

INDIANA PLANT DISEASES, 1921.¹MAX W. GARDNER², Purdue University.

This is the third of a series of annual reports (16, 17)³, the object of which has been to summarize the plant disease situation in Indiana. This report is based upon our records and observations during the season of 1921 and the plan outlined in the 1919 report (16) has been followed. As in these previous reports, no claim for completeness is made. Of necessity, our attention has been confined largely to agricultural crops and the diseases of economic importance. The diseases are arranged alphabetically by hosts except that under the headings, "Forest and Shade Trees" and "Ornamentals", near the end of this report are grouped such fragmentary records as we have relative to the diseases of such plants. For further information relative to parasitic fungi in Indiana the papers by Jackson (27, 28), Anderson (1), and Van Hook (41), should be consulted. Many of the diseases are well illustrated in the annual reports of the State Entomologist of Indiana, 1907 to 1916.⁴ The geographic distribution and economic importance of the various Indiana crops have been reported by Bryant (6).

WEATHER CONDITIONS.

The season of 1921 in Indiana was characterized by most peculiar weather conditions. The winter of 1920-21 was exceptionally mild and open. The graphs in figure 1 illustrate the departures from normal temperature and rainfall during the growing season based upon the monthly averages given by J. H. Armington, of the U. S. Weather Bureau, in the Indiana section of "Climatological Data."

These figures show that March and April were exceptionally warm and wet, while during late May, June and July, the weather was especially hot and dry, culminating in a destructive drouth in July. The marked feature of the summer, however, was the very high rainfall during August and September with a very high temperature for the latter month. This resulted in truly tropical conditions which, of course, exerted a marked influence on the plant disease situation in Indiana.

The mild, open winter probably favored the severe attack of rye anthracnose in northern Indiana, the fungous foot-rot of rye and wheat, and the wheat leaf rust epiphytotic in southern Indiana. The unusually warm, early, and wet spring probably increased the severity of rye anthracnose, raspberry anthracnose, strawberry leaf-spot, early infection of apple scab, apple blotch, peach bacterial spot, and black-leg on cabbage seedlings. The late frosts of March 29, April 10-11, and April 18 completely ruined tree fruits in central and southern Indiana. Not so much damage was done in the northern part of the state.

¹ Contribution from the Botanical Department, Purdue University Agricultural Experiment Station, Lafayette, Indiana. Presented at the 1922 meeting.

² The writer wishes to acknowledge the assistance and co-operation of H. S. Jackson, E. B. Mains, J. B. Kendrick, G. N. Hoffer, C. T. Gregory and R. J. Hosmer, C. L. Burkholder, F. P. Cullinan, F. C. Gaylord, H. D. Brown, I. C. Hoffman and C. E. Baker.

³ Numbers in parenthesis refer to "literature cited".

⁴ "Proc. Ind. Acad. Sci., vol. 33, 1923 (1924)."

The dry weather of May and the extreme heat and drouth of June and July greatly aggravated tomato Fusarium wilt and yellows in early cabbage, and caused a heavy loss in stand in late potatoes because of rotting of the seed pieces soon after planting. Beet leaf-spot was much worse than usual. The dry weather probably checked apple scab and wheat scab, but greatly accentuated the leaf rust damage in wheat because of the excessive evaporation from the leaves.

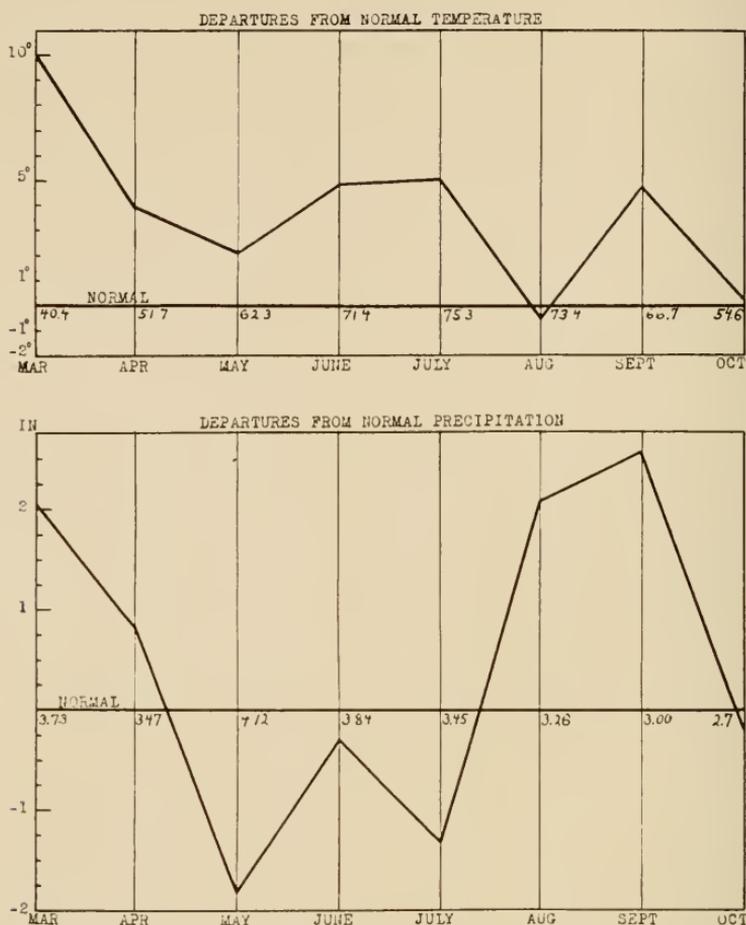


Fig. 1. Indiana weather conditions, 1921. Graphs represent departures from normal temperature and precipitation as shown by the monthly averages for the state as a whole.

The mild, very wet August probably lessened the severity of cabbage yellows, potato wilt, and tomato blossom-end rot in the canning crop. However, the excessive rainfall of August and September and high temperature of the latter month undoubtedly was the cause for the greatly increased severity of watermelon anthracnose in central Indiana, grape black rot, apple black rot, and other fruit rots including that caused by a *Phytophthora*, potato early blight, various powdery

mildews, corn ear rots, tomato fruit rots following growth cracks, and a local outbreak of buckeye rot of tomato. However, such weather was also particularly favorable to the luxuriant growth of late truck crops and extraordinary yields were obtained this season. The first general killing frost occurred October 13. The long growing season and late fall prolonged the activity and increased the severity of tomato leaf-spot, apple scab, apple frog-eye leaf-spot, and the corn ear rots. The corn ear rots were also aggravated by the heavy rains and floods in November.

DISEASES ARRANGED BY HOSTS.

Alfalfa—Leaf-spot caused by *Pseudopeziza medicaginis* was found severe in a field in Marion county and was noted on specimens from Greene county. This disease is co-existent with its host. Gregory noted the leaf-spot caused by *Pyrenopeziza medicaginis* in Warren county. Mains noted the rust (*Uromyces medicaginis*) at Lafayette.

Apple—Since the frost ruined the apple crop in the blotch region (southern Indiana) the blotch sprays were generally omitted and as a consequence of this fact as well as the favorable weather, apple blotch (caused by *Phyllosticta solitaria*) was especially prevalent on the foliage and on what little fruit remained in the case of the susceptible varieties. Gregory noted fruit infection in Floyd County as early as June 4, and Baker found fruit infection on Northwestern at Knightstown on June 10. In an experimental orchard at Laurel, Cullinan noted some blotch infection on Grimes fruit and incriminated a badly cankered Northwestern tree near by as the source of infection. Cullinan also found a few fruit lesions on Stayman in a young orchard near Lafayette on Sept. 28, and the source of infection here was not located. In an orchard near Mooresville there was spread of infection from a row of badly cankered Northwestern to the fruit of the varieties Ben Davis, Stark, York, Grimes, and Jonathan. It was rather severe on the York. A few fruit lesions on Ben Davis were noted at Peru, and a few cankers were noted on Oldenburg and Stark trees in Miami County. In an orchard of young Oldenburg trees at Vincennes, the occurrence of old blotch cankers scattered here and there was indicative of blotch introduction with nursery stock.

In an orchard of mixed varieties near Mitchell, a row of Oldenburg trees was very heavily infected. Observations on the adjacent trees of other varieties revealed a few blotch cankers on the varieties Akin, Ben Davis, Champion, Gideon, Summer Rambo, and Salome. In each case these cankers were on the side of the tree next to the Oldenburg trees. Blotch seemed, however, to be enphytotic in one isolated Summer Rambo tree. Single trees of the varieties Winesap, Delicious, Wealthy and Celestia, as well as two Salome trees similarly exposed to the Oldenburg row, showed no cankers.

The Bordeaux blotch sprays (2, 4, and 6 weeks after petal fall) again gave good control of fruit infection on Northwestern at Knightstown, and practically perfect control of leaf infection in this orchard as well as on the same variety at Mooresville, on Oldenburg at Mitchell, and on Ben Davis at Solon. In all cases, leaf petiole infection on un-

sprayed check trees was very prevalent and in certain cases was found so severe as to kill the leaves outright. Petiole infection is an important feature in the life history of this fungus since it has been found that a very high percentage of the twig cankers are at leaf scars and are the result of mycelial invasion from petiole lesions (19). Thus by controlling petiole infection, canker formation will be largely prevented. Observations at Knightstown show that spraying has practically prevented all canker formation on the wood formed the years the sprays were applied. R. A. Simpson, at Vincennes, likewise has prevented canker formation with frequent Bordeaux sprays. The importance of spraying every year, regardless of crop, is, of course, evident. Observations indicate that as a summer spray lime-sulphur is not as effective against blotch as Bordeaux mixture.

Burkholder reports that the disease occurs here and there in northern Indiana, mainly on the Mann and Oldenburg varieties, both of which are frequently grown in home orchards. The same observer noted blotch this year in DeKalb, Allen, and Noble Counties and it has been reported from Elkhart and Marshall counties.

Scab caused by *Venturia inaequalis* was worse than usual on the foliage this year, not only owing to the early wet spring weather but on account of the great difficulty experienced in properly applying the sprays because of the protracted blooming period which, according to Cullinan, covered almost a month in some localities. In some cases the pink spray or first summer spray was entirely omitted. Undoubtedly the June-July drouth checked scab. H. H. Swaim reported that in spite of its early severity, the disease was well controlled later. Burkholder reports scab worse in northern Indiana than in 1920, especially on Winter Banana in DeKalb County and in Wabash County. Gregory reported scab severe in Floyd, Decatur, and Shelby counties. Complaints accompanied by scab specimens were received in June from Allen, Clay, Ripley, Steuben, Hendricks, and Wabash counties. Severe foliage infection was noted at Mooresville, Paoli, Peru, and Vincennes early in the season.

Some observations upon varietal susceptibility to scab were made in an unsprayed orchard near Mooresville in September. Foliage infection was severe on Maiden Blush, Pewaukee, Chenango, Benoni, Wealthy, Northwestern, Stark, Jonathan and Indiana Favorite, and was present to some extent but not severe on Grimes, Winter Maiden Blush, and York, while none was noted on Transparent. Fruit infection was noted on Maiden Blush, Wealthy, York, and Jonathan. Burkholder reports severe scab on the Delicious variety. At Peru scab was noted much worse on Ben Davis than on Grimes—in fact practically none was noted on Grimes foliage in October. Unsprayed Ben Davis trees showed very abundant foliage infection of scab in May and in October the disease had caused severe defoliation and a total loss of the crop because of the undersized, malformed, scabby fruit. The Ben Davis fruit responded in a peculiar manner to scab infection in that there was marked hypertrophy of the tissue beneath older lesions resulting in conspicuous protuberances on the fruit. In other cases old lesions had checked the

normal growth of the fruit, resulting in cracks and the entrance of rot-producing fungi.

Observation this year on black rot, caused by *Physalospora cydoniae*, gave convincing evidence of the destructiveness of the canker stage of the disease. Complaints accompanied by specimens were received from Fulton and Marshall counties and the serious effects of black rot cankers on Ben Davis trees in an orchard near Peru were very striking inasmuch as many of the larger limbs were being killed. It seemed likely that the fungus might be following winter injury in this case. Black rot was also found causing cankers around 17-year-locust injury on 1918 wood of young Grimes trees near Paoli. The black rot fungus also is a very common secondary invader of blotch cankers.

The frog-eye leaf-spot caused by the black rot fungus was exceedingly prevalent this year throughout the state. The lesions were larger than usual, showing a zone of secondary enlargement around the original circular spot. Frog-eye was noted as early as April 28 at Vincennes. In one orchard in Orange County, much of the yellowing and defoliation during the drouth of June and July was attributable to this disease and the same holds true for unsprayed orchards in general. In an orchard of mixed varieties near Mooresville, observations made on Sept. 15 showed frog-eye to be severe on Ben Davis, Maiden Blush, Pewaukee, Yellow Transparent, Chenango, Wealthy, Winter Maiden Blush, and Northwestern, less prevalent on Benoni, Grimes, Stark, and Jonathan, and absent on Indiana Favorite and York. Near Peru, frog-eye was noted to be much less common on Grimes than on Ben Davis foliage. In this orchard there was not much difference between unsprayed and sprayed trees in the prevalence of frog-eye leaf-spot. Counts were made on the leaves of Ben Davis trees sprayed with Bordeaux for blotch control in Clark county and it was found that 60 per cent of the unsprayed leaves showed frog-eye leaf-spot as compared with 45 per cent of the sprayed leaves. This shows that a 2-4-6 weeks spray schedule does not control this disease.

Fruit infection with black rot was much worse than usual this year, owing probably to the wet August and September. Calyx-end rot of young fruit was observed in Henry County, on July 20 and on Sept. 15 the same type of rot was noted on York in Morgan county. Black rot was also noted on Grimes and Jonathan in the latter orchard. Cullinan reported serious losses due to black rot of Grimes and other varieties in orchards in Franklin, Henry, and Miami counties due to the wet weather. The prevalence of growth cracks, especially in Stayman, also increased the losses throughout the state from black rot, according to the same observer. Windfalls were in general a total loss.

Fire blight, due to *Bacillus amylovorus*, was in general less severe than usual this year. Gregory observed destructive blight in Floyd, Decatur, and Shelby counties and Cullinan reported fire blight severe on Jonathan in an orchard in Franklin county, while Grimes, King David, Stayman, Delicious, and Winesap in the same orchard were not affected. Burkholder noted fire-blight in Adams County and in Elkhart County the disease was found prevalent in a small orchard containing

two pear trees as sources of infection. G. W. Cochran was unable to locate any active fire blight in the neighborhood of LaFayette.

Blister canker caused by *Nummularia discreta* is of very considerable importance in central and southern Indiana, especially in the older orchards of the Ben Davis variety. Its occurrence near Greencastle has been previously reported. Specimens were received from Posey county and the disease is reported on Ben Davis in orchards in Brown and Jay counties. Blister canker was found destructive on a few older trees in an orchard in Orange County and in an orchard in Miami County it is causing serious injury to both Grimes and Ben Davis. In the latter instance the disease has apparently followed winter injury and is actively killing the limbs which were conspicuous this season because of the yellow foliage and dwarfed fruit. On October 5, new stromata were found under the lenticels in recently infected bark, and many fresh stromata had burst through the lenticels producing star-shaped ruptures. The nail-head stromata on the older parts of the cankers are, of course, conspicuous and characteristic. Growers report poor success with attempts to eradicate the disease by cutting-out methods. However, in certain orchards observed, blister canker has affected only a few trees and determined efforts to eradicate such centers of infection should be made. In case removal of all diseased wood is impracticable it is advisable to shave off the bark to prevent spore production, as Anderson (Ill. Cir. 258) has recently recommended.

Rust (*Gymnosporangium juniperi-virginianae*) was noted on the foliage of York and Jonathan in Orange County, on Jonathan in Morgan County, and on Wealthy foliage in Lawrence and Henry counties. Serious difficulty with rust is reported from Brown county. The wide prevalence of red cedar in southern Indiana insures an annual rust infection of the susceptible apple varieties and as a rule no eradication of the cedars has been attempted.

Powdery mildew (*Podosphaera oxycanthae*) was found very severe on the young leaves of young Winesap trees at Vincennes, April 28, on young sprayed Transparent and Carson trees in Morgan county on May 12 by C. E. Baker, and in the fall on young trees in Lawrence county. The wet weather of early spring and later summer probably favored this disease. Burkholder reports that crown gall and hairy root, due to *Bacterium tumefaciens*, is often present on apple nursery stock received by Indiana growers.

This was an epidemic season for sooty blotch and fly-speck, caused by *Gloeodes pomigena* (7) and *Leptothyrium pomi*. Burkholder reports this trouble from Gibson and Pike counties and observed that an extra spray applied about August 1, gave a good control. Cullinan did not find the disease severe in sprayed orchards. In an unsprayed orchard in Morgan County, this disease was noted Sept. 15 on Ben Davis, Maiden Blush, Pewaukee, Grimes, Wealthy, Northwestern, Jonathan, Indiana Favorite, and York. It is especially objectionable, of course, on such light-skinned varieties as Grimes, Maiden Blush, and Northwestern, and on York it was noted that the red coloration was absent underneath the sooty blotches.

The occurrence of a rather destructive rot of apples caused ap-

parently by *Phytophthora cactorum* in three localities in the state is of considerable interest since this disease, which is common in Europe, has been previously reported in this country only from New York (42) and a few other localities. The disease was first noted early in September on Grimes fruit from three trees in a low area in an orchard at LaFayette. It was found mostly on fallen apples and occasionally on low-hanging fruit on the trees. Since it was rather inconspicuous in its early stages, it was overlooked in sorting and later showed up at an alarming rate in the baskets of sorted fruit. It caused a loss of about 10 per cent of the crop from the three trees mentioned. The external appearance of the rot (fig. 2) was a rather indefinite, light brown discoloration of irregular intensity and the infected flesh was firm and at first only slightly discolored with the veins distinctly browned. The rot rapidly involved the entire fruit. Infection no doubt originated from the soil and the heavy rains and presence of standing water under these trees undoubtedly facilitated the development of the



Fig. 2. *Phytophthora* rot of Grimes apples. At the right, field appearance of the disease; at the left, outgrowth of fungus in a damp chamber.

fungus. Cullinan found this disease on Grimes and Ben Davis fruits on the ground in an orchard in Miami County, Sept. 16, and on Oct. 5 a few remaining specimens were found. The disease had caused a marked loss in the Grimes variety and occurred only in the low places in the orchard. In an orchard in Henry County, *Phytophthora* rot was found on Northwestern apples, Sept. 27. The extremely heavy rains of August and September are considered responsible for the outbreak of this disease and its apparent spontaneous appearance in three orchards would indicate that the fungus may be a common soil inhabitant.

Bitter rot due to *Glomerella cingulata* was present to a limited extent on Grimes fruit in an orchard in Franklin County according to Cullinan. The same observer also found a case of brown rot, caused by *Sclerotinia cinerea*, on a Jonathan apple at Lafayette. A peculiar fruit spot, somewhat resembling Brook's fruit spot, but apparently non-parasitic in nature was noted by Burkholder on King David apples grown in Hendricks County and specimens were also received from Henderson, Ky.

Burkholder reported that Jonathan spot (cause unknown) was worse this year than he had noted previously and attributed this to the early ripening of the Jonathan variety. Cullinan also reported this trouble worse than usual, and many growers have expressed great concern about this disease, stating that it is of great importance and necessitates immediate consumption of the fruit. An opinion was expressed that Jonathan spot is worse on lower sites in southern Indiana. The disease also occurs on the King David variety and was noted on the Hubbardston variety at Goshen. Cullinan reported that bitter pit (cause unknown) was common on Grimes, Baldwin, and Arkansas in Franklin County. Burkholder was inclined to associate the severity of bitter pit on Baldwin this year with the early ripening. Water core (cause unknown) was noted on a few Northwesterns in an orchard in Henry County.

A peculiar type of canker following 17-year-locust injury of 1918 on Grimes limbs was sent in from an orchard in Brown County. Healing had been prevented and the callus had been killed back annually. Both old and new calluses were abundantly covered with sporulating acervuli of a species of *Hyaloceras*. In this same orchard was found another distinctive type of canker¹ on old and young twigs of the Champion variety. On young twigs these cankers were black in color and circular with an even, definite margin, and on older limbs were more or less circular and elevated, often with a peripheral crack not unlike fire blight cankers. Preliminary efforts to isolate an organism have been unsuccessful.

The destructiveness of the collar rot of the Grimes variety has been previously reported. In one row of Grimes in an orchard in Morgan County, ten trees have been killed by this trouble. Collar rot was noted on Grimes in Miami County and was reported in six-year-old trees in Fulton County but in general is not as destructive in northern as in southern Indiana. Collar rot was noted on young Oldenburg trees at Vincennes and Cullinan reported that it also occurred on the varieties Rhode Island and Tompkins King. In new orchards this difficulty with Grimes is being met by using double-worked trees and in old orchards inarch grafts have been used to save the affected trees.

Another trouble apparently distinct from collar rot is the root-rot which occurs, according to Burkholder, in practically all varieties planted on recently cleared land in the "sassafras" region embracing Brown, Monroe, Greene, Daviess, Martin, Lawrence, Orange, Washington and Jackson counties or parts thereof. In an experimental orchard near Bedford eleven trees including Northwestern, Grimes, Arkansas, Indian, and Ben Davis died in the fall of 1920 as a result of root rot and in 1921 six more died, including Grimes, Rome, Northwestern, Jonathan, and Ben Davis. A grower in Orange County reported root rot present on Stayman, Jonathan, and Rome and worst on Delicious, and a grower in Brown County reported much difficulty with root rot. Near Mitchell, Oldenburg and Gideon trees were observed which were

¹ Later found to be identical with the non-parasitic brown bark spot of Montana. (Swingle, D. B., and Morris, H. E. The brown bark spot of fruit trees. Mont. Agr. Ex. Sta. Bul., 146:1-22, 1921.)

dying apparently from root-rot. A grower brought in a specimen of a 12-year-old tree from an orchard in Martin County that had died from root rot and reported that it was very destructive in the neighborhood of Indian Springs and Trinity Springs. The varieties affected were Stayman, Grimes, and Willow. Careful inspection of a large orchard planted on old farming soil in this root-rot region revealed no cases of root rot whatever and leads to the inference that the disease is associated usually with newly cleared soil.

Winter injury, evidenced by the death of the bark on one side of the trunk and limbs, in the crotches, and often about the crown, is a serious trouble on young trees throughout the state. It also occurs on old trees and no doubt is often associated with the two troubles described above. Much of the winter injury, according to Oskamp (32), is due to the 1917-18 season.

Frost injury to Ben Davis fruit in an orchard in Miami County produced conspicuous russet or buckskin blotches with lace-like margins on about 50 per cent of the fruits and in many instances there was extreme hypertrophy of the fruit tissue under this russeted area causing a peculiar malformation of one side of the fruit. Characteristic foliage injury was caused by the late frosts. Portions of the lower epidermis and areas of the leaf blade were often killed outright and the subsequent result was a crinkling, rolling and stunting of the older leaves many of which turned yellow and dropped prematurely.

There was considerable spray injury this season. Cullinan noted Bordeaux spray injury to Grimes, Wagener, and Maiden Blush foliage at LaFayette, which resulted in marked defoliation in June soon after the spray was applied. Marginal injury of the leaves as a result of summer spraying with lime-sulphur was noted in Henry County in July and arsenate injury to foliage, consisting of circular reddish brown spots, was noted in Miami County. The Bordeaux blotch sprays caused a marked injury to Ben Davis foliage in Clark County.

Barley.—Loose smut (*Ustilago nuda*) was very common. Gregory reported good control with hot water seed treatment in Blackford, Hancock, Henry and Jasper counties and also reported that in Carroll County the Oderbrucken No. 8, an improved variety from Wisconsin, showed resistance to loose smut. Jackson reported the occurrence of covered smut (*Ustilago hordei*) on winter barley near Lafayette while none was noted on spring barley. The same observer also noted stripe, caused by *Helminthosporium gramineum*, and spot blotch, caused by *H. sativum*. Gregory noted the stripe severe in one field in Hancock County. Mains noted a very little stem rust (*Puccinia graminis*) near Lafayette and reported the presence of a very small amount of leaf rust (*Puccinia simplex*) in the state.

Bean.—As usual, bacterial blight, caused by *Pseudomonas phaseoli*, was the most serious disease of beans in the state, and was very prevalent in the Indianapolis market gardens. It was also noted at Plymouth and Goshen and in a field in Tippecanoe County. Mains grew about 60 varieties of beans in parallel rows in an experimental garden at Lafayette and bacterial blight occurred on all of these varieties including the White Kidney. The variety, Bird-eye, escaped heavy infection. No

infection was noted on the exotic species, Adzuki, Kulthi, Rice and Moth beans, but occurred to a slight extent on Urd bean (*Phaseolus mungo*), Mung bean (*P. aureus*), Hyacinth bean (*Dolichos lablab*), and White Dutch Case-knife bean (*P. multiflorus*).

Mosaic, which, like the preceding disease, is carried in the seed, occurred rather generally. It was noted as early as May 25 at Indianapolis, and later during the season at Vincennes and Lafayette. In the variety plot above mentioned, mosaic occurred to a greater or less extent on all varieties except Wardwell's Kidney Wax, Red Kidney, Saddleback Wax, Dwarf Horticultural, Robust Pea, Black Valentine, Improved Goddard and Webber Wax. Mosaic also occurred on the Adzuki bean (*Phaseolus angularis*), Urd bean, and Mung bean but not on the Kulthi bean (*Dolichos biflorus*), Rice bean (*Phaseolus calcaratus*), Moth



Fig. 3. Lima bean. A. Bacterial blight (3 pods). B. Soil rot (1 pod).

bean (*P. aconitifolius*) and Hyacinth bean. Efforts to cross inoculate beans with soybean mosaic were unsuccessful. Unmistakable evidence of mosaic transmission in the seed of the Adzuki bean was obtained by both field and greenhouse tests.

During the July drouth, R. C. Friesner found a root rot and wilt resembling the *Fusarium* root rot disease in a garden plot of Kentucky Wonder beans at Indianapolis. In late-planted beans near Lafayette there was considerable fungus injury to the crop of seed owing to the extremely wet weather in the fall. Staining and shrivelling of the seed were the outstanding effects produced.

Lima bean.—A bacterial spotting of the leaves and pods due to *Pseudomonas phaseoli* was commonly noted on both bush and pole varieties in gardens and to a considerable degree on the canning crop in Johnson County at the time of harvest in September (fig. 3A). The causal organism was isolated from pod and leaf lesions.

The lima beans grown for canning purposes are harvested while the pods are green and the seeds immature. A considerable percentage of the beans are culled out on the sorting belts and discarded because of discoloration or decay. Several types of diseased beans were observed. In one type a dark brown or black rot of the cotyledonary tissue predominated. Whether or not this was due in part to bacterial blight infection was not determined. Typical *Rhizoctonia* soil rot lesions (fig. 3B) were found on certain pods and some of the seed lesions above mentioned may have resulted from this disease. The predominating type of cull was one showing a shallow brown discoloration confined to the testa and cotyledon epidermis. Such seeds were found in older pods that appeared to be affected with a fungous rot and upon incubation a *Fusarium* developed from these browned beans as well as the rotted pods. The wet weather of September no doubt increased the amount of seed infection of the types represented by these culls.

Mosaic has not been noted to any considerable extent among lima beans, although it occurred in a garden in Lafayette and one case in the greenhouse evidently resulted from seed carriage of the virus. A powdery mildew (possibly *Microsphaera euphorbiae*) became destructive on lima beans grown for experimental purposes in the greenhouse. Reddish brown blotches were produced on the leaves and considerable defoliation resulted. The disease was much more severe on an adjacent row of cowpeas, and also occurred on Kulthi beans and to a less extent on Urd beans. None was noted on Rice and Hyacinth beans, similarly exposed to infection.

Beet.—Leaf-spot caused by *Cercospora beticola* was especially severe this year in the market gardens about Indianapolis. It was observed in July and again in September and at both times was blighting the foliage very generally, causing the beds to present a scorched appearance. On August 5, a number of sugar beet fields were inspected in Adams County and in general only a small amount of leaf-spot was noted. However, in one field, where beets had also been grown the year before, leaf-spot was very destructive and coalescence of the large blackened lesions was killing much of the older foliage in certain areas. It was reported by field men of a beet sugar company that leaf-spot was much worse in one of the sugar beet growing areas in Allen County where crop rotation was not generally practiced by the growers. Lack of crop rotation is evidently very conducive to destructive outbreaks of leaf-spot. Kendrick found leaf-spot causing scorched areas, visible from a distance, in Grant County on September 17, and inspection revealed that the older leaves were killed by the coalescence of the lesions.

Because of unusually hot weather and heavy rains the last of May in Allen County, very heavy losses to the sugar beet growers were caused by damping-off and root rot. A number of fields were visited June 6, and the loss in stand from damping-off and root rot was alarming. In fact some growers had plowed and reseeded their fields. In most fields, however, it was evident that sufficient stand of plants was left to insure a partial crop. Thinning or blocking of the thickly seeded

rows was in progress at this time. The growers reported that a considerable loss of plants from damping-off occurs every year, ordinarily early enough so that by the time of blocking, all affected plants will have disappeared. The peculiar weather of this season, however, produced an excessive amount of the trouble at a much later date than usual so that the affected plants had not yet died at the time of blocking. As a result, it was impossible to detect which plants were healthy and which diseased at the time of blocking the rows and consequently a high percentage of the plants which were left proved to be diseased and later died. The outstanding symptom was a blackening of the cortex of part or all of the root, lack of lateral roots, and a constriction near the ground line. It was evident that many affected plants would recover. Cultural and incubation tests with a number of these diseased seedlings



Fig. 1. A serious sugar beet disease, apparently mosaic in character.

yielded a variety of organisms. It seemed evident that the trouble was primarily climatic and edaphic in origin.

On August 4, a number of beet fields were visited in Adams County and in all fields about two to five per cent of the plants were affected with a very peculiar disease apparently of a mosaic nature. The same trouble was also found by Kendrick in several fields in Grant County on September 17 and is evidently of considerable economic importance. Several types of symptoms were noted. Older leaves were in some cases yellowish, thickened, and strap-shaped, and many were dying prematurely. The younger leaves were tightly rolled backwards longitudinally (fig. 4), often more on one side than the other so as to be curved, were finely crinkled, and frequently showed in transmitted light a network of etiolated veins. This is evidently the same disease described and illustrated by Cunningham (8) in 1899. In some respects the disease resembles curly-top but lacks certain essential symptoms.

Specimens were sent to Carsner at Riverside, Cal., who reported that the disease was not curly-top. The disease does not resemble the mosaic described by Robbins (36) but may be identical with another disease mentioned by him in his account of the mosaic disease. Preliminary attempts to transmit the disease to seedlings by juice inoculation have been unsuccessful.

Crown rot or root rot, caused probably by *Rhizoctonia*, was noted in a few fields. A *Fusarium* was also noted in association with some of these rots. One scab lesion was noted. Considerable drouth injury as evidenced by a general premature death of the older leaves was noted in certain fields. In one field deep soil cracks were abundant and in cases where a crack occurred along the same plane as that occupied by the two rows of lateral roots on a beet tap root the effect was often fatal to the plant.

Blackberry.—Anthracnose, caused by *Plectodiscella veneta*, was noted causing yellowish, greasy, translucent leaf lesions on April 18 near Lafayette, and the fungus was cultured from these lesions. A similar leaf-spot and a subsequent shot hole effect were found on wild blackberries in Lawrence County on April 29. Rust occurs to a considerable extent on wild blackberries and often is destructive in plantings. One complaint of rust injury was received from Vanderburgh County. Mains reports that the long-cycled *Gymnoconia interstitialis* occurs in northern Indiana and the short-cycled *Kunkelia nitens* in southern Indiana. In the vicinity of Lafayette both species occur and are indistinguishable macroscopically. Crown gall was found on the cut ends of root segments of the Taylor variety imported from Ohio for use in an experimental planting at Lafayette. Sooty blotch and fly speck (*Leptothyrium pomi* or *Gloeodes pomigena* [7]) has been noted on the canes of both cultivated and wild plants. Leaf-spot, due to *Mycosphaerella rubi*, was found prevalent at Lafayette.

Cabbage.—Yellows, due to *Fusarium conglutinans*, continued to be the worst cabbage disease in Indiana and was severe on the early crop during the hot weather of June and July. The disease was reported from Lake, Marshall, White, Tippecanoe, Clinton, Jay, Marion, Knox, Jackson, Jefferson, Clark, Floyd and Vanderburgh counties, and is apparently well established in all parts of the state. The yellows-resistant Wisconsin Hollander is coming into more general use as a late variety in Lake County. Marion County growers are trying the resistant All-Seasons variety and are also developing resistant strains of earlier varieties.

Owing, perhaps, to the very wet spring, black leg, caused by *Phoma lingam*, was very prevalent and destructive among young plants recently transplanted. Specimens of diseased transplants were received from Miami County in May and on May 20, black leg was found killing many plants in recently planted fields near Indianapolis. In many cases new secondary roots were being produced above the cankers. This disease is primarily a seed-bed trouble and the bulk of infection occurs therein. It is disseminated with diseased transplants and striking evidence of its introduction into Indiana market garden sections was af-

forded this spring. In March a grower in Marshall County received a consignment of cabbage plants from the Piedmont Plant Co., Albany, Georgia, many of which bore black leg cankers near the ground line. *Pycnidia* containing spores were present in these cankers.

Club-root, caused by *Plasmodiophora brassicae*, has previously been reported from Lake County and was found this year in the muck soils near Goshen. Black leaf spot due to *Alternaria brassicae* was found at Lafayette. Damping-off of seedlings, due to *Sclerotinia libertiana*, was troublesome in a greenhouse near Lafayette in March and a *Sclerotinia* collar rot of older plants was sent in from Miami County in July.

Cantaloupe.—As usual, the most serious disease of cantaloupes was wilt due to *Bacillus tracheiphilus*. It was noted in Marion and Tippecanoe counties in July and was reported from Marshall and Franklin counties. The peak of the wilt epiphytotic comes rather early in the season and fewer blank spaces will result in the field if enough seed is planted so that there are several plants in each hill and if the thinning process is postponed until after the disease has run its course. It should be remembered that this disease is spread entirely by the striped cucumber beetle (*Diabrotica vittata*), lives over winter in this insect, and does not persist in the soil.

Since most of the good melon soil in Indiana is on the sandy ridges along the rivers and is consequently rather restricted in extent on any one farm, there has been a tendency to grow melons in such fields year after year. This practice has resulted in an increased prevalence of diseases which persist in the soil. In general, watermelons can no longer be grown in such fields because of the *Fusarium* wilt and, since cantaloupes are not subject to such a disease, this crop has superseded watermelons in many sections. However, failure to rotate the cantaloupe crop very likely is responsible for the increased prevalence of the leaf blight due to *Alternaria brassicae nigrescens* although the disease also occurs to some extent in fields not previously in melons.

Another disease favored by the continual culture of cantaloupes year after year not necessarily in the same fields, but in the same locality is the mosaic disease which persists over winter in perennial weeds (11) and is carried to cantaloupes by insects. Mosaic was noted in Knox, Marion and Tippecanoe counties but was not prevalent. In a field at Lafayette, a *Fusarium* rot of the fruit (fig. 5), much of which resulted from growth crack infection, caused a 15 per cent loss. A *Fusarium* rot was also reported by U. S. Bureau of Markets inspectors in two cars from Posey County. Anthracnose (*Colletotrichum lagenarium*) was found on a volunteer plant in September in Morgan County, but was not noted in cantaloupe fields.

Carrot.—Leaf-spot, caused by *Cercospora apii carotae*, was especially prevalent in the Indianapolis market gardens this year, particularly where the Skinner system of irrigation was used. It was noted in July and again in September and in many instances was actually killing the leaves. It was also noted near Goshen in September. Microscopic examination of specimens collected in July showed abundant

sporulation on the lesions on the leaf blades but none on the petiole lesions.

Celery.—The heat of July was favorable to the *Fusarium* yellows disease which is present in much of the celery soil, but August and September were not as favorable to the disease. It was noted in Indianapolis market gardens where the growers still grow the susceptible Golden Self-blanching variety and near Lafayette. The use of the resistant Easy-Bleaching variety has saved the celery industry near Goshen. Laboratory studies of the temperature relations of this fungus in culture show that it makes practically no growth at 10° C and 35° C, that it grows well at 16° and 20° C, better at 30°, and best at 25° and 27° C. This would indicate that a high soil temperature should aggravate this disease, and previous observations on this disease in the Kalamazoo, Mich., celery marshes in 1914 indicate that such is the case.

As usual, early blight, caused by *Cercospora apii*, was very destructive and was killing much of the older foliage in the celery patches



Fig. 5. *Fusarium* rot of cantaloupe in ripe fruit.

near Indianapolis and Lafayette in July. In a truck garden in Henry County, July 20, this disease appeared to be worse on the Golden Self-blanching variety than on the Easy Bleaching. The Goshen fields were visited on September 22, and in the crop that was then being harvested early blight was so severe as to necessitate stripping off of many leaves that otherwise would have been salable. In many cases this disease was directly responsible for the loss of three or four large stalks per plant. Laboratory studies of the effect of temperature upon the growth of this fungus have shown that very little growth occurred at 10° C and 35° C, and that growth was good between 16° and 30°, with an optimum at 27° C. Spore germination occurred readily in both water and prune decoction at temperatures from 10° to 30° C. *Septoria apii*, the fungus causing late blight, which is less destructive in Indiana than early blight, was found to grow well only between 16° and 27° C. and to grow best at 20° C. Spore germination occurred readily between 16° and 25° C. Thus *Septoria apii* has a lower optimum temperature for growth and a narrower range for vigorous spore germination than is the case

with *Cercospora apii* and this may account for the greater destructiveness of the latter under Indiana conditions.

An unmistakable mosaic disease (fig. 6) was noted in two fields near Indianapolis on September 7 in the Golden Self-blanching variety. In one field numerous scattered cases were observed. The trouble is evidenced by a characteristic mottling, crinkling and extreme distortion of the leaves. This disease has recently been described by Poole.⁴

Cherry.—Burkholder reported that leaf-spot, due to *Coccomyces hiemalis*, was very severe as usual in southern Indiana and that in unsprayed orchards defoliation was very nearly complete by the first of August.

Clover.—Mains reported that the rusts, *Uromyces fallens* on crimson clover and *U. trifolii* on white clover, were not as prevalent as in 1920. Leaf-spot, due to *Cercospora medicaginis*, was found near Indianapolis on July 13. Powdery mildew was conspicuous on clover in many localities during the fall, due largely to the wet weather.



Fig. 6. Celery mosaic. Leaves thickened and greatly distorted.

Root rot troubles with clover have frequently been reported from southern Indiana. Death of the crop in many fields early in the spring was reported from Harrison County and whether this was due to root rot, anthracnose or other causes is not known. In March, specimens of a root rot were received from Owen County and a *Fusarium* was cultured from a number of roots. This trouble may possibly be identical with a *Fusarium* root rot recently reported from Ohio (39). Mosaic (12) was noted in Marion, Kosciusko, Orange and Tippecanoe counties, usually on red clover. In Marion County it was noted on sweet clover and at Lafayette on alsike clover. Attempts to transfer this disease to soybeans were unsuccessful. Dodder was reported very bad in clover fields in Tippecanoe County and vicinity. This season seemed especially favorable to dodders and the large yellow patches were noted in abundance on wild vegetation along river banks.

⁴ Poole, R. F. Celery mosaic. *Phytopathology*, 12, 151-154, 1922.

Corn.—Hoffer reported a loss of about 10 per cent in the corn crop due to root, stalk and ear rots. He has given a very concise explanation of the present understanding of the root and ear rot problem in a current bulletin of the federal Plant Disease Survey (26) in which he shows that the *Fusarium* root rot is not a specific parasitic trouble comparable to cabbage yellows and tomato wilt but is more or less dependent on predisposition of the plant to infection by certain soil conditions. Ear infection is local and not the result of systemic infection of the plant and seed infection or infestation is important mainly in connection with the vigor of the seedlings and has little direct relation to the occurrence of root rot later. Ear rots due to *Fusarium*, *Penicillium* and *Diplodia* were particularly destructive this year because of the wet fall and the widespread injury by the corn ear worm. Hoffer reported that *Diplodia* ear rot occurred on as high as 75 per cent of the ears in certain fields. Smut (*Ustilago zeae*) was generally prevalent, especially on sweet corn, but, according to Hoffer, was not as abundant as in 1920 owing to the drouth during the early growing season. One lesion of *Physotherma zeae-maydis* was found by Trost at Lafayette on Early Evergreen sweet corn.

Cowpeas.—The spot disease of cowpeas previously reported as due to a *Phyllosticta* occurred at Lafayette and has been found to be bacterial in nature. Reddish brown spots on the leaves, stems and pods and constriction of the pods are produced. The disease is seed-borne and in its effect on the pods causes considerable loss in the yield of seed. Leaf-spot caused by *Cereospora eruenta* occurred in the experimental plot mentioned above and also was noted in Knox County. It became severe enough to kill the leaves in some cases. A powdery mildew became very severe in the fall on cowpeas in the greenhouse. Large brown blotches were produced on the leaves and hypocotyls and the plants were defoliated and killed outright. The attack on cowpeas was much more severe than on adjacent rows of lima beans. Perithecia were not found and whether or not this is *Microsphaera euphorbiae* recorded by Fawcett (13) on cowpeas is not known.

Cucumbers.—Wilt caused by *Bacillus tracheiphilus* was the most important disease in the pickle, market garden and greenhouse crops. Gregory reports wilt destructive to the fall crop in greenhouses at Terre Haute. Observation of numerous fields in the vicinity of Plymouth on August 2 showed a loss of three to ten per cent in stand due to wilt. The disease was also found in Marion and Tippecanoe counties and was reported from Allen, Fountain and Fulton counties. Row planting or the hill system with numerous plants in each hill and postponement of final thinning until the peak of the wilt epiphytotic has passed are suggested as palliatives for this disease. Bacterial wilt has been discussed in more detail in connection with cantaloupes.

Mosaic seemed to be less prevalent than usual this year. In the pickle crop near Plymouth, it was noted only on scattered plants on August 2 and seemed to be of late inception. It was noted as early as July 12 near Indianapolis and was severe by September 7. It was very severe in a field near Hammond on August 31 and was noted near

Goshen in September. The relation of weeds to this disease was mentioned in our account of cantaloupe mosaic. It seems probable that the milkweeds, once infected, serve as a perennial source of infection for cucumbers (11), and that this accumulating reservoir of mosaic in the weed flora has driven the pickle-growing industry out of one region after another.

Angular leaf-spot, due to *Bacterium lachrymans*, was found in only one of several pickle fields visited near Plymouth on August 2 and also occurred in a field near Hammond. Anthracnose, due to *Colletotrichum lagenarium*, was found in one of the fields visited near Plymouth and also, later in the season, in fields near Indianapolis and Goshen. The wet weather of this season of course favored anthracnose. It was again present in the greenhouse where it occurred last year and overhead irrigation was undoubtedly responsible for its prevalence.

Eggplant.—Leaf-spot caused by *Phomopsis vexans* was noted on young plants in a market garden near Indianapolis on May 20. A leaf-spot caused by *Septoria lycopersici* was found on a few plants in our experimental greenhouse. *Phytophthora terrestris* caused a rot of eggplant fruits⁵ in an experimental garden at Lafayette in September. The fungus had been prevalent on an adjacent plot of tomatoes and very evidently the infection spread from the tomatoes to the eggplants. Wilt was noted near Indianapolis and reported from Logansport. From specimens collected a *Sclerotium* was isolated.

Goldenseal.—An outbreak of Botrytis blight occurred in early September in Greene County and was probably attributable to the very cloudy wet weather.

Gooseberry.—Anthracnose caused by *Pseudopeziza ribis* was noted in Cass County and leaf-spot caused by *Mycosphaerella grossulariae* was found prevalent near Lafayette in September. A specimen of powdery mildew (*Sphaerotheca mors-uae*) was sent in from Putnam County in September.

Grape.—Black-rot caused by *Guignardia bidwellii* was exceptionally destructive this season and specimens of fruit infection were sent in with complaints from several localities. P. G. Ewald, county agent of Switzerland County, found fruit infection in June and reported that the Concord variety similarly exposed was free from infection. The disease was reported from Allen, Ripley and Dekalb counties in July and from Lagrange County in September.

Kale.—Yellows caused by *Fusarium conglutinans* occurs to a considerable extent in the Indianapolis market gardens because of the rather general soil infestation of the causal fungus, which also causes cabbage yellows. It was found severe on young plants as early as May 25 and was even more severe in July. Both kale and kohlrabi showed considerable drouth injury in July.

Lettuce.—Downy mildew (*Bremia lactucae*) occurred to a considerable extent in the fall and winter hothouse crops and to a less extent in the spring crops. Preliminary tests of the effect of tempera-

⁵ Kendrick, James B. *Phytophthora* rot of tomato, eggplant and pepper. In Proc. Ind. Acad. Sci., 1922.

ture upon spore germination show that good germination occurs at 4°, 9° and 16° C and practically none at 20° and above. The most prompt germination (within three hours) occurred at 9° C. This indicates that a very low temperature is necessary for infection with this fungus and may explain why it is worse in the winter crops than in the spring crop.

Botrytis rot of the older leaves and stems was found in the spring hothouse crop, and drop due to *Sclerotinia libertiana* occurred rather generally in greenhouses. It was noted in the spring crop and reported very destructive in mid-winter in one Indianapolis greenhouse. A trouble resembling rosette due to *Rhizoctonia* was noted in the field crop in September.

There is considerable difficulty in the greenhouse crop with a marked stunting of the plants. No root or stem lesions are associated with this trouble and it may be due to the use of a poor quality of soil or to a harmful accumulation of soil salts in the surface layers. Leaching by surface watering and better under drainage should correct the latter condition.

Oats.—Jackson reports that there has been somewhat of an increase in the prevalence of the smuts this season owing to a less consistent practice of seed treatment than has been the case in previous seasons. Gregory reports smut losses varying from one to as high as 35 per cent. Jackson and Mains attribute considerable loss in yield to crown rust (*Puccinia coronata*) in central Indiana and Mains reports that there was a very slight amount of stem rust (*P. graminis*) this year. Hosmer found no stem rust in his surveys made in connection with the barberry eradication work. The hot dry weather of this season was very unfavorable to oats.

Onion.—Gregory found smut caused by *Urocystis cepulae* very destructive in the onion set crop on three farms in Lake County, causing as high as 50 per cent loss, and growers informed him that the disease was present on about twelve other farms in the county. On June 16, Gregory found a light infection of onion smut in a field in Jasper County. Red onions seem to show some resistance to this disease. In control tests with the formaldehyde drip on the seed drill, Gregory reported very favorable results, the yield of graded sets being doubled and the amount of undesirable over-sized bulbs reduced one-half.

Smudge caused by *Colletotrichum circinans* was found causing a rather serious rotting of the outer scales of white sets in storage in March. As many as five outer scales were involved and there was practically 100 per cent infection in the sets examined. These onions were grown on soil that had been continuously cropped to onions for about ten years. The disease was noted to a limited extent in the fall in Fulton County. Botrytis rot was found to a considerable extent in Fulton County in the fall. Its occurrence in the recently harvested crop indicates field infection. Black mold (*Sterigmatocystis niger*) was found abundant in the recently harvested crop in Fulton County in the fall. Harmless infection of pink root, a soil *Fusarium* disease, was found near Indianapolis on July 12.

Parsnip.—Leaf-spot, caused by *Cercospora pastinacae*, was found very prevalent in several market gardens near Indianapolis and was also noted near Goshen. As observed September 9, this disease caused a conspicuous mottled or speckled appearance of the upper side of the leaf owing to the yellow color of the very small, thickset, angular, interveinous lesions. On the lower epidermis these lesions presented a dusty or velvety gray surface due to the abundant sporulation of the fungus. As the lesions become older the tissue dies and turns brown and frequently the lesions were so abundant that entire leaves were killed.

Pea.—Bacterial spot of field peas, caused probably by *Bacterium pisi*, was found producing greasy, parchment-like lesions on the leaves and stems in a field in Marion County on May 20.

Peach.—Burkholder reported that leaf curl, due to *Exoascus deformans*, was not as bad as in 1920. He found it destructive in Morgan County and also noted it in Posey County on April 11. It was noted near Lafayette, Vincennes and Bedford in April, and was found rather conspicuous near Peru on May 19. Fruit lesions are shown in figure 7.



Fig. 7. "Birth-mark" fruit lesions of the peach leaf-curl fungus.

Black spot, due to *Bacterium pruui*, was by far the most serious disease of peaches in Knox County and was also found in Dekalb County on August 10. It was particularly severe in Knox County during the early part of this season. On April 28, there was abundant leaf infection and much defoliation had already occurred. A few trees showed very conspicuous blighting of the young shoots of the current season not unlike the twig blight phase of fire-blight on pears. Elongated, blackened cankers had girdled and killed the young twigs. The causal organism was isolated from these blighted twigs and it is likely that this type of attack resulted from bud infection of the previous season. Cankers were not numerous on 1920 wood and usually were located at leaf scars. On June 28, the disease was still prevalent on the foliage and defoliation was still in progress. Very general fruit infection was evident. The disease was somewhat less severe on the trees in the hollows than on the ridges and there was some indication of a partial control from a 1-7-50 Bordeaux spray that had been applied to a few trees on May 29. On October 21, no recent leaf infection was noted and the disease had removed all but a terminal tuft of the younger leaves on each twig. Very few cankers on 1921 wood could be found.

Brown rot, caused by *Sclerotinia cinerea*, was found in Knox County, June 28, on many wounded fruits of an early variety. The fungus was sporulating abundantly at that time. Twig cankers of scab, caused by *Cladosporium carpophilum*, were sent in from Dubois and Greene counties and twig infection was noted in Lawrence, Tippecanoe and Knox counties. Burkholder has found abundant evidence that scab is brought into Indiana on southern-grown nursery stock. A consignment of nursery stock received in Posey County in March was very heavily infested with scab cankers. The fact that certain orchards have the scab disease present and others do not may be explained by the presence or absence of the disease on the original nursery stock. The same condition holds true for black spot and the explanation may be the same.

Root rot caused by *Armillaria mellea* is still present in the orchard in Brown County where it was recorded in 1919, and along with other types of root rot is a serious source of loss in this orchard. Burkholder reported that the root rot situation among peaches very closely parallels that among apples in that the trouble occurs wherever peaches are planted on newly cleared land in the area embracing Brown, Monroe, Greene, Martin, Orange, Lawrence and Jackson counties; and over one-fourth of the peach trees in the state are grown in this area. However, it is not likely that this trouble is all due to the fungus named above. On 1921 twigs the fly speck fungus (*Leptothyrium pomi*) and an occasional colony of sooty blotch (*Gloeodes pomigena*) were noted in Knox County on October 21. Mains reports that the aecial stage of the rust, *Puccinia pruni-spinosae*, is annually prevalent on *Thalictrum dioicum* near Lafayette, but no telial stage on *Prunus* species has been found.

Pear.—Fire blight, due to *Bacillus amylovorus*, was noted near Indianapolis in May, near Goshen in the fall, and was reported from Hamilton County. In general, fire blight was not severe this season. Black rot due to *Physalospora eydoniae* and sooty blotch (*Gloeodes pomigena*) were noted on pears in the market at Goshen. Frost injury ruined the crop in southern Indiana.

Pepper.—Mosaic was very prevalent in the Indianapolis market gardens and was noted at Lafayette. Conspicuous mottling and "pockmarks" on the fruit were caused by this disease. Sunscald of the fruits was found very destructive in the market gardens on July 12. Kendrick⁶ found *Phytophthora terrestris* causing a rot of peppers at Lafayette.

Plum.—Black knot, caused by *Plowrightia morbosa*, became conspicuous in a number of localities this season. It was noted in Miami County and was reported from Marshall, Clinton, Randolph, Hancock, Marion, Monroe, Franklin and Scott counties. Brown rot of the fruit caused by *Sclerotinia cinerea*, was sent in from Marion County. Specimens of plum pockets caused by *Exoascus pruni* were also received this season. Frost injury prevented the set of fruit in southern Indiana.

Potato.—Owing probably to the abatement of the hot weather and the abundant rainfall in August, Fusarium wilt of potatoes was not as

⁶ See footnote under eggplant.

prevalent as in previous seasons. However, it was found causing a 50 per cent loss in one field in Kosciusko County and Gregory noted one field in Carroll County on August 29 in which there was 10 per cent wilt infection. In a field in Laporte County planted with seed tubers selected for freedom from wilt-infection, about two per cent was found on August 3. Gregory noted the disease in Floyd, Harrison, Hancock, White and Cass counties, and Gaylord noted it in Porter County. A very little wilt was noted in Elkhart County. Gaylord found vascular discoloration very prevalent in the Irish Cobblers grown in Harrison County this season. Kendrick has found that only about 40 per cent of the tubers showing vascular discoloration yield an organism in cultural tests. In these isolations, a type of *Fusarium* predominated and in its temperature relations this form resembled *F. oxysporum*. Good growth occurred at 16° and 20°, but was best from 24° to 35°, with a rather distinct optimum at 27° to 30° C.

Gregory reported leaf-roll serious in fields observed in Floyd, Harrison, and Jasper counties and the disease was also noted in Fulton, Kosciusko, and Elkhart counties. Mosaic may be detected with more certainty than leaf-roll under field conditions and striking cases were observed in Early Ohios in Marion County on May 20, and in Lake County in Early Ohios and Rurals as well. Gregory noted mosaic in Floyd and Dekalb counties.

During the winter and early spring, Kendrick tested in the greenhouse, single-eye seed pieces from samples of seed stock sent in from several potato-growing sections in the state in order to ascertain to what extent mosaic and leaf-roll might be present in home-grown seed. Blodgett (5) at Cornell found that these two diseases showed up conspicuously under greenhouse conditions and this method of analysis is particularly useful in Indiana because the symptoms of these diseases may not be at all clear cut under field conditions. Out of 20 lots of seed tubers from twelve counties, nine lots, representing Hancock, Fulton, Whitley, Floyd, Clark, St. Joseph, Laporte and Lake counties, showed leaf-roll and four of these, both mosaic and leaf-roll. The latter four were from Hancock, Whitley, Clark and Lake counties, and the percentages of mosaic were low. In addition one lot of Early Ohio seed from Tippecanoe County showed 95 per cent mosaic. The highest percentages of leaf-roll were in Bull Moose potatoes from Floyd and Clark counties, Carmens from Laporte County, Early Ohios from Tippecanoe County and Rurals from Lake County. These results show that leaf-roll was rather prevalent in the 1920 crop in Indiana and the occurrence of 81 per cent and 98 per cent leaf-roll in two large lots of Rurals from Lake County and 12 per cent mosaic in one of these lots indicates that leaf-roll and, to a less extent, mosaic are responsible in part for the decline in potato yields in Lake County mentioned in last year's report (17). While leaf-roll may be readily detected under field conditions in the cooler northern states, field row tests at Lafayette and Hammond in 1921 with healthy and leaf-roll seed tubers of the Rural variety showed that it was practically impossible to detect leaf-roll under the field conditions existing in those localities. However, the disease reduced

the yield about 40 per cent and must be recognized as an extremely important loss-producing factor in this state. The desirability of obtaining seed potatoes free from leaf-roll and mosaic is perfectly obvious.

In the late crop, early blight, caused by *Alternaria solani*, was exceptionally prevalent this season. Gaylord reported that it was worse in the late crop than he had ever noted in his experience and records its presence in 12 counties. Gregory reported that early blight was epidemic in Floyd and Harrison counties. In some fields the disease appeared to be responsible for the yellowing and premature death of



Fig. 8. Potato diseases. A and B. Effect of *Rhizoctonia* on sprouts. C. Advanced stage of black leg caused by *Bacillus phytophthorus*.

many plants. Early blight was prevalent during the entire season in fields under observation near Lafayette and Hammond.

Gregory found one tuber from the 1920 crop of a grower near New Albany which was affected with late blight rot, due to *Phytophthora infestans*. This is apparently the first specimen record of this disease for the state. Gregory was unable to find any trace of the disease in the 1921 crop on the same farm. Although the extremely wet weather of August and September should have favored the occurrence of late blight, it was not found in any of the numerous fields examined. On the older stems of the early crop, sunken lesions located just below the points of attachment of the leaves were found very abundant. With these lesions, a fungus of the *Gloeosporium* type was commonly asso-

ciated and it is likely that this is identical with the potato anthracnose recently reported from Ohio (9).

Inasmuch as black leg (fig. 8C), caused by *Bacillus phytophthorus*, is one of the cool-climate diseases, it was not surprising to find it occurring to some extent in the early market garden crop near Indianapolis. On May 20 the disease was causing characteristic symptoms on about one per cent of the plants in certain of these fields which, it appeared, had been planted with home-grown seed. In these same fields there was a considerable loss due to the destructive effect of *Rhizoctonia solani* on the young shoots (fig. 8, A and B). The occurrence of numerous blanks in the rows was attributable to this disease and a prevalent stunting of the plants was found to be due to the killing of the main shoot by a *Rhizoctonia* lesion below the ground line and the subsequent development of a lateral shoot from a point below the canker. Typical, brown, *Rhizoctonia* lesions were frequently present on these secondary shoots and also on the roots. This destructive activity of *Rhizoctonia* early in the spring under Indiana conditions is exactly what should be expected in the light of Richard's (35) determination of the low soil temperature optimum (18° C) for the parasitic activities of this organism upon the young shoots. The extremely destructive effect of the disease, especially on the young shoots, emphasizes the necessity of disinfection of the seed for the early crop. The black scurf stage of this disease on tubers was generally prevalent throughout the state.

Scab, caused by *Actinomyces scabies*, is state-wide in its occurrence. In a field near Lafayette much deep scab, such as Coons has attributed to the secondary action of mites in the scab lesions, was noted. In another field there was a very high incidence of the early stage of the so-called russet scab. These lesions were small shallow rounded spots of blackened tissue which later may crack and check and produce the roughened russet scab appearance.

Owing to the excessive rains, the tubers of the late crop very frequently showed extreme cases of enlarged lenticels. This condition was common in low ground in one field observed near Lafayette. A preliminary test indicates that the water loss during four months storage from tubers with enlarged lenticels is 17 per cent more rapid than in the case of normal tubers.

A grower in Franklin County found about 50 per cent of his crop of Early Six Weeks potatoes affected with internal brown spot. In a highly productive muck field in Fulton County planted to a late crop of Rurals, overgrown tubers and second growth knobs were of very frequent occurrence. Sunburn or greening occurred to a considerable extent this season because the soil was frequently washed away from the upper tubers thus exposing them to the sun. In the muck field mentioned above there was also a rather high percentage of tuber rot, some due to *Fusarium*, some apparently to bacteria. The *Fusarium* rot was of a peculiar type, since it was usually associated with the death of rather extensive cortical areas. The bacterial rot was more or less confined to the central tissues of the overgrown tubers.

Rotting of the seed pieces in the soil was the most important source

of loss in the late crop and resulted in very poor stands in central Indiana. Certain fields were almost a total loss because of this trouble. According to Gaylord's observations, this failure occurred mainly in potatoes planted about the middle of June and is attributed by him to high soil temperature. He found that the loss in stand was very much less in the fields which were rolled after the seed was planted.

Quince.—Heavy spotting of the fruit due to *Fabracea maculata* was noted in Lafayette.

Radish.—Black-root, caused by *Rheosporangium aphanidermatum*, was a very serious trouble in the icicle varieties in the early market garden crops. It was noted near Indianapolis in April and May and was prevalent in gardens in Lafayette in May. It is not a factor in the midsummer crop, but may occur in the fall. In a variety test sown by Brown on August 20, the disease occurred in the fall on the varieties Early Long Scarlet, Early Vienna and Cincinnati Market. By the agar plate method a fungus resembling *R. aphanidermatum* was isolated from diseased roots.

Downy mildew (*Peronospora parasitica*) was found doing considerable damage in beds of small red radishes in an Indianapolis market garden on April 27. The leaves were thickly spotted with small, irregularly lobed, sharply defined, black lesions (fig. 9A) bearing sporophores of the fungus on the lower side. On the upper portions of many of the roots were small, sunken, black lesions caused by the same fungus (fig. 9E). Under these root lesions there was in some cases some blackening of the tissue indicating that the fungus had penetrated to a considerable extent. Under damp chamber conditions in the refrigerator, sporulation of *Peronospora* occurred on these surface root lesions and on the cut surfaces of the blackened root tissue. Microscopic examination showed abundant haustoria within the host cells. The occurrence of *Peronospora* in turnip roots has been previously recorded (15). The occurrence of *Peronospora* in red radish roots was noted by a German observer (4) in 1899, however, and in black or summer radishes by another (40) in 1908. On May 25, leaf lesions similar to those described above were noted on older plants on another farm and blackened petiole and stem lesions were also noted. There was extensive blackening of the pith of these seed stems (fig. 9C) due to *Peronospora* infection. In another field, more recent foliage infection on icicle and white globe radishes was abundant, but in this case the lesions were the typical angular, intervenous areas (fig. 9B), yellowish above and covered with a white velvety mass of sporophores below.

White rust (*Cystopus candidus*) occurred in the greenhouse crop near Lafayette in the early spring and was found abundant in the Indianapolis market gardens in May. It was noted in abundance on a row of seed radishes in a Lafayette market garden on June 28. Radish seed pods infected with both downy mildew (fig. 9D) and white rust were collected in 1920 (17, p. 201) and a considerable quantity of seed from these pods was planted in the greenhouse but no evidence of seed transmission of either of these diseases was obtained.

Raspberry.—Anthracnose, caused by *Plectodiscella veneta*, remains the worst disease of the black raspberry in Indiana. It was reported

destructive in Lake, Laporte, Noble, White, Carroll and Miami counties. New infection was found near Lafayette as early as April 18. Spur



Fig. 9. *Peronospora parasitica* on radish. A. Blackened leaf lesions. B. Inter-venous leaf lesions. C. Longitudinal section of seed stem showing blackening of pith. D. Blackened lesions on seed pod. E. Blackened root lesions on red varieties.

blight of red raspberry caused by *Mycosphaerella rubina* was found in St. Joseph County on June 9 and in Dekalb County on July 15. Leaf-spot caused by *Mycosphaerella rubi* was noted near Lafayette on July

7. Crown gall on raspberry plants was sent in from Clark, Putnam and Noble counties.

Rhubarb.—Leaf-spot, attributed to *Ascochyta rhci*, was found prevalent in the Indianapolis market gardens in May and was noted in July near Lafayette.

Rye.—Anthracnose, due to *Colletotrichum cereale*, caused very heavy losses in rye this year. Specimens were received from a grower in Lagrange County on June 14 showing that affected plants were stunted and were dying prematurely. The heads were light colored and the grain was not filled out. There was some anthracnose infection of the heads causing the portions above the point of infection to dry out, but most of the infection occurred at the lower nodes, on the first internode and on the roots. These lesions bore setose, sporulating acervuli. The grower reported that in a seven acre field about one-third of the plants were thus affected, that in an adjacent rye field planted two weeks later, only a few dead plants had appeared, and that, in another adjacent rye field planted one month later than the first field, many dead plants were visible in the portion adjacent to the first field.

On June 18, Kendrick found anthracnose causing heavy losses near Wanatah. In one 50 acre field, 40 to 60 per cent of the plants were dead and in another of 60 acres, 5 to 10 per cent of the plants were dead. Gregory found the disease severe in Perry County on June 20, and reported one field practically ruined and a similar occurrence was reported from Switzerland County. Mains observed the disease in Lawrence County. Jackson found a destructive foot-rot of rye which was not due to anthracnose in a field in Stark County on June 21. Among the several types of fungi isolated from root segments and lower nodes was an orange-yellow type of *Sclerotium*. As has been previously pointed out, the mild open winter and warm, wet spring probably favored anthracnose and foot-rot of rye.

Mains reported that leaf rust (*Puccinia dispersa*) was prevalent this season and considerable loss was attributed to its attack. Hosmer found portions of two rye fields, one in Steuben, the other in Lagrange County, ruined by stem rust (*P. graminis*), and in both cases barberry bushes were found near by. Ergot was reported from Switzerland County. Two heads of the rare loose smut were found in Kosciusko County.

Soybean.—Bacterial blight caused by *Bacterium glycineum* is carried with the seed and, like bean blight, is practically co-existent with the crop. The disease occurred in fields near Lafayette and was reported from Greene County. The causal organism has been studied in culture and found to be the non-chromogenic strain of *Bact. glycineum* (29).

Mosaic (22) was found to a limited extent. Attempts to infect field beans with soybean mosaic were unsuccessful, as were also attempts to infect soybeans with mosaic from field beans, from Adzuki bean, and from red clover. A spotting of the older leaves of the varieties Black Eyebrow, Dunfield and Ito San with which a *Macrosporium* was associated was noted at Lafayette. An objectionable lavender staining of the seeds of certain varieties was found to be due to fungus invasion

and a *Fusarium* was isolated from the few seeds that were plated out. This trouble was probably attributable to the wet weather.

Spinach.—Downy mildew (*Peronospora effusa*) was found very destructive in two beds of spinach in a greenhouse at Lafayette on March 15. Large areas on the leaves were covered with the gray coating of sporophores and spores and the older leaves were dying from the effects of the disease. Infected leaves were, of course, unsalable, and the disease caused a considerable loss to this grower. In spore germination tests it was determined that temperatures of 4° to 27° C permitted germination, but that only a low percentage germinated at temperatures of 20° and above, while prompt and vigorous germination occurred at 4°, 9° and 16° C. The temperature of 9° seemed to be the optimum for germination while 16° seemed more favorable to subsequent growth of the germ tube.

In a plot of spinach grown under Skinner irrigation in a market garden at Lafayette, about 50 per cent of the plants were found affected with a destructive crown rot on June 21. The plants were of a marketable size at this time and the loss was great. The affected tissue of the recently affected stems and petiole bases was water-soaked and dark green. From diseased plants, a very rapid-growing *Phytophthora* species was isolated. Spinach blight or mosaic was noted near Goshen on September 22. Nematode root-knot was also noted in the same region.

Squash.—Oval, sunken lesions resembling anthracnose were found on small white squashes in the local market on February 7. The fungus isolated proved to be a *Gloeosporium* species not identical with the cucurbit anthracnose fungus. In pure culture this fungus was found to grow fairly well at 9° and 16° C, and more vigorously between 20° and 35°, with a fairly distinct optimum at 27°.

Strawberry.—Leaf-spot caused by *Mycosphaerella fragariae* was rather severe this season near Lafayette. The disease was noted in Lake county and was reported from Clark and Kosciusko counties. Lesions bearing an abundance of viable conidia were found on green overwintered leaves in a garden near Lafayette on April 19.

Sweet Potato.—Black rot, caused by *Ceratostomella fimbriata* was the cause of storage loss in the 1920 crop in Jay County and badly rotted roots were received from that county on April 29. W. J. Piggott reported the disease prevalent in the 1921 crop in Knox County, and it was noted by Gregory in Floyd and Tippecanoe counties.

Fusarium stem-rot or wilt was noted in the Indianapolis market gardens on July 12, and at Vincennes on June 28. Gregory reports the disease destructive in Floyd County. A complaint of serious difficulty due to this disease was received from a grower in Boone County and growers in Carroll County reported this disease severe on the Yellow Jersey variety but not on the White Yams.

Scurf, caused by *Monilochaetes infuscans*, was sent in from Jay County on stored roots of the 1920 crop and also caused a very bad discoloration of Yellow Jerseys grown at Lafayette from seed secured from Vincennes. Specimens of *Fusarium* surface rot were sent in from Union County on Sept. 10, and a *Fusarium* was isolated from the lesions. The same roots were also affected with a very objectionable trouble ex-

actly resembling internal brown spot of the Irish potato. Numerous areas of corky brown tissues were scattered throughout the flesh of the roots. Attempts to isolate an organism from the lesions were unsuccessful.

Tobacco.—Angular leaf-spot (14), caused by *Bacterium angulatum*, was very destructive in Spencer County this year and was worse in 1920, according to the grower who sent in the specimens and who estimated that the crop was damaged to the extent of fifty per cent by this disease in 1920. As a result of this experience the growers harvested earlier in 1921 to avoid the heavy loss due to this disease. The disease was identified by F. D. Fromme.

Tomato.—Owing perhaps to the excessive rainfall in the spring and late summer, leaf-spot, caused by *Septoria lycopersici*, was much worse than usual in both market garden and canning crops. The disease was noted at Vincennes as early as June 29, and on early tomatoes in a market garden near Kokomo on July 2. The plants for the latter had been grown in a greenhouse that was also used for a hothouse tomato crop, and thus were undoubtedly exposed to infection. At this early date, practically no leaf-spot was evident in the canning crop fields in that region. On July 12, the disease was noted in a number of market gardens about Indianapolis and was especially destructive on staked tomatoes under Skinner irrigation and in a greenhouse where overhead watering was practiced. On July 21, leaf-spot was found to be rather worse than was to be expected at this date in a number of canning crop fields in Marion County. Late in the season the disease became very destructive in the canning crop, as well as the market gardens and caused very general premature defoliation. It was observed in severe form near Indianapolis, Greenwood, Whiteland, and Marion in September.

Considerable evidence was obtained which corroborates the belief that leaf-spot is primarily of plant-bed origin except in cases where crop rotation is not practiced. For instance, leaf-spot lesions were noted on purchased transplants that a grower was setting out on June 1 near Hammond, and later the disease became severe on these plants. At Lafayette no leaf-spot occurred in the plant-beds and none appeared in the fields planted from these beds. Remnant tomato plants are often left to grow during the season in the plant-beds and in two cases observed, one near Indianapolis, on July 13, and one in Johnson County on July 16, leaf-spot was present on these old plants. Leaf-spot may also occur on other plants in these beds since Norton (31) in 1917 found that the tomato *Septoria* would infect eggplant, potato, and horse nettle, and Beach (3) corroborated these results in 1919. Pritchard and Porte (33) in 1921 also report horse nettle susceptible. By means of remnant tomato plants and other hosts the volume of infective material in the plant-bed soil may be augmented each summer. It is of primary importance in leaf-spot control that plant-bed rotation and sanitation be practiced. By sanitation is meant the destruction of all remnant tomato plants and susceptible weeds in and near the beds and the precaution not to use such soil for eggplants or potatoes.

The extreme heat of June and July was very favorable to the wilt

disease, caused by *Fusarium lycopersici*. The disease was found as early as May 25 in hothouses near Indianapolis and by July 12 it was very destructive. One grower had replaced the soil of his wilt-infested house and another moved his house to avoid using the old wilt-infested soil. While both secured a good crop, yet in both cases scattered cases of wilt occurred. By July 12 wilt was also severe in the market garden field crop and in one field that had been in tomatoes several consecutive seasons there was a fifty per cent incidence of the disease. Wilt was also found destructive in a hothouse at Vincennes on June 28 and there was evidence of spread of the disease to several other houses with infected transplants. It is, of course, to be recognized that any means by which soil from a wilt-infested hothouse is carried to a house where none of the disease has occurred may introduce the disease. In experimental fields at Lafayette, wilt was first noted on June 21, and by the middle of July there was a scattered infection involving about two per cent of the stand. The danger of plant-bed soil infestation as a source of this disease was clearly demonstrated by the discovery of two remnant tomato plants affected with wilt in a plant-bed in Johnson County on Sept. 16. This further emphasizes the necessity of keeping plant-beds free from tomato plants during the summer since wilt-infected plants increase the volume of infective material in the soil.

The outstanding feature of the wilt situation this year was the abundant and conclusive evidence of the introduction of this disease into canning crop fields with southern-grown transplants, a danger which has been previously pointed out (18). For a considerable number of growers this evidence was obtained at a high cost. It is likely that in several localities southern-grown plants will no longer be acceptable. On June 30, thirteen fields were inspected near Whiteland, in 12 of which Georgia plants had been used. Wilt was already prevalent among the Georgia plants in every one of the 12 fields and none was noted in the one field planted entirely with home-grown plants. In fact, in fields where both Georgia and home-grown plants had been used, the Georgia plants could be located at once by the abundant wilt infection. Somewhat similar observations were made near Kokomo on July 2. Wilt was present in 12 out of 21 fields examined and Georgia plants were used in five of these 12 fields, and Louisiana plants in 3. The disease was severe in four of the five fields of Georgia plants. On July 20, wilt was found present in eight out of eleven fields near Greenfield and was severe in five of these fields, all of which contained Georgia plants. And again, in fields containing both home-grown and Georgia plants, the disease was confined to the latter. In a number of fields near Indianapolis containing Louisiana plants there was evidence that about two per cent of the Louisiana transplants had been infected. In the Indianapolis territory, however, there is also considerable soil infestation with the wilt fungus. As a basis for comparison it is of interest that, in four fields near Southport comprising about 60 acres and planted entirely with home-grown plants, no cases of wilt were found on July 13.

To summarize these field observations, it is worthy of note that wilt was already severe in 26 of the 76 fields examined before July 22

and that 23 of these 26 fields contained southern-grown plants. The source of the plants in the remaining three could not be determined. In numerous instances the southern plants were a total failure and had to be replaced with home-grown plants. The loss in time and labor to many growers was in itself very discouraging. The loss and inconvenience to the canners who purchased southern-grown plants were serious factors. In addition to the instances above mentioned, canners in Delaware, Dubois, Madison, and Grant counties reported similar losses in southern plants. In one case reported, three acres on one side of a field were planted with Indiana plants and six acres on the other side with Georgia plants and wilt was severe among the Georgia plants while none appeared in the home-grown plants. The really alarming feature of this situation is, of course, the permanent infestation of more and more of our Indiana tomato soils with the wilt fungus.

Mosaic was noted in a greenhouse in Lafayette in March and in the Indianapolis hothouses in May. It was found in a market garden near Vincennes on June 28, in a garden at Lafayette on July 6, and in the market gardens near Indianapolis on July 12. The disease was not, however, as prevalent in the market gardens at this date as in the canning crop fields, but later became very general in the gardens. In 30 acres of tomatoes examined near Paoli on June 29, only one mosaic plant was found. Canning crop fields in Washington, Johnson, Howard, Tipton, Marion, and Hancock counties were examined between June 29 and July 21 and mosaic was found in 55 out of 76 fields. On July 13, a tomato plant with six shoots showing extreme mosaic and one shoot apparently normal was found and several similar cases were noted in the same field.

Mosaic has been particularly prevalent in central Indiana and the reason for this condition has been established and reported at some length in another paper (24). In brief, it has been found that the mosaic disease crosses very generally from tomatoes to certain perennial weeds related to the tomato and, once infected, such weeds send up diseased shoots year after year. Four common Indiana weeds are thus involved, *Physalis subglabrata*, *P. virginiana*, *P. heterophylla* and *Solanum carolinense*, and of these the first two are particularly abundant in the fields of the corn belt in this state and are by far the most important carriers of mosaic. These weeds, as they become infected, constitute a perennial source of infection. Mosaic has been found in abundance on the *Physalis* plants in fields previously in tomatoes. As more and more new fields are used for tomatoes and the perennial weed flora becomes infected with mosaic, it is only a matter of time before all of the tomato growing regions will become generally and permanently infested with the disease. However, as the situation is understood at present, the greatest immediate danger seems to lie in the presence of mosaic weeds in and near tomato seed-beds and plant-beds, since these weeds serve as early sources of mosaic infection for the tomato plants. In a field survey, unmistakable evidence of the plant-bed origin of mosaic was obtained. As a mosaic control measure it is very necessary that tomato plant-beds be kept free from weeds and remnant tomato plants all summer and that a determined effort be made to eradicate all weed

hosts from the vicinity of the beds. A number of tomato varieties were inoculated with mosaic at Lafayette and all proved susceptible. Peculiar, elevated or embossed, brown fruit lesions were observed on badly diseased plants, accompanied by outright blighting of the young shoots. Such severe symptoms are suggestive of certain types of responses on the part of the host in the case of cucumber mosaic.

Our description of the organism which causes bacterial spot under the name of *Bacterium exitiosum* was antedated by Miss Doidge (10) in Transvaal and as a result the name of the causal organism is *Bacterium vesicatorium*. As a result of our recommendations (21) a considerable amount of the tomato seed used for the canning crop was treated for the control of this disease. The effectiveness of this operation was not carefully checked, but in one region (Jefferson County) where treated seed was used, careful scrutiny of the canning factory sorting belt for several hours on Sept. 8 revealed only three cases of bacterial spot on the fruit. In a Johnson County factory drawing from an acreage planted largely with treated seed, a small amount of bacterial spot was noted on the belt at occasional intervals, but as compared with previous years, the tomatoes were relatively free from the disease. On the other hand, the disease was prevalent as early as July 13 in several fields on plants grown from untreated seed. Leaf, stem, pedicel, and calyx lesions were abundant. Among the 76 fields visited early in the season, bacterial spot was found in ten, and in six of these the plants were known not to have been grown from treated seed. In general the disease made an early appearance this year. Rather severe foliage infection and distortion of the young growing parts was noted in three out of 21 fields near Kokomo on July 2. However, southern-grown plants were used in these fields. As a result of inoculation tests, it has been found that insect wounds are not necessary to permit fruit infection and that the characteristic fruit lesion is the result of very early infection probably through some natural break in the epidermis. Although infection has been readily obtained through stink-bug punctures, the resulting lesions are not typical.

Early blight, caused by *Alternaria solani*, was found rather severe on the foliage of staked Bonny Best tomatoes in Indianapolis market gardens on July 12. Early blight seems to be more prevalent in the canning crop in southern Indiana than in the central part of the state. Late in the season a spotting of the small green fruits remaining on the vines was observed in 1920 and again this year, and these lesions are probably attributable to the early blight fungus. These lesions in no way resemble nailhead spot nor bacterial spot. The presence of the elongated, blackened early blight lesions on the stems of young transplants and the possible later effect of these lesions upon the plants in the field was noted in our 1919 report (16). A destructive outbreak of a very similar collar rot was reported in a field near Greenfield on July 6. This field was planted with home-grown plants of which about fifteen per cent were weakened and stunted by these stem cankers. The same trouble was also noted to a less extent in one other field in the same locality. Spores of the *Alternaria solani* type were found on these cankers but there was no foliage infection on the plants. It is be-

lieved, however, that this collar rot is attributable to the early blight fungus and is identical with the trouble described as foot-rot by Rosenbaum (37) in 1920 and later as collar rot, by Pritchard and Porte (34) in 1921. It is evident that transplants showing these stem lesions should not be set in the fields.

Leaf mold caused by *Cladosporium fulvum* was, as usual, very destructive in the greenhouse crop and was noted in many houses near Indianapolis on July 12. Observation had led to a supposition that this disease was favored by high temperatures but it was found that the fungus grew well in pure culture between 16° and 25° C and very slowly at 30° and that spores were produced at all temperatures between 9° and 30°, inclusive. Spore germination in water or in prune juice occurred at temperatures from 10° to 35°, inclusive, and very readily between 16° and 30° with an optimum for germ tube development at 25° C. These temperature ranges are somewhat wider than those reported by Makemson (30). The spores are easily detached and carried by air currents since abundant secondary infection occurred in the Petri cultures.

Anthracnose of the fruit caused by *Gloeosporium phomoides* was somewhat more prevalent than usual in the canning crop and was present to a serious extent on the sorting belts of factories in Jefferson, Johnson, and Marion counties early in September. It was also noted in the field in Johnson County on Sept. 16. In a variety planting at Lafayette this disease became rather conspicuous on the Yellow Plum variety late in August. In tests with the fungus in pure culture it was found to have no sharp temperature limitations. It grew fairly rapidly at temperatures from 9° to 35° C with somewhat of an optimum at about 27° and a surprising tolerance for temperatures as high as 35°. The original source of field infection in the case of this disease remains unknown since foliage infection does not seem to occur.

In an experimental plot at Lafayette a destructive epidemic of buckeye rot due to *Phytophthora terrestris* occurred during September⁷. The plants were grown in a rather low place and the prevalence and spread of this fungus are attributed to the heavy rains and consequent surface flooding. A high percentage of the fruit became infected. It was evident that wounds were unnecessary for fruit invasion, and that immature fruits were highly susceptible.

The non-parasitic blossom-end rot occurred to a serious extent in the early market garden crop as noted about Indianapolis on July 12, but was much less destructive in the canning crop than in 1920, due supposedly to the rainy weather of August and September. Probably for the same reason the non-parasitic growth-crack trouble was much worse than usual in the canning crop. It was found very severe in September in the stock observed in several canning factories. Cat-face was also present to a limited extent in the canning crop. Sun-scald was rather destructive in the market garden crop during the July drouth and was not necessarily associated with *Septoria* defoliation. Kendrick noted sun-scald rather prevalent in the canning crop in Grant County

⁷ See footnote under eggplant.

in September where there was considerable defoliation due to *Sep-toria* leaf-spot.

As a result of the very prevalent growth-crack and corn ear worm injury to the fruit combined with the frequent rains during the picking season, fruit rots were very prevalent this season. In 1920, a row of southern-grown plants infected with nematode root-knot were grown in an experimental plot at Lafayette and in 1921 tomatoes were grown in the same soil. The development of a few galls on the roots of the 1921 crop proved that some of the nematodes had withstood the winter. The persistence of these nematodes in the soil under Indiana conditions justifies our previous warning against the use of infested transplants.

A number of non-parasitic injuries and diseases were noted among tomato plants. The field trouble known as hollow-stem wilt was reported from Madison County during the July drouth. An upward roll-



Fig. 10. Turnip yellows. Typical one-sided effect of the disease: one side of plant affected worse; one-half of central leaf affected worse, resulting in curvature, asymmetry, and yellowing of the stunted side.

ing of the leaves called leaf-roll occurs generally in staked tomatoes in market gardens and hothouses. Güssow (25) and others have attributed this trouble to excessive pruning of the plants. In the spring the tomato seedlings in certain sections of a greenhouse bench at Lafayette showed considerable scalding of the foliage. On days of bright sunshine, it was noted that the location of the injured plants coincided rather closely with strips of intense light which were found to be due to the focusing of the sun's rays by the slight cylindrical curvature of certain panes of glass in the roof.

Turnip.—Yellows caused by *Fusarium conglutinans* was found very serious in a market garden near Lafayette on June 4 where cabbage yellows had occurred before. Many plants were affected and typical symptoms were displayed, such as the one-sided yellowing and subsequent curvature of the leaves, death of the leaves on one side of the plant (fig. 10), general stunting of the whole plant, and a brown dis-

coloration of the xylem tissue in the roots. Upon incubation in a damp chamber, grayish mycelium bearing abundant *Fusarium* spores developed from the vascular elements in the cut ends of roots and petioles.

A rather destructive *Alternaria* leaf-spot was found in a patch of turnips on muck soil near Goshen on Sept. 22. Whether or not this was due to *Alternaria brassicae* is not known. A powdery mildew was noted on turnips near Goshen, but no perithecial stage was observed. The mosaic disease described last year (23) was noted at Lafayette on July 22, and was found causing considerable damage in a patch near Goshen on Sept. 22. As a result of the stunting effect of the disease, the roots of many of the mosaic plants were small and worthless. As Schultz (38) has shown, mustard is also subject to this mosaic disease and mosaic was noted on mustard near Indianapolis on May 25.

Watermelon.—Wilt, caused by *Fusarium niveum*, was noted at Vincennes on June 28, and in Tippecanoe County on July 19. This disease remains as one of the limiting factors in watermelon growing in Indiana and, as was pointed out in the 1919 report, much of the suitable watermelon soil has become infested with the fungus. It seems probable that this wilt situation in Indiana is due to the fact, previously mentioned, that the good melon soils are confined to the sand ridges along the rivers and that consequently, on any one farm, there is not very much soil suitable for melons. This condition has resulted in a failure to practice a long time crop rotation which would prevent the accumulation of a soil pathogene. It is largely due to crop rotation that watermelons can be continuously produced in the southern states. The wet weather of late summer favored the development of anthracnose due to *Colletotrichum lagenarium* and serious spotting of the fruits was noted very generally in the local markets. Destructive leaf and stem infection was reported from St. Joseph County on Sept. 29. The non-parasitic blossom-end rot which is usually followed by infection with rot-producing fungi, was reported by one grower in Morgan County late in September.

Wheat.—Gregory reported the prevalence of loose smut (*Ustilago tritici*) in southern Indiana early in June. He noted from four to ten per cent infection in fields in Shelby County, as high as 25 per cent in fields in Rush County planted with untreated seed, and five per cent in one field in Posey County which was planted with grain descending from seed treated in 1919. Loose smut was noted in Lake County on June 1 and in Allen County on June 6, and was sent in from Spencer County. The hot water seed treatment at central treating plants is giving excellent control according to reports received from a considerable number of counties. Stinking smut (*Tilletia foetans*) was noted to a very limited extent in a field in Elkhart County by Gregory and in a field in Tippecanoe County by Jackson.

Hosmer found that stem rust (*Puccinia graminis*) occurred in a destructive form only in the vicinity of barberry bushes, although there was a very light infection in wheat throughout the state, which increased in amount toward the south, according to Jackson. Stem rust was noted in Tippecanoe County and was sent in from Jay County, and Hosmer noted small amounts in Harrison and Franklin counties. The latter observer found wheat fields practically ruined by stem rust near

barberries in LaGrange, Steuben, and DeKalb counties. In DeKalb County, ten acres of wheat across the road from a heavily infected barberry bush were ruined and other fields nearby were badly injured. Wild barberries were found on twelve farms in this county and in every case wheat and rye fields near the barberries were badly rusted.

Leaf rust (*Puccinia triticina*), which is frequently mistaken by growers for stem rust, occurred in epidemic form in southern Indiana this year, and according to Jackson this was the worst outbreak of leaf rust during the last five years. Gregory noted extremely heavy infection in Gibson County and other points in southern Indiana early in June and reports of serious damage were received from Dubois, Vigo, and Jay counties. According to Mains, leaf rust obtained an earlier start than usual, was somewhat worse on spring wheat than on winter wheat, and outside of the barberry areas was much more important than stem rust. Mains and Jackson agreed that very material reductions in yield was to be attributed to leaf rust this year partly because of the extreme severity of the attack itself, and partly because of the fact that the numerous leaf-rust lesions rendered the plants much more susceptible to serious drouth injury during the hot dry weather of late May and June. Mains reported losses as high as fifty per cent in certain fields, and a seven per cent reduction in yield for the state as a result of this disease.

Scab caused by *Gibberella saubinetii* made a late appearance and was not very prevalent this year, although it was slightly more abundant than in 1920. Gregory noted very little of this disease. Mains noted only a small amount near Bedford, Lafayette and Wanatah. A trace was noted in Hancock County, and specimens were received from Marion and Putnam counties.

Rosette occurred only in the experimental field near Wanatah, but its ability to persist through one season without a susceptible crop and to attack the susceptible wheat variety again the third season was demonstrated. The other infested fields were planted with resistant wheat varieties and none of the disease was found. What had every appearance of being the true Australian "take-all" disease occurred in two fields on a farm in Knox County. Jackson examined the fields and found the affected plants stunted and the heads not filled out. This condition occurred in patches and in scattered individual plants. A black layer of mycelium was found about the bases of the stems under the lower sheaths and the roots showed evidence of infection. Jackson found characteristic asci and ascospores of *Ophiobolus graminis* associated with this disease.

Forest and Shade Trees.—Burkholder has found great difficulty with evergreens and other trees planted for ornamental purposes in the north-western part of the state because of sunscald and winter injury. The winter climate of Lafayette seems especially severe on conifers, probably due in part to the desiccating effect of the high winds. The drouth of June and July of this year was also very hard on conifers. During the extreme heat of July there was considerable sunscalding of the foliage of hard maples along city streets. *Rhytisma punctatum* was found on the leaves of hard maple in Orange County in October as was

also powdery mildew (*Phyllactinia corylea*) on chestnut foliage. H. F. Dietz reported chestnut blight due to *Endothia parasitica* in a nursery near Wabash and in a chestnut orchard in Spencer County. A leaf-spot of mulberry due to *Mycosphaerella morifolia* was noted in Fulton County. Powdery mildew (*Microsphaera alni*) occurred on a Russian oak (*Q. pedunculata*) on the Purdue campus. Anthracnose of sycamore caused by *Gnomonia veneta* was noted near Lafayette in May and specimens of twig, petiole, and leaf blade infection were sent in from Evansville the same month.

Ornamentals.—Aster wilt, due to *Fusarium conglutinans callistephi* (2) was very severe during June and July and many florists and owners of home gardens complained of this disease. Carnation rust (*Uromyces caryophilinus*) was as usual prevalent in greenhouses as was also snapdragon rust (*Puccinia antirrhini*). Jackson found crown-gall on cultivated yarrow (*Achillea ptarmica*) and reported (*Mycologia* 14: p. 119) a rust (*Puccinia emiliae*) on pot marigold (*Calendula officinalis*). Sweet peas in a greenhouse were very badly injured by a powdery mildew which in early May was causing the premature death of the plants. Downy mildew (*Pseudoperonospora cubensis*) was found on the leaves of a Cucurbita gourd in Fulton County. Roses were generally and severely injured by powdery mildew (*Sphaerotheca pannosa*) and complaints were received from eight counties. Burkholder reported a fair control of both powdery mildew and black spot (*Diplocarpon rosae*) under outdoor conditions by spraying with a 2-4-50 Bordeaux.

SUMMARY.

The diseases of outstanding importance as observed in 1921 were the *Fusarium* soil troubles, the mosaic diseases, apple scab and blotch, cantaloupe and cucumber bacterial wilt, peach bacterial spot, and tomato leaf-spot.

The diseases found in 1921 which have not, as far as could be ascertained, been previously recorded for Indiana are as follows: Ampelopsis (two species) leaf-spot—*Guignardia bidwellii*; apple fruit rot (*Phytophthora cactorum*) and brown bark spot; lima bean powdery mildew and *Fusarium* seed stain; sugar beet root rot; cantaloupe fruit rot (*Fusarium*); celery mosaic; chestnut powdery mildew (*Phyllactinia corylea*) and blight (*Endothia parasitica*); clover root rot (*Fusarium*), mosaic, and powdery mildew; cowpea bacterial spot, powdery mildew, and leaf-spot, *Cercospora cruenta*; eggplant fruit rot, *Phytophthora terrestris*; goldenseal blight, *Botrytis*; Cucurbita gourd downy mildew, *Pseudoperonospora cubensis*; lettuce, *Botrytis* crown rot and *Rhizoctonia* rosette; hard maple, *Rhytisma punctatum*; pot marigold rust, *Puccinia emiliae*; mulberry leaf-spot, *Mycosphaerella morifolia*; parsnip leaf-spot, *Cercospora pastinacae*; pea, *Bacterium pisi*; peach, *Leptothyrium pomi* on twigs; pear sooty blotch; pepper fruit rot, *Phytophthora terrestris*; privet powdery mildew, *Microsphaera alni*; radish root invasion by *Peronospora parasitica*; spinach crown rot (*Phytophthora*), root-knot, and downy mildew (*Peronospora effusa*); squash *Gloeosporium* storage rot; tomato collar rot; turnip yellows, *Alternaria* leaf-spot, and powdery mildew; wheat, *Ophiobolus graminis*.

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