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A STUDY OF THE FRUIT DISEASES OCCURRING IN A MID-WESTERN MARKET[1]

By GEORGE W. FISCHER

INTRODUCTION

Diseases occurring in a market represent to a fair degree the diseases of fruits and vegetables in the field, since, in the majority of cases, the diseases appearing and developing in the markets are but a delayed expression of infection which occurred in the field. Furthermore, since fruits and vegetables in the markets have been shipped in from various sections of the country as well as from foreign lands, the diseases of these plant products represent not only the phytopathological conditions of the local state or country, but also those of any other part of the world whence they came.

In 1927-28, a survey was made of the vegetable diseases occurring in the Evanston (Illinois) markets.[2] In order to supplement this phytopathological survey of the local markets, a study of the fungi occurring on fruits, together with the diseases produced by them, has been undertaken by the writer.

The responsibility for the presence of diseased fruit in the markets cannot be assigned wholly to producer, neither to transporter, nor to commissioner and retailer; and the absence or paucity of such fruit in a market can result only from the cooperation of these three organizations. That these organizations recently have been cooperating and with success, is evinced by the fact that, during the writer's current investigations, in only a few cases was any disease prevalent to the extent of causing conspicuous loss to the retailer. A large number of diseases were found, but the vast majority were not of conspicuous occurrence. It must be recognized, however, that the present survey has been undertaken only during the fall and winter months (October to April, 1928-29), the months of low temperatures and easy control of diseases from a standpoint of refrigeration. Had the survey included the warmer months, it is indeed probable that quite different results would have been obtained.

[1]Thesis submitted to Graduate School of Northwestern University for the degree Master of Science, but published at Butler University, where the author is now an instructor.

[2]This survey was undertaken by M. S. Dawson. Results are now pending publication.

METHODS AND MEDIA

In collecting material for study, periodical visits were made to the various local fruit markets, and fruit bearing any signs or symptoms of disease was taken. Fruit as it occurred in the box or crate was inspected, as well as that on display. Fruit discarded by the dealers, because of the presence of disease, naturally proved to be the best source of fruit pathogenes.

The diseased fruit was prepared for study in the usual manner by washing first with 0.1 per cent. aqueous solution of mercuric chloride, and then with sterile distilled water. The fruit was then placed in sterile, moist chambers in a warm location (about 19-20 degrees C.) where further development of the diseases took place. Under these conditions, the pathogenes usually produced the various types of fruiting bodies and spores. Single spore cultures were then made by the spore dilution method, and stock cultures were ultimately made of each pathogene so isolated. In the case of fungi which under these conditions would not sporulate readily, as, for example, those causing diseases of cranberry *(Vaccinium macrocarpon Ait.)*, cultures were made by the tissue fragmentation method.

Five different media were used: Blakeslee's agar, corn meal agar, sterilized green beans, cranberry agar, and bread. Of these, Blakeslee's agar proved to be the best. The formula, given by Povah (11), follows:

Dry malt extract	20 grams
Dextrose	20 grams
Peptone	1 gram
Agar-agar	20 grams
Distilled water	1 liter

This seems to be by far the best all-round medium, as the pathogenes grew rapidly on it, and produced not only good vegetative growth but usually spores also. All forms cultured on this medium retained their vitality for at least three months, and some even longer. Indeed, it has been shown by Povah (12) that cultures varying in age from three months to five years may still show vitality and resume growth when hot agar is poured into the tube.

The well-known corn meal agar was prepared by the method described by Shear and Wood (16). The supposed advantage in this medium is the production of perfect stages of Fungi Imperfecti. Mycelial, or vegetative growth, is often extremely scant upon this medium, and in all cases much slower than upon Blakeslee's agar.

Green beans proved to be an excellent medium. They were prepared as follows: One green bean was placed in each of a number of test tubes and to each was added about 5 cc. of distilled water. The tubes were plugged and autoclaved at fifteen pounds pressure for one hour. This medium is inferior to Blakeslee's agar in that it is consumed much more rapidly, and hence cultures must be transferred more often. Sterilized green beans are superior to any other medium used, since, for any particular pathogene, growth was more rapid and spore production more luxuriant.

Cranberry agar was used in an effort to induce sporulation of those cranberry fungi which are apparently sterile on all other media used. Other pathogenes were also cultured on this medium, but the results do not justify its further use. Bread was used for various species of Mucor, since Povah (11) has shown the advantages of its use as a standard medium for the study of all the Mucorales.

With a view toward having some kind of record of the comparative growth of the pathogenes on the various media, a table was prepared to show this comparative growth on the three media which were used most extensively in this work, namely, Blakeslee's agar, corn meal agar, and sterilized green beans. The data so obtained is given in Table I.

INOCULATION METHODS

In many cases it became desirable to inoculate various hosts with certain pathogenes, either for the purpose of proving pathogenicity or studying the development of the pathogenes on their hosts.

All fruit before inoculation was thoroughly washed with 1-1000 solution of mercuric chloride, rinsed with sterile distilled water, and then placed in sterile moist chambers.

Inoculations were made by the wound method, that is, the fruit was stabbed with a spear-point needle (previously sterilized) carrying spores, or mycelium, or both, of the pathogene desired. In cases where pathogenicity was to be proved, checks or controls were kept.

TABLE I. GROWTH OF PATHOGENES ON VARIOUS MEDIA

This table includes only the pathogenes which were cultured on more than one medium. Explanations of abbreviations and symbols follow the table. Accordingly, Phomopsis citri, for example, should be interpreted thus: on Blakslee's agar the mycelium is rather luxuriant, very few pycnidia are produced, but each contains abundant conidia. No perithecia were observed.

PATHOGENE	BLAKESLEE'S AGAR				CORN MEAL AGAR				STERILIZED GREEN BEANS			
	MYC.	PER.	CON.	PYC.	MYC.	PER.	CON.	PYC.	MYC.	PER.	CON.	PYC.
Acanthorynchus vaccinii	G	F	O	O	P	G	O	O	F	G	O	O
Alternaria citri	E	O	P	O					F	O	G	O
Alternaria mali	G	O	E	O	E	O	G	O	F	O	G	O
Botrytis cinerea	G	O	G	O	P	O	O	O	F	O	G	O
Cephalothecium roseum	P	O	E	O	P	O	F	O	P	O	G	O
Colletotrichum gleosporioides	F	O	E	O	P	O	G	O				
Diplodia natalensis	E	O	F	F	P	O	F	G	G	O	G	G
Fusicoccum putrefaciens	G	O	G	F					G	O	E	G
Gleosporium musarum	F	O	G	O	F	O	G	O				
Glomerella cingulata	E	P	P	O	F	P	P	O	G	O	F	O
Glomerella cingulata vaccinii	G	O	G	O					G	O	F	O
Guinardia vaccinii	G	O	P	G	P	O	P	P	G	O	P	G
Monilia sitophila	F	O	E	O	F	O	F	O				
Penicillium expansum	P	O	E	O	P	O	F	O				
Pestalozzia guepini	G	O	E	F	P	O	E	E	P	O	E	E
Phoma mali	G	O	E	G	P	O	E	E	F	O	E	E
Phomopsis citri	G	O	E	P	F	O	G	P	G	O	E	E
Physalospora malorum	G	O	G	F	G	O	G	G	E	O	G	E
Pleospora mali	G	G	G	O	F	G	F	O				
Sclerotinia fruticola	G	O	G	O					F	O	G	O
Sporonema oxycocci	G	O	G	F					F	O	G	G
Thielaviopsis paradoxa	G	O	E	O	P	O	E	O	E	O	E	O
Trichoderma lignorum	G	O	E	O	P	O	P	O				

Abbreviations—MYC.=vegetative mycelium; PER.=perithecia; CON.=conidia; PYC.=pycnidia.
Symbols—E=luxuriant or abundant; G=good or moderate; F=scant or few; P=poor or very few; O=none.

DISEASES FOUND AND PATHOGENES ISOLATED

The hosts, twenty-two in number, are treated separately and in alphabetical order. In order to avoid repetition of material readily obtainable elsewhere, the diseases and pathogenes will merely be listed according to host, except in cases where more lengthy consideration is justified. The only comprehensive "Check List of Diseases of Economic Plants" is that published by Anderson *et al.* (1) in 1926, and, unfortunately, it is not complete. Reference to this work is frequently made.

1. Amygdalus Persica L. (Peach)

Anderson *et al.* (1) list some nine or ten diseases that might be expected to occur. Peaches had almost disappeared from the markets when this survey was made, and consequently the observations on this host are almost negligible. One disease was found.

Sclerotinia fruticola[1] (Wint.) Rehm. Brown Rot—Common and very destructive during this survey.

2. Ananas Sativus Schult. (Pineapple)

Thielaviopsis paradoxa (De Seyn) Hoehn. Soft Rot—This disease was common in the markets. According to Link and Gardner (8), so common and destructive is it that in shipments of Cuban pineapples 15-25 per cent. losses due to Thielaviopsis rot are accepted as a matter of course. Cobb, according to Edgerton (4), states that the macroconidia produced by this fungus will germinate only after a period of rest. The writer, however, has germinated freshly formed macroconidia on Blakeslee's agar, where they develop a mycelium rapidly. Prompt germination of microconidia is undisputed.

The cultural characteristics of this fungus are peculiar enough to justify some mention. Within twenty-four hours after inoculation on Blakeslee's agar a distinct odor is produced which is strongly suggestive of stewed apricots. Within another twenty-four hours a stronger and even more pleasant odor is developed. This second odor is probably due to the formation of an ester, probably ethyl-acetate. On the third day, however, all odor is gone, and no odor has ever been noticed subsequent to the third day. The pycnidial stage, mentioned by Patterson *et al.* (10), was not observed.

Trichoderma lignorum (Tode) Harz. Trichoderma Rot—A minor disease, but collected on several occasions.

[1]The nomenclature of Roberts and Dunegan (15) has been followed.

3. Citrus Aurantifolia Swingle. (Lime)

Diplodia natalensis Ev. Stem-End Rot—Rare during this survey, having been found only once. Although not found on any other citrus host, cross-inoculations to grapefruit, oranges and lemons were very successful; in each case the typical Diplodia stem-end rot was produced. (See Plate V, Fig. 10.) Conidia of *Diplodia natalensis* are shown in Fig. 9, Plate III.

Penicillium digitatum (Fr.) Sacc. Green-Mold Rot—Very common and destructive.

4. Citrus Grandis Osbeck. (Grapefruit)

Phomopsis citri Fawc. Stem-End Rot—Common and destructive during this survey. Affected fruit placed in moist chambers or artificially inoculated, developed an appearance such as is shown in Fig. 9, Plate V.

Oospora citri-aurantii (Ferraris) Smith. Soft Rot, Sour Rot, Oospora Rot—This disease of citrus fruits was found a number of times during the present survey, and every fruit attacked was rendered not only worthless, but obnoxious, due to the foul odor which usually accompanies the later stages of the disease. The pathogene is illustrated in Figs. 15 and 16, Plate III.

Penicillium digitatum (Fr.) Sacc. Green-Mold Rot—This disease was the cause of more loss to the retailer than any other disease found on grapefruit.

Colletotrichum gleosporioides Pens. (*Glomerella cingulata* (Ston.) Spauld. and Schrenk). Anthracnose, Anthracnose Rot—This is a minor disease, fairly common, but never destructive, as observed during this survey.

5. Citrus Limonia Osbeck. (Lemon)

Penicillium italicum Wehm. Blue-mold rot.

Penicillium digitatum (Fr.) Sacc. Green-Mold Rot—These diseases, as usual, were very common and destructive, and were the source of considerable loss. They were the only diseases found on this host.

6. Citrus Nobilis Lour. (Tangerine)

Phomopsis citri Fawc. Stem-End Rot—This disease was found on numerous occasions, causing appreciable loss.

Penicillium digitatum (Fr.) Sacc. Green-mold rot.

Penicillium italicum Wehm. Blue-mold rot.

7. Citrus Sinensis Osbeck. (Orange)

Oospora citri-aurantii Smith. Sour Rot—Of rather common occurrence. Artificial inoculations were very successful; each time the characteristic wrinkled appearance resulted, as shown in Plate IV, Fig. 2.

Alternaria citri Pierce. Black Rot—Black rot was found on numerous occasions on navel oranges, but rarely to the extent that the fruit attacked was rendered unsalable. Bartholomew (3) states that it is as yet undetermined whether or not the fungus causing the Alternaria rot of lemons is the same as that causing the black rot of the navel orange. The writer has successfully cross-inoculated lemons with *Alternaria citri* from navel oranges. The decay so produced was very similar to that described for Alternaria rot of lemons, especially type No. 2 of Fawcett and Lee (6). It seems probable that the black rot of oranges and the Alternaria rot of lemons have the same casual organism. Oranges infected with *Alternaria citri* and placed in a moist chamber soon showed considerable signs of the disease, as illustrated by Figs. 11 and 12, Plate V.

Penicillium digitatum (Fr.) Sacc. Green-mold rot.

Penicillium italicum Wehm. Blue-Mold Rot—These were the most destructive diseases of oranges in the local markets. Local fruit dealers, in saving diseased fruit for the author, would often have ten or a dozen oranges laid away, all affected with blue and green-mold rots.

Fusarium sp. Fusarium Rot—Among the pathogenes isolated from diseased oranges was a Fusarium, belonging to the section Roseum of Sherbakoff (17). The fungus is apparently a weak parasite, since ripe fruit which had remained too long in the markets seemed to be especially suspectible. Turrley (18) reports a Fusarium on grapefruit which produces a rot of very similar behavior. Sound oranges inoculated with this Fusarium developed the characteristic, slow-developing, tough, brown rot illustrated in Fig. 7, Plate V.

Colletotrichum gleosporioides Penz. Anthracnose Rot—As with grapefruit, this disease is only a minor one, due to the fact that it develops so slowly, and attacks, chiefly, over-ripe fruit.

8. Cucumis Melo L. (Canteloupe, Melon, Etc.)

This host includes such melons as honey dew, Persian melon, canteloupe, muskmelon, etc. Two of the six pathogenes isolated from these melons are probably heretofore unreported.

Alternaria sp. Alternaria Fruit Spot—This was by far the most conspicuous pathogene isolated from melons during this survey. The fungus appears to belong to Elliot's (5) *Alternaria brassicae* var. *microspora* group. The disease is evident as soft, discolored spots, often with white or gray mycelium on the surface (Plate V. Fig. 8).

On Blakeslee's agar the fungus is mouse-gray (Ridgway, 13) above and black beneath. Conidia from agar cultures are ovate, obovate or short clavate, often verrucose, dark brown, transversely 1-3 septate, and occasionally with one longitudinal septum. The size is variable, ranging 10.5-17.5 x 5.5-10.5 microns, but averaging 12-16 x 7-10.5 microns.

Monilia sitophila (Mount) Sev. Soft Rot—This fungus has not previously been reported as parasitic on melons, yet the writer has collected it from both cassaba and honey dews, and, by artificial inoculations, established its pathogenicity on these hosts. It produces a soft rot, developing with fair rapidity. The affected areas, especially in a moist chamber, become covered with a beautiful fluffy, salmon-orange (Ridgeway, 13) mass of mycelium and spores. When inoculated into healthy honey dew melons, the fungus produces a decay like that described above.

Rhizopus nigricans Ehrenb. Watery Rot—Not common, but rapid in development and consequently destructive.

Cephalothecium roseum Corda. Pink-Mold Rot—Although this fungus has not previously been reported as pathogenic on honey dews, it has twice been found on these by the author. The rot produced is not rapid and is only a minor disease. It is evident as a small, rather dry, softened area, over which is the characteristic pink covering of conidia and conidiophores. When inoculated into a sound honey dew, the fungus produced a slow, dry decay which soon became covered with pink tufts of conidia and conidiophores.

Fusarium sp. Fusarium Rot—A species of Fusarium belonging to the section Martiella of Sherbakoff (17). The disease produced is a soft decay, over which is developed a mycelium and spores. Blakeslee's agar is turned morocco red (Ridgway, 13) by the fungus. On this medium there is a white surface mycelium. Here and there are produced olive-buff (Ridgway, 13) masses of macroconidia. In old cultures one or more cells of these spores may develop into echinulate chlamydospores. These are mostly terminal (but often intercalary), globose, echinulate, light-brown, and measure 6-12 microns. Microconidia are elliptical, minute, continuous, and measure 4-8 x 2-3 microns. Conidia and chlamydospores are shown in Fig. 13, Plate III.

9. Cydonia Oblonga Mill. (Quince)

Most of the quinces in the local market had some blemishes or disease. In fact, it took considerable inspection to obtain disease-free fruit for inoculation. Of the eight pathogenes isolated from quinces, one *Botrytis cinerea* Pers. has not previously been reported for this host.

Sclerotinia fruticola (Wint.) Rehm. Brown Rot—Brown rot was, without doubt, the most common and destructive of the quince diseases found in the local markets during the past fall and winter.

Penicillium expansum (Link) Thom. Blue-Mold Rot—Common but not as destructive as brown rot.

Fabraea maculata (Lev.) Atk. Black Spot—This disease was by far the most common of those found on the quince. Scarcely a single quince was absolutely free from the disease and most were conspicuously spotted with it. However, the disease is, at most, only a conspicuous external blemish, since the fruit is not affected internally.

Glomerella cingulata (Ston.) Spauld. and Schrenk. Bitter Rot—Bitter rot was not as common on quince as on other hosts studied, and appeared to cause comparatively little damage.

Phoma mali Schulz and Sacc. Fruit Rot—Common but not as destructive as some other quince pathogenes, since the rotted areas seldom attain any great size.

Botrytis cinerea Pers. Gray-Mold Rot—This fungus has apparently not been previously reported as causing a disease of quince fruits. Certain diseased quinces collected during the fall of 1928 developed, in a moist chamber, a rapid, soft, brown rot, which became covered with the grayish-brown mycelium and spores of *Botrytis cinerea*.

That this fungus is distinctly pathogenic on this host was decidedly proved by inoculation experiments. Within forty-eight hours distinct circular decay had started. At the end of five days the rotted area had increased to approximately 30 millimeters in diameter. The decay was not confined to surface tissue, but very early penetrated deeply into the fruit inoculated. The rot soon enveloped the entire fruit, after which the above-described conidial production followed. Figs. 5 and 6 (Plate IV) show a quince five and thirty days, respectively, after inoculation. (Fig. 6 is not the same quince as shown in Fig. 5.)

Cephalothecium roseum Cnrda. Pink-Mold Rot—This pathogene was commonly found around black-spot lesions (caused by *Fabraea maculata)* and occasionally had enlarged these areas. Otherwise the destruction caused by this fungus was almost negligible.

Alternaria mali Roberts. Alternaria Rot—Alternaria rot was of frequent occurrence on quinces during the autumn of this survey. An excellent account of the casual organism, *Alternaria mali,* is given by Roberts (14).

10. Diospyros Kaki L. (Japanese Persimmon)

Botrytis cinerea Pers. Gray-Mold Rot—Collected only once. This disease is apparently uncommon.

Penicillium expansum (Link) Thom. Blue-Mold Rot—This common pomaceous fruit parasite was isolated a few times from persimmons, but was not observed to be as destructive as on quinces or apples.

Alternaria sp. Black Rot—In addition to the two pathogenes described above, a species of Alternaria was also isolated. This fungus has distinctly muriform spores, and belongs to Elliot's (5) *Alternaria tenuis* group.

11. Fortunella Marquarita Swingle. (Oval Kumquat)

Phomopsis citri Fawc. Stem-End Rot—This disease was very prevalent and destructive on kumquats in the local markets. Nearly every basket of the fruit had at least one which was noticeably affected with the disease. It is evident as a very soft, watery decay, usually at the stem end, although this was not always the case.

Alternaria citri Pierce. Black Rot—One kumquat collected was affected with a dark decay, more internal than external. The pathogene was obtained by transfers of diseased tissue to Blakeslee's agar. The fungus resembles *Alternaria citri* in every way, and, in the opinion of the author, is identical with it. Future observations will determine the importance of this disease of kumquats.

12. Fragaria Spp. (Strawberry)

Anderson *et al.* (1) list eight fruit-rotting organisms of the strawberry. Only two of these were found by the writer, however. They were the two most destructive in storage and transit.

Botrytis cinerea Pers. Gray-mold rot.

Rhizopus nigricans Eherenb. Leak—These two diseases were fairly common on strawberries in the local markets, although the latter was not found until the reappearance of strawberries late in February, when it was commonly found.

13. Malus Sylvestris Mill. (Apple)

Of the ten pathogenes isolated from various varieties of apples, only one, *Penicillium expansum,* was conspicuously common. In fact, the apple scab fungus, *Venturia inequalis* (Cke.) Anderh., conceded by most authorities to be the most important pathogene of the apple, was found only once. The answer presents itself immediately. Apple scab is almost entirely a disease of the field, and cannot be expected to be found on the ultra-fancy apples, from well-sprayed trees, such as now grace the markets.

Penicillium expansum (Link) Thom. Blue-Mold Rot—This disease was found on every variety of apple in the markets, and was the source of more loss to the retailer than all the other diseases of this host combined.

Rhizopus nigricans Ehr. Rhizopus rot collected once during the entire survey.

Physalospora malorum (Pk.) Shear. Black Rot—Jonathan, Grimes Golden, Rome Beauty, Yellow Ortley and Spitzenburg were the varieties which were found affected with this disease, which was often found but not to the extent of causing any severe loss. Apples inoculated and left undisturbed were eventually reduced to mummies as shown in Plate IV, Fig. 4. *Physalospora malorum* is illustrated in Figs. 7 and 8, Plate III.

Alternaria mali Roberts. Alternaria Rot—This disease was found a sufficient number of times to indicate that it is an important disease of apples in storage and transit. It was found more frequently on Rome Beauty, Jonathan and Greening than on any other varieties. The decay usually penetrated deep into the apple, as shown in Plate IV, Fig. 3. The fungus is illustrated in Figs. 11 and 12, Plate III.

Mucor griseo-lilacinus Povah. Mucor Rot—Diseased tissue transfers, of a rotted apple collected on one occasion from apples of the Greening variety, to Blakeslee's agar, yielded in every case an interesting species of Mucor, which proved to be *M. griseo-lilacinus.* The fungus produces a rapid, soft, brown rot.

Botrytis cinerea Pers. Gray-Mold Rot—Collected on only one occasion, gray-mold rot of apple seems to be of little importance.

Venturia inequalis (Cke.) Aderh. Scab—This disease was found on one occasion in a basket of poor quality Russets, of which many of the fruit were affected.

Glamerella cingulata (Ston.) Spauld. and Schrenk. Bitter Rot—Bitter rot was collected several times, but the disease was not observed to be in any measure serious.

Pleospora mali Newton. Pleospora Rot—This disease, newly discovered, and its causal organism recently described by Newton (19), was found on one occasion on some apples of undetermined variety. The rotted areas closely resembled those produced by *Alternaria mali*.

Phoma mali Schulz and Sacc. Phoma Rot—This fungus was isolated from rather dry brown, rotted spots on apples, and was first obtained in culture by transferring bits of diseased tissue to Blakeslee's agar. Later, apples were found which had somewhat larger rotted areas, scattered over which were numerous small pycnidia. Fig. 1, Plate IV, shows the result of inoculation of an apple with *Phoma mali*. Conidia are shown in Fig. 4, Plate III. The rot develops comparatively slowly, and is consequently of less economic importance than some other apple rots.

14. Malus Spp. (Crab Apple)

Penicillium expansum (Link) Thom. Blue-Mold Rot—Common on crab apples during this survey.

Physalospora malorum (Pk.) Shear. Black Rot—On only two occasions were crab apples collected which were affected with this disease.

Phoma mali Schulz and Sacc. Phoma Rot—Rare on the markets during current investigations.

Glomerella cingulata (Ston.) Spauld. and Schrenk. Bitter Rot—Also uncommon, being found only twice.

15. Musa Sapientum Linn. (Banana)

Only one disease was found on this host—the common ripe rot or anthracnose.

Gleosporium musarum Cke. and Mass. Ripe Rot—So common was this disease that practically any banana from the local markets became entirely rotted by it if placed in a moist chamber. However, since the disease involves little or no more than the peel of the banana, and since it is associated with the normal ripening of the fruit, it does not cause fruit so affected to be discriminated against by the consumer. *Gleosporium musareum* is illustrated in Figs. 5 and 6, Plate III.

16. Opuntia Tuna Mill. (Prickly Pear)

This fruit is not common on the markets and consequently has been neglected by practically all who have engaged in fruit disease work. The author has found only one pathogene on the prickly pear.

Penicillium expansum (Link) Thom. Blue-Mold Rot—This common parasite of pomaceous fruits was observed to produce a soft, watery, light-brown rot of the prickly pear fruit. Not long after the diseased fruit was placed in a moist chamber, the rotted area became covered with blue-green tufts of conidiophores and conidia. The disease was found only a few times.

17. Persea Americana Mill. (Avocado Pear, Alligator Pear)

Glomerella cingulata (Ston.) Spauld. and Schrenk. (*Colletotrichum gleosporioides* Penz.) Anthracnose Rot—Many avocados were found in the local markets which were more or less severely affected with anthracnose. The disease was evident as a dark-brown, soft rot, sometimes so covered with conidia as to present a shiny brownish pink appearance to the rotted area, which was sometimes quite large.

Pestalozzia guepini Desm. Fruit Spot—This disease was found once on avocado, where it was producing large dirty-white spots with considerable rotted tissue beneath. More or less imbedded in the mycelium of these spots were numerous acervuli of the causal organism. The conidia are illustrated in Fig. 3, Plate III.

Horne (7) also reports a *Pestalozzia* sp. on avocado, but does not assign it to any described species.

18. Prunus Spp. (Plum)

Sclerotinia fruticola (Wint.) Rehm. Brown Rot—Common and very destructive during the short time this fruit was on the market.

Penicillium expansum (Link) Thom. Blue-Mold Rot—Not as common and destructive as brown rot, but was the source of appreciable loss. Infection was nearly always at the stem end.

19. Punica Granatum L. (Pomegranate)

Botrytis cincrea Pers. Gray-Mold Rot—Gray-mold rot is rather slow-developing on this host and hence is not destructive. It was found several times.

Penicillium expansum (Link) Thom. Blue-Mold Rot—Less common but more destructive than the gray-mold rot.

20. PYRUS COMMUNIS L. (PEAR)

Penicillium expansum (Link) Thom. Blue-mold Rot—Of the six pathogenes isolated from pear, blue-mold rot was by far the most common and destructive, and was the source of considerable loss to local fruit dealers.

Sclerotinia fruticola (Wint.) Rehm. Brown Rot—Brown rot of the pear was found only once, and on a collection of the Kiefer variety.

Rhizopus nigricans Ehr. Black-Mold Rot—Found a few times on a few of the softer, fancier varieties.

Glomerella cingulata (Ston.) Spauld. and Schrenk. Bitter Rot—Uncommon during the present survey.

Fabraea maculata (Lev.) Atk. Black Spot—Common on pears during the fall and early winter of 1928, but was not nearly as serious as the same disease on quince, inasmuch as the spots were much smaller and less conspicuous.

Botrytis cinerea Pers. Gray-Mold Rot—Not common.

21. VACCINIUM MACROCARPON AIT. (CRANBERRY)

Ten pathogenes were isolated from this host, three of which were not identified, due to the absence of spores on Blakeslee's, corn meal, or cranberry agar, or on sterilized green beans.

Acanthorynchus vaccinii Shear. Blotch Rot—Approximately 10 per cent. of the cranberry fungi cultures yielded *Acanthorynchus vaccinii.*

Glomerella cingulata vaccinii Shear. Anthracnose, Bitter Rot—Bitter rot was as prevalent on cranberries in the local markets as was the blotch rot. Berries so affected had a dry, tough rot, chiefly on the sides. Conidia illustrated in Fig. 2, Plate III.

Guignardia vaccinii Shear. Early Rot—Early rot was uncommon in the local markets during this survey. The fungus was almost entirely sterile on all the media used except cranberry agar. Pycnidia were formed in abundance on the other media, but were nearly all sterile, while on cranberry agar, every pycnidium examined contained numerous conidia.

Fusicoccum putrefaciens Shear. [1]End Rot—This is usually cited as the most destructive of the many cranberry diseases in the United States. From 750 cultures which Bain (2) made from cranberries rotted in storage, 63 per cent. developed *Fusicoccum putrefaciens.* The

[1]Now shown to be *Godronia Cassandrae* by Shear, Phytopath. 19: 1017-1024. 1929.

author, however, obtained this fungus only once from cultures from over eighty diseased cranberries known to have come from various cranberry-producing regions. *Fusicoccum putrefaciens* is illustrated in Figs. 10 and 14, Plate III.

Sporonema oxycocci Shear. Ripe Rot—Ripe rot, while sometimes important, has not been found by other investigators to cause destruction to the extent caused by the cranberry fungi described above. It is possible that this year the disease was more prevalent than usual, for of the author's cranberry cultures, 8 per cent. yielded the ripe rot organism. The organism is illustrated in Fig. 1, Plate III.

Botrytis cinerea Pers. Gray-Mold Rot—Only one diseased cranberry yielded cultures of *Botrytis cinerea,* showing that, as usual, this disease is of uncommon occurrence.

Penicillium spp. Soft Rot—Two or three undetermined species of Penicillium were also isolated from diseased cranberries. These are evidently of some importance, since approximately 15 per cent. of the author's cranberry cultures yielded species of Penicillium. Bain (2) reports 13 per cent. for only one undetermined species of this genus.

None of the above-listed cranberry fungi represent the most common fungus obtained from diseased cranberries. Approximately 30 per cent. of all diseased cranberries studied yielded a dark-gray, luxuriantly-growing fungus which is possibly *Helminthosporium inaequalis* Shear, but since none of the cultures of this fungus have yet produced spores, its identity is uncertain.

22. Vitis Spp. (Grape)

One of the four pathogenes isolated has not previously been reported as parasitic on this host.

Botrytis cinerea Pers. Gray-Mold Rot—Isolated from two collections of diseased grapes from local markets.

Mucor heimalis Wehm. Mucor Rot—Diseased tissue transfers of some diseased grapes, softened and shriveled, of the Rabier variety, yielded in every case a species of Mucor, which was later identified as *M. heimalis.*

Alternaria mali Roberts. Alternaria Rot—Fragmentation cultures of a collection of rotted Malaga grapes yielded only one pathogene, a species of Alternaria, which was later identified as *A. mali.* The fungus so nearly agrees with *Alternaria mali,* both macro- and microscopically, that, in the opinion of the writer, it is identical with it. Grapes, when inoculated, developed a soft brown rot in a few days, which advanced rapidly until a diameter averaging 10-15 mm. had been reached, after which the progress was very slow. This fungus is well known as a parasite of apple leaves and fruit, but apparently has never been reported as a parasite of grapes.

Penicillium spp. Penicillium Rot—Two or three species of Penicillium have also been isolated from decaying grapes. Penicillium rots of grapes are quite common in the markets, where they cause, perhaps, greater loss than any other pathogene on this host.

The writer wishes to acknowledge his indebtedness for innumerable valuable suggestions and ever-ready assistance to Professor A. H. W. Povah, under whose supervision this survey was made, and also to Professor W. G. Waterman for instruction in photography.

SUMMARY

1. Of the twenty-two different kinds of fruits on the markets in Evanston, from October, 1928, to March, 1929, inclusive, none were disease-free, and from some as many as eight to ten pathogenes were isolated.

2. Over eighty diseases were found on fruits in the Evanston markets during this survey.

3. The fungi causing these diseases represent twenty-seven genera and thirty-five species, all but two[1] of which were isolated in pure culture and studied on various media.

4. Four hosts are reported for the first time as follows:

5. *Botrytis cinerea* is established as an active parasite on the quince fruit, producing a rapid, soft, brown rot.

6. *Monilia sitophila* produces a soft, transparent decay on the honey dew and cassaba melons.

7. Honey dew melon is subject to a soft, relatively dry decay, produced by *Cephalothecium roseum*.

8. *Alternaria mali* is reported for the first time as a pathogene of grapes, causing a soft, brown decay.

[1]*Fabraea maculata* and *Venturia inaequalis*, whose conidia could not be induced to germinate.

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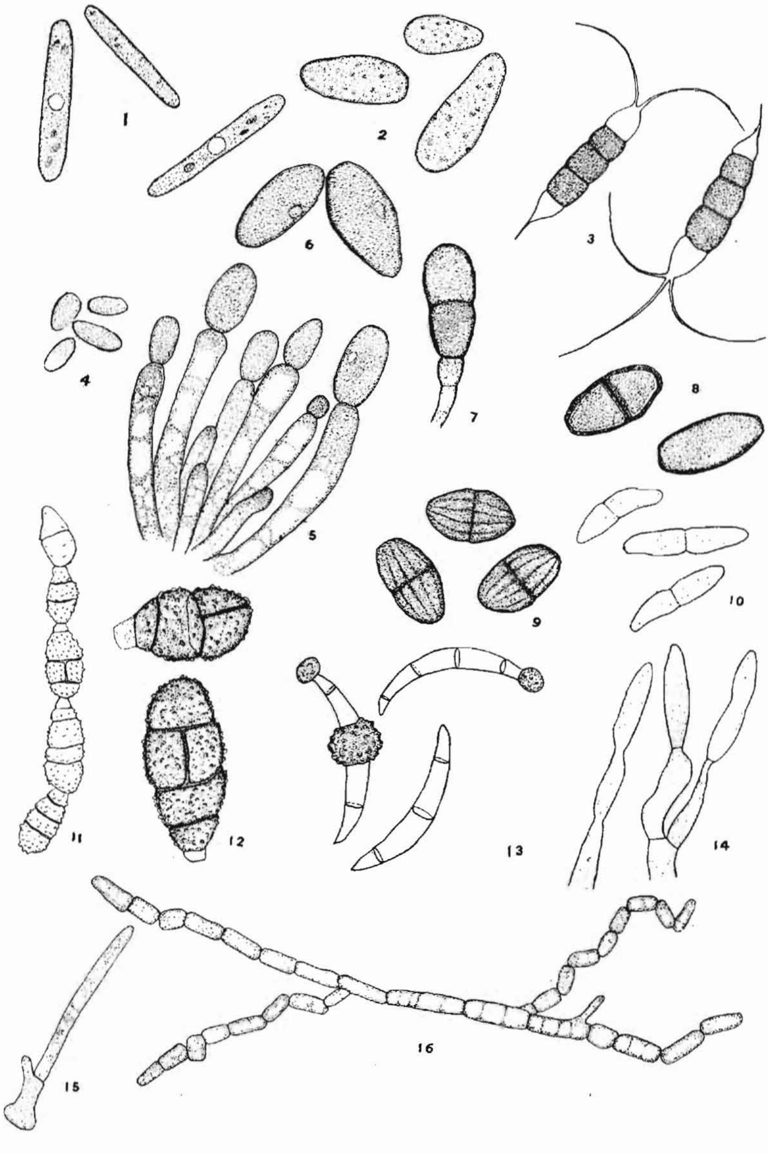
PLATE III



EXPLANATION OF PLATES

All drawings were made with the aid of the camera lucida. Except where otherwise stated, the fruits illustrated in Plates IV and V were artificially inoculated.

PLATE III

Fig. 1. Mature conidia of *Sporonema oxycocci;* x 1150.

Fig. 2. Mature conidia of *Glomerella cingulata* var. *vaccinii;* x 1000.

Fig. 3. Mature conidia of *Pestalozzia guepini;* x 1000.

Fig. 4. Mature conidia of *Phoma mali;* x 1000.

Fig. 5. *Gleosporium musarum;* cluster of conidiophores and conidia in various stages of development; x 1000.

Fig. 6. Mature conidia of *Gleosporium musarum;* x 1000.

Fig. 7. Single conidiophore and conidium of *Physalaspora malorum;* x 1000.

Fig. 8. Septate and nonseptate conidium of *Physalospora malorum;* x 1000.

Fig. 9. Mature conidia of *Diplodia natalensis,* showing striations on the exospore; x 1000.

Fig. 10. Mature conidia of *Fusicoccum putrefaciens;* x 1000.

Fig. 11. Single chain of conidia of *Alternaria mali;* x 250.

Fig. 12. Single conidia of *Alternaria mali,* showing the verrucosity typical of mature conidia; x 725.

Fig. 13. Conidia from an old agar culture of *Fusarium* sp. Section Martiella (Sherbakoff, 17), isolated from honey dews. Note how some of the cells develop into echinulate chlamydospores; x 650.

Fig. 14. *Fusicoccum putrefaciens,* simple and branched conidiophores with conidia; x 1000.

Fig. 15. *Oospora citri-aurantii;* germinating spore eighteen hours after being sown on Blakeslee's agar; x 1000.

Fig. 16. *Oospora citri-aurantii;* germinating spore twenty-four hours after being sown on Blakeslee's agar, showing how the hyphae break up into conidia; x 1000.

PLATE IV

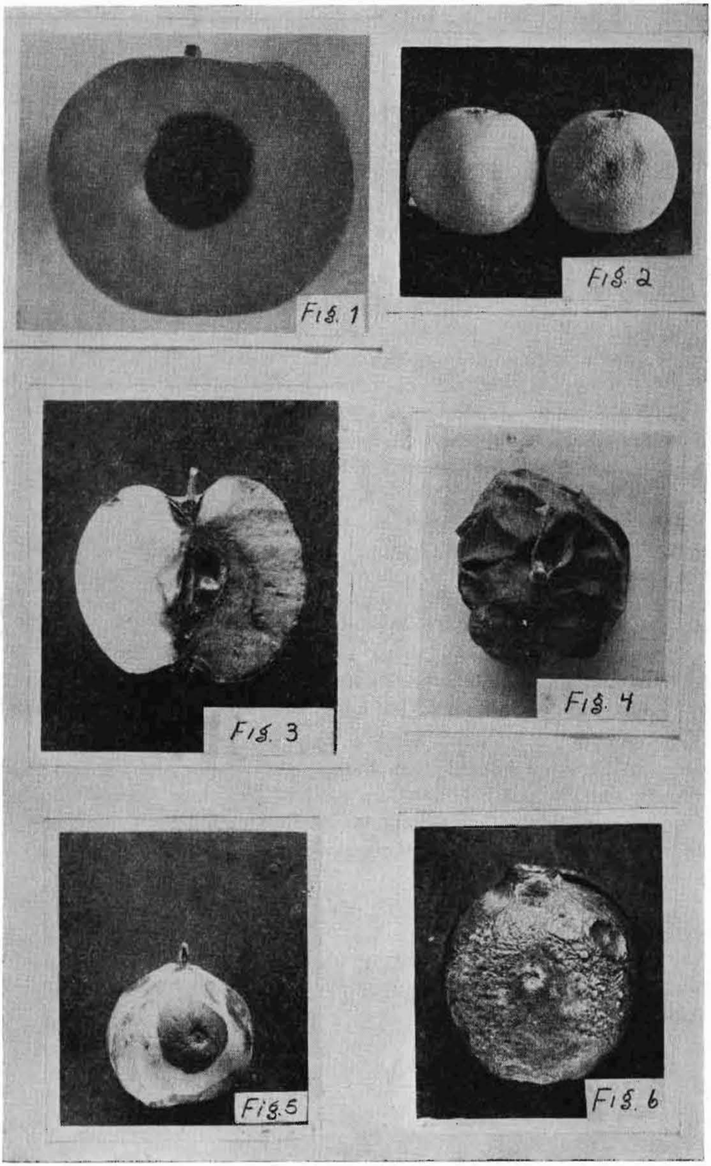


PLATE IV

Fig. 1. Apple, two weeks after inoculation with *Phoma mali,* showing concentric growth of the rotted area.

Fig. 2. On the right, an orange two weeks after being inoculated with *Oospora citri-aurantii,* showing the wrinkled appearance of the rotted area. On the left is the control.

Fig. 3. Vertical section of an apple, half of which had been rotted by *Alternaria mali.*

Fig. 4. Grimes Golden apple one month after inoculation with *Physalospora malorum*, showing the mummified condition which results.

Fig. 5. Quince five days after being inoculated with *Botrytis cinerea,* showing the lesion produced.

Fig. 6. Quince thirty days after inoculation with *Botrytis cinerea,* showing the thoroughly rotted condition and the spore-production on the surface.

PLATE V

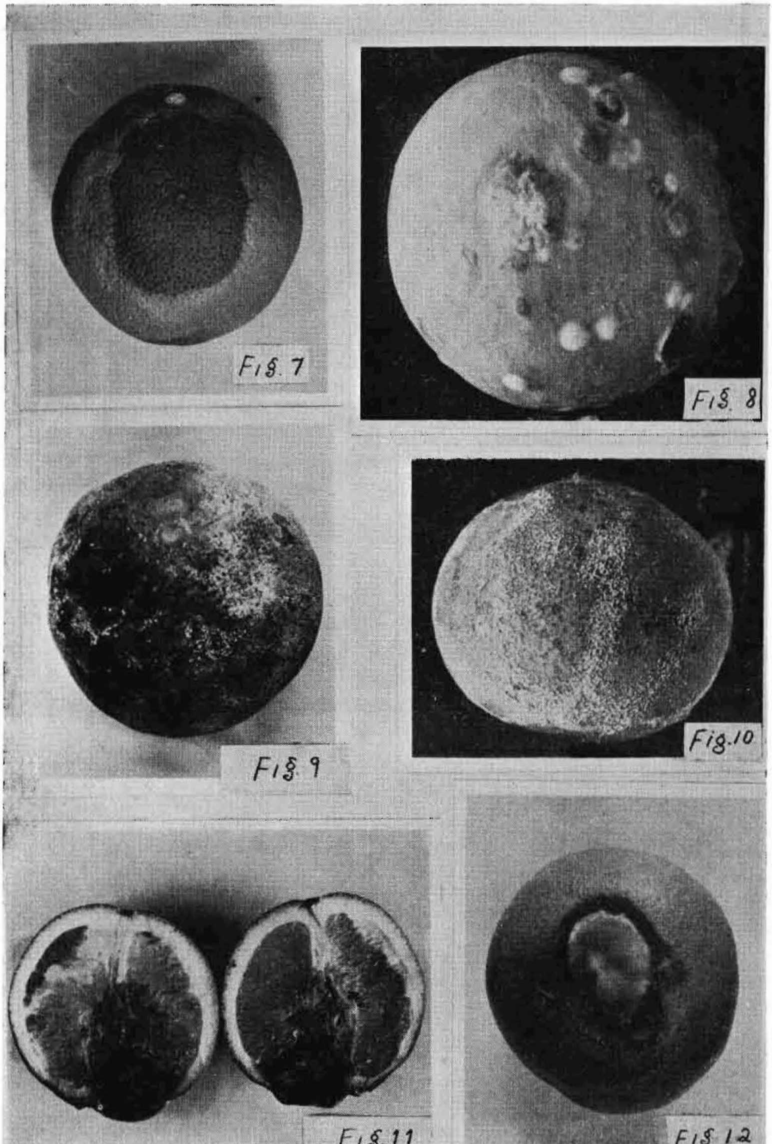


PLATE V

Fig. 7. Orange three weeks after inoculation with *Fusarium* sp., showing the brown, leathery rot produced.

Fig. 8. Honey dew melon naturally affected with Alternaria fruit spot (*Alternaria* sp.).

Fig. 9. Grapefruit three weeks after inoculation with *Phomopsis citri*, showing the numerous white pycnidia on the surface.

Fig. 10. Grapefruit ten days after inoculation with *Diplodia natalensis*, showing the growth of the fungus in longitudinal ridges corresponding to the divisions in the grapefruit.

Fig. 11. Same as Fig. 12, but cut longitudinally to show the extent of the black rot in the interior.

Fig. 12. Same orange as in Fig. 11, before being cut longitudinally. This was a market specimen of black rot of the navel orange, caused by *Alternaria citri*.