 107-8.

Sclerospora sp. on corn, never determined, though material was studied by Dr. Weston.

(26) Subramaniam, L. S.
1931 A note on the downy mildew of sugarcane in India. Agriculture and Live-Stock in India, Vol. 1, pt. 1, pp. 32-33, pls. 5 and 6. Jan. 1931 (Calcutta). (Published for the Imperial Council of Agric. Research.) Plate 5 is colored showing symptoms on cane leaf and pl. 6 shows details of conidia, etc. The disease was found on one cane plant in 1930 at Pusa. Inoculations were tried on cane, maize, sorghum, Pennisetum typhoideum, Eleusine coracana, Euchlaena and Setaria italica, maize being the only possible host to become infected. All plants destroyed apparently and disease eliminated. A detailed study of the organism was made, based on material from the one infected cane plant.

Said to be Sclerospora sacchari.

(27) Swingle, Walter T.
1916 In a letter to Dr. C. L. Marlatt, dated February 29, 1916 Dr. Swingle says "..... in February, 1916, Mr. S. Kanecko, Agriculturist of the Sugar Experiment Station at Daimokko, Formosa, informed me that the disease has subsequently proven to be very bad on corn, in some cases destroying the crop entirely, and that the Formosan Government has prohibited the growth of corn in the vicinity of cane

fields." The disease referred to is Sclerospora sacchari as described from Formosa by T. Miyake.

(28) 1933 Takasugi, H. and Akaishi, Y.
Studies of the downy mildew (Sclerospora graminicola (Sacc.) var. setariae-italicae Traverso) on Italian millet in Manchuria. I. About the germination of oospores.
S. Manchuria Ry. Co. Agric. Exp. Stat. Res. Bull. 11, pp. 1-20, 8 pl. 1933. (Japanese with English abstract. Abstract in Exp. Sta. Rec. 70: 489-490. 1934 and in Rev. Appl. Mycol. 13: 436. July, 1934.)
Field investigations 1927-'29 in 15 districts in Manchuria showed 10 to 25% damage to Setaria italica by Sclerospora graminicola, oospores of which remain viable for over eight years.

(29) 1934 Takasugi, H.
Additional list of the fungi of Manchuko. Trans. Sapporo Nat. Hist. 13: 185-190. 1934. (Abstract in Rev. Appl. Mycol. 13: 804. Dec., 1934).
Rice was attacked by Sclerospora oryzae Brizi. (usually referred to as S. macrospora Sacc.)

(30) 1936 Uppal, B. N. and Weston, W. H., Jr.
The basis for merging Sclerospora indica with S. philippinensis. Indian J. Agr. Sci. 6: 715-719. (Abstract in Rev. Appl. Mycol. 15: 794-5. Dec. 1936)
Comparison of material on corn shows such slight differences S. indica is reduced to a synonym of S. philippinensis. Sixty percent of the Indian conidia were 33-44 mu long and 65% of the Philippine conidia were 31-39 mu long. Width frequencies overlap mostly but S. indica has a tendency to be slightly narrower.

(31) 1932 Uppal, B. N. and Desai, M. K.
Two new hosts of the downy mildew of sorghum in Bombay. Phytopath. 22: 587-594. Illustr. June, 1932.
Euchlaena mexicana and different varieties of corn were successfully inoculated using oospores of Sclerospora sorghi from sorghum. Only 6.8% of plants of Philippine corn became infected as compared to 34.4% of Golden Bantam. Conidia 15-28.9 x 15-26.9 mu on both corn and sorghum with slight variations in numbers in size groups. Disease occurs naturally on corn as well as sorghum in Bombay. Oospore production on sorghum only. Authors believe the downy mildew seen by Butler on E. mexicana at Poona in 1905 was S. sorghi instead of S. graminicola since latter does not infect teosinte apparently.

(32) Van Hall, C. J. J.
1921 Ziekten en plagen der culturgewassen in Nederlandsch - Indie in 1920. Meded van het Inst. voor Plantenziekten 46, 50 pp. (Abstr. R.A.M. 1: 18-20, 1922)
Outbreaks of "yellow disease" of maize due to Sclerospora javanica serious in some localities - damage estimated at 30 to 50% of crop. S. javanica is now a synonym of S. maydis.

(33) Wallace, G. B.
1933 Report of the Mycologist. Ann. Rept. Dept. Agric. Tanganyika Territory 1932, pp. 76-80. 1933. (Abstract in Fev. Appl. Mycol. 12: 552. 1933)
Sclerospora sp. caused considerable damage to sorghum, 9.6, 5.9, 10.8 and 10.7 percent infection on four varieties in trial grounds, another variety was practically immune.

(34) Wallace, G. B.
1937 A revised list of plant diseases in Tanganyika Territory. East African Agric. Journ. 2: 305-310. Ja. No. 4.
Sclerospora sp. reported on corn, S. sorghi on sorghum.

(35) Weston, W. H., Jr.
1920 Philippine downy mildew of maize. Journ. Agr. Res. 19: 97-122. 12 pls. (2 col.) May 1, 1920.
Destructiveness, symptoms, hosts, and detailed study of the pathogen, here named Sclerospora philippinensis.

(36) Weston, W. H., Jr.
1921 The occurrence of wheat downy mildew in the United States. U. S. Dept. Agric. Circ. 186. June, 1921.
Sclerospora macrospora found in Tennessee and Kentucky in 1921 and herbarium specimens show it was collected in California in 1919. Found on Bromus commutatus as well as wheat.

(37) Weston, W. H., Jr.
1921 Another conidial Sclerospora of Philippine maize. Journ. Agr. Res. 20: 669-684.
Downy mildew which attacks Saccharum spontaneum and corn especially is described as S. spontanea. Symptoms said to be similar to those of S. philippinensis as given by Weston in paper on Philippine downy mildew of maize.
Spore measurements of the two species, based on measurements of 700 spores, are analyzed. The bulk of the spores of S. philippinensis fall in groups 31 to 36.9 mu in length and 17 to 18.9 mu in width, those of S. spontanea in the groups 37 to 46.9 mu in length and 15 to 16.9 mu in width. The spores of S. philippinensis are usually 1.55 to 2.14 times as long as they are wide and S. spontanea 2.35 to 2.94 times as long as wide. As few as 200 spore measurements give the same ratios.

(38) Weston, W. H., Jr.
1923 Production and dispersal of conidia in the Philippine Sclerosporas of maize. Journ. Agr. Res. 23: 239-278, 10 plates., Jan. 27, 1923.

Discussion of the nocturnal production and dispersal of conidia of Sclerospora philippinensis and S. spontanea. S. philippinensis produced from 758,033,400 to 5,946,069,600 conidia per corn plant during one night. Production of conidia may continue for weeks, up to two months or more. Conidia responsible for spread locally but oospores probably means of distribution to new and distant areas.

(39) Weston, W. H., Jr.
1924 Nocturnal production of conidia by Sclerospora graminicola. Journ. Agr. Res. 27: 771-784. 2 pls. March 8, 1924.

Studies made on Setaria viridis found naturally infected in Minnesota and some of plants transferred to Washington, D. C. and studies continued. Nocturnal production of conidia established, and development of conidiophores and conidia and their structures studied. Conidia 11-35 x 10-21 mu, usually 16-22 x 12-16 mu. Drawings in plates show various stages of development of conidiophores and conidia.

(40) Weston, W. H., Jr. and Weber, Geo. F.
1928 Downy mildew (Sclerospora graminicola) on Everglade millet in Florida. Journ. Agr. Res. 36: 935-963. 2 plates. June 1, 1928.

Sclerospora graminicola was found on Chaetochloa magna ( - Setaria magna) or Everglademillet in Florida 1922. This host is indigenous, perennial and common on low ground in Florida. Photomicrographs of oospores, also other figures shown. Discussion of disease, of organism, and of importance. Conidia 13-36.9 x 11-24.9 mu, usually 15-27 x 13-21 mu; oospores 19-45 mu, usually 27-39 mu, a majority 30-36 mu.

(41) Weston, W. H., Jr.
1929 A new Sclerospora from Fiji. Phytopath. 19: 961 - 967. Oct. 1929.

Described S. northi which attacks Erianthus maximus var. Seemanni causing shredding of leaves similar to effects of formation of oogonia in sugarcane attacked by S. sacchari, in Miscanthus by S. miscanthi and in Setaria (Chaetochloa) by S. graminicola. Conidia not known.

In discussing relationship and characters of Sclerosporas on members of the tribe Andropogoneae casts doubt on validity of S. miscanthi, S. sacchari, and S. spontanea as distinct species.

States that Mr. D. S. North reports a leaf-splitting disease of "Veico", a wild cane (probably Saccharum spontaneum), fungus perhaps S. spontanea. Also Sclerospora sp. on cultivated cane, formerly assumed to be S. sacchari but now thought by North to be distinct as it does not cause elongation of the shoots, rarely shows the downy conidial phase, and produces oospores more readily, accompanied by more leaf splitting.

(42) 1932 Weston, W. H., Jr., and Uppal, B. N.
The basis for Sclerospora sorghi as a species. Phytopath. 22: 573-586. June, 1932.
Detailed study of measurements of conidia and oospores of S. sorghi on sorghum and S. graminicola on Pennisetum typhoideum, structural and physiological distinctions discussed, drawings.

(43) 1939 Bell, Arthur F.
Report of the Division of Entomology and Pathology. in Thirty-ninth Ann. Rept., pp. 45-59. Queensland Bur. Sugar Expt. Stas. (Australia). 1939.
(NOTE. This article was received after the Sclerospora material had been prepared for reproduction. The data presented are in marked contrast with that previously available from Australia.)
"Downy mildew at present constitutes the chief sugar-cane disease problem in that State, and is, to a considerable extent, a limiting factor in the control of other diseases." (p. 56)
"Field observations over the past two years have strongly suggested the possibility that maize grown in the vicinity of canefields has been responsible for the spread of outbreaks of downy mildew, if not for their initiation." (p. 57)
In a test of possible downy mildew hosts, interplanted with downy mildew diseased sugar-cane, all three varieties of Zea mays "rapidly became heavily infected and produced spores in quantity from both surfaces of leaves. Leaf streaks were readily visible on all sorghums, but no visible downy mildew was produced; on only one occasion were a few spores scraped from the leaves of Natal 6, but nothing from the other varieties. A few odd leaf streaks and a few spores and sporophores were observed on Johnson grass on one occasion, a few leaf streaks but no spores on Soudan grass, and no symptoms or spores on the remainder. Sugar cane was

reinfected by the exposure of freshly-cut setts of the variety P.O.J. beneath the leaves of diseased maize.

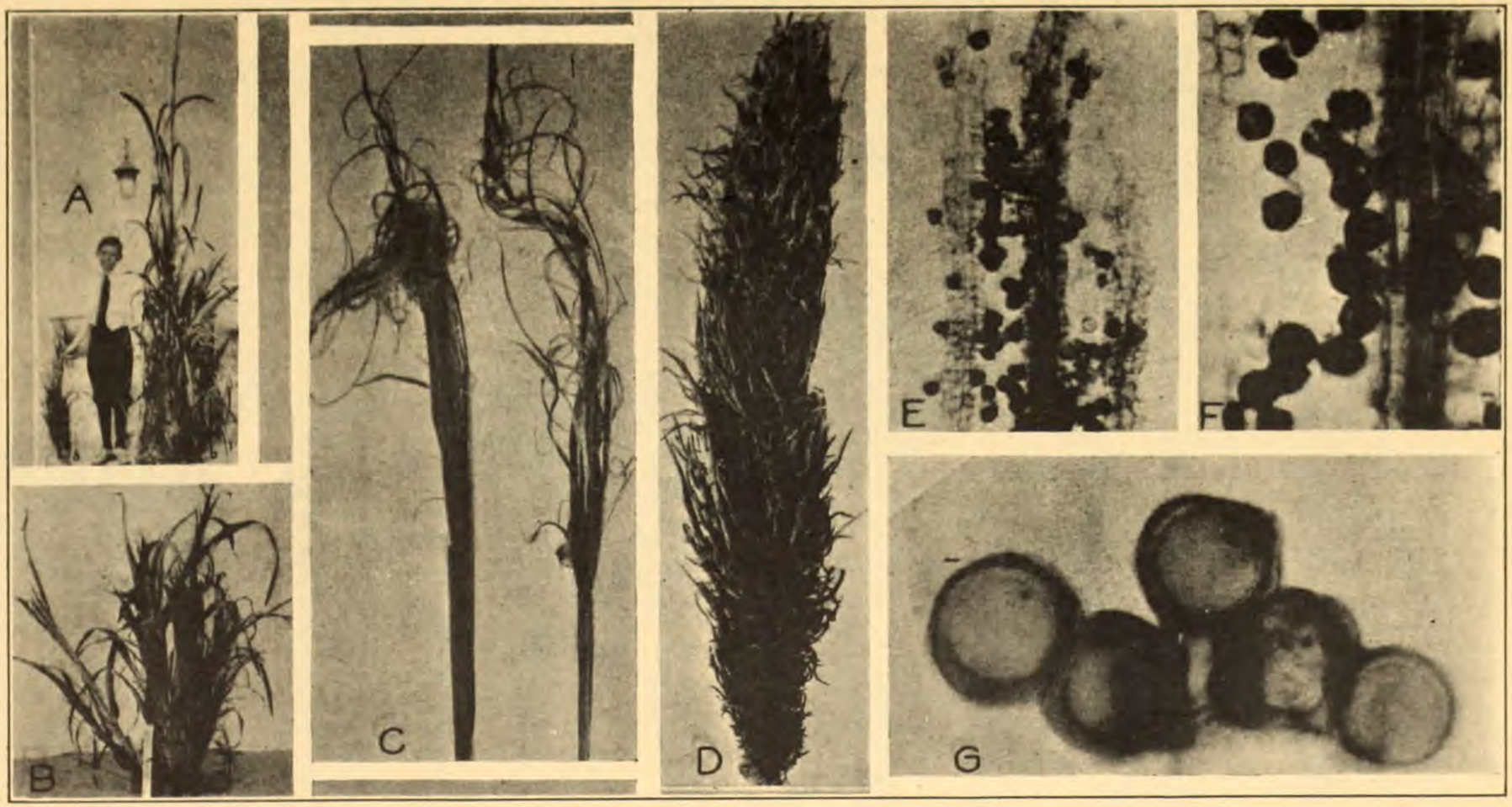
The results of this trial and current field observations have indicated that maize is readily infected with sugar-cane downy mildew, that infection sweeps through the maize in the course of a very few weeks, and that the disease produces a marked stunting of plant and cobs. The ultimate course of the fungus in the maize plant has not yet been determined, but it is obvious that planting of corn in the vicinity of sugar-cane, in the presence of downy mildew, must be condemned."

The corn and sorghum varieties tested are listed as "(a) Zea mays L.: 3 varieties - Imperial Yellow Dent, Funk's 90-Day, and Reid's Yellow Dent. (b) Sorghum app. Snow.: 3 varieties - Natal 6, Wheatland Milo, and American Early Red."

Minimum temperature for sporulation is about 16° C., maximum about 31° C. with no well defined optimum, in tests made. Daily exposure to sunlight seemed to be necessary to produce daily sporulation.

Sclerospora spp.

Plate 1, Sclerospora graminicola

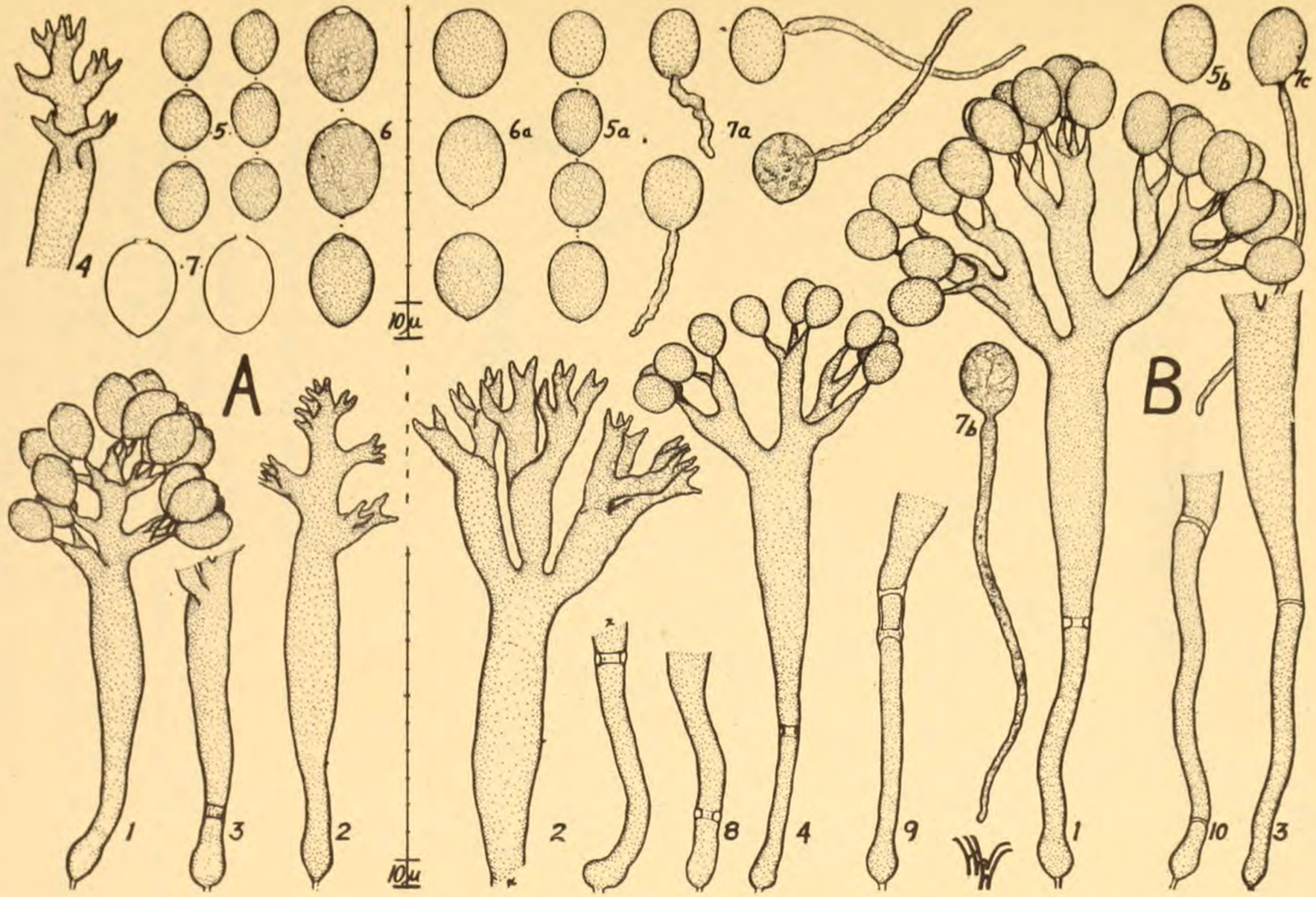



A. Everglade millet infected with S. graminicola (left) and healthy (right).
B. Everglade millet stunted by long standing systemic infection.
C. Shredding of tops following formation of oospores.
D. Infected head largely transformed into a mass of elongated bracts.
E, F, and G. Oospores as seen at different magnifications - G treated to bring out structure.

(From Jour. Agr. Res. 36: 935-963. June, 1928. Plate 2)

Sclerospora spp.

Plate 2 S. graminicola and S. sorghi

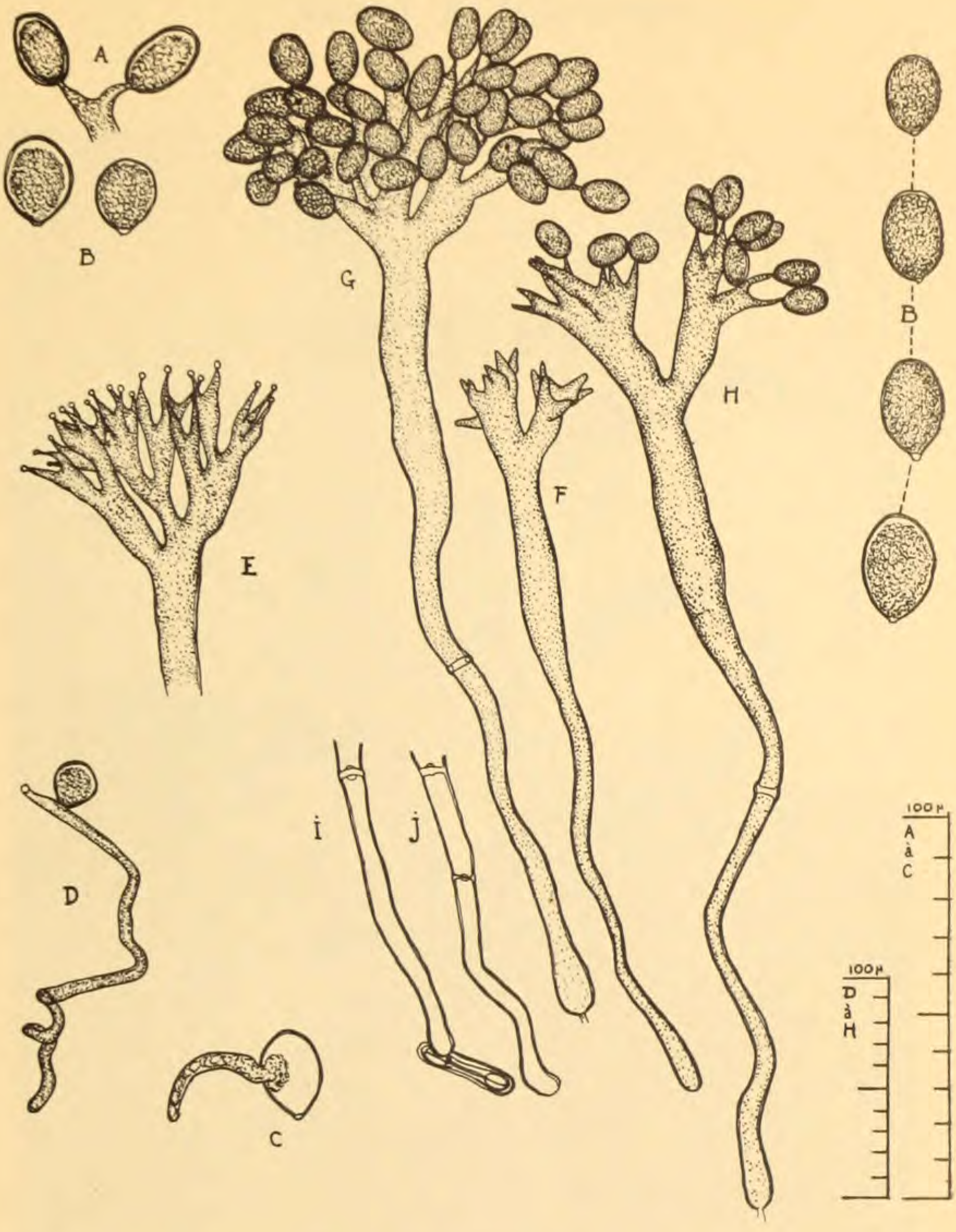



A. --S. graminicola on Pennisetum typhoideum, 1-4 conidiophores, 5-7 conidia showing papillae through which zoospores emerge at germination.
B. --S. sorghi on sorghum, 1-4 and 8-10 conidiophores, 5-7 conidia, showing that germination is by formation of hyphae.

(From Phytopath. 22: 573-586. June, 1932. Plate I.)

Sclerospora spp.

Plate 3 S. maydis




A.--Sterigmata bearing conidia.
B.--Conidia.
C, D.--Germination of a conidia.
E.--Conidiophore with conidia beginning to form.
F.--Poorly developed late conidiophore before formation of conidia. G.--Fully developed conidiophore prior to dehiscence of conidia. H.--Conidiophore from which conidia have begun to dehisce. I, J.--Septation of basal cells.

(From Publ. Inst. Nat. Etude Agron. Congo Belge Ser. Scient. No. 13. 1937, Plate, page 14.)

Sclerospora spp.

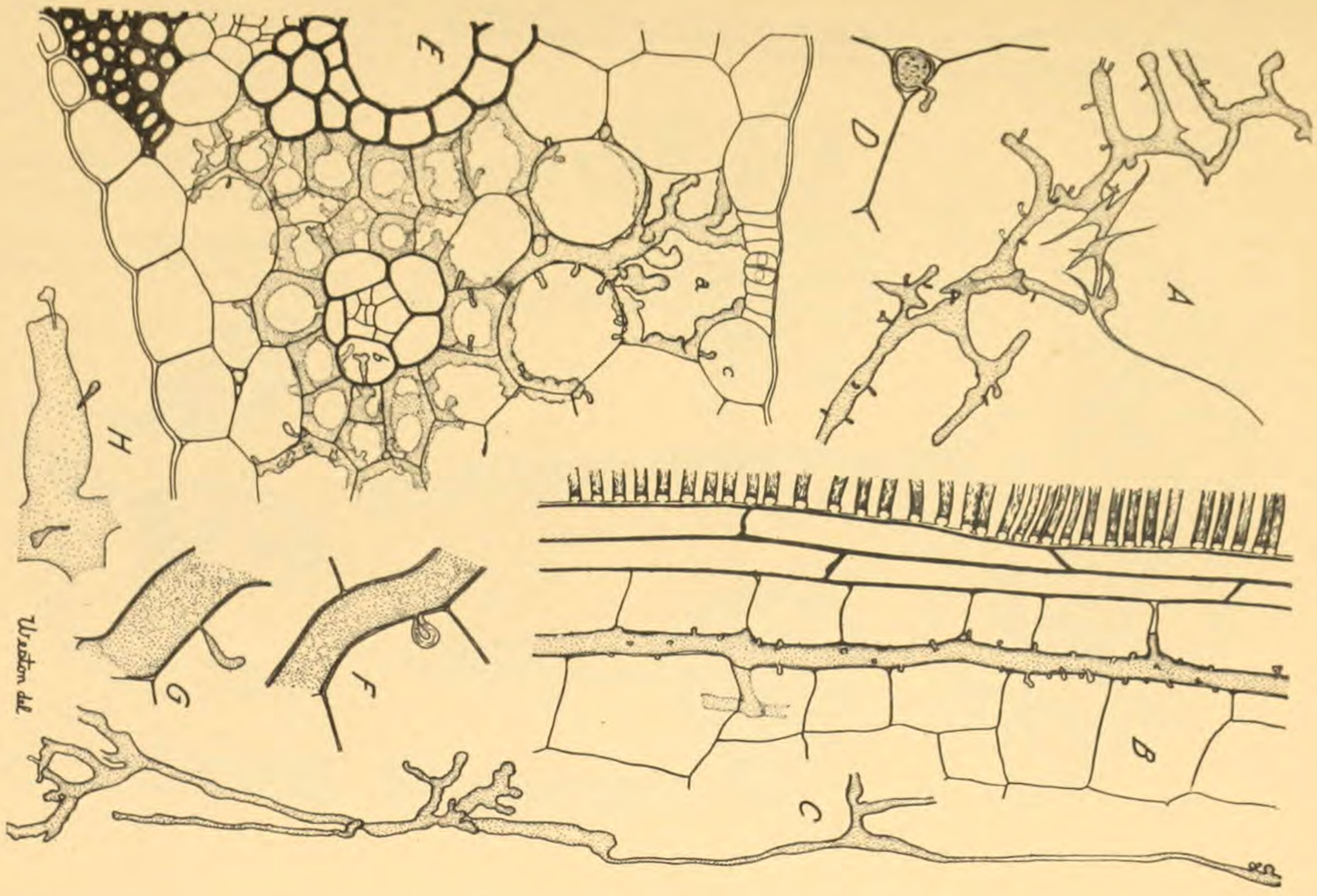
Plate 4 S. philippinensis

Young plants of Guam White Dent maize, the two on the right showing chlorotic condition caused by S. philippinensis. The plants are 31 days old and developed symptoms of the disease 25 days after emerging from the soil.

(From Jour. Agr. Res. 19: 97-122. May, 1920. Plate B)

Plate 5 S. philippinensis

Sclerospora spp.

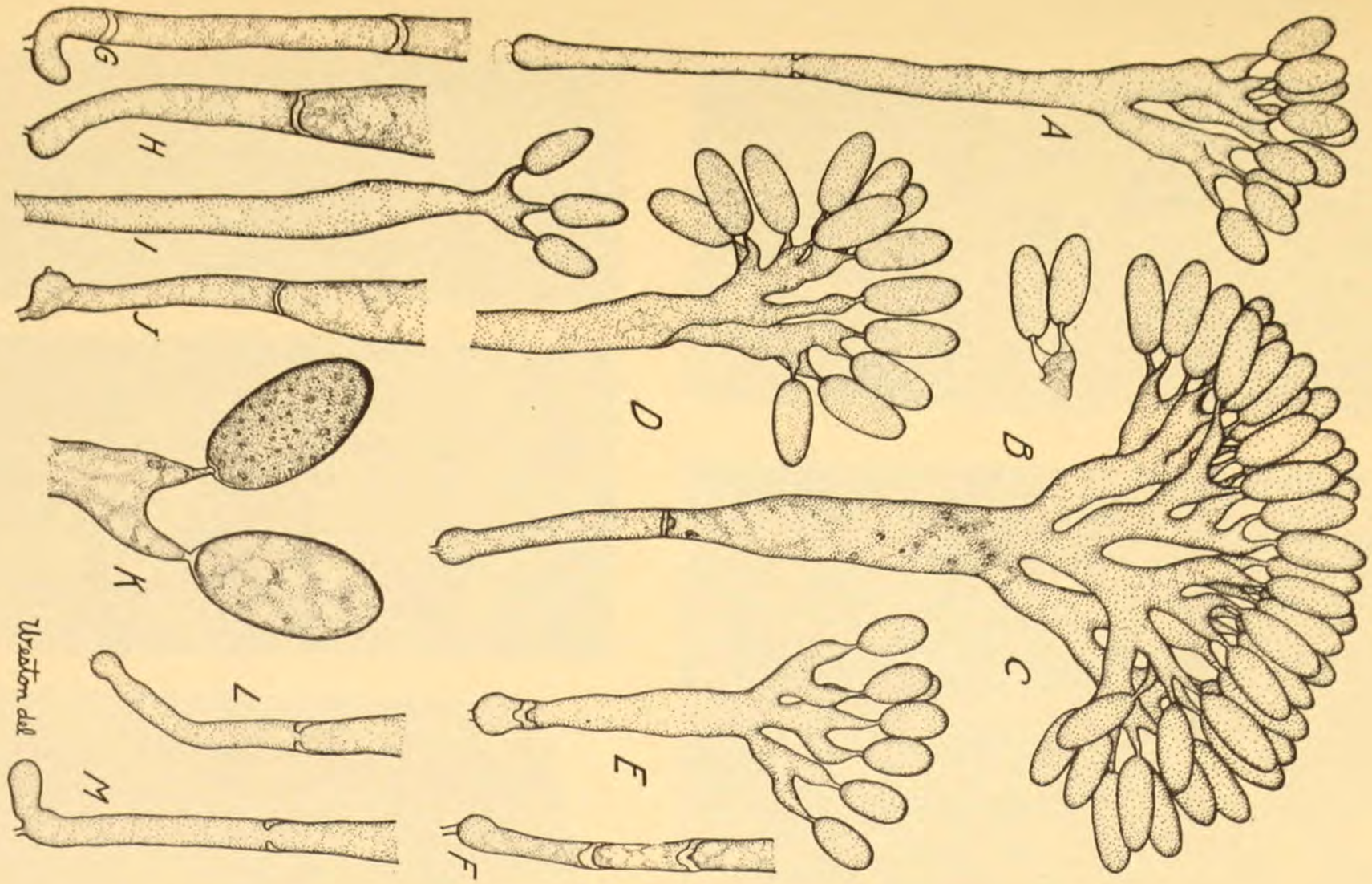



A, B, C. Mycelium, showing numerous haustoria in A and B. (x 375).
D, F, G, H. Haustoria further enlarged. (x 850).
E. Transverse section from a badly diseased maize leaf. (x 375). Conidiophores form from mycelial branches such as those shown forming at (a) before growing through the stoma.

(From Jour. Agr. Res. 19: 97-122. May, 1920. Plate 23)

Sclerospora sp.

Plate 6 S. philippinensis

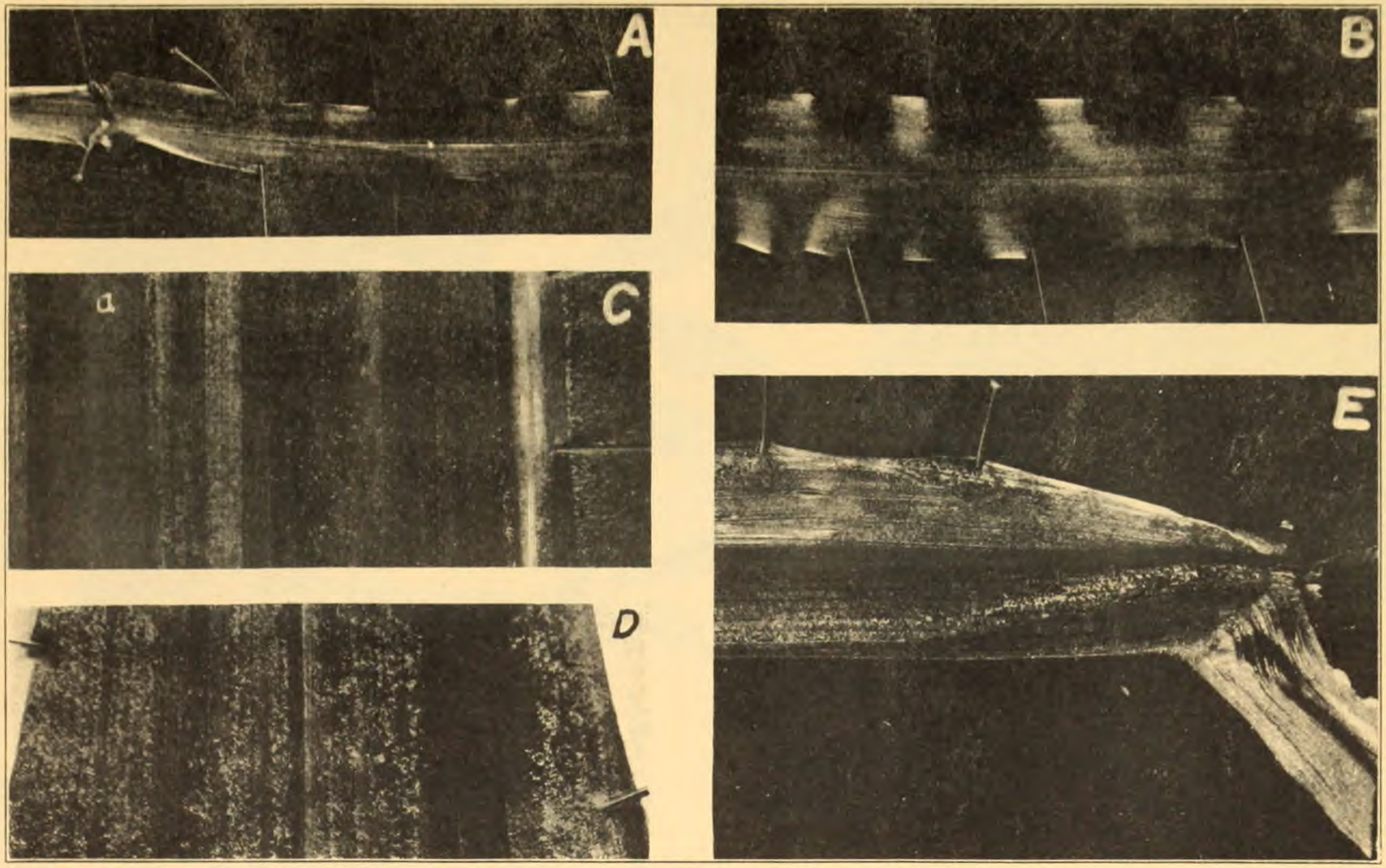



Conidiophores, immature (A, I); nearly mature (D); and mature (C, E, latter stunted by hot, dry season). H, J, L, typical basal cells and F, G, M showing some variations. B.--Tip of a branch showing two conidia from stained material (x 750). K.--Tip of ultimate branch with right conidium shown as in section and left in surface view (x 850). All except B, G, K, and M from fresh material. G, I, and M material from teosinte, others from maize.

(From Jour. Agr. Res. 19: 97-122. May, 1920. Plate 24)

Sclerospora spp.

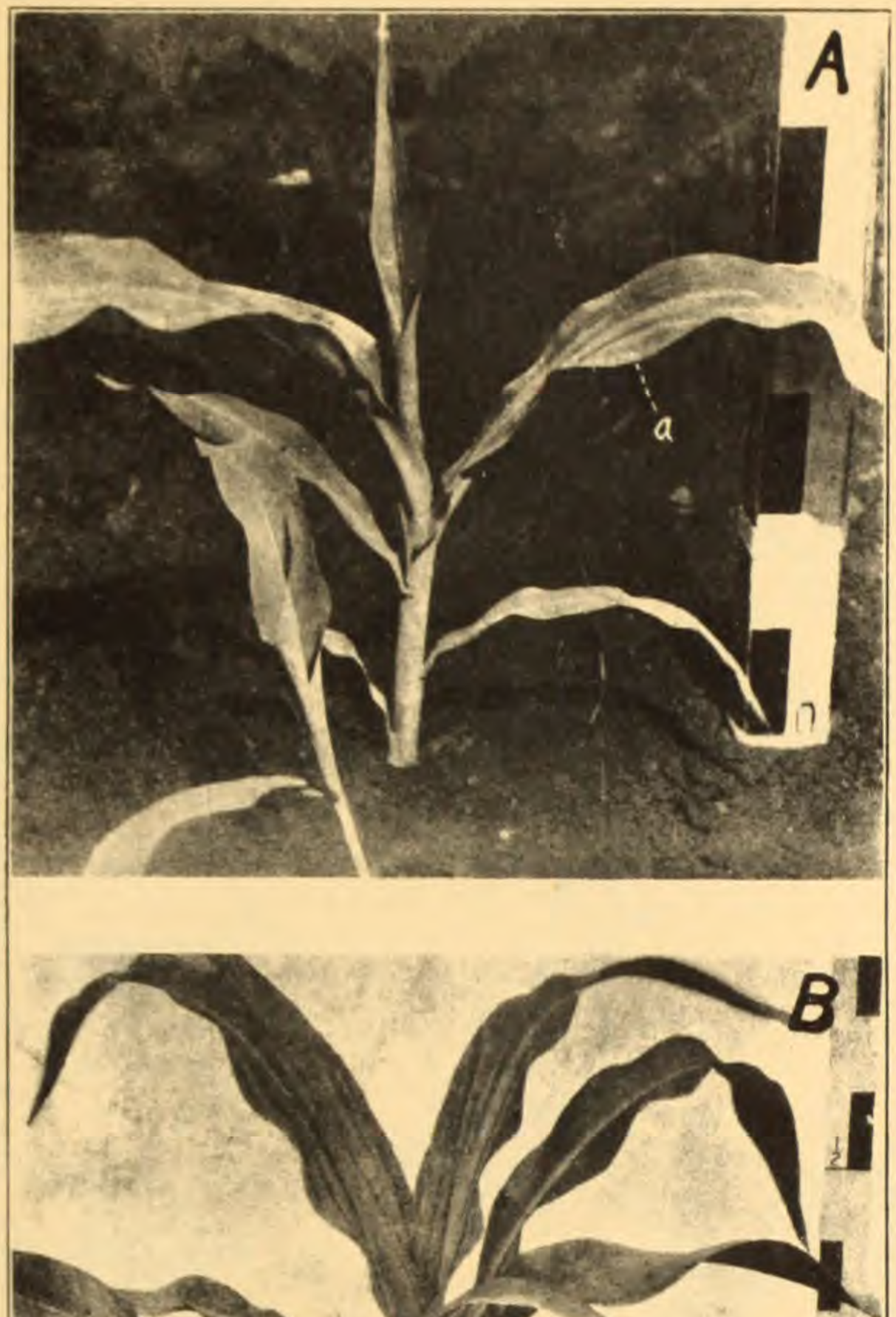
Plate 7 S. philippinensis




A and B. Etiolated markings due to S. philippinensis on maize - natural size.
C, D, and E. Downy growth of conidiophores of S. philippinensis on maize leaves (C & D) and sheath (E).

(From Jour. Agr. Res. 23: 239-278. Jan. 27, 1923. Plate 4)

Plate 8 Sclerospora (species not given)

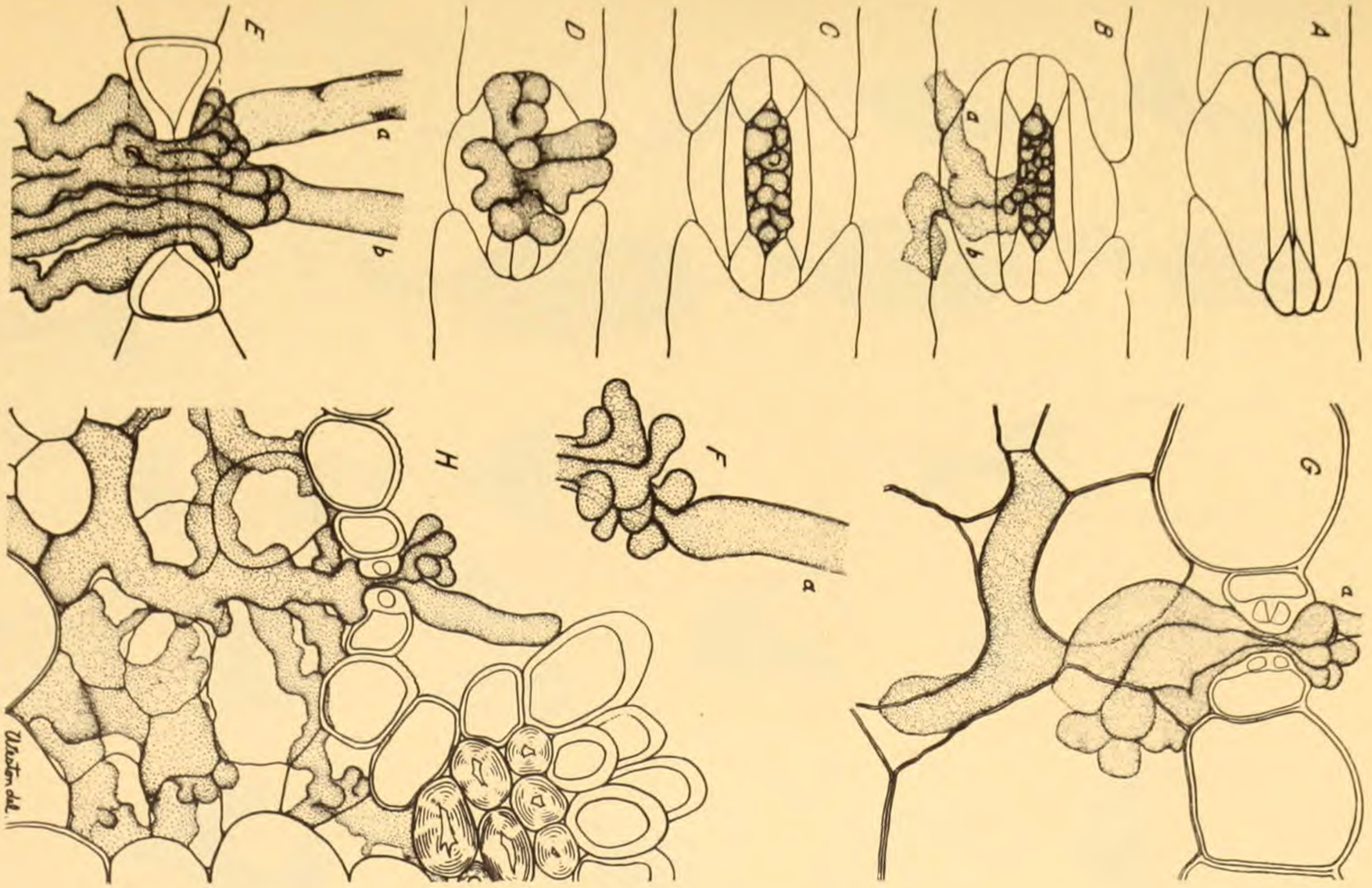



A. Two young maize plants (Guam White Flint) 10 days after emerging; the smaller and nearer one, healthy; the larger one already infected and showing (at a) the etiolated conidiophore-bearing areas characteristic of the downy mildew.

B. The same plants about a month later. The conidiophore-bearing area which was inconspicuous and occupied only a few square centimeters on the leaves of the young plant is now very extensive and conspicuous and supports the production of vast numbers of conidia each favorable night. The meter stick, which is the same as that shown in A, is marked off in 5-cm. divisions.

(From Four. Agr. Res. 23: 239-278. Jan. 1923. Plate 2)

Plate 9 S. spontanea Sclerospora sp.

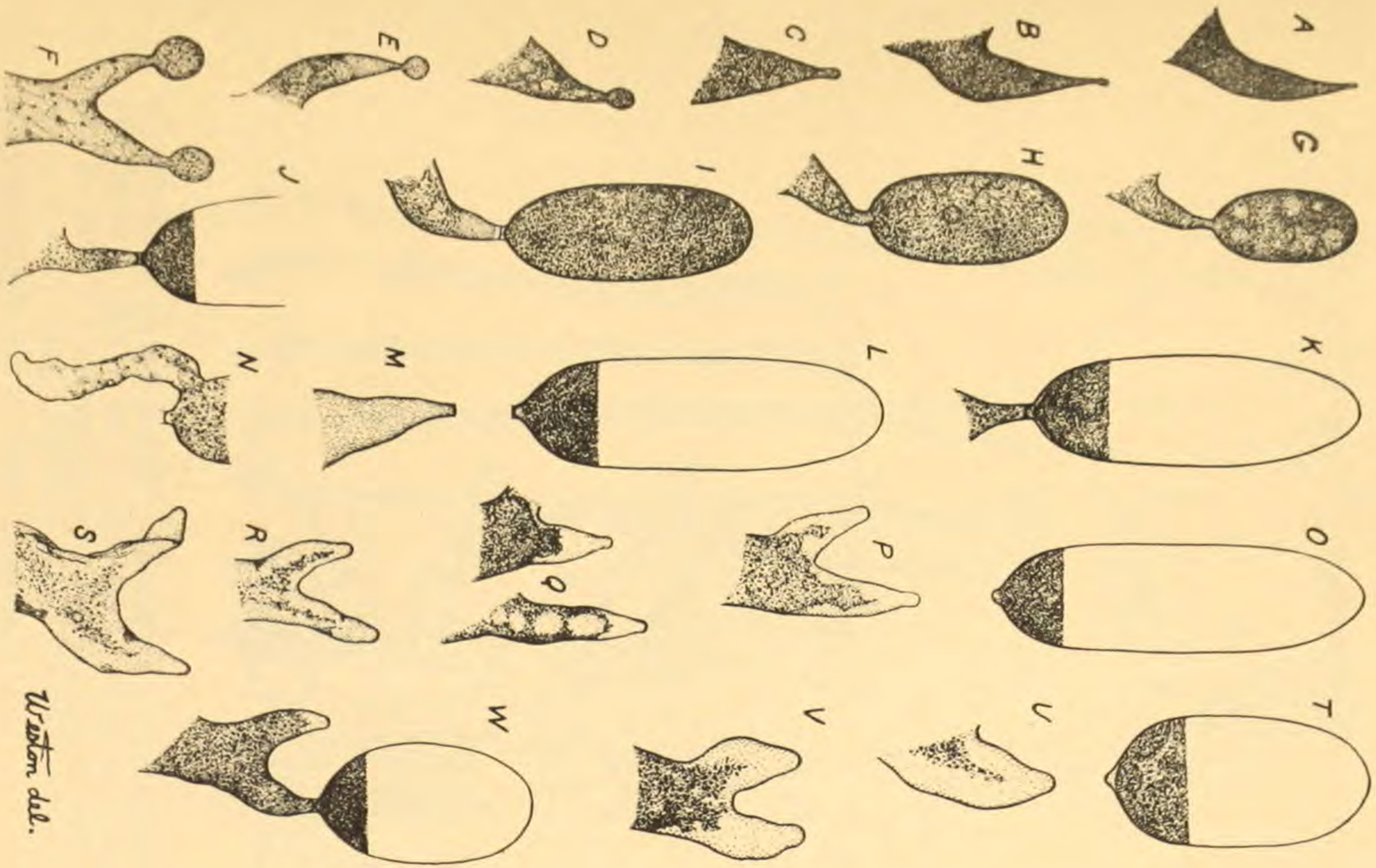



A - D. Stages in the development of the branches from which the conidiophores arise.
E. Another stoma showing these branches in corss-section.
F. A detail of development similar to E.
G & H. Cross-sections of similar material showing more host tissue.
The base of a mature conidiophore shows at (a) of figure G and in H one of the knob-like structures protruding from the stoma has begun to elongate into a conidiophore.

(From Jour. Agr. Res. 23: 239-278. Jan. 1923. Plate 7)

Sclerospora spp.

Plate 10 S. spontanea and S. philippinensis




A - K.--Successive stages in the development of the conidia of S. spontanea from the tips of the sterigmata. Material found on maize, 2-3 a.m. x 1000

L, M, N--Showing break where conidia were broken off prematurely.

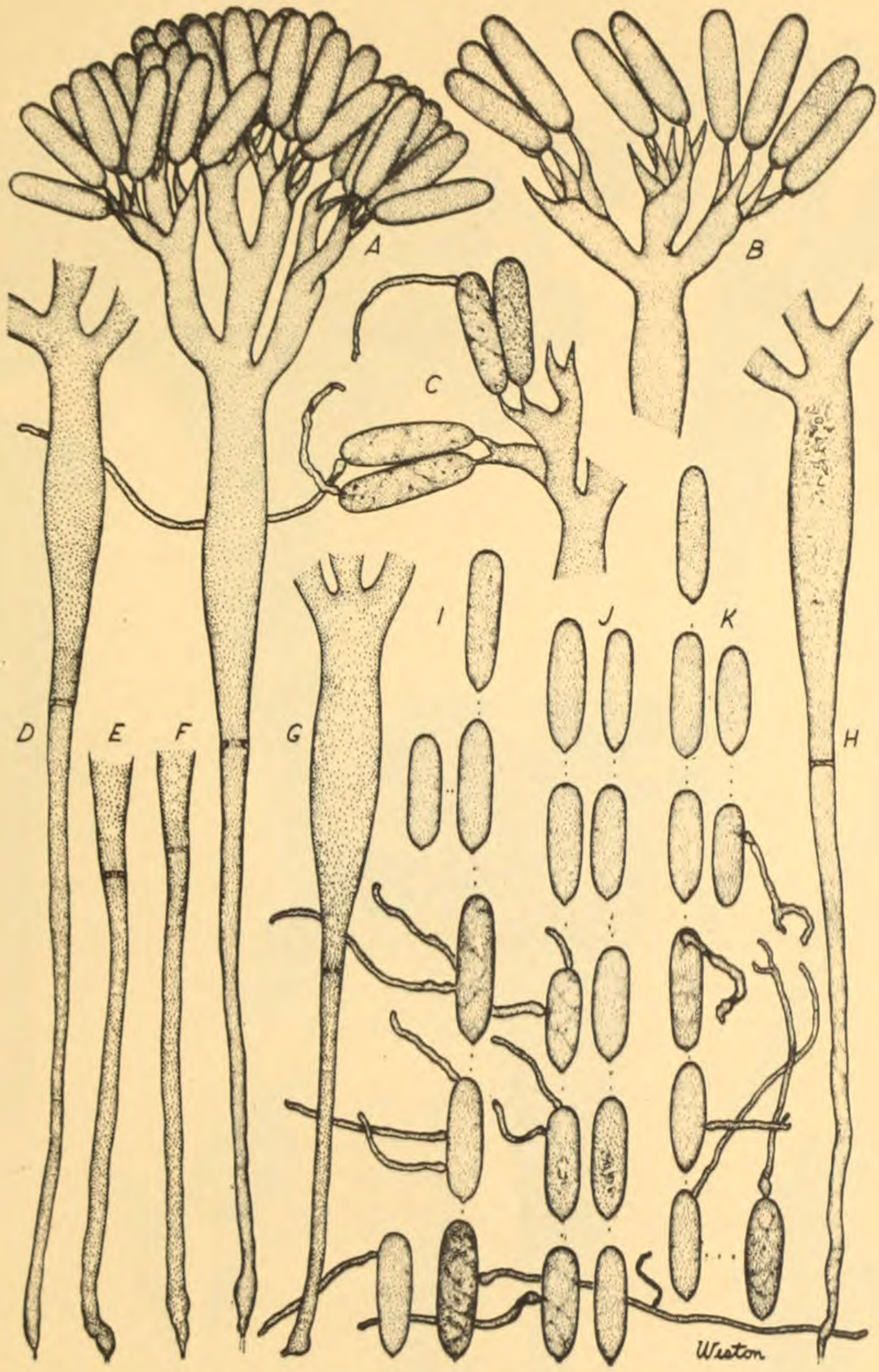
O - S.--Showing shape of papilla of attachment of the conidia and rounded tip of sterigmata when conidia are thrown off naturally.

T - W.--S. philippinensis conidia and sterigmata showing shape of points of separation when separation is natural. x 1000.

(From Jour. Agr. Res. 23: 239-278. Jan. 1923. Plate 9)

Sclerospora spp.

Plate 11 S. spontanea




A.--Typical and B poorly developed conidiophores. C.--Conidia germinating while still attached. D-H.--Typical basal portions (D, E, and G from Saccharum spontaneum; F and H from sugarcane). I, J, K.--Typical conidia, some germinating (I from maize, J from S. spontaneum and K from sugarcane).

(From Jour. Agr. Res. 20: 669-684. Feb. 1921. Plate 79)

Sclerospora spp.

Plate 12 S. sacchari after Miyake (No translation of legend available)