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During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

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MOLDS FOUND IN INDIANAPOLIS MARKETS

By PAUL LENTZ

A number of molds are noted for the destruction they cause in fruits and vegetables, and have thus become a dreaded problem for dealers in these commodities. Although much work has been done on molds and hosts in general, comparatively little study has been given to date to the various kinds of fungi common to fruit markets of particular cities. An extensive paper on the subject has been written by Fischer (4), who studied the diseases of fruits found on the markets at Evanston, Illinois, during October, 1928 to March, 1929. He lists 29 genera of fungi found on various hosts, and includes notes on most of them. While Fischer's work was concerned with parasites and diseases of fruit alone, the present study is an analysis of the molds found upon both fruits and vegetables. Its purpose is to determine those molds which were most prevalent on the markets at the time this study was made, and furthermore, to attempt to associate the several molds with four main groups of hosts, viz: (1) those products growing beneath or near the soil; (2) the ordinary orchard fruits; (3) citrus fruits, and (4) the miscellaneous hosts which do not fit into any of the preceding groups. The present study was carried out in the Indianapolis markets.

The pathogenes were identified to genus only and in a limited way, some correlation was attempted between the pathogenes and the type of host upon which each seemed most prevalent. Taking, for example, a very familiar case: Penicillium occurs very frequently upon citrus fruits, to the exclusion, almost, of any other pathogenes upon this type of fruit. As an aid in this correlation, and for the sake of comparison and discussion, advantage was taken of data compiled over a period of several years in the Butler University Botanical laboratories, in addition to the results obtained from this study. During the years from 1935 to 1939, inclusive, these data were compiled from studies which were made for several weeks each year of molds found growing on various fruits and vegetables and their manufactured products. The results from the latter observations may not be taken as absolutely conclusive, since they were made by students in the department who had comparatively little experience in the identification of molds (genera numbers 22-35 in table II). However, they are reliable enough to use for comparison.

METHODS

A study was made of the market molds of Indianapolis during the three-month period from September 15 to December 15, 1939. During this time fruits and vegetables which showed evidence of being hosts to molds were collected and the molds upon them were identified either macro- or microscopically. Each host vegetable was placed into a separate sterile dish, where it was permitted to remain until fruiting bodies were developed which would permit it to be identified. The macroscopic identification was made in the case of Penicillium, Rhizopus, and other easily recognizable genera, but was almost always supplemented by a microscopic examination. In the latter case, temporary slides were made of the fertile hyphae, and the fungus was thus traced to genus.

OBSERVATIONS

In the three-month period from September 15 to December 15, twenty-one genera of molds were identified from fruits and vegetables obtained from commission houses and markets (the first 21 listed in table II). Penicillium, identified from sixteen of the nineteen fruits and vegetables collected, was the most prevalent genus, followed closely by Rhizopus, which was identified from fifteen different hosts. Other molds which were identified from more than one host were: Alternaria, on six hosts; Aspergillus, four; Oospora, three; Fusarium, three; Monilia, two; Monosporium, two, and Isaria, two. Aspergillus, found on apple, cabbage, onion, and sweet potato, was the most prevalent of the molds found on the onion (table I). It was much more abundant on that host than either Penicillium or Rhizopus. Mucor, which is very closely related to Rhizopus, was found only on the carrot.

Approximately half of the molds identified were found on only one host (table II). There were several hosts from which more than one of these uncommon genera were obtained, viz.: (1) tomato: Sporotrichum, Stemphylium, Haplaria, and Monacrosporium; (2) banana: Spicaria, Trichosporium, and Pachybasium; (3) carrot: Mucor and Graphium. The potato was another host upon which several rare genera were found, Acremoniella being found only on the potato, and Isaria only on the potato and radish.

For the purpose of correlation of mold with host, the various fruits and vegetables were divided into the following groups:

(1) containing those vegetables and fruits which grow either beneath or near the soil, (cabbage, carrot, cauliflower, tomato, egg plant, mango, onion, potato, sweet potato, radish, and turnip) ; (2) including the fruits commonly found in the orchard (apple, peach, apricot, plum, and pear) ; (3) composed of the citrus fruits, (orange, lemon, and grapefruit) ; (4) made up of those hosts which were not placed into any of the preceding groups, (banana, cranberry, and grape).

Only fungi which were found on more than one host were used in the correlation. Because both Rhizopus and Penicillium were found on practically all of the hosts, neither was included in this discussion. The results of the correlation are contained in table III. It is seen in the table that Alternaria, Aspergillus, Oospora, Fusarium, Verticillium, and Isaria were found on a greater percentage of the hosts of group 1 than any other group, excepting, in several instances, group 4. Since the latter group is composed of totally unrelated hosts, its percentage results can be assigned no special significance, and the results of group 4 are used only when the particular mold is found on a number of hosts of group 4 equal to or greater than the number of hosts upon which the mold is found in any other group with which group 4 is being compared. Monilia, Macrosporium and Botrytis were fairly evenly distributed among the various groups; while Monosporium was found on one host each in group 1 and group 4. In comparing group 1 with group 2, it is found that Alternaria, Aspergillus, Monilia, and Macrosporium were found on nearly the same percentage of hosts in the two groups; while Oospora was found on exactly half the percentage of hosts in group 2 as in group 1.

Of the twenty-one genera of molds found between September 15 and December 15 on various market produce, Penicillium, Rhizopus, Aspergillus, and Alternaria were by far the most common. Penicillium was very common on practically all of the hosts, but was, of course, most prevalent on the citrus fruits. Rhizopus was common on the soil vegetables and orchard fruits, as was Aspergillus. Alternaria was isolated mostly from the soil vegetables such as cabbage and cauliflower, being especially prevalent on these two.

As a result of the attempt to correlate the various molds with the different types of hosts, it was found that while this may be done to a certain degree, it was not feasible to make this correlation

too definite. While certain of the molds such as Alternaria and Fusarium wre found predominately on the soil hosts, still the broad potentiality to endure a wide range in pH and moisture permitted most of the molds to grow upon various hosts. In general, it may be said that while the preceding two were limited mainly to the soil vegetables of group 1, Aspergillus and Monilia were more inclined to attack orchard fruits and Penicillium was predominantly the citrus fruit mold. In the miscellaneous group, Melanconium was found exclusively upon the grape, and Trichosporium was found only on the banana.

Several molds were identified in this study which had not previously been identified from uncooked fruits and vegetables in the Butler laboratories. Tbese include Isaria, Haplaria, Synsporium, Monacrosporium, Trichosporium, Sporotrichum, Acremoniella, Melaconium, Graphium, Pachybasium, and Spicaria.

DISCUSSION

There are several factors which promote infection of market produce by molds. Among the most important of these are: (1) age, (2) treatment during production, (3) treatment during transportation, and (4) temperature and weather.

It is important that the fruits and vegetables which are to be sold on tbe market be firm and healthy. In order to assure this, very little time should elapse between picking and retailing; since a breakdown of the fruit tissue and subsequent susceptibility to fungus infection is a characteristic consequence of delay and prolonged storage. In relation to age, it may be said that the largest and oldest specimens of a particular fruit or vegetable are usually more susceptible to injury, decay, and infection than are smaller, more compact specimens (7).

A large percentage of the diseases of fruits and vegetables can be traced back ventually to the producer. Thus it is necessary that the fruit should be in good condition when it leaves the field. Many of the market diseases are but belated evidences of improper procedure and lack of care in production and harvesting. First, the seed should be disease-free and in good condition. Seed should be selected which will produce healthy plants. Then the plants should be kept in good condition by proper cultivation, and if necessary,

should be sprayed or otherwise treated to control fungus and insect parasites.

The treatment which fruits and vegetables receive in shipment is very important in determining what the condition of the produce will be when it reaches the market. Careless handling and improper packing may cause tremendous losses in transit (2). Bruised fruit and fruit with torn skins are especially susceptible to fungus invasion. Sound produce should, of course, never be transported or stored in proximity to diseased fruit.

Finally, weather and temperature are factors which may influence the soundness of market produce. Freezing may damage the crop in the field, in transportation, or on the market; while heat may cause damage in transit or on the market, or often may cause sunburn or scald in the field. Dampness may cause considerable loss in transportation.

It might be interesting to compare the relative amounts of spoiled produce which were evident in the various sources of pathogenes for this study. The Indianapolis Producers Market was a very profitable source of diseased fruit. This is an open air market in Indianapolis where growers may come to sell their produce (3). Much of the fruits and vegetables sold here are ungraded; thus there is a considerable spoilage. The commission houses, which supply the retailers, were also a good source of material for this work. As many as two or three bushels of spoiled bananas were sometimes thrown away Saturday noon by banana merchants, and these were accompanied by comparable amounts of other spoiled produce. The City Market was a very poor field for obtaining diseased specimens, and the retail grocery stores were only slightly better, although a continual dribble of such vegetables and fruits as spoiled carrots, radishes, and grapes was obtained from the latter. In general, it may be said that there is a gradual weeding out of the poorer quality fruits and vegetables from producer to retailer, so that the standard becomes higher as the produce undergoes a discriminative selection on its way from producer to consumer.

Several rather unique features appeared in this study. Bartholomew (1) says that with the possible exception of Penicillium, Alternaria causes more decay of California lemons than any other known fungus, and states that the loss due to Alternaria is equally high in other lemon growing regions. Yet Alternaria was not identified

upon any of the citrus fruits in either of the studies incorporated into this paper (tables I and II).

A disease of grapes known as bitter rot has become widespread in the southern part of the United States (6). But thus far its appearance has been rather limited as far north as Indiana. Thus it is of some interest to note that the typical sooty spore pustules of Melanconium, the fungus causing bitter rot, were identified several times on grapes obtained from Indianapolis retailers.

SUMMARY

1. Twenty-one genera of molds were isolated from fruits and vegetables obtained from Indianapolis markets during the period from September 15 to December 15, 1939.

2. Penicillium, Rhizopus, Aspergillus, and Alternaria were the most common molds isolated, followed by Oospora, Fusarium, Monilia, Monosporium, and Isaria.

3. Plants which were host to four or more genera of mold include: Banana, cabbage, carrot, egg plant, onion, potato, and tomato.

4. In correlating genera of molds with types of hosts, it was found that Alternaria and Fusarium grow predominately upon hosts growing in or near the soil, Aspergillus and Monilia were more common upon ordinary orchard fruits; while Penicillium was the only genus found on the citrus fruits.

5. Melanconium which is somewhat out of its normal range in Indiana, was identified from grapes.

6. Mucor was isolated only once, from the carrot.

7. Molds identified in this study, which had not previously been identified from uncooked fruits and vegetables in the Butler laboratories include: Isaria, Haplaria, Synsporium, Monacrosporium, Trichosporium, Sporotrichum, Acremoniella, Melanconium, Graphium, Pachybasium, and Spicaria.

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TABLE I

Pathogenes listed by host. Those marked with * were found during the present study (September 15 to December 15, 1939). Others have been determined at other times by students in the class in microscopy.

	Host	Pathogenes
1.	Apple	Rhizopus*, Penicillium*, Aspergillus*, Alternaria, Mucor, Macrosporium, Rhizoctonia
2.	Banana	Rhizopus*, Penicillium*, Aspergillus, Spicaria*, Mucor, Monilia, Monosporium*, Trichosporium*, Pachybasium*
3.	Cabbage	Rhizopus*, Peuicillium*, Alternaria*, Aspergillus*, Monilia*, Oospora*
4.	Carrot	Penicillium*, Mucor*, Trichothecium, Rhizopus*, Oospora*, Graphium*
5.	Cauliflower	Alternaria*, Oospora*
6.	Cranberry	Alternaria, Penicillium*
7.	Egg Plant	Rhizopus*, Macrosporium, Penicillium*, Alternaria*, Monosporium*
8.	Grape	Penicillium*, Aspergillus, Botrytis, Alternaria*, Macrosporium, Melanconium*
9.	Mango	Rhizopus*, Penicillium*, Fusarium*
10.	Onion	Rhizopus*, Penicillium*, Aspergillus*, Synsporium*, Alternaria, Fusarium, Verticillium, Cladosporium, Botryosporium
11.	Peach	Rhizopus*, Penicillium*, Monilia*
12.	Pear	Aspergillus, Rhizopus*, Penicillium*
13.	Plum	Rhizopus*, Penicillium*, Monilia*
14.	Apricot	Oospora

TABLE I—(Continued)

Host	Pathogenes
15. Potato	Rhizopus*, Aspergillus, Fusarium*, Penicillium*, Verticillium, Stysanus, Mycogone, Rhizoctonia, Diplosporium, Mortierella, Acremoniella*, Dendrostibella, Acrostalagmus, Isaria*
16. Sweet Potato	Rhizopus*, Penicillium*, Fusarium, Aspergillus*
17. Radish	Fusarium*, Botrytis, Rhizopus*, Isaria*
18. Tomato	Rhizopus*, Penicillium, Aspergillus, Sporotrichum*, Alternaria*, Oospora, Maerosporium, Haplaria*, Colletotrichum, Cladisporium, Stemphylium*, Monacrosporium*
19. Turnip	Rhizopus*, Penicillium*, Monilia, Alternaria*
20. Citrus Fruits	Penicillium*, Monilia, Botrytis, Macrosporium

TABLE II

Hosts listed by Pathogenes. The first 21 genera were found in the present study. The others were found in past years by students in the microscopy class.

Pathogenes	Hosts
1. Penicillium	apple, banana, cabbage, carrot, cranberry, egg plant, grape, mango, onion, peach, pear, plum, potato, sweet potato, turnip, citrus fruits, tomato
2. Rhizopus	apple, banana, cabbage, carrot, egg plant, mango, onion, peach, pear, plum, potato, sweet potato, radish, tomato, turnip
3. Alternaria	apple, cranberry, cabbage, cauliflower, egg plant, grape, tomato, turnip, onion
4. Aspergillus	apple, banana, cabbage, grape, onion, pear, potato, sweet potato, tomato
5. Oospora	apricot, cabbage, carrot, cauliflower, tomato
6. Fusarium	mango, onion, potato, sweet potato, radish
7. Monilia	banana, cabbage, peach, plum, turnip, citrus fruits
8. Monosporium	banana, egg plant
9. Isaria	potato, radish
10. Mucor	carrot, apple
11. Haplaria	tomato
12. Synsporium	onion
13. Monacrosporium	tomato
14. Trichosporium	banana
15. Sporotrichum	tomato
16. Acremoniella	potato
17. Melanconium	grape
18. Graphium	carrot

TABLE II—(Continued)

	Pathogenes	Hosts
19.	Pachybasium	banana
20.	Stemphylium	tomato
21.	Spicaria	banana
22.	Macrosporium	apple, egg plant, citrus fruits
23.	Rhizoctonia	apple, potato
24.	Trichothecium	carrot
25.	Verticillium	onion, potato
26.	Cladosporium	onion, tomato
27.	Botryosporium	ouion
28.	Stysanus	potato
29.	Mycogone	potato
30.	Diplosporium	potato
31.	Mortierella	potato
32.	Dendrostilbella	potato
33.	Acrostalagmus	potato
34.	Colletotrichium	tomato
35.	Botrytis	citrus fruits

TABLE III

Correlation of pathogenes with host types. Column one of each group indicates number of hosts from that group upon whieh the mold was found. Column two of each group represents the percentage of total hosts of that group upon which the mold was found.

	Pathogenes	Group 1		Group 2		Group 3		Group 4	
1.	Alternaria	6	54%	2	40%	0	0%	2	66%
2.	Aspergillus	5	45%	2	40%	0	0%	2	66%
3.	Oospora	4	36%	1	20%	0	0%	0	0%
4.	Fusarium	5	45%	0	0%	0	0%	0	0%
5.	Monilia	2	18%	1	20%	1	33%	1	33%
6.	Macrosporium	2	18%	1	20%	1	33%	0	0%
7.	Botrytis	1	9%	0	0%	1	33%	1	33%
8.	Verticillium	2	18%	0	0%	0	0%	0	0%
9.	Isaria	2	18%	0	0%	0	0%	0	0%
10.	Monosporium	1	9%	0	0%	0	0%	1	33%

Group 1—Soil vegetables.
Group 2—Orchard fruits.
Group 3—Citrus fruits.
Group 4—Miscellaneous hosts.