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STEPHEN A. FORBES, *Chief*

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A Preliminary Report on the Occurrence and Distribution of the Common Bacterial and Fungous Diseases of Crop Plants in Illinois

BY

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ARTICLE IV.—*A Preliminary Report on the Occurrence and Distribution of the Common Bacterial and Fungous Diseases of Crop Plants in Illinois.* BY L. R. TEHON.

The common diseases of crop plants, caused by the attack of parasitic fungi and bacteria, take an annual toll of the crops of Illinois that runs into values the magnitude of which is seldom realized; and the fact that Illinois stands second, among the United States, to none but Texas and Iowa in the value of its agricultural products lends an especial significance to their destructiveness.

As early as 1881 the State Laboratory of Natural History, since merged in the State Natural History Survey, undertook the study of the parasitic fungi of the state, and in that and the following year A. B. Seymour was employed to make an extensive collection of diseased plants. Studies based upon Seymour's collection, but confined to identification and classification, were made later by T. J. Burrill on the rust-producing fungi, and by Burrill and F. S. Earle on the powdery mildew-producing fungi, of the state.

In the forty years which have elapsed since Seymour made his collection, the classification, the structure, and the life histories of the bacteria and fungi which cause the diseases of crop plants have been the subject of extensive and exhaustive investigation. As a consequence, little of economic significance now remains to be done in that direction.

The next important step in the study of plant diseases is concerned with epidemiology—the fluctuation in severity and abundance from year to year exhibited by all diseases. An explanation of the causes underlying these fluctuations promises things of the greatest importance to the growers of our crops in the improvement of control measures and the regulation of times and methods of their application.

A necessary preliminary step is the accumulation of a complete catalog of the kinds of diseases present, and of accurate information concerning their distribution and severity in our state. With this purpose in mind the Natural History Survey began in the summer of 1921, and continued through the summers of 1922 and 1923, an examination of the crops of the state[1] the results of which are incorporated in these pages.

[1] The work has been carried on under the general supervision of Dr. F. L. Stevens, Professor of Plant Pathology in the University of Illinois, and under the direction of the writer. The rapid progress made is due in a large measure to the enthusiastic and capable assistance in the field of P. A. Young during the summers of 1922 and 1923, and of O. A. Plunkett, C. L. Porter, and C. O. Peake, during the summer of 1922.

The reader will find that the diseases discussed in this preliminary report are grouped according to the crops which are subject to them. Because of the great importance of the cereal crops their diseases are discussed first. Following them are the diseases of forage crops; the diseases of fruits, including small fruits; the diseases of vegetable and field crops; and the important diseases of a few commonly grown ornamental plants. The plan of the discussion has been to give in each case a brief description of the disease, a short summary of its history in Illinois, a statement of its distribution as now known, some indication of the crop losses for which it is held responsible, and, finally, a brief statement of the usual methods of control.

As a basis for the interpretation of the discussions, available information on the distribution and value of each crop has been summarized in a preliminary paragraph or two accompanied by an illustrative map.[1] This information has been taken from the reports of the State Agricultural Statistician as printed in the "Illinois Crop Reports" issued by the federal Bureau of Markets and Crop Estimates, and from the reports for 1920 of the Bureau of the Census.

Accompanying the discussion of each disease is a map showing its known distribution in Illinois. For the purpose of the report the county has been selected as the unit for expressing occurrence since it would be obviously impracticable to show on so small a map the actual place at which the disease was found. The county serves as a practical unit for the additional reason that diseases found in one field or in one orchard usually may be found in the fields and orchards throughout a considerable area of neighboring territory.

It is not to be assumed that at this stage of the survey the maps will show the entire range or the only places of occurrence for any disease; actually, they show only those counties in which the disease has been found during our three seasons of work; but even with this limitation they emphasize the almost universal prevalence of many diseases and the limited occurrence of others.

In discussing the damage which diseases do to crops, use has been made of estimated crop reductions, which are summarized in the text and given in detail in tables at the end. The estimated reductions represent the effect which each disease has had, in the judgment of experienced and competent workers, upon the yield of the crop in any one season. Estimates are commonly expressed in percentages; and the equivalent loss, in terms applicable to any crop, is arrived at in the manner illustrated by the following example:

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[1] In order to have the maps illustrate clearly the relative importance of crops in the several parts of the state it has been necessary to choose an arbitrary unit in each case, such as 1,000 acres or 2,000 bushels, to be represented by a single dot; but, when a county grows an amount which involves less than the arbitrary number, a dot has been used to indicate that the crop is grown there. As a consequence, when a county contains a single dot, the reader may interpret it to mean that less than the amount indicated as equivalent to a dot on that map is grown there.

It has been estimated that during the year 1921 the scab disease caused a reduction of 4 per cent in the state's wheat yield; leaf rust, 1 per cent; stem rust, 0.5 per cent; loose smut, 3 per cent, and all other diseases, 1 per cent. These, when added, give a total reduction of 9.5 per cent. The actual wheat yield of the state for that year is reported to have been 45,234,000 bushels. By considering that the absence of disease would have resulted in an ideal, or 100 per cent, yield so far as damage from disease is concerned, it can be seen that with diseases present the actual yield was only 90.5 per cent of the ideal. A 100 per cent yield may then be calculated as 49,982,000 bushels. With this figure as a basis the probable losses from disease-attack can be transferred from indefinite percentages to their more concrete and understandable equivalents in bushels. Thus an estimated reduction of 4 per cent from scab infection becomes equivalent to 1,999,000 bushels; and a 3 per cent reduction from loose smut infection becomes equivalent to 1,499,000 bushels

With the exception of the year 1923, the loss figures showing percentages and bushels have been taken from "The Plant Disease Bulletin. Supplement: Crop Losses from Plant Diseases in The United States". This is a publication issued by the Plant Disease Survey of the United States Department of Agriculture. It is based upon information supplied from each state by persons interested in, and familiar with, crops and their diseases.

Equivalent valuations have been figured in all cases in terms of the market price, usually as of December 1, reported by the State Agricultural Statistician in the "Illinois Crop Reports".

Observations which have been introduced in order to show how prevalent and how destructive diseases may become should serve a further purpose—that of impressing upon the individual farmer his need for taking every available precaution to prevent the occurrence of similar devastating outbreaks among his own crops.

Diseases of Cereals

Wheat

Under average conditions wheat ranks third among the cereal crops of Illinois in acreage and production, and second in value. Its place in the system of crop rotation suitable to Illinois soils is so difficult to fill with other crops that its continued importance is assured. Both spring and winter wheats are grown in the state, the latter in all parts of the state and the former in only the northern third. About three million acres are devoted to wheat each year, approximately 160,000 of which are seeded to spring wheat. The importance of the wheat acreage in various parts of the state is indicated on Map 1. Since 1921 there has been a steady increase in acreage, due no doubt to a more general use of such satisfactory hard winter-varieties as Turkey 10-110, Kanred, and others. The estimated value of the wheat crop in Illinois has varied in recent years from $16,000,000 to $72,000,000.

Each season the wheat crop is affected adversely by the attack of fungous diseases. The effects of the diseases are shown by reduced yields and often by the inferior quality of the grain. There are many of these diseases, and the injuries suffered from their combined attack always result in appreciable losses. Estimates of these losses were placed as low as 4.4% or 2,726,000 bushels in 1918, and as high as 22.0% or 18,524,000 bushels in 1919. During an average year it is thought that the reduction in yield for the state as a whole is between 8% and 9%.

There is much variation from year to year in the severity of one or more of these fungous diseases. Some are serious every year, and most of the others cause important injury some seasons or in restricted localities. Their destructiveness calls for the thoughtful attention of the wheat grower.

Rusts

Two rust diseases have been found on wheat in Illinois. The one known as *leaf rust* is the more prevalent. *Stem rust* is common but seldom causes the tremendous losses here that it does farther north.

Leaf Rust

Caused by *Puccinia triticina* Eriks.

Leaf rust is the most common and the most important of the wheat diseases occurring in Illinois. Even in years unfavorable to its development it is so abundant that nearly every plant in every field has become infected by the time the grain is mature. Its effect upon the crop is manifested by weakening of the stalks and sometimes by badly shrunken or "shriveled" grain. In extreme cases the weakening of the stalks results in a falling and lodging of the straw, which increases the destructiveness of the disease by making it difficult or impossible to harvest the crop.

The disease appears as small reddish spots mostly upon the leaves but occasionally upon the stems. These spots, which lie beneath the epidermis of the leaf and between the veins, are rarely more than one sixteenth of an inch long, but several together may be much longer. The breaking of the epidermis reveals a mass of orange powder within the spot. The grains of powder are the spores of the fungus, and each grain, or spore, is capable under proper conditions of starting a new infection.

In Illinois, infection takes place either in the fall or spring. The great acreage of winter wheat gives this rust an opportunity to develop serious infections during the fall on young wheat, and these infections live over the winter, producing spores the following spring and thus continuing the spread of the disease until the grain matures. Following the maturity of the grain, the rust develops a "resting stage" which is

to be found chiefly upon the under side of the leaves and on the stalks, where it appears as covered spots, similar in size and shape to the others but *black*.

The period between harvest and the appearance of the new crop is bridged[1] by infections on volunteer wheat in clover and other secondary crops. There is an alternate stage,[2] similar to that ascribed to stem rust, which occurs on 12 species of meadow rue (Thalictrum), but it is noteworthy that in Illinois our common meadow rue *(T. dioicum* L.) has not been found rusted.

The history of the introduction and spread of leaf rust in Illinois is not known. The first definite record of its occurrence in this state is a specimen collected by A. B. Seymour in McHenry county August 22, 1881. The following year specimens were collected in Adams county June 26, 29, and July 6, and in McLean county July 17. In 1883 C. A. Hart collected leaf rust in Adams county, and during later years G. P. Clinton made several collections in Champaign, Ogle, and Knox counties. H. W. Anderson has collected specimens in Pike county, and H. L. Bolley[3] has recorded its presence in eastern Illinois in 1905.

Field observations of the past three seasons have brought together a large quantity of additional data on the distribution of the disease throughout the state. In 1922, specimens were collected in 140 places distributed widely over the state and showing the occurrence of leaf rust in 82 of the 102 counties. Those counties from which specimens were not secured are widely dispersed, and are so distributed that collections made in adjacent counties indicate the occurrence of leaf rust in them as well.

During 1923 additional collections of rust were made, resulting in a large compilation of field notes. From these the distribution of leaf rust is seen to include practically the entire state, as shown on Map 2. Indeed, from our observations it appears highly improbable that in the whole state there occurs a single field of wheat in which at least some leaf rust can not be found.

Losses from this disease are difficult to determine, but for the years 1919-1923 inclusive they have been estimated to vary from 0.5 per cent (221,000 bushels) in 1920 to 10 per cent (5,543,000 bushels) in 1922 (see Table 1). The annual losses can not be apportioned among the counties nor according to any lateral or longitudinal division of the state. There is to be seen, however, a marked correlation of abundance and severity of infection with the growing of soft winter-wheats such as Red Wave, Early May, Fultz, Blue Stem, Harvest Queen, and Fulcaster.

The variation of leaf-rust infection from season to season depends, as is indicated in Table 2, upon both the number of infected stalks and

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[1] Valleau, W. D., Over-summering of leaf rust of cereals in Kentucky. Phytopath. 13: 338-340. 1923.

[2] Jackson, H. S., and Malns, E. B., Phytopath. 11: 40. 1921; also Jour. Agr. Res. 22: 151-172. 1921.

[3] Sci., n. s., 22. 51. 1905.

the amount of diseased leaf-tissue[1] on each stalk. Of the two, the amount of diseased leaf-tissue is the more important, since, as is indicated in Table 3, it varies more than the number of infected stalks and is more closely in accord with the estimates of loss.

In 1918 and again in 1923, when the estimated loss from rust was low, the infected plants numbered more than 80 per cent. The increase in the number of infected plants in 1922, when loss was estimated at not less than 10 per cent, was not more than 15 per cent, while the increase in diseased leaf-tissue on each plant at the same time was 24.1 per cent greater than in 1923, and 47.5 per cent in excess of that in 1918.

Variations in the amount of infection in different places and in different years are definitely attributable to climatic conditions throughout the growing period of the crop. Leaf-rust infection of wheat in Illinois begins in the fall previous to the harvest. How far fall infection may influence the seriousness of the spring attack is not entirely evident, but it is noteworthy that in the fall preceding the very severe epidemic of 1922, winter-wheat fields were in many places so thoroughly infested with rust as to assume an orange tinge, visible from a long distance.

Moisture and warmth in the fall are conducive to abundant infection of the young crop, and the survival of the fall infection is limited in varying degrees by the severity of the winter. Whatever infective material remains alive until spring serves as a source of inoculum for the spread of the rust, and the amount of new infection at this time will be influenced favorably or unfavorably by the presence or absence of suitable climatic conditions.

The importance of leaf rust as a limiting factor in the production of wheat in Illinois is not a matter of light concern. It is true that in certain sections even in years of serious epidemics, there is only a slight loss, but these sections are not the large wheat districts of the state. The part of the state in which leaf rust is most abundant and generally most severe concides with the region of greatest wheat production. Estimates made following the 1922 epidemic and reproduced in Table 4 show the seriousness of the disease in 12 of the most important wheat counties of the state. The total-loss estimate for these counties was 1,373,588 bushels, which may be valued at $1,469,739.16.

Complete prevention of leaf-rust attack and its consequent injury to the wheat crop in Illinois is at present impossible. The fact that the rust overwinters upon the wheat and does not commonly have an alternate host precludes the possibility of control through eradicating other hosts. Hard winter-wheats are more resistant than the soft varieties, and losses may be considerably reduced in places where these wheats make a good crop. Where hard wheats are not satisfactory the ultimate use of special resistant strains of the soft wheats appears to be the ultimate solution. The experiments of the U. S. Department of

[1] The amount of diseased leaf-tissue is measured by a scale prepared by the Office of Cereal Investigations of the U. S. Department of Agriculture, in terms of the amount of leaf-surface occupied by the rust spots.

Agriculture and the Indiana Agricultural Experiment Station indicate the possibility of developing rust-resistant strains from the soft wheats, and the already-proved occurrence of these strains in such varieties as Fulcaster, Fultz, and Red Cross should be especially encouraging to the wheat growers in our own soft wheat regions.

Stem Rust

Caused by *Puccinia graminis* Pers.

The second of the two rusts occurring on wheat in Illinois is stem rust, variously known as "rust," "black-stem-rust," "black rust," and "red rust." During the early spring this rust appears upon growing wheat plants, showing as red eruptions upon the stems and leaf sheaths. These eruptions are distinguishable from leaf-rust spots in part by their location upon the stems, but more certainly by their appearance. They are usually two to four times longer, or more; the quantity of spores seems greater and more bulging; and the epidermis appears torn and ragged around the edges of the spots.

Just previous to the maturity of the wheat this rust, like the leaf rust, develops a resting stage, the spots of which appear much the same as those of the red stage in size and shape, but are black. This black stage, or "black rust," serves to carry the fungus through the winter months and to furnish infective material for the production of the alternate stage upon the common barberry in early spring. Recent propaganda on barberry eradication in the north-central states has made the life history of this fungus, its seriousness as a crop pest, and its prevalence in wheat regions matters of common knowledge.

Of the cereal rusts occurring in the United States, stem rust is undoubtedly the most important. It is estimated that since 1918 the crop reduction for the United States in any one year from this source has not been less than 804,000 bushels. In Illinois, however, stem rust is not, during average years, the serious menace that it is in the grain states of the north and west. Nevertheless the annual toll taken by this disease in Illinois is one not to be overlooked. Burrill[1] estimated that in 1885 the loss from stem rust in Illinois amounted to $1,875,000, and in 1917 W. P. Flint reported a loss of 10 to 20 per cent of the crop. Estimates of loss in Illinois for the years 1918-1923 inclusive have varied as indicated in Table 5, from a trace in 1918 and 1922 to 901,800 bushels in 1923, valued at approximately $829,600.

The history of stem rust in Illinois is more definitely traceable than that of any other disease. The first record of occurrence is a specimen collected by A. B. Seymour in McLean county July 11, 1881. During the same season Seymour collected stem-rust specimens in Marshall, McHenry, Piatt, and Tazewell counties, indicating that at that time the disease had a wide-spread distribution over the northern half of the state.

[1] See Stevens, F. L., Diseases of economic plants. (1921) p. 12.

In 1911 Burrill reported its occurrence in Champaign and Montgomery counties, and in 1918 various persons made collections of it in Boone, Cook, Lake, Williamson, Henry, Winnebago, Macoupin, and Bureau counties. E. F. Guba made an additional collection in DuPage county in 1919. At present stem-rust is known to be present on wheat in 68 of our 102 counties, as shown on Map 3. These 68 counties are so distributed as to represent all parts of the state.

Seasonal variation in the prevalence of stem rust, like that of leaf rust, depends upon the number of infected wheat plants and the amount of infection on each plant. The variation in crop loss is, however, slight, seldom amounting to more than 1 per cent. Stem rust appears later in the season than leaf rust, and the early maturity of our winter wheats not only greatly curtails the period through which injury to the crop may occur, but necessitates proportionately greater degrees of infection for every degree of estimated loss. This fact is illustrated in Table 6. The effect of the joint occurrence of relatively large amounts of diseased leaf-tissue and high percentages of infected stalks became apparent in 1923, when the estimated loss reached 1.5 per cent.

Our observations, summarized in Table 7, show definite differences in susceptibility to rust infection among wheat varieties. In general the soft winter-wheats which are grown in the southern part of the state are more susceptible than the semi-hard wheats of the Crimean type grown farther north. This is noticeable not only in many fields over wide areas, but also in adjacent fields.

Control of stem rust in Illinois is difficult. The extreme length of the state from north to south, together with its peculiar latitudinal situation, presents many diversities of condition including variations in soil, temperature, moisture, and physiography. Correlated with these conditions are diverse factors of an epidemiological nature which serve to complicate the problem further. The growing of resistant varieties such as the hard winter wheats, where these are suitable to local conditions, will serve to minimize crop losses from stem-rust attack. The present tendency throughout the state to increase the acreage of the Turkey wheats promises to materially curtail losses from rust.

In those sections where only the soft wheats appear to be suitable the early maturity of the crop serves in a large measure to prevent very serious crop losses. Nevertheless as considerable difference in resistance to rust appears to exist in the more common varieties of soft wheat under field conditions, a judicious selection from those kinds least susceptible to attack is quite worth while when practicable. Field observations during 1923, when stem rust was especially abundant, show the different percentages of stalks infected for seven varieties of soft wheat, as indicated in Table 8. Red Cross, Indian Swamp, Fultz, and Fulcaster appear less susceptible than Red Wave, Mediterranean, or Red Chaff.

Throughout the northern third of Illinois spring wheat is grown to some extent, and it is in this section of the state that the common barberry *(Berberis vulgaris* L.*)* may be expected to play a part in the development

of spring stem-rust infections. That the barberry does initiate some of the northern infections is apparent, since stem rust makes its appearance in the north and in the south almost simultaneously. In 1923 the first rust infection was found in southern Illinois June 4 and in northern Illinois June 7. The severity of the northern winter makes it unlikely that northern infections could arise simultaneously with southern infections without the presence of the barberry. Stem-rust infection has been found on the barberry in 23 counties,[1] as shown on Map 4. Most of these counties lie in the northern third of the state, and it is the belief of those engaged in the eradication of the barberry that local epidemics of stem rust are traceable to the barberry. Undoubtedly eradication of this shrub northward will result in a marked reduction of stem rust, and the losses it occasions, in that section of the state.

Smut Diseases

Three of the four smut diseases of wheat occur in Illinois. They are widely distributed over the state, and cause a considerable crop loss each season. Two of them affect the wheat heads, while the third attacks the leaves.

Stinking Smut

Caused by *Tilletia laevis* Kühn

Stinking smut, also known as "bunt", fills the grains with a black mass of fungus spores without changing the external appearance of the head. The appearance of diseased heads is nearly normal, and usually it is not until the wheat is harvested that the presence of the disease is discovered. During threshing many of the infected grains are broken, and the liberation of the smut is accompanied by a very noticeable foul odor.

The first record of stinking smut in Illinois is a specimen collected by G. P. Clinton at Urbana June 30, 1892. July 28 of the same year N. W. Graham collected the disease at Carbondale. During a field survey made in 1918 by the Office of Cereal Investigations of the United States Department of Agriculture 51 fields examined in Illinois showed an average of 1.8 per cent of diseased heads, but the distribution of infection is not apparent from the report. In a second survey, made in 1919, among 92 fields examined in Illinois the heaviest stinking-smut infection found was 24 per cent, and the average for all fields was 0.3 per cent.

From the estimates of crop losses shown in Table 9 the seriousness of this disease is apparent. Loss from stinking smut is capable of accurate estimation, since each infected head is entirely destroyed. Hence the percentage of infected heads in a field represents the loss in yield

[1] Recent information on the occurrence of stem-rust infection on the barberry was furnished by Gordon C. Curran, State Leader of Barberry Eradication in Illinois.

in that field, and the average percentage of infected heads in the fields of the state represents the loss for the state. Complete data are not always obtainable, but estimates indicate losses varying from a trace to 6 per cent of the state crop.

There is a further loss from this disease through dockage when smutted grain is sold. The presence of stinking smut in threshed wheat tends to give it an offensive odor. When the amount of stinking smut is great the odor is so pronounced that it reduces the value of the grain for milling purposes, and most dealers impose a dockage, or reduction in price, upon such wheat. Dealers often refuse to purchase badly smutted wheat.

The occurrence of stinking smut in Illinois is shown on Map 5. Its distribution coincides with regions devoted to wheat production, but it is rarely found in the northern or southern thirds of the state.

Examinations of fields in many parts of the state in 1923, the results of which are given in Table 10, suggest the field-by-field prevalence of this disease and indicate the severity of infection and loss on the average farm. An average infection of 4.08 per cent was found in 1140 acres distributed among 22 counties. All degrees of infection were found.

While the acreage examined is not large in comparison with the total wheat acreage of the state, if 20 acres be taken as the average amount of wheat per farm it may be inferred that data from 57 average farms are included. These are widely distributed over the state, and may be considered as representative of conditions of infection to be found on the average farm. Not every wheat field measured up to the average amount of stinking-smut infection, but other fields showed sufficiently greater amounts to bring the average infection for each field up to 4.08 per cent.

The yield per acre of wheat for the entire state for 1923 is estimated at 18 bushels. At this rate the 1140 acres examined would yield 20,520 bushels, but this is less by 4.08 per cent than it might have been without stinking-smut infection. The yield from this acreage with stinking smut absent would have been 21,111 bushels; hence there is an apparent reduction in yield of 861 bushels which, when distributed among the 57 average farms represented, gives a loss in yield of 15.1 bushels per farm. With stinking-smut infection absent the individual farmer might have secured the same yield from 19 1/6 acres that he was able to secure from 20 acres with stinking smut infection present; or had he chosen to plant 20 acres free from stinking-smut infection, he might have secured a yield of 375 bushels in place of 360 bushels.

Mention has already been made of a cash loss in marketing smutted wheat. This loss takes the form of a dockage in the price, which amounts in practice to a reduction in grade. When wheat is offered for sale it is graded, and the current market-price for the grade applied. Assuming that a load of wheat grades "Hard Red No. 1," should stinking smut be

found in the wheat it will be regraded "No. 1—Smutty" and a reduction made in the price in proportion to the amount the dealer believes the wheat has been damaged.

Actual figures on dockages of this kind for the 1922 crop are given in Table 11, in which appears a reliable report of the marketing of 1,082,913 bushels of wheat in 26 representative counties. Of the crop reported on, 25,865 bushels or 2.38 per cent were so badly smutted that a dockage in price was applied, averaging 7.44 cents per bushel and amounting to a total of $1,924.36. Had it been possible to include all instances of grain so badly smutted as to be unfit for sale these figures would have been noticeably increased.

The highest dockage actually applied was 10 cents per bushel and the lowest 2 cents. The largest amount of smutted wheat reported from any one county was 6,850 bushels, or more than 10 per cent of the crop reported on from that county, while the smallest amount, aside from those reporting none, was 100 bushels or about 1/400 of the reported crop.

Although the crop of the state was more than 50 times the amount reported, the report may be considered representative of dockages applied throughout the state. On this basis, among the 55,432,000 bushels produced in 1922 there would be 1,324,824 bushels smutted, and the total dockage for the state at the average rate of 7.44 cents per bushel would amount to $98,566.90. If one adds to this amount the cash value of field losses estimated in Table 9 at $1,157,740, the total loss to the wheat growers of our state in 1922 from stinking-smut infection reaches the astonishing total of $1,256,306.90, which is more than 2.1 per cent of the entire value of the harvested crop.

A similar but more complete dockage report for the 1923 crop, summarized in Table 12, includes 43 counties and 3,002,523 bushels of wheat, of which 143,184 or 4.4 per cent were smutted and 105,574 or 3.51 per cent sufficiently smutted to receive an average dockage of 4.88 cents per bushel, making a total loss of $5,157.57.

The greatest amount of smutted wheat reported from any one county was 28,200 bushels and the smallest 150. The highest dockage reported was 15 cents per bushel and the lowest 1 cent. In addition to what is shown in the table many indefinite but reliable reports were received of buyers refusing to purchase very severely smutted lots of wheat. In many cases lightly smutted wheat was received at elevators and mills without a dockage being applied.

The 1923 report includes approximately 1/20 of the state's crop. If it be considered typical of the entire crop there would be in the 1923 crop 2,110,914 bushels sufficiently smutted to bring about, at the average rate of 4.88 cents per bushel, a total cash dockage on the state's wheat crop of $103,012.60.

If one adds to this the field loss shown in Table 10 of 2,558,000 bushels valued at $2,402,520, he finds indicated a total cash loss of

$2,505,532.60 from stinking-smut infection in the state's wheat crop. This loss represents slightly more than 4.26 per cent of the total value of the wheat crop harvested in 1923.

Field observations on the amount of stinking smut in varieties of wheat commonly grown in Illinois as shown in Table 13 indicate that soft wheats are more susceptible to smut infection than the hard winter wheats.

When stinking-smut infection is present in wheat, several methods are available for preventing its appearance in succeeding years. These methods include change of seed, crop rotation, and seed treatment. Change of seed is often effective if care is taken to see that the new seed is not infected with stinking-smut spores. Crop rotation is useful in reducing the amount of infective material in the soil. Seed treatment, however, is by far the most effective means of control. Infection resulting from spores in the soil is usually slight. The greatest amount of infection comes from spores carried on the seed. If these seed-borne spores are killed very little smut infection will be found in the succeeding crop.

Three methods of seed treatment, or seed disinfection, are in common use: (1) Formaldehyde in the proportion of 1 pint to 50 bushels of seed is sprayed over the seed, the whole throughly mixed and covered for five hours. (2) Copper-sulfate solution in the proportion of 1 pound of bluestone to 10 gallons of water is also used. The seed is dipped in this solution, thoroughly wetted, and then dried. Both the formaldehyde and copper-sulfate treatments, though effective, are attended with difficulties in the using, and if not carefully handled are apt to cause some injury to the seed.

More recently there has come into use (3) the copper-carbonate dust treatment, in which copper-carbonate powder is thoroughly mixed with the seed at the rate of 2 ounces per bushel. This dry treatment may be applied at any time before planting. It does not materially injure the seed and may be depended upon to reduce stinking-smut infection to a minimum.

A more consistent use of seed treatment throughout our state is greatly to be desired. In the past it has been the custom of growers to wait until serious losses occurred before using preventive measures. A consistent program of seed treatment employed each year will not only obviate the necessity for special efforts, but will also prevent the constant loss from light infections that occurs each year.

Loose Smut

Caused by *Ustilago tritici* (Pers.) Rostr.

Another smut disease of wheat occurring in Illinois is *loose smut*. This is more generally distributed throughout the individual fields of the state than stinking smut, but is, on the whole, much less abundant. It is known throughout the state as "smut," "loose smut," and "black head."

It appears at the flowering time of wheat. The glumes, flowers, and grain are entirely destroyed, and their place is taken by a loose mass of olive-green or black powder. By harvest-time nothing remains but a little black powder on the top of the stalk where the head should have developed.

The black powder on the diseased heads is blown by the wind to the flowers of healthy plants, infecting them with the disease, and as the grain develops, it also is infected. When such an infected grain is used for seed it produces a plant bearing a black head, from which no new grain can be harvested. The infection is carried in this way from crop to crop *inside* the seed.

The earliest records of loose smut in Illinois are specimens collected by A. B. Seymour in McLean county June 27, 1879, and in Champaign county June 5, 1882. Later collections were made in Champaign county in 1888, 1889, 1891, and 1892.

The distribution of this disease, so far as it is known to us at the present time, is shown on Map 6. It is known to occur in 55 counties, most of which lie in the southern two thirds of the state and comprise the wheat-producing section.

Loose smut is an important factor in lessening the production of wheat in Illinois. Over a period of seven years there has been, as is shown in Table 14, a yearly infection, and consequent loss ranging from 1.5 per cent or 899,000 bushels in 1923 to 3 per cent or 1,644,000 bushels in 1922. The average annual loss for the 7-year period from loose-smut infection was 2.43 per cent.

In 1922 an examination of 81 fields, summarized in Table 15, indicated an average loose-smut infection of 2.13 per cent. These fields were distributed among 26 counties and included 1756 acres.

A similar examination in 1923 indicated, as shown in Table 16, an average loose-smut infection of 1.56 per cent in 254 fields distributed among 40 counties. A total of 4,849 acres was covered, averaging slightly more than 118 acres for each of the 40 counties.

The average production of wheat per acre in 1923 was 18 bushels. On a farm growing 20 acres of wheat the production would be 360 bushels. However, this is only 98.44 per cent of what the crop might have been had loose-smut infection not been present. Production without smut should have been slightly more than 365.7 bushels, or an increase in yield of 5.7 bushels, worth in cash $5.35. This increase is equivalent to the crop harvested from 0.32 or nearly ⅓ of an acre; hence the farmer stands to lose not merely $5.35 worth of salable grain, but also the cost of grain production for nearly ⅓ of an acre for the entire season. The total of the two is an item not to be overlooked in the economics of production, whether from the standpoint of the individual farmer or from the standpoint of the state's agricultural interests.

Control of loose smut, while attended with some difficulty for the inexperienced, is thoroughly practicable and should be much more commonly undertaken. Seed should be thoroughly cleaned, and then soaked

for from five to seven hours in water at about 62 to 72° F. It is then placed in small bags which can be readily handled, and immersed for one minute in a tub of water heated to 110°-120° F. At the end of the minute it is immersed for ten minutes in a tub of water heated to 129.2° F. and kept at that temperature. The temperature of this tub must not rise above 131° F. At the end of the ten-minute period the wheat is cooled in a tub of cool water and spread out to dry. If the treatment is carefully done, and an accurate thermometer used, there will be no injury to the seed and practically perfect smut-prevention will be obtained.

Flag Smut

Caused by *Urocystis tritici* Ecke.

A third smut disease of wheat occurring in Illinois is *flag smut*. It attacks the leaves of the wheat plant and appears at first as lead-colored stripes, and those eventually break open, disclosing a mass of smut spores. Diseased plants are usually so deformed that they do not mature. Very rarely does a diseased stalk bear grain.

Flag smut was first found in Illinois (and in the United States) in 1919 in a few fields near Granite City in Madison county. In 1920 it was found scattered over an area of about 2,500 acres in the same region. Since that time, through the search made by the State Department of Agriculture and the Natural History Survey, the disease has been found to occur in the nine counties shown on Map 7. During 1923 it was also found rather wide-spread in Missouri and Kansas.

In Illinois this disease has been most abundant and most serious in the soft-wheat region in the American Bottoms in Madison and St. Clair counties. Here, in certain wheat fields in 1923, infections involving more than 20 per cent of the stalks were seen. The area of infestation in the seven contiguous counties shown on the map appears to be continuous. At present only a few fields in the southwestern part of Logan county are known to be infested, and in Hancock county just one infested field has been found.

Flag smut is an extremely serious disease. Season by season the limits of its known occurrence are being extended, and the farmers of the state will do well to watch carefully for it in their fields. Once found, every effort should be made to keep it under control.

As a means of control two procedures are possible, and both should be used. All seed wheat should be thoroughly treated with copper-carbonate dust before planting. The method used is that described for stinking smut (see p. 184). Wherever possible, resistant varieties such as Fulcaster, and the Turkey wheats should be used.

Scab

Caused by *Gibberella saubinetii* (Mont.) Sacc.

Scab is one of the very serious diseases of wheat in Illinois. Like the other diseases which appear in epidemic form, its distribution appears

practically coextensive with wheat-growing. When heads begin to mature, a pink moldy growth may be seen at the base of infected spikelets. These spikelets turn yellow or brown, ripening prematurely, and the grain which they bear is shriveled and often fungus-covered.

The first record of the occurrence of scab in Illinois is its presence near Kappa, Woodford county, in 1896. The next definite record is by H. W. Anderson, who reported it in 1918 as "unusually severe," causing 5 per cent loss near Decatur and some damage in Rock Island, Winnebago, and Lake counties. As indicated on Map 8, it is known to occur at the present time in 45 counties, most of which lie in central and southern Illinois. Their general distribution suggests, however, that this disease occurs over the entire state.

The importance of scab as a wheat disease in Illinois during the years 1917-1923 inclusive is indicated by the estimated losses shown in Table 17, which range from 1 per cent or 616,000 bushels in 1918 to 18 per cent or 15,156,000 bushels in 1919.

During 1922 this disease was not found in great abundance in the fields of the state, but in 1923 it appeared to be more prevalent. An examination of 2050 acres of wheat distributed among 24 counties in 1923 revealed a scab infection involving 3.26 per cent of the heads, on each of which 51.14 per cent of the spikelets were diseased, which indicates a loss of 1.66 per cent of the crop in the fields examined. This, however, includes all the observations made during the season, and it is probable that the early reports are not as typical as the more severe infections found later in the season.

A considerable difference in the amount of scab infection was observable on different varieties of wheat. Eight varieties on which special observations were made showed an average infection of 2.3 per cent, as indicated in Table 18, with individual varieties varying in amount of infection from 0.248 per cent to 6.43 per cent. The average percentage of infection on five varieties was less, and on three varities more, than the average for all as shown in Table 19. The amount of departure from the average varied from 2.05 per cent less in the case of New Columbia to 4.13 per cent more in the case of Turkey Red. Varieties indicated in Table 19 as having infections less than the average should be useful in regions where scab is serious.

The fungus causing scab on wheat also causes a serious corn disease, and it has been demonstrated that the disease lives in the soil on corn debris. For the prevention of serious losses from scab it is important to select varieties of wheat showing a degree of resistance to the disease, to employ a rotation scheme calling for the separation of wheat and corn on the same land by at least one year's planting of a non-susceptible crop, and to use particular care in field culture, seeing that corn stalks are either removed or completely plowed under.

Septoria Diseases

Of these diseases there are two. One attacks the leaves of the wheat and is known as *speckled leaf-blotch;* the other appears especially on the glumes and is commonly known as *glume* blotch. Little is known of their early occurrence in Illinois. Between June 18 and 28, 1919, three slight infections and one of 10 per cent were found by workers of the United States Department of Agriculture, but the localities are not known. The seriousness of these diseases emphasizes the need for effective control measures.

Speckled Leaf-Blotch

Caused by *Septoria tritici* Desm.

Every season there appears on the leaves of wheat plants spots of discolored, diseased tissue. In unusual seasons this spotting may become so severe as to injure all of the leaves seriously and to kill many of them. The disease first appears as a more or less oval brown spot. Later, several spots may grow together, occupying a large part of the leaf surface. As the spots grow older, they show tiny black specks irregularly distributed over them. The presence of the specks—which are the fruiting bodies of the fungus causing the disease—gives the disease its name.

There are no early reports of the presence of speckled leaf-blotch in Illinois, but in 1919 S. C. Chandler collected it at Ashley, Washington county, April 14, and in Perry county April 19. These two collections constitute the first actual record of this leaf blotch in Illinois. During 1922 it was found in Saline county, but the abundance of leaf rust that season probably prevented its being noticed elsewhere. In 1923 leaf rust was markedly less abundant, and reports of speckled leaf-blotch were proportionately more numerous. The disease was already prevalent to a considerable extent when field work was begun, as is shown by our first report of it, a 20-acre field of Red Wave in Madison county having an infection involving 75 per cent of the plants, Table 20. Fully 25 per cent of the leaf surface was occupied by spots, and the lower leaves of the plants were so seriously infected as to have the appearance of "firing." From that time on, the disease was found to be prevalent and abundant wherever looked for. Speckled leaf-blotch is now known to occur in 23 counties distributed widely over the state, as shown on Map 9.

The infections found in wheat fields in the 23 counties are shown in Table 20, from which it appears that 89.4 per cent of the wheat plants were diseased, and that 32.2 per cent of the leaves on each diseased plant showed leaf blotches. On this basis it would appear that this disease injured 28.78 per cent of the leaves of the wheat plants grown in the state in 1923. It is not to be supposed that such a marked injury can result otherwise than in an appreciable reduction both in the quality and quantity of grain produced.

In the examination of fields for this disease the variety of wheat was recorded for 2,499 acres. As shown in Table 21, there were notable differences in the amount of infection found on nine varieties. Among the soft wheats Fulcaster, Fultz, and New Columbia appear to have suffered most, while Red Cross and Red Wave both appear to have shown some resistance. Of the hard winter wheats Turkey 10-110 showed the most disease, and Turkey Red and Black Hull were about equal in resistance.

No practical means of control for this disease is yet known, but the differences among several varieties of wheat in susceptibility to attack suggest the advisability of planting the less susceptible varieties where speckled leaf-blotch is prevalent.

Glume Blotch

Caused by *Septoria nodorum* Berk.

The glume blotch disease of wheat had not been definitely reported in Illinois previous to 1923. A single instance of infection was found June 18 in a field near Waterloo, Monroe county. In this field more than 80 per cent of the plants were diseased, and on individual heads the infection involved from 40 per cent to 100 per cent of the spikelets. Undoubtedly this disease is of much more common occurrence than our observations indicate.

Anthracnose

Caused by *Colletotrichum cereale* Manns

This disease has probably been present in Illinois for many years, though there are no definite reports of its presence previous to 1923. During the 1923-season anthracnose infections appeared in serious amounts in the regions shown on Map 10, and Black Hull, Fultz, Red Wave, Turkey Red, and Turkey 10-110 were the varieties diseased. Red Wave and Fultz showed most serious infections.

As it appeared in 1923 this disease was a serious one, causing weakening and falling of the straw, premature ripening, and lodging of the grain in the field. Losses in seriously infested fields were great.

Foot-rot

Caused by *Helminthosporium* spp.

Under this name are included a number of wheat troubles variously known as "foot-rot," "root-rot," "rosette," etc. Attention was first called to the serious nature of these diseases in Illinois in April, 1919, when they were mistaken in certain fields in Madison county for Australian take-all. Later in the same year foot-rot was found in Sangamon and Mason counties. In one instance a 50-acre field suffered an

actual reduction in yield of 40 per cent, but in most cases the reduction was less than 20 per cent.

Since that time a foot-rot of the same general character has been found in several parts of the state, and this disease is now known to occur in the six counties shown on Map. 11. Where it has occurred it has been local in character and confined to small spots in a few fields. It is only in unusual years or under very unusual local weather-conditions that it may be expected to become generally serious.

Should it become generally prevalent or serious, resistant varieties such as those developed and recommended by the Illinois Agricultural Experiment Station may be planted.

Black-Chaff

Caused by *Pseudomonas translucens* E. F. S.

This bacterial disease appears as black sunken stripes running lengthwise of the glumes. In severe cases it may cause the grain to shrivel.

A single report of the presence of this disease in Illinois was made by Dr. Erwin F. Smith,[1] who reported a slight infection in Knox county. Map 12, in 1917.

Miscellaneous Diseases

Powdery mildew, resulting from the attack of a superficial fungus *(Erysiphe graminis* DC.*)*, has not been of great importance in Illinois. It was seen and collected by H. W. Anderson at Granite City, Madison county, May 16, 1919, and this is the only definite record of its presence in Illinois at the present time.

Dying of wheat stalks resulting from the attack of a mushroom (*Marasmius scorodonius* Fr.) was reported in 1923. A specimen collected at Worden, Madison county, June 19 shows the sporophores of the mushroom growing directly out of the basal internodes of the wheat culm. This is extremely rare, however, and is not the source of any loss.

Oats

The oat crop in Illinois has been and probably will continue for some years to be one of great importance. It forms a definite part of the cropping plan practiced on most farms in the state. Since 1920 the acreage has varied between 3,860,000 acres in 1922, with a crop of 110,010,000 bushels, and 4,594,000 acres in 1921, with a crop of 121,741,000 bushels.

The acreage seeded to oats in each county in 1922 is indicated on Map 13. Every county in the state has at least some acreage. Hardin county, with 500 acres, grows the least, and Iroquois, with 215,500 acres, grows the most. By far the least acreage is found in the southern and

[1] Plant Disease Survey Bul. 2: 98-99. 1918.

western parts of the state, while in the northern and eastern parts large acreages occur. If a line be drawn approximately from Rock Island through Havana to Mattoon and eastward, it will be found that nearly 85 per cent of the states oat acreage lies north of the line, with especial concentration in Lee and Ogle counties to the north, and Iroquois, Champaign, and McLean counties to the east.

Crown Rust

Caused by *Puccinia coronata* Cda.

Crown rust of oats is similar in many ways to stem rust of wheat, and one may easily be mistaken for the other since both attack oats. As a rule, however, the black stripes of the crown rust do not appear broken and ruptured as do those of stem rust, but remain covered by the epidermis of the plant.

This disease was first reported in Illinois in Adams county in 1881 by A. B. Seymour. It has since been found by Seymour, Anderson, and others in McLean, Tazewell, McHenry, and Lake counties. Its distribution as now known is shown on Map 14. It is prevalent in all parts of the state.

It has been estimated that during the year 1919-1923 inclusive, crown rust caused a reduction in the oat crop varying from 1 per cent in 1919 to 4 per cent in 1922. As indicated in Table 22, these reductions ranged from 1,323,000 to 4,583,000 bushels and in valuation from $782,000 to $1,787,000.

In 1922 an examination of 42 fields of oats, distributed among 23 counties and including 538 acres, indicated an average crown-rust infection involving 91,038 per cent of the stalks and an average amount of diseased tissue per stalk of 58.05 per cent. In 1923 a similar examination, covering 69 fields distributed among 26 counties and including 1226 acres, showed a crown-rust infection involving 90.85 per cent of the stalks and an average amount of diseased tissue per stalk of 36.94 per cent. These differences between two years are shown in Table 23 in connection with estimated percentages of crop reduction, and from this comparison it appears that the annual variation in crop-injury is, as in the case of the wheat rusts, not so much a matter of the number of diseased plants, as of the amount of diseased tissue on each plant.

Crown rust has an alternate stage on the buckthorn (*Rhamnus cathartica* L.) similar to that described for stem rust of wheat. In northern Illinois, where this shrub is commonly used for hedges, it has been responsible for local epidemics of considerable importance.

Control measures involve the use of resistant varieties,[1] among which are Appler, Burt, Early Ripe, Golden Rustproof, Green Russian, and

[1] Durrell, L. W., and Parker, J. H. "Comparative Resistance of Varieties of Oats to Crown and Stem Rusts." Iowa Agricultural Experiment Station Research Bulletin 62. 1920.

Ruakura. Further control may be secured by the removal of cultivated or wild buckthorn shrubs in the neighborhood of oat fields.

Stem Rust

Caused by *Puccinia graminis* Pers.

The stem rust disease of oats is similar in appearance to stem rust of wheat, and the two diseases are caused by the same fungus. On oats in Illinois stem rust appears much less commonly than crown rust and is not often severe in its attack.

The earliest record of this disease in Illinois is a collection by A. B. Seymour from McLean county in July, 1881. Further collections were made by him the same year in Champaign, Fulton, McHenry, and Piatt counties. No further collections or records appear to have been made until 1922, but in that and the following year a distribution of stem rust was found as shown on Map 15. Probably it is much more wide-spread.

Oat losses from stem-rust attack are rarely severe. Estimates made since 1919 attribute to this disease only a trace of loss annually. An examination in 1923 of 22 fields distributed among 15 counties and including 765 acres indicated that 16.31 per cent of the stalks were infected and that the average amount of diseased tissue on infected stalks was 27.97 per cent. The amount of disease per stalk for all plants, on this basis, would be 4.56 per cent—an amount so small as to have practically no effect upon the expected yield.

Control of stem rust of oats may be secured in the same manner as on wheat. (See p. 180.) The oat varieties which show resistance to stem-rust infection are few and include especially White Russian, Green Russian, and Ruakura.

Loose Smut

Caused by *Ustilago avenae* (Pers.) Jens.

Loose smut of oats is similar in appearance to that of wheat already described. The heads are attacked, and the grains transformed to masses of black powder. Losses from this disease are large, and its importance is great. Estimates of crop reduction due to this disease, shown in Table 24, for the years 1917-1923 inclusive range from 5 per cent to 7 per cent—equivalent to 5,790,000 to 18,395,000 bushels, with values ranging from two to eleven million dollars.

The earliest record of this disease in Illinois is a specimen collected by A. B. Seymour at Normal, McLean county, June 26, 1879. In the following years Seymour made collections in Adams, Lake, and McLean counties, thus demonstrating a rather wide occurrence of loose smut in northern Illinois. In 1900 A. D. Shamel sent out from the Illinois Agricultural Experiment Station an inquiry concerning the occurrence of oat smut in the state. In summarizing the returns, he stated that smut occurred in 12 counties, for the most part widely distributed over the state,

and that the loss that season probably reached $5,000,000 or about $45.00 for every 40-acre oat field.

Oat smut is now known to occur in all but 21 of the 102 counties of the state. Its distribution, as shown on Map 16, is so general that one may reasonably suppose that it actually occurs in every county.

In 1922 an examination of 121 oat fields was made to determine the amount of loose smut present in the average field. These fields were distributed among 43 counties and included 1242 acres. The average infection amounted to 8.36 per cent, which is equivalent to a crop reduction of the same amount. A similar examination was made in 1923 of 111 fields distributed among 41 counties and including 1596 acres. The average loose-smut infection was 5.54 per cent.

The value of seed treatment as a means of loose-smut control was apparent in several instances. In 1923 eight fields in 6 counties and including 170 acres, had been planted with treated seed. The average infection found in these fields was 0.42 per cent, or 5.12 per cent less than the average found in fields generally. In terms of the average yield of the state the grower whose oat seed was treated should have secured a yield per acre 1.73 bushels greater than the grower whose seed was not treated.

Seed treatment is accomplished most easily and satisfactorily by using formalin according to the "dry" method. Formalin, or 37 per cent formaldehyde, diluted with an equal quantity of water, is sprayed over the seed, as it is shoveled from one pile to another, at the rate of 1 quart to 50 bushels of seed. The seed is then covered for 5 hours and is then ready for planting.

Corn

In terms of acreage, and in terms of money value, corn is the most important crop grown in Illinois; and the importance to the nation of Illinois' corn crop compares favorably with that of other states. In the years 1920 to 1922 (Surratt, A. J., Illinois Crop Summary, Dec. 1, 1922, Circ., 323, p. 60) Illinois was second only to Iowa in acres planted to corn, and production during those years was also second only to that of Iowa. The yield per acre for the state as a whole is, however, remarkably low, ranging during those years from 34 to 35.5 bushels. Practically every state in which similar conditions are approximated is reported to have much higher yields per acre. The extensive reach of Illinois from north to south may be responsible in some measure for this difference, since low yields occur in the extreme south and high yields in the north. The greatest corn acreage lies in a district running east and west through the central two-thirds of the state, and here the yields are neither very high nor very low.

In spite of the fact that corn constitutes by far the most important cereal crop in Illinois its diseases appear not to be so well understood or so amenable to control as those of wheat. The diseases of corn include

smut, rust, and a long list of others generally grouped under the inclusive list "root-, stalk-, and ear-rots." Among this group are diseases resulting from a number of parasitic and semi-parasitic fungi, and at least two kinds of bacteria. Recognition of these diseases is, even to experts, often a difficult matter.

The losses from corn diseases in Illinois are almost beyond estimation, affecting, as they do, not only the ultimate yield from the stand, but the development of the stand itself. Crop reductions from all reported diseases during the years 1917-1923 inclusive, have been estimated, as indicated in Table 25, to have varied from 2 per cent in 1917 to 20.5 per cent in 1923. The cash value of these reductions would vary between seven and fifty-six million dollars.

Root-, Stalk-, and Ear-Rots

Included in this category are a number of diseases the nature of which is not entirely understood. Among the fungi responsible are *Gibberella saubinetii* (Mont.) Sacc., *Fusarium moniliforme* Shel., and *Diplodia zeae* (Schw.) Lev. Despite the little knowledge of these diseases now at hand, they are among the most important affecting corn, and well deserve the amount of attention they are now receiving at the hands of investigators.

Estimates of crop reductions from these diseases have been made for 1918-1923 inclusive, and are brought together in Table 26. These estimates range from 3 per cent in 1918 to 15 per cent in 1923, or from 10,870,000 to 59,525,000 bushels and the valuations for the 6-year period ranged from $7,385,000 to $38,691,000. Large as these estimates may seem they are probably far below the actual loss.

Root- and stalk-rots of corn are chiefly caused by the fungi *Fusarium moniliforme, Diplodia zeae*, and *Gibberella saubinetii*. The degree of injury done by these organisms is dependent upon the relative susceptibility of the corn plant in the various stages of its development and the effects of the attack appear as rotted roots, barren stalks, or poorly filled ears.

Ear-rots are due to the same fungi as the root-rots, but the importance of the fungi is in the following order: *Diplodia, Gibberella,* and *Fusarium*.

The *dry ear-rot* caused by *Dipolodia zeae* is the source of considerable damage each year. In 1911 Burrill recorded the presence of this rot in 14 counties scattered throughout central Illinois. He estimated the damage to be from 1 per cent to 5 per cent, and noted that there was very little of this disease in the extreme northern and southern sections of the state. In 1912 he recorded it as having been more prevalent than in 1911.

The distribution of these various rot-diseases of corn in Illinois is probably wide-spread. So far as known to us, it is shown on Map 17. The 1923 observations, while not capable of a statistical summary, show the severity of these diseases to be very great. In 15 fields examined in

8 counties and including 303.5 acres, an average of 5.26 per cent of the plants were affected with rot.

Control of these diseases lies in the selection of disease-resistant varieties and the use of disease-free seed, the balancing of nutritive elements in the soil, and the use, in some cases, of seed treatments.

Corn Smut

Caused by *Ustilago zeae* (Beck.) Ung.

This is the most conspicuous of the corn diseases. All aerial parts of the corn plant are subject to its attack. In its final stage it results in the production of large malformations filled with smutty black powder, each grain of which is a spore capable of reproducing the disease.

The annual crop reductions from this disease during a 5-year period varied, according to the estimates shown in Table 27, from 1.5 per cent to 3.5 per cent. While the mere statement of so small a percentage each year is not impressive, the equivalent reduction in bushels, from seven to twelve million, is startling.

The first record of corn smut in Illinois is found in a collection by A. B. Seymour at Camp Point, Adams county, in 1879. The disease was collected again in 1881 in McHenry, Piatt, McLean, and Champaign counties by Seymour. Subsequent collections show the presence of smut in Champaign county in 1890, 1891, 1893, 1895, 1896, and 1897.

These early records are sufficient to show that corn smut had attained a rather wide distribution in the state a quarter of a century ago.

The present known occurrence of this disease in Illinois is shown on Map 18. It is apparent that it is prevalent in all parts of the state. However, as the map indicates, it is most abundant and most prevalent in a region running east and west through central Illinois. This region is the "corn belt" of the state, and it is here that corn smut is of greatest importance. In 1922 it was found in 55 of the 102 counties of the state. During that season it appears to have been especially prevalent in the southern tip of the state and throughout the northwest.

Field observations in 1923 in 26 fields (618 acres) scattered through 17 representative counties indicated an average of 7.35 per cent of smutted plants. Probably this is not indicative of the seriousness of infection throughout the state, since in making the notes from which the figures are drawn, corn in all stages of development was seen.

There is little evidence of resistance among the corn varieties seen. Under favoring conditions, however, Democrat corn always appears more severely smutted than other kinds.

Very little can be done in the control of corn smut. The fungus appears able to live through the winter in manure and in corn refuse, so that there is an abundance of infectious material ready to attack the new crop. Wider spacing of plants for more thorough ventilation, later

planting, and an endeavor to destroy the conspicuous spore-masses of this fungus will help to keep the disease in check.

Brown-Spot

Caused by *Physoderma zeae-maydis* Shaw

This disease is usually of minor importance in Illinois. It was first discovered here in 1911,[1] but the locality in which it occurred is not known. A specimen has been preserved which shows that it was present in Champaign county in 1912.

Brown-spot is now known to occur in 26 counties with the distribution shown on Map 19. Although our losses from it are not usually great, it may in unusual seasons become so severe as to do serious damage. This was the case during 1923, when an examination of 15 fields distributed among 10 counties and including 381 acres showed an average of 83.4 per cent of the stalks to be diseased.

The fact that this disease can, under favoring conditions, produce such severe infections emphasizes the need for keeping it under control. In general this depends upon the usual sanitary practises of crop production—clean fields, good seed, and the disposal of diseased plants elsewhere than in manure. The field notes summarized in Table 28 indicate that the Yellow Dent corn commonly grown throughout most of the state shows the greatest resistance under field conditions, and Democrat comes next. Certain special varieties appear to show high susceptibility. Should the brown-spot disease become a serious menace in any district where unusual varieties are commonly grown, a change to Yellow Dent or Democrat may be found advantageous.

Rust

Caused by *Puccinia sorghi* Schw.

This disease is similar to the rusts of other cereals. It attacks the leaves and produces short rusty-red stripes. The fungus causing it has an alternate stage which occurs on the wood sorrel (Oxalis), but this stage has never been found in Illinois. Corn rust probably overwinters by means of its summer spores.

Specimens collected by A. B. Seymour in 1881 and 1882 show that corn rust was present then in at least eight widely scattered counties in the northern half of Illinois. In 1911 Burrill recorded its presence in Montgomery county, and in 1912 in Union county; E. F. Guba collected it near Galesburg in 1919; and a further collection was made in Champaign county in 1919 by H. W. Anderson. At present it is known to occur in the 16 counties shown on Map 20.

[1] Barrett, J. T. *Physoderma zeae-maydis* Shaw, in Illinois. Phytopathology 3: 71. 1913.

Very little loss has ever been attributed to this disease. In 1919, a year when the rust seems to have been unusually abundant, only a trace of loss was reported. The disease is apparently limited in distribution, being confined for the most part to the northern section of the state, and even there it is seldom abundant. No satisfactory method of control is known, and it is doubtful whether one is needed with a disease of such slight importance.

Rosen's Disease

Caused by *Pseudomonas dissolvens* Rosen

This bacterial disease is characterized by the rotting of the basal internode of the stalk. As the rotting progresses, the stalk becomes weakened in spots and leans sidewise. The progress of the rot is such that a continual leaning of the stalk results in further twisting, so that by the time the stalk is down the remaining fibers of the diseased internode may be twisted as much as two and a half complete turns.

It was found in Illinois in 1921 in two counties, Jackson and Randolph, where it was reported as serious in the fields affected by it. In 1922 it was again found in small amounts in a single field in Union county, where it was reported to be causing the death of 1 per cent of the stalks. In 1923 it was seen in Alexander county, where an examination of 100 acres revealed two infected stalks. As indicated on Map 21, its distribution is limited to four adjacent counties in southwestern Illinois.

Rosen's disease of corn is not yet well known, and control methods have not been worked out.

Black-Bundle Disease

Caused by *Cephalosporium acremonium* Cda.

The black-bundle disease of corn has not been commonly recognized in Illinois. It appears, however, to be an important disease.

Its appearance in the field is recognizable from the fact that the affected stalk takes on a striking red color. As the disease progresses, the stalk begins to wilt at the top, the red color spreads downward throughout the stalk, and the entire stalk wilts and dies. A slashed stalk shows the bundles to be discolored and blackened.

The present known distribution of this disease is shown on Map 22. Undoubtedly it is much more widely distributed.

Its seriousness where seen, is indicated from an examination of three fields comprising 9 acres in Champaign county. In one field 1 per cent of the stalks were diseased, and in each of the other two fields 2 per cent of the stalks. In Clark county an examination of 4 fields comprising 75 acres showed 1 per cent, 2 per cent, 2 per cent, and 3 per cent of the stalks diseased. The percentage of infection is directly cor-

related with loss, since infected stalks are usually sterile or bear only nubbins.

Control consists in using carefully selected seed known to be nearly disease-free.

Stewart's Disease

Caused by *Pseudomonas stewarti* E. F. S.

One of the serious diseases of corn is Stewart's disease. Ordinarily it is most serious on sweet corn, but under certain conditions field corn may also suffer severely. The bacterium which causes the disease invades and plugs up the fibers of the stalks, thus interfering with the development of the plant.

Stewart's disease is known to occur in 9 counties as shown on Map 23.

An examination of sweet-corn fields in seven counties during 1923 indicated that an average of 13 per cent of the stalks were diseased. Such a percentage of infection is certain to result in a noticeable reduction in yield and indicates the necessity for using early-maturing varieties. Northern-grown seed appears to be least often diseased and may be used to advantage.

Rye

Rye is one of the less important of the cereals grown in Illinois, coming after oats but before barley, and the crop of the state has had an annual valuation of approximately $3,000,000 during recent years. Small acreages are to be found in every county in the state, but the greatest acreage is in northwestern and western Illinois, where, in 1922, it reached a total of 120,000. The smallest acreage is in the extreme southern tip of the state, where, in 24 counties, only 4,000 acres were planted in 1922. The distribution of rye acreages is shown on Map 24.

Brown Rust

Caused by *Puccinia dispersa* Eriks.

Brown rust is the most common and most serious disease of rye in Illinois. It is comparable on rye to the leaf rust (*P. triticina* Eriks.) of wheat. It appears especially on the leaves, where it produces small oval spots, distinguishable from the spots of stem rust in part by their position on the plant but more particularly by their much smaller size and definitely brownish color. The amount of infection is generally light, and the loss is usually estimated as a trace to 2 per cent.

Early reports of brown rust in Illinois are few. A. B. Seymour made the first collection in La Salle county in June, 1882; Burrill reports its presence in Champaign county in 1911; and a collection was made by H. W. Anderson at Urbana, Champaign county, June 10, 1919.

It is known to occur in 14 counties distributed widely over the state, as shown on Map 25.

Examinations made during 1922 in 13 fields distributed among 11 counties indicated that an average of 40 per cent of the stalks were rusted, and similar examinations made during 1923 in 20 fields distributed among 14 representative counties and including 209 acres indicated that an average of 90 per cent of the stalks were rusted, the diseased leaf-tissue averaging 35.3 per cent on each infected plant and 31.7 per cent on all plants.

No satisfactory means of preventing the occurrence of this disease is known.

Stem Rust

Caused by *Puccinia graminis* Pers.

Stem rust of rye is similar to the stem rust of wheat previously described and is caused by the same fungus. In Illinois, however, it appears to be much less prevalent on rye than on wheat.

Although this disease has undoubtedly been present in the state for many years, it was definitely reported for the first time in 1918, when it was collected in McHenry county. In 1922 it was found in 10 counties scattered through northern Illinois. Its known distribution, as shown on Map 26, includes 16 counties, most of which are grouped in the northern part of the central section of the state.

Aside from the eradication of the common barberry, no satisfactory methods of control are known.

Ergot

Caused by *Claviceps purpurea* (Fr.) Tul.

Ergot attacks individual grains in the rye heads, causing them to become greatly enlarged and distorted. The disease does not often cause much loss, since it is seldom present in fields, and usually only a few grains in a head are diseased. The greatest danger from this disease lies in the poisonous nature of distorted grains. Seriously affected rye, or wheat that has become mixed with rye, should not be fed to stock when this disease is present in any quantity.

Few reports of the presence of ergot in Illinois have been made. In 1919 it was present in several fields in Carroll county, and the infection is said to have been fairly heavy but appears to have been controlled by a change of seed. In 1923, and for several years before, there were light infections in a few fields in Ogle county. Usually the most serious infections are to be found on rye growing in wheat. An example of this is found in observations made in Hancock county in 1923. Several fields of wheat badly mixed with rye showed from 30 to 90 per cent of the rye heads infected, with from 10 per cent to 60 per cent of the grains diseased. Aside from the loss in production, such grain would be wholly unfit for feeding purposes.

The known occurrence of this disease, as shown on Map 27, indicates a fairly wide-spread distribution in northern Illinois.

Many other grains and grasses are susceptible to ergot attack. Cutting them about flowering time prevents the spread of the disease; and infected seed may be cleaned of it by floating out the ergot grains in a 20 per cent salt solution.

Scab

Caused by *Gibberella saubinetii* (Mont.) Sacc.

Scab on rye has the same appearance as scab on wheat. It is not known to be especially prevalent. A trace of infection was reported in a 5-acre field in Christian county in 1923—the only definite record of occurrence in Illinois. Control measures for this disease on rye are the same as those recommended for wheat scab. (See p. 187.)

Leaf Smut

Caused by *Urocystis occulta* (Wallr.) Rab.

Leaf smut of rye is very similar in appearance and in its effect upon the plant, to the flag smut of wheat, and the fungi which cause the two diseases are much alike.

Leaf smut attacks the leaves, forming long black stripes. As the leaf dies, the black stripes break open, shredding the leaves and letting loose large quantities of smut powder, the grains of which are the spores by which infection is spread.

The earliest definite records of occurrence are two collections made in Lake county in 1918 by J. L. Smith and by L. W. Almy. The known occurrence of leaf smut, shown on Map 28, includes 5 widely separated counties.

The presence of this disease in any quantity is certain to result in serious losses. Fortunately the amount of infection in Illinois is small, and except in isolated cases only slight losses occur. In individual fields, however, serious infections sometimes occur which result in large crop-reductions. The control measures recommended for flag smut of wheat will prove effective for this disease. (See p. 186.)

Barley

Least important of the cereals grown in Illinois is barley, yet between 170,000 and 190,000 acres are grown each year from which are harvested about five million bushels, valued in 1922 at over three million dollars. The distribution of the acreage is shown on Map 29, from which it is apparent that intensive production of this crop is limited to the northern quarter of the state. Although nearly every county grows some barley, more than 90 per cent of the acreage lies in this sec-

tion of the state, and it is here that the diseases of barley are of most importance.

Leaf Rust

Caused by *Puccinia simplex* (Koern.) Eriks. & Henn.

Leaf rust of barley, which is similar in appearance to the leaf rusts of wheat and rye, is not known to be of common occurrence or to be widely distributed in Illinois. It is known to occur in the two counties shown on Map 30, but is undoubtedly prevalent at least throughout northern Illinois.

Stem Rust

Caused by *Puccinia graminis* Pers.

Stem rust appears to be of comparatively rare occurrence on barley in Illinois. In appearance it is the same as stem rust on wheat, oats, and rye. Wild barley (*Hordeum jubatum* L.) is often infected with stem rust, but it appears not to have been definitely recorded as appearing on cultivated barley previous to 1918. In that year H. W. Anderson collected a specimen of it near Halfway, Williamson county.

Stem rust is now known to occur on barley in the six counties shown on Map 31. As seen in the northern counties, the infection was much more severe than is usually found on the other cereals subject to this disease.

Eradication of the common barberry in the northern counties should help to control this disease.

Loose Smut

Caused by *Ustilago nuda* (Jens.) K. & S.

Loose smut of barley is the most serious of the barley diseases. In appearance it is very similar to loose smut of wheat. The heads are transformed to masses of loose black powder. The spread of infection occurs at blossoming time, and diseased grains, which develop in an apparently normal way, perpetuate the smut. Plants growing from infected grain produce the worthless smutted heads.

The known distribution of loose smut, as shown on Map 32, includes 11 counties, of which 9 lie in the northern part of the state, and 6 are important barley producers. The disease appears widely distributed over the state, but is found most abundantly in northwestern Illinois in the region where the barley acreage is greatest. During 1923 examinations made in 11 fields distributed among 6 counties and including 92.5 acres indicated that an average of 6.4 per cent of the stalks were diseased. This is equivalent to a crop reduction of the same amount. While this figure may not be representative of the amount of disease to be found in all the fields of the state, it is indicative of the seriousness of the disease and emphasizes the value of seed treatment. The methods

of seed treatment recommended for loose smut of wheat will be found effective. (See pp. 185-186.)

Covered Smut

Caused by *Ustilago hordei* (Pers.) K. & S.

This disease, which is hardly distinguishable from loose smut in the field, has been found in Illinois once only. C. L. Porter collected it at Galena, Jo Daviess county, July 26, 1922. There was very little infection found, and the damage was slight. Probably this disease is much more wide-spread.

Barley Stripe

Caused by *Helminthosporium gramineum* Rab.

Stripe is next to smut the most serious disease of barley, and causes heavy losses each year. Its appearance is so characteristic as hardly to allow of its being mistaken. The leaves of diseased plants show wide longitudinal stripes in which the green has turned yellowish or brown. Diseased plants are dwarfed, die early, and rarely produce well-filled heads.

It is known to occur in 5 counties, as shown on Map 33, but is probably more generally distributed.

Its serious nature is apparent from 9 fields examined in 1923, in which an average of 31 per cent of the plants were diseased.

Stripe is readily controlled by means of a "wet" formalin seed treatment. The formalin is diluted at the rate of 1 pint to 30 gallons of water. The solution is then thoroughly mixed with the seed. After being covered for two hours the seed is ready for sowing.

Diseases of Forage Crops

During ten years preceding 1922, the tame hay acreage in Illinois averaged 2,970,000 acres, yielding annually an average of 3,808,000 tons, valued at $60,790,000. All parts of the state have large acreages devoted to hay and the other forage crops. The state total of 3,645,000 acres for 1922 is more than 14 times that devoted to rye, nearly 20 times that devoted to barley, only 200,000 acres less than that devoted to oats, 22 times that devoted to spring wheat, 600,000 acres more than winter wheat, and more than one-third of the corn acreage.

Among the crops that go to make up this acreage are especially alfalfa, clover, timothy, and redtop. Each crop is subject to the attack of diseases which reduce either the yield, the value, or the quality of the crop to a greater or less extent.

Alfalfa

Leaf Spot

Caused by *Pseudopeziza medicaginis* (Lib.) Sacc.

This disease is the only important alfalfa disease occurring in Illinois. The first report of its presence in the state was made by Burrill in 1912, when it was found in Champaign, Edgar, and Union counties. Anderson reported it in Tazewell and Champaign counties in 1919. It is now known to occur in 67 counties widely distributed throughout the state, as shown on Map 34, but appears to be more general northward.

Plants infected with this disease lose their vigor, and a loss in hay through falling of the diseased leaves also occurs. Generally not more than one of a season's cuttings (usually the second) is seriously diseased, but the effect on that cutting may be very severe. An examination in 1922 of 61 fields distributed among 38 representative counties and including 349 acres indicated that 66.6 per cent of the plants were diseased and that 7.64 per cent of the leaves were spotted. Similar examinations made in 1923 in 36 fields distributed among 20 counties and including 261 acres indicated that 77.5 per cent of the plants were diseased and 3.85 per cent of the leaves spotted.

As a means of control, it is best to cut the infected crop as soon as it becomes apparent that the result of the infection is apt to be severe. If this is done the succeeding crop will usually be relatively free from the disease.

Rust

Caused by *Uromyces striatus* Schr.

This disease is said to be responsible for local losses in neighboring states. In Illinois it has been found in two counties, Edgar and Woodford. In neither case was the infection either abundant or severe.

Anthracnose

Caused by *Colletotrichum trifolii* Bain

This disease has been found in two counties, Putnam and Henry, but is not known to be of common occurrence or of a serious nature in our state.

Root-and-Crown-rot

Caused by *Fusarium* sp.

During three seasons past there have been incidental reports of a root-and-crown-rot of alfalfa apparently due to the attack of a species of Fusarium. The first instance of this was from Randolph county, and later reports and specimens have been received from Carroll county.

The disease is serious and destructive where it appears, but no specific control-measures can be recommended.

Sweet Clover

Leaf Spot

Caused by *Cercospora davisii* E. & E.

Leaf spot was found in Pike county near Barry in 1919 by H. W. Anderson.

Anthracnose

Caused by *Glocosporium caulivorum* Kirch.

Anthracnose seems to be the one serious disease of sweet clover. It causes stem cankers and some reduction in yield.

The distribution of anthracnose as known at the present time appears limited, as shown on Map 35, to northern Illinois, where it is known to occur in 15 counties.

Red Clover

This crop is subject to the attack of five diseases.

Anthracnose

Caused by *Colletotrichum trifolii* Bain

Anthracnose has been found on red clover in the counties indicated on Map 36. Its distribution appears limited to the extreme northern part of the state. The fields in which it was found did not appear to be greatly injured, and the degree of infection was usually slight.

Caused by *Glocosporium caulivorum* Kirch.

This disease has been found on red clover in Union, Ogle, DeKalb, Champaign, and Sangamon counties.

Powdery Mildew

Caused by *Erysiphe polygoni* DC.

Powdery mildew appeared throughout the eastern part of the United States as a serious disease of red clover in the fall of 1921. This outbreak spread rapidly westward, and in the spring of 1922 became very noticeable in Illinois.

Plants attacked by powdery mildew appear to have had their leaves dusted with flour. If diseased clover is allowed to stand after time for cutting, the quality of the hay is impaired, and the quality and quantity of yield from crops grown for seed is also impaired.

The distribution of this disease in Illinois is shown on Map 37.

No means of control are available, but much of the injury may be avoided by seeing that the cutting of the crop is not delayed.

Leaf Spot

Caused by *Polythrincium trifolii* Kuntze

Leaf spot has been found on red clover in McDonough, Carroll, Winnebago, Adams, Schuyler, Union, Saline, Coles, Pulaski, and Menard counties.

Rust

Caused by *Uromyces fallens* (Desm.) Kern.

Rust has been found on red clover in Kane, Putnam, Kendall, Union, DeKalb, Ogle, Vermilion, Edgar, Lake, Wayne, Bureau, Tazewell, and Menard counties.

Timothy

Stem Rust

Caused by *Puccinia graminis* Pers.

The commonest and most serious disease of timothy in Illinois is stem rust, but no early records of its occurrence are available. Its known distribution, shown on Map 38, includes 55 counties and indicates a widespread and common occurrence in northwestern and southern Illinois.

Leaf Smut

Caused by *Ustilago striaeformis* (Westd.) Niessl.

Smut has been found on timothy in Illinois, in three counties: Madison, Sangamon, and Moultrie. The infection in Moultrie county resulted in a 20 per cent crop-loss in one field. Other infections were not severe.

Redtop

Stem Rust

Caused by *Puccinia graminis* Pers.

The only important disease of redtop commonly found in Illinois is stem rust.

Its presence on this crop was recorded by A. B. Seymour in 1881. It is now known to occur in 26 counties as shown on Map 39. The distribution in these counties suggests that the disease is of state-wide occurrence, though possibly more abundant southward.

Diseases of Fruits

Apple

Among the fruits grown commercially in Illinois the apple is by far the most important. While production varies greatly from year to year, the value of the state's crop always runs into large figures. Since 1916 the lowest yield has been 2,381,000 bushels and the highest 9,720,000. The lowest valuation has been $5,575,000 and the highest $10,206,000. The commercial crop is much less than this, ranging since 1920 from 397,000 to 1,620,000 bushels, and from $2,977,000 to $6,845,000 in valuation.

The relative importance of apple-production in Illinois by counties for 1919 [1] is indicated on Map 40, from which it may be seen that the chief apple-producing section of the state lies southwest of a line drawn from the northern boundary of Hancock county to the northern boundary of Clark county. North of this line production is mostly incidental and comes chiefly from small farm orchards maintained for the convenience of the owners, only the surplus reaching the markets.

Scab

Caused by *Venturia inaequalis* (Cke.) Wint.

Scab is probably the most common apple disease occurring in Illinois. It has been known in the state at least since 1863, in which year it is mentioned in the Transactions of the Illinois Horticultural Society as occurring in Ogle county. During subsequent years its occurrence is noted in these Transactions in Carroll, Ogle, Bureau, Tazewell, Champaign, Adams, Pike, Cumberland, Madison, Marion, Jefferson, Richland, Union, and Johnson counties.

The distribution of scab in the state is shown on Map 41. In 10 counties only, of the 102 of the state, has its presence not been demonstrated, and even in these counties it is probably present.

This disease attacks the leaves, the flowering parts, and the fruit, and results in a reduction in the quantity of fruit set, in leaf injury and early defoliation, and in fruit-spotting. It also increases the number of windfalls. Crop reduction occasioned by this injury is great and has been estimated for a 5-year period ending with 1923, as recorded in Table 29, to have ranged from 3.5 per cent in 1923 to 12 per cent in 1921. In crop reductions these percentages are equivalent to 277,000 bushels valued at $318,000 in 1923, and to 387,000 bushels valued at $967,500 in 1921.

The seriousness of scab is illustrated in Table 30, which shows that in 18 counties in central and southern Illinois 23 representative orchards examined in 1923, including 1728 acres, had an average of 12.7 per cent

[1] U. S. Census Bulletin for 1920. Agriculture: Illinois. Statistics for the state and its counties.

of the trees infected and 9.4 per cent of the fruit noticeably marred by scab infection. Were it possible to include the much more severe infections commonly encountered in smaller orchards, these figures would be greatly increased.

Control of scab consists in the timely and thorough application of effective sprays. Infection takes place in spring from the overwintering spores, which are usually ready to begin their work between May 10 and May 20 in Illinois, when they take advantage of any moist period to produce infection. Application of sprays just previous to predicted rains during the middle fortnight of May should succeed in keeping the disease under control.

Blotch

Caused by *Phyllosticta solitaria* E. & E.

Blotch, next to scab the most serious apple disease found in Illinois, attacks twigs, stems, fruiting spurs, leaves, and fruit. Its chief damage, however, consists in the injury done to the fruit. On susceptible varieties it may kill fruit spurs and thus considerably reduce the yield.

The early history of blotch in Illinois is unknown. The disease first appeared in the United States about 1895, and its spread has been very rapid. Burrill reported blotch as occurring in 8 counties in 1911 and again in 5 counties in 1913. Its present distribution is shown on Map 42, which illustrates the southern distribution of the disease and its extension westward and northward with commercial apple-growing. It is known to occur in 63 of the 102 counties of the state.

The crop reductions from blotch attack have been estimated, as shown in Table 31, to have increased from 2 per cent in 1918 to 5.5 per cent in 1923.

The severity of this disease, when sprays are not applied, is illustrated in Table 32, which summarizes observations made during 1923 in 16 orchards distributed among 14 counties and including 131 acres. Practically 100 per cent of the trees were infected, and 90.4 per cent of the fruit was diseased. The effect of a thorough application of sprays is shown, on the other hand, by an examination made in the same year in 7 commercial orchards distributed among 5 representative counties. These orchards included 265 acres and showed only 25.2 per cent of the trees infected, with 2.5 per cent of the fruit diseased.

Fire-blight

Caused by *Bacillus amylovorus* (Burr.) Trev.

This disease, the oldest and best known of apple diseases in Illinois, attacks every above-ground part of the tree. Blossoms and leaves, when diseased, look as if scorched by fire and burned black. On branches and trunks cankers are formed, from which an exudate is given off.

Spread of the disease is accomplished by insects and to some extent by the wind.

The history of this disease in Illinois, as indicated by discussions in the Transactions of the Illinois Horticultural Society, is practically coextensive with apple-growing; and while the injury to apples is not so great as to pears and quinces, the loss to the state is larger because of the greater importance of the apple crop.

Damage done by this disease is often very severe. In 1914[1] it was placed at $500,000 for one county and at $1,500,000 for the state as a whole. For the period 1918-1923, inclusive, the crop reduction has varied, as shown in Table 33, from a trace in two seasons to 1.5 per cent in two other seasons. The equivalent reduction in bushels has ranged from 3,000 to 112,000 bushels and the valuation from $7,500 to $128,000.

The known distribution of fire-blight is shown on Map 43. There are only 13 counties in the state in which this disease is not known to occur.

There is no satisfactory means of control. Cutting out diseased parts with tools sterilized in a 1-1000 mercuric chloride solution is helpful in a new orchard, but in old orchards the only effective measure is the prompt eradication of blight cankers.

Rust

Caused by *Gymnosporangium juniperi-virginianae* Schw.

Rust is one of the very common apple diseases found in the state. Leaves and fruit are especially susceptible to attack. Leaf injury and defoliation, if severe over several seasons, markedly stunts the growth of trees. On the fruit, rust spots cause malformation or disfiguration, which prevents the fruit from being marketed as first-class produce.

According to Burrill,[2] rust has been present on apples in Illinois since 1881 or 1882. The earliest actual collection was made by a Mr. Snow in Perry county in 1896. G. P. Clinton made two collections in 1898, one in Washington county and one in Marion, and a further collection was made in Richland county in 1899 by a Mr. Woodworth.

In 1911 Burrill found the disease in 5 widely separated counties and in 1913 in 2 counties additional. The known distribution of apple rust at the present time is shown on Map 44.

The damage resulting from the attack of this disease is estimated by Anderson[3] to be over $25,000 annually. Estimates of crop reductions made for the years 1919-1923, inclusive, and reproduced in Table 34, range from a trace to 1.5 per cent, annually amounting to between

[1] Pickett, B. S. The blight of apples, pears and quinces. Ill. Agr. Exper. Sta. Circ. 172. 1914.
[2] Parasitic fungi of Illinois. Bul. Ill. State Lab. Nat. Hist. 2: 240. 1885.
[3] Diseases of Illinois Fruits, Ill. Agr. Exper. Sta. Circ. 241: 37. 1920.

15,000 and 159,000 bushels, the valuation ranging from $21,000 to $166,000.

The seriousness of rust in apple orchards is indicated by an examination made in 1922 of 50 orchards distributed among 25 counties. An average of 58.6 per cent of the leaves and 3 per cent of the fruits were found diseased. Fruit infection was seen for the most part only in those orchards where extremely severe leaf infections occurred.

The fungus which causes apple rust is similar to the rust fungi of cereals in that it depends for its propagation upon the presence of a second host, which is, in this case, the common cedar (*Juniperus virginiana* L.). On the cedar the fungus causes the well-known "cedar apple." Spores borne upon these apples are transferred to near-by apple-trees on air currents, and the infection of the apple is accomplished.

There has been an attempt to secure the eradication of cedars in certain parts of Illinois as a preventive measure in the control of apple rust. On Map 45 is shown the distribution of cedar rust so far as it is now known. A comparison of the distribution here shown with that of the apple rust on Map 44, reveals a very striking correlation.

Control of apple rust may be accomplished more or less successfully by the application of Bordeaux mixture and lead arsenate or by lime-sulfur. More effective control can be had, however, by eradicating all red cedars within one mile of the orchard. Where cedars are too abundant for eradication, new orchards should include only resistant varieties, among which are especially the Grimes and the Liveland Raspberry.

Black Rot

Caused by *Physalospora cydoniae* Arn.

Black rot attacks the fruit, leaves, and twigs; but, as with blotch, the greatest loss comes from the injury done to the fruit.

Leaf infection, in the form of round spots, is commonly recognized under the name of "frog-eye". Twig and limb cankers are comparatively rare, but when cankers on old limbs have enlarged sufficiently they girdle the limb and bring about the death of all parts beyond them. The entrance of the fungus into the apple is dependent upon the presence of wounds—especially insect punctures. Besides the actual rotting of fruit, diseased apples drop early, and considerable rotting occurs in storage.

The earliest record of the occurrence of this disease in Illinois is 1879, but the exact location is not known. The present known distribution, as shown by the 1922 and 1923 survey, is indicated on Map 46. The disease has been found in orchards in 69 counties, and ranges in its distribution from the northern to the southern boundary of the state. There appear to be two general regions of occurrence: The first lies in the southeastern part of the state in the Ohio, Wabash, and lower Mississippi valleys; the second appears to conform to the upper Mississippi Valley north of the junction of that river and the Illinois. Northward,

this area spreads eastward so as to include the Rock River valley, the tributaries of the Illinois, and the watershed of Lake Michigan.

Losses from this disease are probably greater than is ordinarily suspected. Estimates of crop reductions for the years 1918-1923, inclusive, and reproduced in Table 35, vary from a trace to 2 per cent. When definite estimates have been made they have ranged from 33,000 to 199,000 bushels, and from $61,000 to $208,000 in valuation.

The seriousness of black-rot infection is indicated by an examination, made in 1922, of 22 orchards distributed among 18 counties and including 54 acres. Of the trees 91.2 per cent were infected, and the notes indictate that 27.3 per cent of the leaves and 0.92 per cent of the fruits were diseased.

To keep black rot under control it is necessary to cut out and burn all dead wood in the trees, to cut out all cankers with sterile tools, to keep fallen fruit picked up, and to apply an extra spray of Bordeaux in late July or early August.

Blister Canker

Caused by *Nummularia discreta* Tul.

Blister canker, also known as "Illinois canker" and as "nail-head," is one of Illinois' serious apple diseases. It was first reported in the state by Hasselbring in 1902. Since that time the disease appears to have been increasing and spreading steadily. This has been especially true because of the large proportion of Ben Davis apples grown; for this variety, more than any other, is susceptible to attack. Besides Ben Davis, Delicious, Gano, and Willow Twig are especially susceptible.

As usually seen in its advanced stages the blister canker is characterized by a covering of dead bark, often loose and shredding, through which project warts having the appearance of heads of nails driven into the tree.

The distribution of blister canker in Illinois is shown on Map 47. It reaches from the southern tip of the state, where infections have been found in Massac and Pope counties, to the northern boundary, where infections have been seen in Lake, McHenry, and Boone counties. The disease is known to be present in 66 of the 102 counties of the state, and in practically all of the important apple-growing counties. As we know it at present, the disease occupies a range of territory including, in southern Illinois, the tributaries of the Wabash and Ohio rivers and, in the extreme southwest, those of the Mississippi. Northward the disease is wide-spread in the valley of the Mississippi and Illinois rivers.

Injury by this disease results in the death of the wood. Girdling eventually occurs, and all the twigs or branches beyond the girdle die. Or, if the canker is on the main trunk, the whole tree dies.

Crop losses from blister canker are large, and the disease is especially serious, because the damage done to a tree in one season can not be repaired but continues to cause losses season after season. Anderson[1]

[1] Anderson, H. W. Diseases of Illinois Fruits. Ill. Agr. Exper. Sta. Circ. 241: 31. 1920.

estimates an average annual loss of 1 per cent of the apple crop, the valuation ranging from $25,000 to $30,000. For the 1922 and 1923 seasons estimated losses of 1 per cent were equivalent to 98,000 bushels valued at $102,000 and 74,000 bushels valued at $85,000.

The seriousness of this disease in our orchards is illustrated by the results, shown in Table 36, of an examination of 21 Ben Davis orchards distributed among 14 representative counties. The examinations were made during the summers of 1922 and 1923 and showed that 21.8 per cent of the trees were diseased.

How uncared-for infections may result was shown in 1922 by a special survey, with careful examination of trees in three Wayne county orchards. In orchard Number 1, which was about 50 years old, there were 400 trees, of which 95 per cent were diseased with blister canker; 100 trees had been killed and were being taken out; 100 other trees were dead or so nearly dead as to bear no crop; 150 trees were so severely diseased as to have their crop materially reduced; and only 50 trees were still in good bearing.

In orchard Number 2, which had 150 trees, 100 were dead or nearly so, and the remaining 50 were badly diseased and bearing small crops of inferior fruit.

Orchard Number 3 had about 300 trees, many of which were dead and many others dying. More than 80 per cent of the trees were diseased with blister canker, and the crop was poor in quantity and of inferior quality.

Control of this disease consists in carefully pruning out all infection as soon as it becomes apparent, and in the use, so far as practicable, of varieties relatively resistant to the disease.

Bitter Rot

Caused by *Glomerella cingulata* (Stonem.) S. & v. S.

Bitter rot, a disease which affects the fruit especially, though often causing stem cankers, is apparently limited to the extreme southern part of the state.

The past history of this disease in Illinois is not well known except for the serious outbreak of 1901 and 1902. At that time the disease was studied by Burrill, Blair, Clinton, von Schrenk, and Spaulding, and the loss in the state estimated at a very large figure. During subsequent years the disease appears to have become less and less severe until 1923, when another outbreak occurred. Bitter rot was seen in the counties indicated on Map 48, and the crop reduction due to its presence was estimated at 1 per cent or 74,000 bushels valued at $85,000.

Control of bitter rot demands careful attention to the application of sprays before the disease appears. When it does appear sprays should be supplemented by careful and thorough hand-picking of diseased fruits. Since the disease overwinters in the twig cankers, these should be cut out of the trees wherever they are found.

Brown Rot

Caused by *Sclerotinia cinerea* (Bon.) Schroet.

While very serious on peaches and plums, brown rot does not often become either abundant or severe on apples. Its occurrence in Illinois was noted by Clinton[1] in 1902 and by Conel,[2] in 1914. Very little damage has ever been attributed to it in our state, though in rainy seasons it may become very severe locally.

Its known occurrence in Illinois is shown on Map 49, which indicates a greater frequency of occurrence in the southwestern tip of the state, where its abundance is probably encouraged by the moisture present in the valley of the Ohio and the Mississippi.

The methods useful in controlling brown rot are outlined under peach brown-rot. (See p. 220.)

Powdery Mildew

Caused by *Podosphaera leucotricha* (E. & E.) Salm.

Powdery mildew of apple is not a common disease. It appears as a white, powdery coating on the under surface of the leaves, and occasionally upon the leaf stems and on young twigs.

The damage from this disease consists chiefly in a stunting of the leaves and an early leaf-fall.

Powdery mildew is apparently of rare occurrence in Illinois. Its distribution, as known at present, is shown on Map 50.

The usual spray schedule is sufficient, under ordinary circumstances, to keep it under control.

Sooty Blotch

Caused by *Glocodes pomigena* (Schw.) Colby

This disease is very often found associated with the "fly-speck" disease on apples. It differs in appearance, however, being diffuse and causing a blotchy appearance over a considerable part of the surface of the fruit. The chief injury is a disfiguration of the fruit.

The distribution of sooty blotch in Illinois is shown on Map 51. It is known to occur, as the map indicates, in 19 counties, 17 of which are situated in the southern half of the state.

Varieties known to have been severely affected include especially Ben Davis and Grimes Golden. There is not, however, any apparent distinction between varieties as to susceptibility. The disease appears to develop commonly in damp situations or during moist seasons.

For control, the usual sprays in July and August are helpful. In orchards on low ground open pruning of the trees serves to keep the disease well controlled.

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[1] Clinton, G. P. Apple rots in Illinois. Ill. Agr. Exper. Sta. Bul. 69. 1902.

[2] Conel, J. L. A study of the brown rot fungus in the vicinity of Champaign and Urbana, Illinois. Phytopath. 4: 93. 1914.

Fly-speck

Caused by *Leptothyrium pomi* (Mont. & Fr.) Sacc.

Fly-speck appears to be of common occurrence within the state. The common name is descriptive of the disease, which appears as black specks, usually smaller than a pin-head, on the fruit. It may also occur on the twigs.

No actual damage is caused by this disease. Its only effect is, in serious cases, to mar the appearance of the fruit, thereby impairing its market value to a certain extent.

Distribution within the state is shown on Map 52.

According to Colby,[1] when infections are severe enough to mar the fruit, the specks can be removed by the use of Javelle water. This practice is probably advisable only in preparing the very finest fruit for the market.

Crown-gall

Caused by *Pseudomonas tumefaciens* E. F. S.

Crown-gall, known also under the names "crown knot," "hairy root," and "root knot," is common not only on apples, but on many other plants.

The disease is recognized in two common forms, as galls and as hairy root. It is most common and most serious in nurseries; but the rigid requirements of nursery inspection laws have prevented its serious spread into orchards.

Its known distribution in orchards is shown on Map 53. A very much wider distribution in nurseries would be evident were it possible to bring together proper reports. Distribution in orchards is apparent as a rule only when trees die and crown-gall is demonstrated upon their removal to have been the cause of death.

Serious losses in nurseries from this disease and the doubtful seriousness of its effects on older trees indicate a need for further investigation.

Cankers

Bark cankers of apple are frequently met with in orchards. Among those usually considered as diseases the following are known to occur in Illinois:

Valsa canker (*Valsa ambiens* Fr.) has been found in Pike and DeKalb counties.

European canker (*Nectria ditissima* Tul.) is reported from Stephenson county.

Myxosporium canker (*Myxosporium corticolum* Edg.) has been found in Champaign county.

These cankers can be cut out with sterilized tools when seen, and subsequent injury to the infected trees thereby avoided.

[1] Colby, A. S. Sooty blotch of pomaceous fruits. Trans. Ill. St. Acad. Sci. 13: 139-175. 1920.

Leaf Spots

There are numerous leaf spots of apple which are of relatively common occurrence but which usually do very little damage. Among those known to be present in Illinois is one caused by *Coniothyrium pyriana* (Sacc.) Shel., which has been found in Champaign and Ogle counties, and a second caused by *Phomopsis mali* Rob., found in Union county.

The regular spray schedule is sufficient for their control.

Pear

Pear, so far as number of trees indicates, is the third most important fruit crop of Illinois. According to the census reports for 1920 there were within the state 54,585 pear trees of bearing age, distributed so as to include 21.3 per cent of the farms of the state. Pear culture is, however, on the decline—a fact which is due in no small degree to the serious effects of the diseases to which it is subject. The number of bearing trees in 1920 was nearly 14,000 less than in 1910.

Since 1912 the annual production has varied from 100,000 to 603,000 bushels valued at $270,000 to $735,000. The ten-year average from 1912 to 1921, inclusive, was 397,000 bushels, for which an average price of $1.24 is estimated, bringing the annual valuation of the crop up to $473,000 for that period.

The distribution of production, in bushels, according to the 1920 census, is indicated on Map 54. In general, production is massed in the southwestern half of the state, and here there appear to be three centers: (1) along the Mississippi north of its junction with the Illinois River, including especially Adams and Hancock counties; (2) in the extreme southwestern part of the state, along the Mississippi including especially St. Clair, Randolph, Jackson, Union, and Pulaski counties: and (3) an area of concentration practically confined to Marion county.

According to the data of the 1920 census the most important counties, mentioned in the order of their rank, are Union, Marion, Pulaski, St. Clair, Jackson, Adams, and Hancock.

Blight

Caused by *Bacillus amylovorus* (Burr.) Trev.

This disease is the same as the fire-blight of apple and quince.

The history of pear blight in Illinois is better known than that of any other disease. From discussions in the Transactions of the Illinois Horticultural Society in 1862 it appears that the disease had by that time become wide-spread, generally recognized, and universally feared. For years it was the subject of much discussion at horticultural meetings within the state, and the fear was often expressed that unless some means of control were discovered it would shortly wipe out every orchard in the state.

This disease is now so universally known that no description of it should be necessary. An enumeration of its various names, such as blight, pear-blight, fire-blight, blossom-blight, blight-canker, spur-blight, etc., will serve as an identification of the disease even to the inexperienced orchardist.

As the various names imply, pear blight attacks leaves, twigs, flowers, fruit, and even large branches and trunks. One reason for its extremely serious effects upon the pear tree is its ability to cause trunk-cankers which girdle trees and result in their death.

Losses from pear blight are great—so great that to term this disease the one limiting factor in the growing of pears in Illinois is not an exaggeration. Losses result annually in crop reductions, but the injury to trees is often so severe that its effects impair the quantity of the crop through many subsequent seasons. Anderson[1] estimates that losses from blight average annually in the United States 25 per cent of the potential bearing power of the trees. Pickett[2] places the loss from this disease on the fruits mentioned at $500,000 for 1 county and at $1,500,000 for the entire state, and reports that southern Illinois is more affected than northern.

Estimates of crop reductions caused by this disease in Illinois in 1922 and 1923 are shown in Table 37. In the former year the reduction of 5 per cent was equivalent to 26,800 bushels valued at $26,800, and in 1923 the crop reduction of 6 per cent was equivalent to 19,000 bushels valued at $17,800.

The distribution of pear blight in Illinois is shown on Map 55. It occurs from the northern to the southern and from the eastern to the western boundaries of the state and is known in all but 27 counties, the majority of which produce very small pear crops.

In Table 38 are shown the results of field examinations made in 28 orchards in 1922. These orchards were located in 25 counties. From the table it appears that 50 per cent of the trees showed infections involving 16.9 per cent of the branches on each tree. This is equivalent to 8.5 per cent of all the branches on all the trees, and represents the damage done to the trees in a single season of rather mild disease. It is not to be supposed that this injury was uniform on all branches, for injury to branches varies greatly. Such infections, however, usually involve a complete loss of the fruit which would have been produced, and give rise in many cases to cankers in the body of the tree, which may persist from year to year. Such "hold-over" cankers provide an abundance of material for bringing about new infections the following season. Moreover, the annual enlargement of these cankers usually results in the eventual death of large parts of the tree.

During the season of 1923 similar examinations, summarized in Table 39, were made in 16 orchards aggregating 131 acres, and distributed

[1] Anderson, H. W. Diseases of Illinois Fruits. Ill. Agr. Exper. Sta. Circ. 241 : 71. 1920.

[2] Pickett, B. S. The Blight of Apples, Pears and Quinces. Ill. Agr. Exper. Sta. Circ. 172. 1914.

among 9 counties. Practically 100 per cent of the trees were infected with blight, which involved an average of 43.1 per cent of the branches.

No satisfactory means of control is known but, as in the case of apple fire-blight, cutting out diseased twigs in young orchards and eliminating hold-over cankers in old orchards are helpful. A certain amount of freedom may be secured by planting relatively resistant varieties, such as Kieffer, Duchess, Koonce, Anjou, Seckel, Vermont Beauty, Garber, and Lincoln. However, even these varieties are so susceptible to attack that only the closest attention to the orchard will prevent extremely serious losses.

Leaf Blight

Caused by *Fabraea maculata* (Lev.) Atk.

This disease of the pear is second in importance to pear blight. Though common, it is not often sufficiently abundant to cause serious damage. It is limited for the most part to the leaves, where it causes circular spots, at first carmine-red, later developing a brown center bearing a single black spot. Similar spots are occasionally produced on the fruit and on the twigs. Severe infections result in serious defoliation.

As a rule the loss caused by this disease is small. Epidemics are rare, and fruit is seldom infected. The disease should not be confused, as the name indicates that it might be, with pear blight.

The earliest known occurrence of it in Illinois was in Union county in 1912. Its present known distribution is shown on Map 56.

The prevalence of leaf blight in orchards and its importance as a disease was illustrated by examinations made in 12 orchards in 1922. Among some 400 trees 33 per cent were infected and 49 per cent of the leaves were diseased.

Control of this disease is obtained by the use of the usual sprays.

Scab

Caused by *Venturia pyrina* Aderh.

Scab is not of common occurrence in Illinois. In appearance it is similar to the scab of apples and is caused by a similar fungus.

Its known occurrence in the state is shown on Map 57, which indicates a wide distribution. It has not appeared commonly, however, in the important pear-producing regions. The 8 counties in which it is known to occur are widely separated but, with the exception of Jackson county, lie outside of the areas of intensive culture.

Injury by this disease to leaves and fruit, as in the case of apple, constitutes its chief menace. Control is accomplished with the usual sprays.

Black Rot

Caused by *Physalospora cydoniae* Arn.

This disease is identical with the black rot of apples but it is not of such common occurrence, nor apparently so serious, on the pear.

It is known to occur, as shown on Map 58, in seven counties, four of which lie within the northern third of the state. Its occurrence in Randolph and Jackson counties, in the southwest, brings it within the intensive pear-producing region and indicates the possibility of severe loss under certain conditions.

Leaf Spot

Caused by *Mycosphaerella sentina* (Fr.) Schroet.

Leaf spot is a disease which is often confused with the leaf blight previously described. It is distinguishable, however, by its more angular spots, which are usually brownish, with, at later periods, grayish centers bearing several small black dots. It does not occur on the fruit or twigs. Leaf-spot attack results in the early falling of leaves; hence it is of importance in nurseries, where serious infections may materially interfere with the proper development of young trees.

The first report of this disease in Illinois was made by Burrill in 1912, when he recorded its occurrence in Union county. Its distribution as known at present is shown on Map 59, but it probably has a much wider occurrence than the map shows.

Control, when necessary, is gained by the use of the usual sprays.

Quince

This fruit is not grown commercially to any great extent in Illinois. For the most part single trees, or a few trees at the most, are maintained to supply the home table.

The diseases of the quince important in Illinois are few, and probably result in greater losses than would be the case were trees maintained in well-cared-for commercial plantings. The following are known to occur in Illinois.

Leaf Blight

Caused by *Fabraea maculata* (Lev.) Atk.

This disease is the same as the leaf blight of pear, but its effect on quince is much more marked and constitutes the chief cause of loss from disease. In appearance it is similar to pear leaf-blight, but it is much more commonly found on the fruit of quince, where severe infections cause marked distortion. On twigs the spots are elongated, and they frequently cause the death of the twigs by girdling.

Leaf blight is known to occur in Illinois in eleven counties, nine of which lie in the southern tip of the state, as shown on Map 60. The two central counties, indicate a possible northward extension of the disease under favorable conditions.

Control is had by the application of lime-sulfur spray, as for pears.

Fire-Blight

Caused by *Bacillus amylovorus* (Burr.) Trev.

Fire-blight of quince is caused by the same bacterium as fire-blight of apple and pear blight. It is usually fairly common, but is less severe on quince than on the other fruits.

Its presence in the state has been recorded from time to time, and its present known occurrence, as shown on Map 61, gives it a distribution practically co-extensive with the observed cultivation of the quince.

Injury to uncared-for trees may often be very serious, but a careful pruning-out of diseased parts as they appear will prevent its spread as will also the elimination of hold-over cankers.

Powdery Mildew

Caused by *Podosphaera oxyacanthae* (DC.) De Bary

Powdery mildew is one of two rather uncommon diseases of quince in Illinois. It appears as a whitish powder covering the upper side of the leaves and often extending down the leaf-stems. Under favoring circumstances the mildew may result in severe leaf-injury, accompanied by early and damaging leaf-fall.

The first collection of this disease was made by G. P. Clinton in September, 1894, presumably in Champaign county. It was found in 1922 in Coles and Edgar counties, where severe infections were seen on a few trees. Its present known distribution is small, as shown on Map 62.

Rust

Caused by *Gymnosporangium germinale* (Schw.) Kern

The rust of quince is similar in appearance to apple rust, and is caused by a similar fungus. It is not known to occur commonly in Illinois, but it is a much more serious disease than the apple rust because it attacks especially the fruits and twigs.

Quince rust was found in Hardin county in 1919, and this constitutes the only record of its occurrence in the state.

As with apple rust, control is to be had through the eradication of near-by cedars.

Miscellaneous Diseases

The quince, which is closely related to the apple and the pear, is subject to the attack of several diseases commonly found on those fruits. Among these should be noted especially black rot, bitter rot, brown rot, crown-gall, and bark cankers.

None of these have so far been found on quince in Illinois with the exception of a bark canker caused by the fungus *Valsa leucostoma* (Pers.) Fr., which was found in 1919 in Tazewell county.

Peach

Peaches constitute one of the most important fruit crops of Illinois. Though the production of large crops is dependent upon favorable weather, the average annual production is large and of considerable value.

Map 63 shows the status of peach-production in Illinois in 1919, as indicated in the Census Reports of 1920; Map 64 shows the distribution of peach trees in the state in 1923 according to later U. S. Census figures. The area of greatest production lies generally in the southern half of the state below a line drawn east and west along the northern boundary of Pike county. Within this region peach-production is intensified in certain areas. One such area is along the Mississippi from Pike county south through St. Clair county. A second includes especially Marion and Jefferson counties, and a third the three extreme southern tiers of counties. This last area is by far the most important, since it includes Union county, with its tremendously large production, and Jackson and Johnson counties. Union, Marion, and Jackson are the most important peach-producing counties in the state.

According to the 1920 census there were within the state a total of 1,851,037 peach trees, of which 1,011,325 were reported to be of bearing age. Many of the remaining 800,000 and upwards will have come into bearing since then, and it is probable that the regions of important production will have been altered so as to correspond more directly with tree distribution, as shown on Map 64. In general, the large commercial area remains the same, but with a marked northward extension along the Illinois River. The total number of trees is reported to be distributed over 55,968 farms or 23.6 per cent of the farms of the state.

During 1912-1921, inclusive, the peach-production of the state ranged from 76,000 bushels (valued at $281,000) in 1921 to 1,998,000 bushels (valued at $2,297,000) in 1913, the yearly average for the decade being estimated at 724,500 bushels, valued at $1,543,000.

Brown Rot

Caused by *Sclerotinia cinerea* (Bon.) Schroet.

This disease, though sometimes attacking pomaceous fruits, is primarily a disease of the stone fruits. It is by far the most serious peach disease in Illinois and is most injurious to the fruit, causing large losses not only in the orchard, but also when the fruit is in storage or in transit. Under favorable circumstances the brown-rot fungus may cause a blossom-blight and a twig-blight; and less frequently, cankers on limbs.

The early history of this disease in Illinois is not known. Probably it is coextensive with peach-growing. Burrill recorded its occurrence in 1911 in 3 counties, Champaign, Montgomery, and Union, with the note that there was little injury that season because of unfavorably dry weather.

The known distribution of brown rot of peaches in Illinois, is as shown on Map 65. It appears to be general over the southern tip of the state, including the counties important in commercial peach-production. Northward, distribution is more scattered, covering in a general way the territory between the Illinois and Mississippi Rivers. Toward the east, an irregular distribution occurs in six counties which lie along the tributaries of the Illinois and Wabash Rivers. It is probable that brown rot is even more wide-spread than has been recorded.

Estimates of crop reductions from brown rot for 1917-1923, and reproduced in Table 40, vary from none in 1918 to 12 per cent in 1917, equivalent to 50,000 bushels valued at $97,000. These amounts represent the loss in orchards, and do not include the tremendous losses which often occur between the harvesting of the crop and its ultimate disposal to the consumer.

An examination in 1922 of 32 orchards of varying size, scattered uniformly through 24 counties, indicated an average infection of 17 per cent of the trees and nearly 15 per cent of the fruit. Field notes of 1923 show that in 9 orchards the average of infected trees was slightly more than 62 per cent, with infected fruit averaging 26 per cent.

Control of brown rot is often difficult, since an outbreak may occur whenever sufficiently wet weather comes on. Twig and blossom blight is especially to be expected in damp springs and serious fruit infection may appear any time during the season during damp warm weather. The application of proper sprays should therefore be made with particular reference to predicted weather conditions. Assiduous adherence to such a schedule may reasonably be expected to do away with the considerable losses which might otherwise occur.

Leaf-curl

Caused by *Exoascus deformans* (Berk.) Fckl.

This disease is probably second to brown rot in destructiveness to peaches. It is confined to the current year's growth, affecting leaves, twigs, and blossoms. The leaves appear thickened along the veins, causing the blade to become folded, wrinkled, and puffed, and the edges to curl in on the under side. Ultimately the leaves turn yellow and fall from the tree.

The early history of this disease in Illinois is not known. It was reported by Burrill to have occurred in Champaign county in 1890 and in Champaign and Livingston counties in 1911. The extent of its prevalence as now known is shown on Map 66, which indicates its occurrence in 62 of the 102 counties of the state. The area of most common occurrence lies along the northern boundary of the region of commercial peach-production and this fact lends color to the belief that this is a northern disease. It should be remembered, however, that leaf-curl is very readily controlled and that its apparent common distribution on the northern edge of the commercial district may result from a more perfect control south-

ward and also from the presence of an increasing number of private plantings northward in which disease-control is not practiced.

The abundance and severity of leaf-curl on peach may be illustrated by notes from the observations made in 1923.

"In Pike county, in a one-acre block of Lemon Clings all were infected and suffering considerable defoliation. A ten-acre tract of Belle of Georgia and Champion showed a large amount of infection, with defoliation of 10 to 15 per cent on the Belle of Georgia. In Edwards county a one-acre orchard of Elbertas showed 10 per cent of the leaves infected, and a two-acre tract of Hales 50 per cent of the leaves infected."

The use of resistant varieties is helpful in controlling this disease. At least, an effort should be made to avoid the planting of susceptible varieties, such as Lemon Cling and Belle of Georgia. Less susceptible, but still remarkably subject to infection, are the Elberta, the Hale, and the Carmen.

Further control is readily accomplished in most cases by the application of the customary dormant lime-sulfur spray, with especial attention given to thoroughly coating the buds.

Bacterial Shot-hole

Caused by *Pseudomonas pruni* E. F. S.

This constitutes the third important disease of peaches in Illinois. It affects both the fruit and twigs, but is especially noticeable on the leaves, where it appears as small spots, at first light colored but later becoming darker and eventually turning brown. Ultimately the spots separate from the leaves and fall out, giving the characteristic shot-hole appearance. Serious infection causes defoliation. On twigs spots are formed which turn dark and may kill the twig. Small purple spots, usually not more than 1/16 of an inch in diameter, are produced on the fruit, the skin cracks, the appearance of the fruit is marred, and it is made especially susceptible to attack by brown rot.

The history of the bacterial shot-hole as a serious peach disease in Illinois dates back only to 1915. According to Anderson[1] it was observed near Centralia in 1912. Since that time it has been widely observed, and is a disease needing careful attention for its control.

Its distribution as indicated by specimens collected in 1922 and 1923 is shown on Map 67, which indicates its occurrence in 82 counties

There appears to be no marked fluctuation in its severity from year to year. A crop reduction of 2 per cent was estimated for 1922 and 1923. In the first year this amounted to 22,000 bushels valued at $38,000 and in the second year to 14,000 bushels valued at $36,000.

Infection is very general where it has been observed to occur. In 20 orchards examined during 1923 in 12 representative counties and covering 1002 acres, 92.2 per cent of the trees were affected by this dis-

[1] Diseases of Illinois Fruits. Ill. Agr. Exper. Sta. Circ. 241: 90. 1920.

ease, diseased areas were found on an average of 31.4 per cent of the leaves, and the amount of infected fruit varied from 10 per cent to 45 per cent.

The fact that this disease is caused by a bacterium renders it difficult to control, and spraying seems to have little effect. Cultivation and the application of fertilizers, especially sodium nitrate, which tend to increase the vigor of the trees, are effective in holding it in check.

Scab

Caused by *Cladosporium carpophilum* Thuem.

Scab of peaches, also known as "freckle," is a very common disease in Illinois and is probably more disastrous in its effect than is usually supposed. While attacking leaves and twigs to a certain extent, it is primarily a disease of the fruit. Usually it appears on the exposed side of the fruit and is often considered as a natural reaction to sunshine—hence the name "freckle." Serious infection, however, results in misshaped, unevenly ripened fruit. Cracks often appear which reach to the stone of the peach. The fruit is thus rendered unsuitable for ready marketing and is also made more liable to brown-rot injury and internal breakdown.

The early history of this disease in Illinois is not well known. The earliest record of it is a specimen collected by F. S. Earle in Union county in 1881.

During 1922 and 1923 scab was found to occur in 46 counties, the distribution of which is shown on Map 68. It occurs most commonly in the south quarter of the state. Occurrence northward is much more scattered and irregular, and reaches only to Carroll and Ogle counties.

The prevalence of scab is illustrated by an examination, in 1923, of 12 orchards, distributed among six counties. Infection was found on 86.7 per cent of the trees and involved 79 per cent of the fruit produced in the 12 orchards. The apparent damage caused by fruit infection varied greatly in the several orchards and various expressions concerning its frequency occurred in the notes as follows: great, 5 times; much, 3 times; some, 2 times; little, twice. Of the 88 acres reported on, great damage was found on 54, much on 7, some on 23, and little on 4. In reports showing much to great injury to the crop, mention is made repeatedly of the quantity of fruit cracked and deformed. Where injury was less it consisted chiefly in a lesser degree of deformation and spotting of the fruit which detracts from its appearance and makes it unsalable as of the first class.

Control of peach scab consists partly in the use of resistant varieties and partly in the use of a well-applied spray. Early Crawford, Hiley, and Carmen are commonly thought to be most resistant, with Elberta, Hale, and Belle of Georgia next. These varieties, however, may not always be suitable to the needs of the grower, who must then depend upon his sprays for control. As infection begins when the petals have been

off the tree about a month the first application of lime-sulfur spray should be made three to four weeks after petal-fall. Subsequent applications of this spray for the control of brown rot serve also to control scab.

Die-back

Caused by *Valsa leucostoma* (Pers.) Fr.

Of lesser importance than the preceding diseases is die-back. It occurs on the trunk and limbs but is especially a disease of the twigs.

Infection of buds, and of twigs through wounds, occurs during the growing season, and is followed by the death of the twigs, which, during the season following, may be killed-back for four inches or more.

The distribution of die-back of peaches in Illinois is indicated on Map 69, where it is shown to occur in 17 counties widely scattered through northern Illinois, and in one county in southern Illinois.

Spraying does not appear to control die-back satisfactorily, though it does lessen the amount of the disease. It is important to cut out carefully all parts showing evidence of infection.

Minor Diseases

Besides those previously noted, there occur in Illinois several peach diseases which do not materially affect either the welfare of the tree or the quantity or quality of the crop.

Leaf spot, caused by *Cercospora circumscissa* Sacc., has been found in Champaign and Marion counties. It is not known to be widely distributed, or common where it does occur.

Frosty mildew, caused by *Cercospora persica* Sacc., appears as a yellow leaf-spot, the under side of the spots having a frosty appearance from the spore-bearing hyphae of the fungus. This disease is reported to have been found in Illinois previous to 1885, by F. S. Earle,[1] and it was found in Union county in 1881 by A. B. Seymour. These early reports constitute all that is known of its occurrence in this state.

Apricot

The apricot is not grown extensively in Illinois. It is nevertheless subject to the attack of a number of diseases, several of which are the same as, or similar to, those affecting peach, plum, and cherry, and, in general, control is secured by the same means. Those known to occur on apricot in Illinois are the following:

Scab, caused by *Cladosporium carpophilum* Thuem., was found in Boone and Schuyler counties in 1922.

Bacterial shot-hole, caused by *Pseudomonas pruni* E. F. S. has been found in Coles, Monroe, Hardin, Edgar, Massac, Saline, and Ran-

[1] Ellis, J. B., and Everhart, B. M. Journ. Myc. 1 : 56. 1885.

dolph counties, all in the southern half of the state and most of them in its tip.

Brown rot, caused by *Sclerotinia cinerea* (Bon.) Schroet., has been found in Schuyler, Bond, and Fulton counties.

Plum

Although commercial production of this fruit is not practiced extensively in the state, most farms have one or more trees which supply the home table, and not infrequently small orchards which supply local markets.

Many of the diseases of the plum are the same as those attacking the peach. Others which attack plums attack cherries also.

Brown Rot

Caused by *Sclerotinia cinerea* (Bon.) Schroet.

Brown rot of plum is similar to the brown rot of peach, and is caused by the same fungus. It is the most important plum-disease occurring in the state, and for several years past has caused an average annual crop-loss estimated at five per cent.

Its distribution in Illinois is shown on Map 70. It is known to occur in 50 counties, distributed in all parts of the state.

Brown rot appears to be a disease more serious on plum than on peach. Its severity is illustrated by an examination of 395 trees made in 21 counties in 1922, where it was found on 43.9 per cent of the trees, and 8.8 per cent of the fruit. A similar examination in 1923 of 83 trees in 8 well distributed counties showed that an average of 94.4 per cent of the trees were infected and 50.5 per cent of the fruit diseased.

The fruit loss, however, is not the whole story for the brown-rot fungus causes a twig and blossom blight which does notable damage each year. In 1922, instances were common where from 10 to 30 per cent of the young twigs were killed.

Brown rot of plum is controlled like that of peach by the use of sprays, but owing to the unusual seriousness of the plum disease, extreme care must be taken to apply them thoroughly.

Leaf Blight

Caused by *Coccomyces prunophorae* Higg.

Leaf blight is, next to brown rot, the most common disease of plum in Illinois. Its injury appears limited to the leaves, on which it causes round, discolored spots, rather definitely limited in size. The spotted tissue eventually falls out of the leaf, giving it a "shot-hole" appearance, and serious defoliation often results.

The known occurrence of leaf blight in Illinois is shown on Map 71. It has been found in 56 counties widely distributed over the state.

Loss from this disease is difficult to estimate, but it was less than 1 per cent in 1922 and about 1 per cent in 1923. The field notes for 1923 indicate that of the plum trees examined in 9 counties 100 per cent were affected, each tree having more than 90 per cent of its leaves spotted by this disease.

Control of leaf blight is obtained by the use of the usual sprays, though in this case the addition of lead arsenate to the lime-sulfur increases its effectiveness, while a further addition of iron sulfate (1¼ pounds to 50 gallons of spray) lessens the injury to the foliage.

Black-knot

Caused by *Dibotryon morbosum* (Schw.) T. & S.

Unique among the diseases of stone fruits is the black-knot of plum, in that it is wholly confined to the woody part of the tree, and the injury which it causes is permanent.

It first appears on young branches, where it causes knots up to six inches in length and half an inch in diameter. The knots are usually on but one side of the twig, though they often completely encircle it. They are at first greenish and quite soft but later become black and hard.

The history of black-knot in Illinois, so far as known, dates from the year 1887, when it was found at Edgewood, Effingham county. In 1898 it was reported from Clark county, in 1899 from Marion and Stark counties, in 1900 from Cook and Madison counties, and in 1902 from Edgar county. The majority of these early collections were presumably from nurseries, as they are among the collections of the State Nursery Inspector. In 1911 Burrill reported the disease in Champaign, Clark, and Montgomery counties, with the notation that it was serious locally. In 1913 he added Bond, Coles, and Crawford counties to the list, saying that black-knot was common in the last two.

The distribution of black-knot as known at the present time is shown on Map 72. It is known to occur in only 21 counties, few of which are in the northern part of the state.

The best protection against the losses which black-knot causes, lies in the use of resistant varieties, among which the Wild Goose is pre-eminent. With other varieties constant watchfulness is necessary to insure cutting out all knots as soon as they are recognized. Badly affected trees are beyond hope and had better be cut down at once. Spraying is not effective.

Scab

Caused by *Cladosporium carpophilum* Thuem.

Plum scab is apparently of rare occurrence in Illinois. Up to the present time it has been found in only three counties along the northern

boundary of the state—Jo Daviess, Stephenson, and Winnebago. The DeSoto variety appears to be most often diseased.

Bacterial Shot-hole

Caused by *Pseudomonas pruni* E. F. S.

This disease, which is the same as the bacterial shot-hole of peach, causes serious damage to both the leaves and the fruit, and produces cankers on the twigs. On the whole the disease appears to produce more serious effects on the plum than on the peach. It is not, however, so common or abundant on the plum, possibly because the more immune varieties, the Americana and Wild Goose, are among those most commonly grown. Japanese varieties are very susceptible.

The distribution of this disease appears at the present time to be limited to southern Illinois. It is known to occur in 13 counties as shown on Map 73.

Control measures are the same as for peach shot-hole (p. 222).

Leaf-curl

Caused by *Exoascus mirabilis* Atk.

Recently there has appeared in Illinois a disease of plum not previously known in the state, best described under the name of leaf-curl. Infection, which appears to take place in the bud or when the branch is still very young, results in a marked distortion of leaves, dwarfing and distortion of the twig, and eventual death of the part diseased.

The known occurrence of this disease in the state is shown on Map 74. It is not yet commonly distributed, but it has a wide range and the damage it causes is often serious. So far as observations go it appears to be rather definitely limited to the Wild Goose group of plums.

It can be controlled in some measure by means of the usual sprays, but their use should be supplemented by pruning out diseased parts, taking particular care to cut a considerable distance below the manifest injury and to have the tools thoroughly disinfected.

Cherry

Cherries like plums are not extensively cultivated in the state on a commercial scale but they are grown almost everywhere to supply home tables and local markets in season. On this account diseases of the cherry are the more common and serious for isolated trees or small orchards usually receive less care than commercial plantings.

Powdery Mildew

Caused by *Podosphaera oxyacanthae* (DC.) De Bary

Cherry is the only one of the Illinois fruits that is commonly subject to attack by a powdery mildew. Early in June, white, powdery

spots appear on the under side of the leaves and rapidly increase in size and number thereafter until they cover the entire under surface. The leaves then begin to curl upward and inward and similar patches of powdery mold appear on the twigs.

The damage from this disease results from interference with the functioning of the leaves, and the injury done by the fungus causes early defoliation and a marked stunting of diseased twigs.

The history of powdery mildew on cherry in Illinois reaches back to 1881, when it was found in McHenry, Rock Island, and Piatt counties by A. B. Seymour. In 1882 Seymour found it in Adams and McLean counties. It was reported in Ogle county in 1888 and 1890, in Kankakee county in 1899, in Union county after 1880 by F. S. Earle, and in Champaign county in 1893, 1897, 1911, and 1919. These early reports show its occurrence in nine counties, eight of which lie within the northern half of the state.

As a result of the surveys made in 1921, 1922, and 1923 powdery mildew is now known to occur on the cherry in 65 counties as shown on Map 75. These counties may be roughly divided into two groups, lying respectively in the southern tip of the state and the northern half. Between these groups is a considerable area in which this disease has not yet been found.

Control of this disease is usually satisfactory if the ordinary lime-sulfur spray schedule is followed. If special control measures become necessary, it is best to use sulfur dust. Because powdery mildew is a superficial disease, dusting is effective even when begun after it has made its appearance.

Brown Rot

Caused by *Sclerotinia cinerea* (Bon.) Schroet.

The brown rot of cherry is the same as the brown rot of peach and plum. In Illinois, however, the abundance of sweet cherries explains the rare occurrence of the disease, since they are less susceptible to its attack than sour cherries.

It is known to occur in 14 counties, widely distributed over the state, as shown on Map 76. It is somewhat the most common in southern Illinois.

Leaf Blight

Caused by *Coccomyces hiemalis* Higg.

This leaf blight is similar to leaf blight of the plum and is caused by a similar fungus. It is, in Illinois, the most serious of the diseases to which the cherry is subject.

In late May or early June small, purplish, irregular or angular spots appear on the leaves, which, when badly spotted, turn yellow and fall off. Severe defoliation, which is by no means uncommon under Illinois conditions, results in a serious weakening of the tree.

Leaf blight of cherry is known to occur in 84 counties. Its distribution, as shown on Map 77, indicates a wide-spread and common occurrence in all parts of the state.

It was estimated to have causeed a 1 to 2 per cent crop-loss during the seasons of 1922 and 1923.

Its control is relatively easy, by the use of either lime-sulfur or Bordeaux mixture just after the petals fall and again about two weeks later. If lime-sulfur is used lead arsenate and iron-sulfate should be added.

The black cherry, *Prunus serotina* Ehrh., which has been commonly domesticated, is subject to a leaf blight very similar in appearance to the preceding and caused by a similar fungus (*Coccomyces lutescens* Higg.). Its known distribution in Illinois on black cherry is shown on Map 78.

Bacterial Shot-hole

Caused by *Pseudomonas pruni* E. F. S.

This disease is similar to the disease of the same name on peach and plum, and is caused by the same bacterium. It has been found on cherries in Saline county, in the southern part of the state, and in Knox county in the northern part.

Grape

Grape-growing on a commercial scale is not general in Illinois but it has been developed in more or less restricted areas. Nevertheless, there are to be found in the neighborhood of every town of any size one or more growers who cater to the local market, and it is unusual indeed to find a farm which does not have one or more vines producing grapes for home consumption. According to the 1920 census there were 1,642,527 grape-vines of bearing age in the state, yielding a crop of 10,339,018 pounds in 1919. In addition there were 180,172 vines not yet of bearing age. The distribution of these vines in the state is shown on Map 79.

Concentration of grape-production on a commercial basis occurs especially in territory adjacent to large cities; near Cairo in the south, St. Louis in the southwest, Springfield, Bloomington, and Peoria in central Illinois, La Salle and Chicago farther north, and Rock Island and Moline in the west. The region of greatest production in the state, is not, however, so related. This is the region surrounding Nauvoo, in Hancock county, where nearly 25 per cent of the vines of the state are located and where in 1919 more than 20 per cent of the entire crop of the state was grown.

Aside from the strictly commercial concentration of grape-growing in certain regions, production is more or less general over the entire state. There is no community in which the grape crop does not have some importance, and its total value is undoubtedly great.

Black Rot

Caused by *Guignardia bidwellii* (Ell.) V. & R.

Black rot is the most important grape disease in Illinois. While it attacks all above-ground parts of the vine, it is most commonly seen as a fruit rot and leaf spot.

On the fruit it first appears as a small white spot, which is soon surrounded by a brown ring. The fruit beneath the spot becomes rotten, and small black dots appear upon the surface of the spot. Eventually the entire fruit rots and shrivels to a small, dark mummy. The black-rot leaf-spot appears as a brown, more or less circular spot with a darker margin. In late summer it bears minute black dots on its surface. Stem lesions are charaterized by a dead brown area over which are scattered tiny black dots.

The history of this disease is extensive. It is reported to have been present in destructive amounts in Madison county as early as 1861, and references are made in the Transactions of the Illinois Horticultural Society to a grape disease, probably black rot, which appeared from time to time in Champaign, Hancock, and Madison counties.

Its present known occurrence in the state is shown on Map 80. The 63 counties are so distributed as to indicate that it has a state-wide distribution.

Control is secured in this and other diseases of grapes by the careful and thorough application of sprays.

Downy Mildew

Caused by *Plasmopara viticola* B. & C.

Downy mildew is probably second in seriousness among grape diseases occurring in Illinois. It is especially a leaf disease, but also attacks young stems, fruit, and leaf-stems. On the leaves it appears as white mildewed spots on the lower surface. The leaves first take on a slightly water-soaked appearance where the mildew occurs, and as the spots enlarge they curl upward and inward and are eventually killed. Diseased flowers do not set fruit; and fruit, when attacked, either shells off from the vine or dies and becomes mummified.

The history of this disease in Illinois dates back to 1882, when it was collected by A. B. Seymour at Fall Creek, Adams county. A later collection was made by G. P. Clinton at Urbana in 1892, and Burrill records its occurrence in Champaign county in 1912 and 1913.

Its present known distribution in the state is shown on Map 81. Its occurrence has been demonstrated in 30 counties, with a very irregular distribution suggesting a wide range of occurrence for the disease.

Control is accomplished through the usual sprays.

Anthracnose

Caused by *Gloeosporium ampelophagum* (Pass.) Sacc.

Anthracnose, a disease of lesser importance on grapes in Illinois, attacks all green parts of the vine, but especially the young shoots, berries, leaf stalks, and berry stems. On shoots and other stem parts it causes small reddish brown, somewhat sunken spots, which enlarge to an oval, with a gray and noticeably sunken center. Spots on berries first appear round and dark brown, but are later surrounded by a bright red ring, giving them a marked bird's-eye appearance. The attacked berries eventually rot.

Anthracnose has probably been present in Illinois ever since grapes have been grown in the state. Evidently, however, it has been confused with black rot, so that early reports found in the Transactions of the State Horticultural Society are not definite enough to be dependable.

The present known occurrence of anthracnose is shown on Map 82. Of the 18 counties in which it is known to occur all but three lie in the northern half of the state. The relatively unimportant nature of this disease to the commercial producer is apparent from the fact that, with the exception of the grape regions in Madison, Sangamon, and La Salle counties, anthracnose has not been found in the important grape-growing centers. Its known range in the state appears, from our present information, to be strikingly northern.

A partial explanation of the absence of anthracnose from commercial regions is to be found in the fact that the Concord grape, so commonly grown in Illinois, appears to be markedly resistant.

Where special effort is necessary to control this disease, the usual program of summer spraying, supplemented by a dormant spray (lime-sulfur, 1-8), will be found satisfactory.

Powdery Mildew

Caused by *Uncinula necator* (Schw.) Burr.

Powdery mildew, like the downy mildew, is chiefly a leaf disease, but differs in that it is caused by a fungus which is almost entirely superficial. All young parts of the vine are subject to attack. Whitish, powdery spots appear on the leaves. As the spots grow larger they cause a stunting of young leaves, and older leaves curl upward and eventually die. Mildewed blossoms fail to set fruit, and diseased berries either shell off or are badly deformed or cracked.

It is thought that powdery mildew shares with the downy mildew the place of second importance among grape diseases in Illinois, but observation on distribution and severity are not yet sufficient to show its relative importance clearly.

The earliest definite record of this disease is a collection made at Cobden, Union county, in 1881. Anderson collected it at Urbana, Cham-

paign county, in 1921. Burrill[1] records its presence in Wabash, Union, and Champaign counties.

The present known occurrence of powdery mildew on cultivated grape is shown on Map 83 to include 8 counties, but it is probably much more widely distributed.

The usual sprays suffice for its control.

Brambles

The brambles include raspberries, blackberries, loganberries, and dewberries. Commercial production of these fruits, while of considerable importance for the state, is not scattered uniformly over the state, but appears to be localized in small areas of concentrated production.

All the brambles are subject to the same diseases, but one disease may commonly be severe on one bramble and mild on another. These diseases will, therefore, be discussed from the standpoint of the disease rather than the host, with appropriate notes on susceptibility under each.

Anthracnose

Caused by *Plectodiscella veneta* Burk.

Anthracnose is especially a disease of the raspberry, although blackberries, dewberries, and loganberries are subject to it; but besides the raspberry only the blackberry appears to suffer from it severely.

Anthracnose appears at first on the canes as small, purplish, slightly-raised spots which increase in size, their centers becoming cracked and dull gray. They are usually oval with a raised purplish border, but when numerous they grow together, forming large, irregular, grayish cracked areas on the canes. Similar spots occur on the petioles, leaf ribs, and berry-stems; and more rarely small purplish spots appear late in the season on leaves

Damage done by anthracnose is limited almost entirely to canes, but by direct injury to them the entire plant is weakened. Losses from this disease have been variously estimated. Anderson[2] reports that in 1908 the loss was 8 per cent of the crop. In 1923 it was estimated at 3 per cent.

The earliest Illinois record is in a collection made by Charles Wheeler[3] at Evanston, Cook county, in 1881. Another collection was made by F. S. Earle in Union county in 1884.

At the present time the disease is known to occur in 45 counties, most of which lie in the northern half of the state, as shown on Map 84. Anthracnose appears, however, to have an extensive distribution, including all parts of the state, and an examination of gardens would undoubtedly show its occurrence in every one of our 102 counties.

[1] Bul. Ill. St. Lab. Nat. Hist. 2: 407. 1887.
[2] Ill. Agr. Exper. Circ. 211: 114. 1920.
[3] Ellis, J. B., and Everhart, B. M. Journ. Myc. 3: 129. 1887.

It is difficult to control, and measures must be thoroughly and conscientiously carried out if the desired results are to be obtained. Lime-sulfur is applied as a spray before growth starts (2½ gallons lime-sulfur to 50 gallons water) and again just before blossoming. New plants should be free from anthracnose when set. In the patch clean cultivation is essential, as the shade and moisture provided by rank weeds are extremely favorable to infection.

Cane Blight

Caused by *Leptosphaeria coniothyrium* Sacc.

Cane blight is known only on the raspberry. Both red and black varieties are subject to attack. This, like anthracnose, is primarily a disease of the canes. The first sign of its presence is a wilting of branches about the time the berries start to ripen. On the canes, below the wilted branches, there may be found at this time diseased areas usually several inches long in which the bark is light-colored and the wood dead and discolored. On diseased bark there appear small black dots, which are often surrounded by smoky halos.

Damage from this disease results first from its direct effect upon the fruit of wilted branches and second from its injurious effects upon the plant itself. The crop loss from it in Illinois is estimated at about 0.5 per cent annually.

The earliest report we have of cane blight in Illinois is one by Burrill, mentioning its occurrence during 1912 in Kane and Randolph counties. These two occurrences, one in the extreme north and one in the extreme south of the state, indicate that at that time it may have been much more widely distributed over the state than was supposed.

Its present known occurrence in the state is shown on Map 85. It has been found in 36 counties, and has a wide though irregular distribution, reaching both the southern and the northern borders of the state. Southward, its occurrence is only occasional, as shown by the few counties in which it has been found, and the limited number of times it has been seen. The northern third of the state appears to be an area of concentrated occurrence, from which more than 60 per cent of our specimens and reports have come.

Control of cane blight can be attained in some measure through the use of resistant varieties. The Columbian is reported to be very resistant, and the Cuthbert most susceptible. Sprays applied for other diseases are helpful but do not prove satisfactory alone. The nature of the disease and its life history suggest that new plants should be free from it when set, that old canes should be cut out and burned as soon as possible, and that care should be taken in cultivation to avoid injuring canes and thus providing points of entrance for the fungus.

Spur Blight

Caused by *Mycosphaerella rubina* (Pk.) Jacz.

Spur blight, or "gray bark," is a disease of the red raspberry. It appears on young canes as a brownish discoloration, located usually just below the leaf stems on the lower parts of the canes. It can be seen after about the middle of July. The diseased area then enlarges lengthwise of the stem for several inches above and below the nodes, and the bark becomes dry and brown, and splits longitudinally. Later, usually in September, tiny black spots appear on the diseased areas.

The damage done by this disease is of the same nature as that done by anthracnose and cane blight. Spur blight is, however, so uncommon that the actual loss in the state is slight.

The present known occurrence of spur blight in Illinois is shown on Map 86. It has been found in six counties only, all of which are in northern Illinois.

Control is not usually necessary, but where desirable may be attained by the application on young canes only of 3-2-50 Bordeaux mixture to which has been added two pounds of rosin-fish-oil soap. Four applications should be made, at two-week intervals, beginning when the canes are 8 to 12 inches high.

Leaf Spot

Caused by *Mycosphaerella rubi* Roark

Leaf spot, also known as Septoria leaf-spot, is the most common of the bramble diseases. Red raspberry and dewberry are most susceptible to it but it is unusually abundant on all the brambles. It begins to appear early in June as small purplish spots on the leaves. These enlarge somewhat, their centers turn gray or ash-color—on the blackberry tan or brown—with a definite purple border. Eventually minute black dots appear scattered over the spots.

Injury from this disease is usually limited to the leaves, but canes may sometimes be diseased. In favorable seasons infection may become so severe as to cause early and damaging defoliation.

The earliest record of this disease is a report of its occurrence in Illinois in 1887 by G. Martin[1] under the name of *Rhabdospora*. No specific locality is given. Under the name of *Septoria rubi* West., it was reported by Burrill in Champaign county in 1911 and in Champaign and Union counties in 1912.

It is now known to occur in Illinois as indicated on Map 87. It has been found in 35 counties widely distributed over the state. Its distribution is not uniform, however, and occurrence is rare northward. It increases in frequency southward, until in the southern third of the state it appears to be abundant everywhere.

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[1] Journ. Myc. 3: 90. 1887.

It is rarely necessary to employ control measures against this disease. When necessary, either lime-sulfur or Bordeaux, made up according to the 3-2-50 formula to avoid injury from stronger mixtures, will be found satisfactory.

Orange Rust

Caused by *Gymnoconia interstitialis* (Schlecht) Lagerh.

Orange rust, the most conspicuous and one of the most serious of the bramble diseases, is in Illinois especially a blackberry disease. It is easily recognized by the striking orange color of the leaves of infected plants in spring.

In late April or early May small greenish-yellow spots appear on the under surface of the leaves of infected plants, and within a few weeks the leaf surface ruptures, exposing large patches of orange spores on the lower surface. The disease is systemic, and persists within the plants from year to year, dwarfing, deforming, and eventually killing them. All sprouts from runners of diseased plants are infected.

The history of bramble orange rust in Illinois dates back to 1850. Its present known distribution on economic hosts is shown on Map 88. It appears to be more common and more abundant southward, and is rather rare in the northern third of the state.

Control is to be had only by digging out and burning infected plants. The disease pervades all parts of the plant, persisting there until the plant dies. Infection may be prevented to some extent by planting resistant varieties, such as Snyder, and by taking care to eradicate all wild blackberries in the neighborhood.

Crown-gall

Caused by *Pseudomonas tumefaciens* E. F. S.

Crown-gall, while occurring on all the brambles, is in Illinois particularly destructive to red raspberries. Damage from this disease is extremely serious and is said to be the most important of the factors limiting raspberry production in the state at the present time.

Its known occurrence is shown on Map 89. It has been found in 28 counties widely scattered over the state, but appears to be less common southward.

Plants in the nursery suffer most from it, and it is there that most plants become infected. If the grower would avoid loss from this disease he must insist on plants absolutely free from infection.

Bramble-streak

The so-called bramble-streak is a disease affecting only the black-cap raspberry. In other states it is said to be extremely serious.

It was first found in Illinois by A. S. Colby near Peoria in 1922.

Observations during the season of 1923 have established its occurrence in 6 additional counties, distributed as shown on Map 90.

No definite cause is known for it, but it appears to be serious where seen and should receive prompt attention from growers. The only control known is to dig out and burn diseased plants.

Leaf Blight

Caused by *Cercospora bliti* Tharp

This bramble leaf blight, first described in Texas and said to be serious there, was found in 1922 in Jackson county, Illinois. It is caused by a fungus which makes large inroads upon leaf-tissue and may cause serious defoliation.

Powdery Mildew

Caused by *Sphaerotheca humuli* (DC.) Burr.

Powdery mildew is of rare occurrence in Illinois and causes no damage. It has been found in Champaign, Ogle, and Marion counties on blackberry; and on raspberry in Ogle county. On dewberry it has been found in Champaign county; and on the native wild blackberry, in Marion county.

Gooseberry and Currant

These two fruits are not grown to any great extent commercially in Illinois, but they are extremely common in the home gardens. As with the brambles, their diseases are so largely the same for both that they are discussed together.

Anthracnose

Caused by *Pseudopeziza ribis* Kleb.

Anthracnose is the most important disease of gooseberry and currant and occurs commonly on both. On leaves it has the form of dark or reddish brown, very small spots, scattered over the upper surface in greater or less numbers. These spots enlarge only slightly, and as they grow old develop a single black dot in their center. Seriously infected leaves become mottled, or turn yellow and fall early in the season.

Damage done by this disease results from the injurious effects of premature defoliation, from spotting of the fruit, which sometimes occurs, and from poor development of fruit, due to infection of the fruit stems.

The present known occurrence of the disease in Illinois is shown on Map 91. It has been found in 21 counties, widely distributed over the state.

Control is secured, when necessary, by the use of lime sulfur (1-50), making the first application as soon as the leaves appear, and following with additional treatments every fortnight until about the first of August.

Leaf Spot

Caused by *Mycosphaerella grossulariae* (Fr.) Lind.

The leaf spot of currant and gooseberry is, like anthracnose, chiefly a leaf disease. While both fruits are commonly subject to it, currants usually suffer the more severely.

It appears on the leaves as spots, more or less circular in outline, from one eighth to a quarter of an inch in diameter, and with a dark reddish or brownish margin, within which is an area of dead, brown leaf-tissue, over which a number of tiny black dots are scattered. Injury takes the form of a yellowing and dying of the leaf, followed by early defoliation.

The larger size of the spots, the central dead area, and the numerous tiny black dots serve to distinguish leaf spot from anthracnose.

Not many early reports of this disease in Illinois appear to have been made. At present it is known to occur in 30 counties, which are grouped in three districts, as shown on Map 92. In the north, leaf spot has been noted in 5 counties and a majority of the reports show that it occurred in this region especially on red currant. In central-eastern Illinois reports from 4 counties note its occurrence especially on the flowering currant. In the southern tip of the state leaf spot appears commonly prevalent and abundant through 20 counties. In this region gooseberries and currants are both commonly found diseased, though here there is again a majority of reports on currant.

For control of leaf spot, the same application as for anthracnose will be found effective.

Powdery Mildew

Caused by *Sphaerotheca mors-uvae* (Schw.) B. & C.

Powdery mildew is of less importance than leaf spot. Both currant and gooseberry are subject to its attack, but it is more frequent or gooseberry.

It appears, like other powdery mildews, as a white, powdery growth over the leaves. Berries and young shoots are often attacked. The injury consists in stunting the growth of leaves and shoots, and in disfiguring the berries to the extent of making them unsalable.

Powdery mildew has been known to occur in Illinois since 1881, when it was found in McLean county, and it has since been reported in La Salle, Pulaski, and Gallatin counties.

It can be controlled by the use of lime-sulfur (1-40) spray applied when the buds open and at 10-day intervals thereafter until 5 applications have been made. A better spray, since no injury to the fruit results from its use, is potassium sulphid, one ounce in 2 gallons of water.

Strawberry

Among the fruits raised for commercial sale in Illinois the strawberry occupies a leading position—second, it is said, only to the apple. That this is true may be understood if it be remembered that in addition to extensive areas of production for large-city markets there is usually one gardener at least near every town of any size who maintains a patch ranging from half an acre to five or more acres to supply the seasonal demands of the town.

According to the U. S. Census report for 1920 there were in the state 4958 acres given over to strawberry culture from which 6,901,199 quarts of berries were harvested. The regional distribution of commercial production corresponds to that of the acreage devoted to strawberry culture, which is shown on Map 93. There is a considerable concentration of strawberry production in western Illinois in Adams, Hancock, and McDonough counties; in northern Illinois in Winnebago county; in central Illinois in Macon and Sangamon counties; and southward in Williamson and Johnson counties. The greatest commercial production occurs, however, in Pulaski county (480 acres), Fayette county (330 acres), Union county (310 acres), and Marion county (160 acres).

According to the U. S. Bureau of Markets, commercial acreage during the years 1918-1923, inclusive, ranged from 3000 to 3590 acres, yielding from 48 to 79 crates of 24 quarts each, per acre. The total annual yield of the state for this period ranged from 383 to 566 cars of 400 crates each.

According to the same authority the crop of 1921—some 175,600 crates—sold for $3.77 per crate, making a total value of $662,245 for the commercial crop reported on. This statement includes only about three fourths of the acreage reported in the census tables, and a total value for the entire state of nearly $883,000 is a reasonable estimate.

Mycosphaerella Leaf-Spot

Caused by *Mycosphaerella fragariae* (Schw.) Lind.

Leaf spot is the one extremely important strawberry disease commonly occurring in Illinois. It is limited, for the most part, to the leaves, on which it produces spots which are at first minute, purplish red, and apparent only on the upper surface. Later they enlarge and show on both surfaces as circular spots with a small light-brown central area surrounded by a distinct purplish ring. An abundance of them on a leaf often causes its death.

Spots of similar appearance often occur on the leaf and on fruit stems, and when on the latter they may so weaken it as to reduce the size and quality of the fruit.

At the present time this disease is known to occur in 85 counties, the state-wide distribution of which is shown on Map 94. It is probably to be found everywhere throughout the state.

It is so common and so generally injurious that the reduction in yield has been estimated for several years past at between 10 and 12 per cent. In 1921 a reduction of 10 per cent would have meant a loss from the commercial crop of practically 17,300 crates or slightly more than 44 cars, equivalent to 6 crates per acre, or a reduction of the average acre yield from 60 crates to 54.

Control where necessary may be had by an application of Bordeaux mixture before the blossoms open and again at intervals after harvest. Cleaning off infected leaves when new plants are set also helps.

Dendrophoma Leaf-Spot

Caused by *Dendrophoma obscurans* (Ell.) And.

A second leaf-spot, less common than the preceding, but sometimes very injurious, produces rather large brown spots, surrounded by a diffused darker brown or purplish border of considerable width. If the attack is severe a large part of the leaf may be involved, considerably reducing its effective surface.

The first reports of this disease in Illinois were made by Anderson in 1920.[1] Since then it has been seen frequently, and its present known distribution is shown on Map 95. It is known to occur in 12 counties widely distributed over the state. The district of most frequent occurrence, so far as now known, lies in central Illinois, and it is in this region also that reports of greatest severity originate.

Leaf Scorch

Caused by *Mollisia earliana* (E. & E.) Sacc.

This is a leaf spot of strawberry of relatively infrequent occurrence. H. W. Anderson[2] first reported its occurrence in Illinois in Champaign county in 1921 on certain varieties imported from Michigan. It has not been reported from any other part of the state.

Control of Fruit Diseases

Diseases of fruits are chiefly controlled either by spraying with suitable preparations or by the cutting out of diseased parts. Other practices which are helpful have already been mentioned in connection with the diseases for which they are effective. A combination of sprays with insecticides is often useful as controlling the ravages of both diseases and insects.

[1] Anderson, H. W. Dendrophoma leaf blight of Strawberry. Ill. Agr. Exp. Sta. Bul. 229. 1920.

[2] Plant Disease Survey Bulletin. Supplement 20: 107. 1922.

Two sprays are in common use and have generally been found satisfactory. These are Bordeaux mixture and lime-sulfur, both of which are obtainable as commercial preparations or may be made up as needed. When small quantities are wanted, commercially prepared Bordeaux mixture is satisfactory; and when lime-sulfur is used, it is generally more convenient to use a ready-made material. Descriptions of these sprays, the methods of preparation, and the times of application are to be found in publications of the Illinois Agricultural Experiment Station, especially Circular No. 277, "Directions for spraying fruits in Illinois," published jointly by the Department of Horticulture and the Natural History Survey in February, 1924.

Diseases of Vegetable Crops

Potato

In the production of potatoes Illinois held in 1922 the sixteenth place, while in acreage it was twelfth. According to the Census reports for 1920 there were 86,384 acres devoted to potato-growing in the state. The distribution of the commercial acreage as reported in 1922 is shown on Map 96, each dot representing approximately 500 acres. From this map it appears that St. Clair county is the outstanding producer, with a noticeable extension of the industry into counties immediately to the north and south. A second area of intensive growing is found in northern Illinois, beginning in Rock Island county and running more or less continuously through the border counties of the state north, east, and then south to include Will county, with Whiteside and Cook counties leading in acreage.

The potato crop is estimated to have ranged from 5,200,000 bushels in 1919, valued at $10,192,000, to 9,568,000 bushels in 1923, valued at $8,420,000.

Early Blight

Caused by *Alternaria solani* (E. & M.) J. & G.

Early blight is the commonest potato disease in Illinois. It appears on the leaves as circular grayish to brownish spots, dry, dead, and concentrically marked. They first appear about the time the tubers begin to form, and gradually increase in size and number, coalescing and occupying large areas of leaf tissue. In severe cases all the leaves on the plants may be completely killed, leaving only the stem alive and green.

Burrill recorded the presence of this disease in Champaign county in 1911. During 1922 and 1923 it was found in 15 counties, the distribution of which is shown on Map 97. It appears from this map that it is more common in the southern half of the state than northward.

Crop reductions from early blight have been estimated at 1 per cent in 1922 and 1.5 per cent in 1923, equivalent to 68,000 bushels valued at $61,200 and 145,000 bushels valued at $127,600 for the years mentioned.

Late Blight

Caused by *Phytophthora infestans* (Mont.) De Bary

In most of the states where potato growing is important, the most dreaded disease is late blight. In Illinois it was first reported in 1882 by A. B. Seymour, who collected specimens August 7 at Camp Point, Adams county, and at Freeport, Stephenson county, September 13. A collection by Burrill, without date or place, is reported by G. W. Wilson.[1]

These are the only records of the occurrence of late blight in Illinois. It is noteworthy that in all the examinations of potato fields made by our Survey during the past three seasons no instance of late blight has been found. It has never been known to cause serious loss in Illinois.

Scab

Caused by *Actinomyces scabies* (Thax.) Güss.

Scab is a very common tuber disease of the potato in Illinois. It is characterized by roughening and pitting of the tuber. It first appears on the surface of the tuber as a tiny reddish or brownish spot, which increases in size, deepens in color, and eventually develops the rough, corky incrustation so commonly seen.

It has not been widely reported in Illinois. It was reported present in Champaign and Coles counties in 1911, and in Champaign county in 1912 by Burrill. It is now known to occur in 16 counties, the distribution of which is shown on Map 98. This indicates a wide range over the state, and it is probable that further search will prove the disease to be much more general than it now appears to be. Observations made in 1923 indicated an injury equivalent to a crop reduction of approximately 1 per cent. In terms of the 1923 yield, this is equivalent to 96,000 bushels valued at $84,400.

Control of scab is difficult, since the disease infests soil in which it has once occurred. Rotation of crops on infected soil, treatment of infected seed-potatoes with formalin or mercuric chloride, and withholding fertilizers which favor scab development serve to keep the disease in check.

Black Leg

Caused by *Bacillus astrosepticus* van H.

This is a bacterial disease which causes a stunting of the plants and a rotting of the stem below the ground, later resulting in the death of the plant. It was present, but not seriously abundant, in 1923 in three counties, Logan, Lawrence, and Monroe. It is seed borne, and prevention demands careful selection and treatment of seed tubers.

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[1] Bul. Torr. Bot. Club. 34: 392. 1907.

Black Scurf

Caused by *Rhizoctonia* sp.

This disease, which results in blackened, rotted stems, the wilting and dying of young shoots, and aerial tubers, has been found but once in Illinois, in July, 1922, near Ryder, Jefferson county.

Infection arises from diseased tubers and from soil infection. Preventive measures include use of clean seed, crop rotation, and general sanitary practices in field cultivation.

Wilt

Caused by *Fusarium* sp.

The wilt disease results in wilting and stunting of the tops, death of roots, and serious storage rots. It was found in 1923 in Lawrence county. In a small field of Irish Cobber practically all the plants were diseased, and it appeared that the loss would be severe. As a preventive measure, the use of infected tubers for seed should be avoided.

Curly Dwarf, or Mosaic

This disease, of unknown cause, results in stunted and variously deformed plants, mottled coloring of the leaves, and noticeably reduced yields. It is probable that it is wide-spread in the state, but it has been noticed thus far only in Carroll county, where it was found in several fields in 1923. Its history there indicated that it had been present for several years. It is seed borne, and tubers for seed should be selected from fields free from disease.

Tomato

The tomato is an important crop in Illinois. In 1921 there were only 9 states having a greater acreage, and in the same year the total commercial crop was exceeded by only 8 states. During the years 1918-1921 the tomato acreage in the state varied from 7,064 to 9,355 acres; and the yield, from 24,724 tons to 59,584 tons. This crop is used for local consumption, for immediate distribution and sale, and for canning and the manufacture of tomato products.

In addition to the commercial crop of the state, growers maintain small patches in the neighborhood of towns, from which the local seasonal market is supplied.

The tomato is subject to a variety of diseases, several of which are similar to those of the potato.

Early Blight

Caused by *Alternaria solani* (E. & M.) J. & G.

Early blight is one of the commonest and most wide-spread of tomato diseases in Illinois. It causes numerous small, more or less angular, con-

centrically-marked spots upon the leaves, and when serious infection occurs the leaves dry up and die.

As shown on Map 99, it has been found in 17 counties.

The severity of the disease, as indicated by field observations, indicates an injury equivalent to a 4 per cent reduction in the crop for each of the years 1921, 1922, and 1923. Such a percentage, when applied to the commercial product of 1921, the last year for which published figures are available, represents a reduction in yield of 1,030 tons, equivalent to the yield of 294 acres.

Control is readily obtained by spraying with Bordeaux mixture, beginning at the first sign of the disease and continuing the application every 3 to 10 days through wet weather.

Wilt

Caused by *Fusarium lycopersici* Sacc.

Wilt, the most destructive of the tomato diseases in Illinois, gains entrance through the roots and penetrates the water-conducting tissues, plugging them and causing a wilting, and finally the death of the plant. A characteristic feature of the disease is the fact that besides causing the plants to wilt it turns the sap vessels brown or black. Usually the disease does not become evident until after the fruit has set.

This disease is known to have been in Illinois since 1911, in which year Burrill reported that it was becoming very serious. Presumably he referred to its occurrence in Union county. The following year he reported it as wide-spread in southern Illinois, and according to C. E. Durst probably 50 per cent of the crop was destroyed in Union county.

Tomato wilt is now known to occur in 22 counties, the distribution of which is shown on Map 100. It appears to be limited to the southern two-thirds of the state, and is most common in the southern third.

Field observations made in 1922 and 1923 indicated an injury equivalent to a crop loss of 10 and 12 per cent respectively. If the average of these figures be applied to the 1921 production it would mean a crop reduction of 3,055 tons, equivalent to the yield from some 870 additional acres.

The fungus causing tomato wilt persists in the soil after it is once introduced, and control can be secured only through a rotation of crops, whereby tomatoes are kept off the infected ground for several years.

Leaf Spot

Caused by *Septoria lycopersici* Speg.

Tomato leaf spot is wholly a disease of the leaves. It starts on the lower part of the plant and eventually involves all the leaves. Those severely spotted turn brown and appear blighted, and when the disease is severe throughout a patch serious damage results.

In 1911 leat spot was reported by Burrill in Champaign county and in a group of 8 counties in southern Illinois; but in 1912 in Champaign county only.

At present leaf spot is known to occur in 26 counties, the distribution of which is shown on Map 101. It appears to be wide-spread over the state, but in northern Illinois it is only occasional, while in southern Illinois it is apparently common.

Loss from this disease is not usually great, but may at any time become so. Control is readily obtained with Bordeaux mixture.

Sweet Potato

According to the 1920 census, there were 8,003 acres in Illinois devoted in 1919 to the raising of sweet potatoes, with a yield of 668,845 bushels. According to the reports of the State Agricultural Statistician the acreage since 1919 has been about 9,000 acres, yielding between 850,000 and 990,000 bushels, valued at from $890,000 to $1,179,000.

Only 8 counties are reported to have no commercial acreage in 1922. For the most part the county acreage is small, running from 3 to 90 acres. Union county is an outstanding producer, with an acreage of 1,974. Johnson and Pulaski counties each has over 500 acres and Williamson over 400. The acreage of important counties is indicated on Map 102. The principal sweet potato region lies, therefore, in southern Illinois, with a considerable acreage also in Adams and Cass counties.

Illinois shares fifteenth rank in acreage with Delaware and Maryland. In yield per acre it ranked seventh in 1921, and in total production in the same year it ranked sixteenth.

Two diseases appear to be common in Illinois.

Black Rot

Caused by *Sphaeronema fimbriatum* (E. & H.) Sacc.

Black rot is the most serious disease of sweet potato in Illinois. Dark brown to black spots appear on the surface of the potato and extend in all directions, finally involving the entire root. In storage the rot is also extremely destructive.

This disease is known to occur in Illinois in the six counties indicated on Map 103. They are widely distributed over the state but include only two counties—Pulaski and Cass—with a large sweet potato acreage.

For a control of this disease the use of disease-free roots in starting cuttings, the maintenance of seed beds free from the disease, and the cultural practices used for all soil-infecting diseases are essential.

Wilt

Caused by *Fusarium* sp.

Sweet potato wilt, known also as stem-rot, is caused by a species of Fusarium which grows within the plant, killing and rotting the roots and causing the wilting and death of the tops.

It is known to occur in 8 Illinois counties, rather widely separated, as shown on Map 104. Three of the 8 counties have important commercial acreages. Where the disease has been seen it has been severe in the extreme. The loss in Cass county, on the Nancy Hall variety, ranged from 5 to 10 per cent, in two Union county fields from 5 to 10 per cent, and elsewhere from 1 to 10 per cent.

Control involves the use of healthy seed, clean soil in the seed-bed, and a consistent rotation of crops on infected land.

Cantaloupe

During the years 1918-1921 the commercial cantaloupe acreage in Illinois varied from 865 to 883 acres, the state ranking 14th in acreage of this crop. The yield per acre varied from 142 to 200 standard crates of 45 melons each, and the total yield varied from 356 cars (350 crates per car) in 1918 to 505 cars in 1921.

In addition to this commercial crop there is probably an equal production by local growers who supply the small-town seasonal markets.

The commercial production of cantaloupes, while carried on more or less generally over the state, is usually confined locally to a relatively small area, where suitable soil conditions exist.

Diseases of the cantaloupe, while not numerous, may often be severe.

Wilt

Caused by *Bacillus tracheiphilus* E. F. S.

Wilt is a bacterial disease which causes the vine to wilt and die. It has probably been present in Illinois for years but it has not been often reported. Burrill found it in Union county in 1912, and it was seen in 1922 in the Poag Station melon-district in Madison county, and was more widely observed in 1923.

At present it is known to occur on cantaloupe and muskmelon in 18 counties, the distribution of which is shown on Map 105. It appears wide-spread in the state, with none of the larger areas of production free from it.

Losses due to it as observed in the field during 1923 especially, varied usually from 1 to 10 per cent; more rarely, from 20 to 30 per cent.

Control is obtained by pulling and burning diseased plants, by crop rotation, and by spraying to prevent its spread by insects.

Anthracnose

Caused by *Colletotrichum lagenarium* (Pers.) E. & H.

Anthracnose is a fungus disease which attacks leaves, stems, and fruit of cantaloupe doing serious damage, especially to the fruit under favoring weather conditions. It has not been frequently reported in Illinois, but is known to occur in 8 counties so widely scattered over the state as to indicate its rather general prevalence. Counties in which it has been seen are Carroll, Rock Island, Henderson, Knox, Pike, Lawrence, Gallatin, and Union. The infections seen in Knox, Lawrence, and Gallatin counties were generally severe, while those occurring elsewhere were, for the most part, light.

This disease is controlled by treatment of the seed and by the application of Bordeaux spray (4-4-50) later in the season.

Mosaic

The mosaic disease of cantaloupes, the cause of which is not known, results in a stunting of vines and a poorer crop. It has not been frequently reported. At present it is known to occur in Whiteside, Sangamon, Christian, and Union counties. Rocky Ford melons in Christian county showed 30 per cent of the plants diseased and in Whiteside county Tip-top melons showed infection, while Osage and Rocky Ford plants were free from it.

Milkweeds are said to be subject to the disease, which is carried by insects from them to the cantaloupe.

Watermelon

The acreage devoted to watermelons in Illinois for commercial production varied from 1,100 acres in 1918 to more than 3000 acres in 1919 and 1921 and to nearly 3000 acres in 1920. The yield is said to run from 274 to 615 melons per acre, the latter figure being the average yield in 1921. Total production in 1920 was 1,014 cars of 1000 melons each, and in 1921 it was 1,894 cars. Production for local markets adds considerably to this acreage and yield.

The watermelon is subject to several diseases, some of which are also common to the cantaloupe and cucumber.

Wilt

Caused by *Fusarium niveum* E. F. S.

Wilt, undoubtedly the most serious watermelon disease in Illinois, results in a drooping and wilting of the leaves, and eventually in the death of the plant. The fungus which causes it lives in the soil, gains entrance through the root, and at first plugs the water vessels, later

bringing about the death of the parts attacked. Cutting across the main root near the crown of the plant shows an abnormal yellow color in the woody parts.

First reports of this disease in Illinois were made in 1921 by Anderson, who found it serious locally. In 1922 it was so severe where seen, as to cause a general loss of 25 per cent of the crop. In 1923 wilt appeared less severe but was thought to have resulted in about a 20 per cent crop reduction.

It is now known to occur in 21 counties, widely distributed, as indicated on Map 106, and representative to a marked degree of the regions in which melon culture is important, thus suggesting that wilt is widespread and common in Illinois.

Its seriousness may be illustrated by a summary of some of the 1923 field notes. In Cass county in a 10-acre field of melons, largely Irish Gray, more than 90 per cent of the vines of that variety were dead by September first. In a two-acre field in Mason county more than 50 per cent of the vines were dead by August 31. In Henderson county some 20 acres devoted to melons, especially Irish Gray and Excel, showed 80 to 90 per cent of the vines dead before the melons ripened. It is reported that in White county, where there is a large melon acreage, the wilt completely destroys the crop in many individual fields. In Johnson county 50 to 100 per cent loss is reported. In Gallatin county 5 to 15 per cent loss commonly occurs, but in a 7-acre field of Tom Watson melons 85 per cent of the plants were dead by August 6. In Lawrence county the variety Excel suffered to the extent of 20 to 60 per cent. These notes, while not representing the condition of infection in the average field, are certainly illustrative of the damage this disease can cause.

To escape these tremendous losses, it is necessary to understand that the fungus which causes the disease inhabits the soil and that when soil has once become infected it may remain so for years, producing the disease in every watermelon crop planted on the land. If watermelons are cropped on the same land year after year it is to be expected that within a few years it will be impossible to grow melons profitably on that land. This soil infection is commonly noticed by growers, and there is much doubt whether land once infected with wilt can ever be profitably used again for melons. One grower reports severe wilt on land not cropped to melons for eleven years; another reports bad wilt after 23 years; another, who practices a 3-year rotation, finds he has large losses; and another, after an 8-year rotation, found his crop severely diseased. Certainly it is not safe to crop wilt-infected land to melons short of a 10-year lapse in such cropping. Additional care must be taken to grow crops which will not be likely to spread the infection to the manure heap, and thence to all parts of the farm.

The ultimate solution of the problem of wilt control will probably be found in the development of wilt-resistant varieties. This task has been undertaken and is already yielding promising results.

Anthracnose

Caused by *Colletotrichum lagenarium* (Pers.) E. & H.

Anthracnose of watermelons is usually less severe in Illinois than wilt. However, during the 1923 season unusual weather so favored its development that in many places it resulted in damage so severe as to obscure completely the effects of wilt. Anthracnose causes severe spotting of the leaves and, in serious cases, death of the vine. Sunken diseased spots are produced on the melons which mar their appearance and furnish points of entrance for rot-producing fungi.

This disease has not been reported often in Illinois in years past. The first known outbreak of a serious character occurred in 1923 in the four counties indicated on Map 107. Perhaps it is merely a coincidence that the counties in which anthracnose was found lie in approximately the same latitude. In Mason county certain fields were seen in which 80 per cent of the melons showed anthracnose spots; and in Clark county many fields were a total loss.

Control of anthracnose may be had by treating the seed with mercuric chloride (1-1000) before planting and by the application of Bordeaux about picking-time. Seed treatment alone may result in a great reduction of disease, as was illustrated in one case in 1923, where only 3 per cent of the crop from treated seed was lost, while neighboring fields grown from untreated seed were complete failures.

Cucumber

The production of cucumbers in Illinois, aside from those raised by local gardeners to supply local markets, appears to be largely limited to production for canning and manufacturing purposes. Available figures indicate a rather steady reduction in acreage, yet the state is still among the important producers, and there are sections of it in which cucumbers are an important crop. Estimates indicate a commercial acreage varying from 1700 acres in 1918 to 844 acres in 1921, with an annual production ranging from 90,600 bushels in 1918 to 67,500 bushels in 1921. The average yield per acre for both years was 51 bushels.

In general the cucumber is subject to the same diseases as are cantaloupe and watermelon, though their relative importance is less in the case of the cucumber.

Wilt

Caused by *Bacillus tracheiphilus* E. F. S.

Cucumber wilt is a bacterial disease caused by the same organism that causes the wilt of cantaloupe, and its appearance is practically the same on both.

It has not been reported often in Illinois, and the infections that have been seen have usually been mild. In 1922 it was reported in 6

counties and in 1923 in 11 counties additional, making a total known occurrence in 17 counties. They are widely distributed over the southern two-thirds of the state, as shown on Map 108, suggesting a wide-spread occurrence of the disease in that section of the state.

Its seriousness in 1923 is indicated by some of the field notes. In Sangamon county certain patches showed from 10 to 40 per cent of the plants infected; in Effingham county we have a record of a 10 per cent infection, and a similar record for two patches in Warren county; in Lawrence county 60 per cent infection was recorded; from Union and Alexander counties there were several reports of 1 to 2 per cent, one from Alexander of 5 per cent; and another from Clinton county of 20 per cent; and in Union county in some of the larger fields 20 to 100 per cent of the plants were infected.

Control in this case is the same as that outlined under cantaloupe. (See p. 244.)

Anthracnose

Caused by *Colletotrichum lagenarium* (Pers.) E. & H.

Anthracnose of cucumber is similar to that of watermelon and cantaloupe and is caused by the same fungus.

Doolittle's report of it in Illinois in 1922 is the first record of its presence in the state. In 1923 it was found in Union county, where in many instances it appeared to be a troublesome disease. It was especially prominent near Dongola and Balcom, where the percentage of infected vines varied from 20 to 100. Observations made on about 6 acres in this region indicated the probability of considerable damage resulting from the attack.

Control is to be had through seed treatment and spraying, as indicated for watermelon anthracnose (p. 247).

Mosaic

Mosaic, next to wilt, is probably the most important disease cucumber growers have to contend with in Illinois. While the cause of it is unknown, its appearance is familiar to most growers, who know it not only as mosaic, but also as "leaf-mottle" and "white-pickle."

Bierbaum reported the disease in Union county in 1922, and in 1923 it was found in Union, Sangamon, and Macon counties. Wherever found it has been serious. In Macon county 30 per cent of the plants seen were diseased. In Union county in many fields from 50 to 75 per cent of the plants were diseased, and in one instance 80 per cent of the cucumbers picked for pickling showed its presence. In Sangamon county the percentage of infected plants varied from 15 to 70 per cent.

Control consists in keeping in check such insects as spread the disease from plant to plant, and in eradicating wild cucumbers and milkweed plants from the neighborhood of the field since both of these are subject to the disease and serve to introduce it into the cropped fields.

Downy Mildew

Caused by *Pseudoperonospora cubensis* (B. & C.) Rostow

The downy mildew disease appears as a leaf spot, which may be very destructive under favoring conditions. It was reported by Burrill to have occurred in Union and Effingham counties in 1911, and this is our only report of its presence in the state.

Angular Leaf-spot

Caused by *Pseudomonas lachrymans* E. F. S. and Bryan

The angular leaf-spot of cucumber, caused by a bacterium, is not known to have occurred in Illinois previous to 1923. During that season, it was seen occasionally in Union county and once in Pulaski county. In a 5-acre field in Alexander county practically all the plants were diseased, but the infection was light and little damage resulted.

Asparagus

The land devoted to asparagus-growing in Illinois averages annually nearly 2000 acres for commercial production, and the annual yields per acre is above 95 crates. The annual yield of the state for commercial purposes is about 332 cars of 600 crates each. Illinois ranks either second or third in commercial production, and California is the only state which greatly exceeds it.

Asparagus is subject to two diseases in Illinois, both important, not only to the commercial grower, but to the many gardeners who cater to local markets, and in the home garden.

Rust

Caused by *Puccinia asparagi* DC.

Asparagus rust is widely distributed and often serious in its effects. It has the appearance of the rust described on other plants.

It is not known how long this disease has been present in Illinois, but it was probably first recorded here in 1899. Since that time it has been frequently seen and reported.

It is now known in 30 counties, distributed over the state as shown on Map 109. It appears prevalent in two sections of the state—one in southern and one in northern Illinois, and its presence in Champaign, Edgar, and Coles counties probably indicates a wider distribution.

Its control lies in the use of varieties not susceptible to rust. Among these are the Palmetto varieties and resistant strains of Washington asparagus. Additional control may be gained by dusting with sulfur or spraying with sulfur-soda-soap.

Anthracnose

Caused by *Colletotrichum* sp.

Anthracnose of asparagus has not been often reported. It produces on the stem a light-colored spot of considerable size which becomes covered by black dots, composed of the reproductive structures of the fungus.

Its only known occurrence in Illinois was at Polo, Ogle county, in 1922 and it was not serious there.

Beet and Swiss Chard

Beet and Swiss chard are among the commonest of the garden vegetables. It is seldom that a garden, no matter how small, does not have at least its row of beets, and local gardeners usually grow a considerable quantity for sale in season at their local markets. There is one disease common to both plants.

Leaf Spot

Caused by *Cercospora beticola* Sacc.

Leaf spot is the only serious disease of these vegetables known in Illinois. It appears as roundish gray-brown spots with purple borders, often so numerous as to destroy the leaf, resulting in smaller roots, and spoiling the leaves for use as greens.

It has been known in Illinois at least since 1888, when it was found in Champaign county by M. B. Waite. It is known at the present time in 67 counties, the distribution of which is shown on Map 110. It is evidently wide-spread and common in the state.

Cabbage

Beginning with 1919, Illinois has ranked among the states growing important cabbage crops. An acreage of from 1300 to 1600 acres, with an annual yield per acre of from 5 to 8 tons and a total production for commercial purposes of from 530 to 1040 cars of 12.5 tons each, places the state high in the list as to cabbage production. If the diseases of this crop were under control the yield per acre might equal or exceed that of Wisconsin and Michigan.

Yellows

Caused by *Fusarium conglutinans* Woll.

Cabbage yellows stands out pre-eminently as the limiting factor in cabbage production in Illinois. It is commonly known as "yellows," "yellow-sides," and "dry-rot." Its first symptom is a yellowish color of the lower leaves, often restricted to one side of the plant or even to one side of the leaf, which first appears from two to four weeks after trans-

planting. The yellow leaves are eventually shed, and the plant may die, or, if it continues to live, it produces a long leafless stem capped by a small and worthless head.

How long this disease has been present in Illinois is not known. Burrill reported it in Cook county in 1911, with the note that it was doing considerable injury. In the following year he reported it from Madison and St. Clair counties, as causing there a 50 per cent loss, estimated at $35,000.

It is at present known in 22 Illinois counties as shown on Map 111, which may be taken to indicate in a measure its abundance in the state. It is commonest and most severe southward; but toward the north, while still extremely severe, it is confined rather noticeably to commercial or local-garden plantings. Late crops appear to be most severely injured.

Control of this disease requires either a soil not infected with its fungus, or the use of resistant varieties, among which are certain selected strains known as the Wisconsin Hollander. It may possibly be carried by the seed, and seed disinfection is advisable to prevent its introduction. Rotation is essential to check its injurious development after it has been introduced.

Black Rot

Caused by *Pseudomonas campestris* (Pam.) E. F. S.

Black rot is second in importance among cabbage diseases in Illinois. Infection starts in the water pores at the leaf margin, travels down the veins, killing the leaf tissue as it goes, and finally enters the stem, where the bacteria clog the sap-carrying tissues and pass to other parts of the plant.

Black rot is widely prevalent in the state. It is known in 41 counties, as shown on Map 112. It seems to be most general in southeastern Illinois, but its prevalence elsewhere is shown by the widely scattered counties in which it occurs. Losses from this disease in Illinois have been estimated to range from 1 to 4 per cent of the annual crop.

Control consists in seed treatment, in crop rotation, and in avoiding the replanting of land to related crops, such as radishes and cauliflower.

Club-Root

Caused by *Plasmodiophora brassicae* Wor.

Club-root, a malformation disease of the cabbage, produces large knots or galls on the roots changing their structure so as to interfere with their normal function, and the plant becomes sickly, grows slowly, and often fails to head.

The only reliable early record of club-root in Illinois is a report by Burrill of its presence in 1911 in Cook county, where it was doing only a small amount of damage. In 1923 it was again found in Cook county, on only a few plants in a 1-acre field.

Club-root is controlled by growing the young plants in beds not infected and in using a rotation without crucifers other than cabbage.

Black Mold

Caused by *Alternaria brassicae* (Berk.) Sacc.

Black mold, or black leaf-spot, appears chiefly as round black spots often marked with concentric brown rings on the lower leaves of the plant.

This disease is not often serious in the field. It was reported by the Bureau of Markets to have caused some damage to cabbage heads shipped from Illinois in 1921. It has been found on field cabbage in Knox, Marion, Pulaski, and Alexander counties, which indicates a wide range over the state. Northern infections appear less severe than southern.

Miscellaneous Diseases

Two leaf diseases of cabbage which are of minor importance have been found in Illinois. One, commonly called "ring spot", caused by *Mycosphaerella brassicicola* (Duby) Lindau, was found in Pope county in 1922; the other, a leaf spot caused by *Cercospora bloxami* B. & Br., was found in Pope county in 1922 and in Alexander county in 1923.

Cauliflower

The growing of cauliflower is of some importance in the trucking areas of the state. In general, this crop is subject to the same diseases as is cabbage, though in Illinois black rot is the only one thus far seen. It has been found in Peoria county, where from 5 to 30 per cent of the plants were infected, and in Cook county in the south Halsted district, where from 1 to 10 per cent of the plants were infected.

Measures of control are described under cabbage.

Bean

In trucking areas bean-growing is of some importance, and local gardeners usually cater to the needs of markets.

Anthracnose

Caused by *Colletotrichum lindemuthianum* (S. & M.) B. & C.

Anthracnose of bean is especially destructive. It appears as a spot on the leaves, stems, and pods. It is most injurious on the pods, where it forms a round, sunken, rust-colored spot with a reddish border.

The first report of this disease in Illinois was made by C. E. Durst, who found it in 1912 injuring 20 per cent of the crop near Anna, Union

county. In 1922 and 1923 it was found in Jackson and Peoria counties, where it appeared to injure from 1 to 5 per cent of the crop.

Blight

Caused by *Pseudomonas phaseoli* E. F. S.

Blight is a bacterial disease. It may be severe on the leaves and pods, where it causes dark, water-soaked spots. It is known in 8 widely scattered Illinois counties, the distribution of which is shown on Map 113.

Rust

Caused by *Uromyces appendiculatus* (Pers.) Lev.

Rust of the bean is especially a disease of the leaves, although it occasionally attacks stems and pods. It appears as rusty spots or blisters, which eventually break open, exposing a mass of rusty powder.

It is known to have been present in Illinois since 1881, in which year it was found by A. B. Seymour in Union county.

It is now known in 6 counties, the distribution of which is shown on Map 114. Apparently it is widely distributed, but is most common in southern Illinois.

Onion

Approximately 1000 acres are devoted annually to the growing of onions for commercial purposes in Illinois. The yield varies from 200 to over 400 bushels per acre, and the total production varies from 400 to 800 cars of 12.5 tons each per annum. It is estimated that of the 442 cars produced in 1921, 44 were sold in home markets and 398 were shipped outside the state.

Smut

Caused by *Urocystis cepulae* Frost

The one onion disease of importance in the field in Illinois is smut. It is carried over in the soil from year to year, from which it attacks only the seedling plants, causing dark stripes on the leaves, dwarfing, death of the tops, and death of the bulbs.

This disease was first reported in Illinois in 1918, when it was said to have caused a 25 per cent crop injury accompanied by a 10 to 15 per cent crop loss. Presumably the report was made by J. C. Walker and had to do with the Cook county onion district. The disease is now known to occur in Cook and Peoria counties.

Treatment for prevention consists in spraying the seeds with a formaldehyde solution as they are being planted.

Lettuce

This crop, so commonly grown in home gardens, by local truckers for their markets, and to some extent in greenhouses for winter-con-

sumption, and southward for supplying the early demand of northern markets, is subject to several diseases, of which only one appears common in Illinois.

Leaf Blight

Caused by *Septoria lactucae* Pass.

The blight of lettuce attacks the outer leaves, though rarely causing much damage. It has been in Illinois at least since 1887 according to Martin,[1] and is now known in 19 counties, distributed as shown on Map 115. Its range apparently extends from northern Illinois to the southern tip of the state, and it is most general in the extreme south.

Its control requires merely the practice of sanitary cultivation.

Rhubarb

Rhubarb is not subject to many diseases in Illinois, but at least one of them is extremely serious.

Crown and Stalk Rot

Caused by *Phytophthora* sp.

Crown and stalk rot is the most serious disease of rhubarb in Illinois. How long it has been present in the state is not known, but it certainly has been destructive since 1919. At present it seems to be confined to southern Illinois. It is of especial concern in Union county and has been found in Pulaski county also.

Some idea of the seriousness of the disease may be conveyed by two field notes made in 1923: Near Alto Pass, in Union county, a new field of about 5 acres showed a large percentage of infected plants, and along one side a third of the plants were already dead. In spots in a half-acre field in Pulaski, from 10 per cent to 40 per cent were infected and many were dead.

This disease has not been studied, and control measures can not be recommended.

Leaf Spot

Caused by *Phyllosticta straminella* Bres.

Leaf spot of rhubarb is common in Illinois and at times destructive. Stevens reported the disease as injurious in 1918 in Kankakee and Champaign counties.

During 1923 it was found in 16 counties as shown on Map 116. It is evidently wide-spread and appears not to be limited to any one part of the state.

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[1] Journ. Myc. 3: 63. 1887.

Anthracnose

Caused by *Colletotrichum crumpens* Sacc.

This disease is reported by Stevens as causing a serious rot of the leaf stalks in many Illinois localities.

Radish

The radish is commonly grown by local gardeners for sale at local markets and early in the season is to some extent shipped to more northern markets. It is subject to several diseases, which are, however, rarely severe in Illinois.

White Rust

Caused by *Albugo candida* (Pers.) Kze.

White rust is a fungous disease which results in excessive growth and distortion of the flowers and seed pods. For the most part it is injurious only to plants grown for seed.

The earliest reported occurrence of it in Illinois was in Champaign county in 1882. It is now known in 17 counties widely distributed over the state, as shown on Map 117. The area of most general occurrence appears, however, to lie within the northern third of the state.

Other Diseases

Downy mildew, caused by *Peronospora parasitica* (Pers.) De Bary, was found in Ogle county in 1922; and a leaf spot, caused by *Cercospora cruciferarum* E. & E., was found in Champaign county by Clinton in 1896 but has not been reported from Illinois since then.

Horseradish

This crop is commonly grown in home gardens, and local gardeners often grow it in quantity and prepare the roots for sale at their local markets and to manufacturers of condiments.

Leaf Spot

Caused by *Cercospora armoraciae* Sacc.

The one disease of horseradish known to occur in Illinois is a leaf spot, round and light-colored. Often the dead spots fall out and severe infection may result in considerable leaf injury.

This disease was first found in Illinois by Clinton, who collected leaves infected by it in Champaign county in 1896. It was also found in 1898.

This leaf spot is now known to occur in 24 Illinois counties, as shown on Map 118. They are widely scattered over the state and indicate a state-wide distribution for the disease.

Diseases of Ornamental Plants

The diseases of ornamental plants affect the appearance of the plants and often check growth and flowering.

Rose

Many kinds of roses are grown in Illinois—Rugosas, Ramblers, Climbers, and Teas for outdoor decoration, and an endless variety under glass for cut flowers. The distribution of the diseases here reported is limited mainly to those found on outdoor plants.

Powdery Mildew

Caused by *Sphaerotheca pannosa* (Wallr.) Lev.

Powdery mildew covers rose leaves with a white, powdery, fungous growth. When present in abundance it attacks the young shoots and leaves, and causes their dwarfing, curling, and malformation. It is often serious on cuttings in the greenhouse.

It was first reported in Illinois by Seymour, who collected a specimen at Camp Point, Adams county, in July 1879 and at Villa Ridge, Pulaski county, in 1881, and again in Cook county in the same year.

At present powdery mildew on roses is known to occur in 68 counties, the distribution of which is shown on Map 119. It appears generally distributed over the state, and is especially common in both the extreme north and the extreme south. Something of its general occurrence may be inferred from the fact that the Survey herbarium now contains more than 200 specimens of mildew, collected on cultivated roses, including practically every type grown for outdoor decoration. The Ramblers and Climbing roses seem to be most severely attacked.

Mildew is readily controlled either indoors or out, by dusting the plants thoroughly with a mixture of 90 parts sulfur and 10 parts lead arsenate.

Black Spot

Caused by *Diplocarpon rosae* Wolf

Black spot of the rose is a leaf disease, producing irregularly circular black spots on the upper surfaces of mature leaves. Those diseased usually fall prematurely, and serious infections may prove destructive.

At present, black spot is known to occur in 51 counties, distributed as indicated on Map 120. It is wide-spread in the state and appears to be commonest and most general in the southern tip and in the northwest corner of the state.

Many reports indicate that black spot is injurious to potted roses in greenhouses, and this has been found to be true especially in Christian and Logan counties.

It may be controlled by the application of ammoniacal copper carbonate, lime-sulfur, or Bordeaux.

Leaf Spot

Caused by *Phyllosticta rosae* Desm.

Leaf spot of rose is of less common occurrence than black spot and is not often serious.

It is known to occur in 18 counties, as shown on Map 121. With this, as with the black-spot disease, there appear to be two regions of most common occurrence, one in the southern tip of the state, and one in the extreme northwest.

It may be controlled, when necessary, by application of any of the standard fungicides.

Lilac

The lilac, with its several cultivated varieties, is of large importance in the decorative plantings of the state, and is also of considerable value to the nurseryman. In Illinois it is subject to only one serious disease.

Powdery Mildew

Caused by *Microsphaera alni* (Wall.) Salm.

Powdery mildew of lilac appears, as a rule, late in summer, covering the leaves with a whitish powder, which presently becomes gray and dirty. When the season favors, it may cause severe and early defoliation.

This very common disease has the distinction of being the first one definitely recorded in Illinois. It was collected in McLean county in 1872 and again in 1879 by Seymour. Further collections were made in 1881 and 1882 in 9 counties—Jo Daviess, McHenry, Lake, Cook, Rock Island, La Salle, McLean, Jackson, and Union—indicating a widespread occurrence over the state at that time.

At present, powdery mildew is known in 59 counties, the distribution of which is shown on Map 122. The commonness of the disease where it has been found may be illustrated by the fact that there are in the Survey herbarium 190 specimens of this mildew.

Carnation

The carnation, grown in greenhouses for cut flowers and in many varieties in gardens for decoration and for flowers, suffers from a single common disease, the "carnation rust."

Rust

Caused by *Uromyces caryophyllinus* (Schw.) Wint.

This rust appears as small, reddish-brown, more or less circular spots upon the leaves and stems, the plant tissue for some distance around usually taking on a sickly, yellowish color.

This disease is a pest in greenhouses especially, where it may be quite destructive. It is known in 19 counties in Illinois, as shown on Map 123, indicating its wide-spread occurrence over practically the whole state.

Control measures consist, first of all, in the selection of cuttings which are not infected. Free ventilation, and watering of the soil only, with a periodical spraying with copper sulfate, one pound to 25 gallons of water, are very helpful in preventing the spread of the disease in greenhouses.

Virginia Creeper

The Virginia creeper, commonly used as a decorative vine, is subject to two diseases, which are of some importance in that they may impair the appearance of the vine and may reduce the growth of the plant in the nursery.

Leaf spot

Caused by *Guignardia bidwellii* (Ell.) V. & R.

The leaf spot is identical with the black-rot disease of grapes and has, on the leaves, essentially the same appearance.

It is known to occur in 21 counties, as shown on Map 124. It appears to be especially abundant in southern Illinois, with only occasional occurrence northward.

Powdery mildew

Caused by *Uncinula necator* (Schw.) Burr.

Powdery mildew is identical in appearance with the powdery mildew of grapes.

It is known to occur in 9 counties as shown on Map 125. It is apparently widely distributed in Illinois, with a most frequent occurrence in the northern part of the state.

This and the preceding disease of the Virginia creeper are controlled by the same means as on grapes.

Snapdragon

The snapdragon, grown extensively in greenhouses for cut flowers and in gardens for decoration, is subject in Illinois to one common disease, the snapdragon rust.

Rust

Caused by *Puccinia antirrhini* Diet. & Holw.

Rust is evident on the snapdragon as reddish-brown pustules about the size of a large pin-head upon the leaves. These spots, if numerous, may seriously detract from the appearance of the plant, limit its growth, and check flower production.

Snapdragon rust is known to occur in Illinois in 7 counties, whose distribution, as shown on Map 126, indicates a very wide range of this disease in the state, with the commonest occurrence probably northward.

It is controlled in greenhouses by so directing the watering of the flats and benches as to avoid splashing or dropping of the water from leaf to leaf.

Conclusion

The preceding pages contain an account of 165 of the plant diseases occurring in Illinois. They attack 44 of our crops and, according to the classification given in Table 41, 115 of them are serious either continuously or in years favorable to them while 50 are commonly of less significance. These are not all the diseases attacking crops in this state, yet the number is large enough to suggest that their presence is a continual menace to successful production and that they are, because of their widespread distribution and common occurrence, the cause of a not inconsiderable yearly reduction in the crop yield of the state.

How great the yearly loss is may be inferred from the estimates summarized in Table 42 from the more detailed estimates previously given. Five diseases of wheat are estimated to have caused a loss averaging annually 7,712,800 bushels valued at $11,837,000; two diseases of oats have caused an average annual loss of 12,820,000 bushels valued at $6,479,000; and two diseases of corn have caused a similar loss of 35,013,000 bushels valued at $24,840,000. Among the fruits, six apple diseases reduce the crop annually by 814,980 bushels valued at $1,240,500; one pear disease causes a yearly loss of 22,900 bushels valued at $22,300; and one peach disease, a yearly loss of 13,850 bushels valued at $31,220. These 16 diseases attacking 6 of our chief crops are responsible for a reduction in yield averaging annually 56,398,900 bushels valued at $14,452,000. If it were possible to state in concrete terms the losses resulting from the remaining 99 serious diseases and the damage done by the 50 less serious ones, these figures would undoubtedly be multiplied many times; but such a statement would only serve to make more impressive the facts already emphasized—that many diseases are widely distributed, that most of them are serious, and that the infection of crop plants can result only in costly reductions in yield.

Losses can be largely avoided by using the approved methods of prevention and control which are given briefly in this bulletin for nearly all the important diseases. This is a subject, however, which deserves

a more detailed treatment than is consistent with the scope and object of this preliminary report.

TABLES OF CROP REDUCTION AND LOSSES.

TABLE 1.—Estimated Wheat Losses from Leaf Rust, 1919–1923

Year	Crop reduction, bushels	Crop reduction, per cent	Value lost
1919	708,000	1.0	$1,486,000
1920	221,000	0.5	355,000
1921	500,000	1.0	500,000
1922	5,543,000	10.0	5,931,000
1923	1,803,000	3.0	1,604,000

TABLE 2.—Seasonal Variation in amount of Leaf-Rust Infection of Wheat

Year	Acres examined	Per cent of stalks infected	Per cent of diseased leaf-tissue on infected plants	Average per cent of leaf-tissue diseased
1918*	350	83	12	10
1922	310	98	57	55.8
1923	1833	86.8	36.6	31.76

TABLE 3.—Comparison of Loss in Wheat from Leaf Rust with Number of Infected Plants and Amount of Diseased Leaf-Tissue

Year	Estimated crop-loss in per cent	Average per cent of diseased leaf-tissue per stalk	Per cent of infected plants
1918	1.0	8.3	83
1922	10.	55.8	98
1923	3.	31.76	86.8

* U. S. Dept. Agr. Plant Disease Survey Bulletin. Supplement 4 131. 1919.

TABLE 4.—Estimates of Wheat Losses from Leaf Rust resulting from the 1922 Epidemic

County	Acreage	Loss per acre, bushels	Total loss, bushels
Adams	59,250	1.20	71,100
Clinton	61,700	1.64	101,188
Christian	80,000	0.25	20,000
Jersey	60,000	0.60	36,000
Madison	122,000	2.00	244,000
Mason	50,000	0.05	2,500
Monroe	60,900	5.00	304,500
Montgomery	69,000	5.00	345,000
Morgan	95,000	0.15	14,250
Randolph	82,500	2.00	165,000
Sangamon	99,000	0.05	4,950
St. Clair	130,200	0.50	65,100
Total	969,550		1,373,588

TABLE 5.—Estimated Wheat Losses from Stem Rust in Illinois, 1918–1923

Year	Per cent loss	Crop reduction bushels	Value per bushel	Money loss
1918	trace	trace	$2.08	trace
1919	1	842,000	2.10	$1,768,200
1920	0.5	221,000	1.61	355,000
1921	0.5	250,000	1.00	250,000
1922	trace	trace	1.07	trace
1923	1.5	901,800	.92	829,600

TABLE 6.—Comparison of Observations on the Amount of Stem-Rust Infection in Wheat Fields and Estimated Crop Losses

Year	Fields examined	Acres examined	Per cent of infected stalks	Average per cent of diseased tissue per plant	Estimated crop-loss in per cent
1918	51	....	.....	2.9	trace
1919	..	....	1–100	....	1.
1920	92		trace–75	0.62	0.5
1921	..	....	.....	....	0.5
1922	31	760	3.4	17.	trace
1923	64	1208	41	40.	1.5

TABLE 7.—Field Observations on Susceptibility of Wheat Types to Stem-Rust Infection

Variety	Acres examined	Per cent of stalks infected	Per cent of diseased tissue
Soft Wheats:			
Fultz	102	75	22.5
Red Cross	80	61.5	47.5
Red Wave	45	92.5	37.5
Salzer's Advance	48	100.0	60.0
Hard Wheats:			
Turkeys	837	49.2	21.
Kanred	2	30.0	10.

TABLE 8.—Susceptibility of Soft Wheats to Stem-Rust Infection

Variety	Per cent of stalks infected
Fulcaster	44.2
Fultz	42.0
Indian Swamp	24.2
Mediterranean	50.0
Red Chaff	61.7
Red Cross	35.0
Red Wave	92.5

TABLE 9.—Estimated Wheat Losses from Stinking-Smut Infection

Year	Per cent of crop lost	Crop reduction, bushels	Money loss
1917	3.0	940,000	$1,889,400
1918	1.9	1,181,300	2,357,104
1919	0.3	197,600	414,960
1920	trace	trace	trace
1921	trace	trace	trace
1922	2.0	1,082,000	1,157,740
1923	6.0	3,934,000	3,619,280

TABLE 10.—Stinking-Smut Infections found in Wheat Fields in 1923

County	No. of acres examined	Per cent of heads infected		
		Average	Highest	Lowest
Cass	30	3.0	3.0	3.0
Christian	50	18.1	40.0	0.5
Crawford	40	1.0	1.0	1.0
Douglas	280	3.0	15.0	+
Ford	35	0.2	1.0	+
Franklin	10	0.5	0.5	0.5
Hamilton	60	2.0	2.0	2.0
Iroquois	30	10.0	10.0	10.0
Jo Daviess	10	0.2	0.2	0.2
Kankakee	40	0.5	0.5	0.5
La Salle	15	0.1	0.1	0.1
Lawrence	20	2.0	2.0	2.0
Livingston	80	10.0	18.0	0.1
Macoupin	35	25.0	30.0	20.0
Madison	80	2.9	10.0	+
McLean	40	2.7	5.5	0.01
Menard	20	0.5	0.5	0.5
Monroe	100	6.7	25.0	+
Morgan	45	0.1	0.1	0.1
Moultrie	20	0.5	0.5	0.5
Piatt	35	0.2	0.5	0.1
Sangamon	65	0.6	1.5	0.1
Total	1140	Av., 4.08		

TABLE 11.—Cash Dockage on Stinking-Smut-Infested Wheat, 1922-Crop

County	Total wheat marketed bushels	Bushels smutted	Dockage per bu.	Total dockage
Bureau	16,000	0		
Champaign	49,400	2000	$ 0.05	$100.00
		622	0.04	24.88
Douglas	58,000	1500	0.05	75.00
Ford	650	0		
Greene	65,000	1000	0.02	20.00
Henry	.....	200*	1.00	200.00
Iroquois	1,300	0		
Kane	5,000	0		
Kankakee	16,000	5333	0.06	319.98
Knox	55,600	0		
La Salle	35,000	200	0.02	4.00
Lee	.....	360*	1.00	360.00
Macon	72,000	0		
McLean	61,000	3550	0.05	177.50
		2000	0.035	70.00
		1300	0.10	130.00
Mercer	10,000	0		
Monroe	40,000	1200	0.10	120.00
Montgomery	40,300	100	0.03	3.00
Peoria	10,000	2000	0.06	120.00
Piatt	22,000	2000	0.035	70.00
		500	0.06	30.00
Putnam	30,000	2000	0.05	100.00
Randolph	48,135	0		
Tazewell	140,000	0		
Vermilion	36,350	0		
Wabash	60,000	0		
Washington	191,178	0		
Whiteside	20,000	0		
Total	1,082,913	25,865	Av., $0.0744	Total, $1924.36

* Purchase refused because of smut.

TABLE 12.—Dockage on Stinking-Smut-Infested Wheat, 1923-Crop

County	Total wheat marketed bushels	Bushels smutted	Smutted bushels docked	Dockage per bu.	Total dockage
Adams	67,000	0			
Bureau	59,000	0			
Champaign	127,214	1,150	150	$0.05	$ 7.50
Christian	60,000	850	850	0.05	42.50
Clinton	100,000	5,000	5,000	0.05	250.00
Coles	35,000	450	450	0.05	22.50
Douglas	30,000	2,000	2,000	0.10	200.00
Edgar	15,000	0			
Ford	9,250	2,500	2,500	0.01	25.00
Greene	40,000	3,000	3,000	0.02	60.00
Grundy	40,000	0			
Henry	6,750	0			
Iroquois	43,100	8,180	180	0.03	5.40
			1,750	0.10	175.00
Kankakee	100,000	5,360	5,000	0.05	250.00
Kane	1,300	0			
Knox	42,000	2,000	2,000	0.04	80.00
La Salle	44,582	1,300	500	0.03	15.00
			800	0.05	40.00
Livingston	132,092	15,821	1,781	0.02	35.62
			1,390	0.035	48.65
			150	0.075	11.25
			10,000	0.04	400.00
Logan	146,300	400	400	0.025	10.00
Macon	80,000	0			
Mason	38,490	0			
McDonough	61,000	0			
McLean	123,670	9,250	2,250	0.02	45.00
			7,000	0.05	350.00
Mercer	3,000	0			
Monroe	40,000	2,000	2,000	0.10	200.00
Morgan	40,000	5,800	1,800	total loss	.....
Montgomery	30,000	423	423	0.05	21.15
Peoria	34,848	650	500	0.01	5.00
Piatt	294,000	25,950	4,000	0.03	120.00
			4,200	0.035	147.00
			9,500	0.05	475.00
			6,000	0.07	420.00
			500	0.10	50.00
Putnam	40,000	2,000	2,000	0.04	80.00
Randolph	11,171	+	0		
Sangamon	149,000	28,200	2,100	0.02	42.00
			7,000	0.03	210.00
St. Clair	158,100	10,900	6,200	0.11	682.00
			2,200	0.06	132.00
Stark	3,000	0			
Tazewell	150,000	0			
Vermilion	60,036	1,000	1,000	0.05	50.00
Wabash	130,000	0			
Washington	17,000	1,000	500	0.03	15.00
			500	0.15	75.00

TABLE 12—Concluded.

County	Total wheat marketed bushels	Bushels smutted	Smutted bushels docked	Dockage per bu.	Total dockage
Warren	55,500	8,000	8,000	0.045	360.00
Woodford	1,350	0			
White	280,000	0			
Whiteside	10,000	0			
Will	93,770	Some	Some	0.05	Some
Total	3,002,523	143,184	105,574	Av. $0.0488	$5,157.57
		4.4%	3.51%		

TABLE 13.—Observations on the Stinking-Smut Infection of wheat varieties commonly grown in the field

Variety	Acres examined	Per cent of heads smutted
Black Hull	20	0.5
Fulcaster	40	1.0
Fultz	325	5.2
Indian Swamp	15	0.37
Red Cross	100	4.7
Red Wave	125	4.6
Turkey	440	2.26

TABLE 14.—Estimated Wheat Losses from Loose-Smut Infection

Year	Per cent lost	Crop reduction, bushels	Cash loss
1917	3.0	941,000	$1,891,400
1918	1.5	929,000	1,932,300
1919	2.0	1,684,000	3,536,400
1920	3.0	1,326,000	2,134,800
1921	3.0	1,499,000	1,499,000
1922	3.0	1,644,000	961,000
1923	1.56	899,000	845,000

TABLE 15.—Loose-Smut Infections found in Wheat Fields in 1922

County	Fields examined	Acres examined	Per cent of heads smutted
Adams	1	20	+
Bond	3	60	6.3
Calhoun	3	41	0.9
Chistian	3	60	+
Clay	1	20	14.0
Clinton	4	80	+
Edwards	2	40	1.2
Effingham	3	93	10.2
Fayette	2	90	10.7
Fulton	2	30	2.0
Hamilton	2	40	1.2
Jefferson	2	40	1.0
Lawrence	6	120	+
Madison	5	130	+
Marion	2	40	+
Menard	4	76	0.8
Pike	8	203	0.6
Scott	2	40	+
Shelby	2	40	+
Schuyler	7	137	3.6
St. Clair	3	60	1.0
Tazewell	4	120	0.5
Wabash	2	40	0.5
Washington	2	40	+
Wayne	2	35	1.0
White	4	61	0.9
Total	81	1756	Acre av., 2.13

TABLE 16.—Loose-Smut Infections in Wheat Fields in 1923

County	Fields examined	Acres examined	Per cent of heads smutted
Bond	2	110	1.7
Calhoun	1	18	0.7
Cass	1	30	0.6
Christian	2	35	7.0
Coles	12	332	0.4
Crawford	10	200	2.5
Douglas	5	240	0.5
Edwards	12	240	5.0
Fayette	1	40	0.37
Ford	4	65	1.5
Franklin	8	110	3.4
Hamilton	3	55	3.9
Hancock	1	20	0.37
Iroquois	1	40	2.0
Jackson	5	65	5.3
Jo Daviess	1	15	2.0
Kankakee	1	15	1.0
Knox	1	47	+
La Salle	1	15	0.7
Lawrence	2	40	3.0
Macon	7	295	0.1
Macoupin	1	5	0.37
Madison	4	120	0.8
Marion	2	40	1.3
McDonough	1	40	1.0
McLean	1	20	1.0
Menard	1	35	2.0
Monroe	13	156	0.5
Montgomery	3	50	4.0
Perry	7	70	0.25
Piatt	2	35	1.0
Pope	15	310	5.0
Randolph	10	119	0.4
Richland	10	200	2.0
Saline	60	60	0.4
Sangamon	1	20	0.3
St. Clair	4	80	0.7
Wabash	10	200	2.7
Washington	10	297	0.25
White	18	965	0.9
Total	254	4849	Acre av., 1.56

TABLE 17.—Estimated Wheat Losses from Scab in Illinois

Year	Per cent of crop lost	Crop reduction, bushels	Money lost
1917	7	2,288,000	$ 4,598,000
1918	1	616,000	1,281,000
1919	18	15,156,000	31,827,000
1920	2	884,000	1,423,000
1921	4	1,999,000	1,999,000
1922	2	1,131,000	1,210,000
1923	2.2	791,000	727,000

TABLE 18.—Field Observations on the Infection of Wheat Varieties with Scab in 1923

Variety	Number of acres examined.	Per cent of heads infected	Per cent of spikelets per head infected	Actual per cent of infection
Fulcaster	110	0.87	54.00	0.469
Fultz	927	1.53	49.29	0.754
New Columbia	230	0.44	56.5	0.248
Red Cross	20	9.5	66.6	6.327
Red Wave	360	1.625	28.43	0.4619
Stoddard Co. Pride	80	5.5	52.5	2.8875
Turkey 10-110	87	1.61	44.9	0.82289
Turkey Red	85	13.1	49.1	6.4321
		Average per cent for all varieties		2.300

TABLE 19.—Departures of Wheat Varieties from the Average Scab Infection of 2.3 per cent in 1923

Variety	Per cent of infection	Departure of all varieties from average
Fulcaster	0.469	—1.831%
Fultz	0.754	—1.546
New Columbia	0.248	—2.052
Red Wave	0.461	—1.839
Turkey 10-110	0.822	—1.478
Red Cross	6.327	+4.027
Stoddard Co. Pride	2.887	+0.587
Turkey Red	6.432	+4.132

TABLE 20.—Speckled Leaf-Blotch Infections seen on Wheat in 1923

County	Per cent of diseased plants	Per cent of leaves infected per diseased plant
Madison	75	25
Jackson	75	30
Franklin	100	30
Hamilton	100	50
Saline	100	38
White	97	33
Coles	66	34
Macon	85	25
Fayette	100	50
Marion	100	50
Washington	100	50
Perry	100	30
Randolph	100	50
Monroe	100	35
St. Clair	55	20
Macoupin	100	10
Menard	100	10
Sangamon	100	10
Morgan	90	15
Hancock	100	18
Piatt	100	25
McLean	90	50
La Salle	25	5
Average	89.4	32.2

TABLE 21.—Varietal Differences in the Speckled Leaf-Blotch Infection of Wheat in 1923

Variety	Acres examined	Per cent of diseased plants	Per cent of leaves infected per diseased plant	Average per cent of infection
Black Hull	50	87.4	26	22.7
Fulcaster	60	100	50	50
Fultz	1147	89.3	35.1	31.3
New Columbia	240	100	32.9	32.9
Red Cross	80	77.5	27.5	21.31
Red Wave	100	52.4	22.5	11.79
Stoddard Co. Pride	80	100	30	30.00
Turkey 10-110	60	90.1	33.3	30.0
Turkey Red	682	83.4	22.6	18.84

TABLE 22.—Estimated Crop Reduction from Crown Rust of Oats

Year	Reduction, per cent	Reduction, bushels	Money loss
1919	1	1,323,000	$ 962,000
1920	1	1,820,000	782,000
1921	3	4,454,000	1,291,000
1922	4	4,583,000	1,787,000
1923	2.5	3,464,000	1,350,000

TABLE 23.—Comparison of Variation in Crown-Rust Infection of Oats and Estimated Crop Reductions in 1922 and 1923

Year	Acres examined	Per cent of diseased plants	Per cent of diseased tissue per plant	Estimated crop reduction
1922	538	91.038	58.05	4.0%
1923	1226	90.850	36.94	2.5%

TABLE 24.—Estimated Crop Reductions from Loose Smut of Oats

Year	Reduction, per cent	Reduction, bushels	Money loss
1917	7	18,395,000	$11,956,750
1918	6	12,661,000	8,382,870
1919	5	6,616,000	4,631,200
1920	5	9,098,000	3,912,000
1921	5	7,423,000	2,512,000
1922	5	5,790,000	2,258,000
1923	5.5	7,862,000	3,065,580

TABLE 25.—Estimated Crop Reductions from Corn Diseases

Year	Reduction, per cent	Reduction, bushels	Cash loss
1917	2*	8,531,000	$ 9,384,000
1918	4.5	16,222,000	19,466,000
1919	7.0	22,656,000	29,453,000
1920	6.0	18,777,000	11,078,000
1921	13.5	47,752,000	18,145,000
1922	4.0	12,044,000	7,226,000
1923	20.5	86,980,000	56,537,000

* In 1917 smut alone was estimated, but ear-rots and root-rots were reported as doing damage.

TABLE 26.—Estimated Crop Reductions from Root-, Stalk-, and Ear rots of Corn

Year	Reduction, per cent	Reduction, bushels	Cash loss
1918	3	10,870,000	$13,044,000
1919	5	16,183,000	21,037,000
1920	4	12,518,000	7,385,000
1921	10	35,372,000	13,442,000
1923	15	59,525,000	38,691,000

TABLE 27.—Estimated Crop Reductions from the Smut of Corn

Year	Reduction, per cent	Reduction, bushels	Cash loss
1917	2.0	8,531,000	$9,384,000
1918	1.5	5,352,000	6,422,000
1919	2.0	6,473,000	8,414,000
1920	2.0	6,259,000	3,692,000
1921	3.5	12,380,000	3,704,000
1922	2.5	7,412,000	4,447,000
1923	3.0	10,432,000	6,780,000

TABLE 28.—Field Observations on the Susceptibility of Corn Varieties to Brown-Spot

Variety	Acres examined	Per cent of stalks infected
Boone County White	100	100
Reed's Yellow Dent	20	100
Democrat	25	88
Yellow Dent	181	86

TABLE 29.—Estimated Crop Reductions from Apple Scab

Year	Reduction, per cent	Reduction, bushels	Cash loss
1918	4	134,000	$247,900
1919	6	342,000	786,600
1920	8	604,000	845,600
1921	12	387,000	967,500
1922	4	405,000	425,250
1923	3.5	277,000	318,000

TABLE 30.—Prevalence of Apple-Scab Infections in Orchards during 1923

County	Orchards examined	Acres	Per cent of trees infected	Per cent of fruit infected
Edwards	1	5	100	75
Jackson	1	5	100	50
Hamilton	1	½	100	75
Macon	1	½	100	10
Morgan	1	½	100	10
Greene	2	1420	few	trace
Tazewell	1	½	100	50
Logan	2	5	100	75
Montgomery	1	6	100	75
Jackson	1	50	75	60
Johnson	1	20	100	35
Pope	2	80	100	100
	1	20	trace	trace
Marshall	1	20	80	55
Bureau	2	40	30	trace
Douglas	1	½	100	10
Fulton	1	10	75	16
Crawford	1	40	10	5
Pike	1	5	80	20
Total	23	1728	Acre av., 12.7%	Acre av., 9.4%

TABLE 31.—Estimated Crop Reductions from Apple Blotch

Year	Reduction, per cent	Reduction, bushels	Cash loss
1918	2	66,000	$122,000
1919	3	171,000	393,000
1920	4	302,000	422,000
1921	7	226,000	566,000
1922	5	511,000	536,000
1923	5.5	428,000	492,000

TABLE 32.—Prevalence of Blotch in Unsprayed Apple Orchards in 1923

County	Orchards examined	Acres	Per cent of trees infected	Per cent of fruit infected
Hamilton	1	1	100	65
Saline	1	1	100	75
White	1	1	100	50
Randolph	1	2	100	100
Christian	1	2	100	100
Shelby	1	1	100	100
Bond	1	5	100	100
Clinton	1	5	100	70
Union	1	5	100	100
Alexander	1	5	100	100
Johnson	1	10	100	100
Williamson	1	3	100	100
Jasper	1	40	100	75
Effingham	3	50	100	100
Total	16	131	Acre av., 100%	Acre av., 90.4%

TABLE 33.—Estimated Crop Reductions from Fire-blight of Apple

Year	Per cent lost	Bushels lost	Cash lost
1918	1.5	49,000	$ 90,650
1919	trace	+	+
1920	trace	+	+
1921	0.1	3,000	7,500
1922	1.0	98,000	102,900
1923	1.5	112,000	128,000

TAPLE 34.—Estimated Crop Reductions from Apple Rust

Year	Per cent lost	Bushels lost	Cash lost
1919	0.3	17,000	$ 39,100
1920	0.2	15,000	21,000
1921	trace	+	+
1922	1.5	159,000	166,000
1923	1.0	74,000	85,000

TABLE 35.—Estimated Crop Reductions from Black Rot of Apple

Year	Per cent lost	Bushels lost	Cash lost
1918	1	33,000	$61,000
1919	trace	+	+
1920	1	75,000	105,000
1921	2	64,000	160,000
1922	2	199,000	208,000
1923	1	74,000	85,000

TABLE 36.—Blister Canker Infection found in Ben Davis Orchards, 1922 and 1923

County	Orchards examined	Acres	Per cent of trees infected
Hancock	1	2	20
	1	2	20
	1	1	100
Edwards	1	+	trace
Mercer	1	1	40
Schuyler	1	1	100
	1	5	25
Henderson	1	3	30
McLean	1	2	16
	1	1	20
Wayne	1	10	50
	1	20	95
Henderson	1	2	50
	1	100	8
Pike	1	1	90
Jefferson	2	40	2
Ogle	1	2	25
Lake	1	1	100
Boone	1	2	5
Livingston	1	6	25
Total	21	203	Acre av., 21.8%

TABLE 37.—Estimated Crop Reductions from Pear Blight

Year	Per cent lost	Bushels lost	Cash loss
1922	5	26,800	$26,800
1923	6	19,000	17,800

TABLE 38.—Abundance of Pear-Blight Infection in 1922

County	Orchards	Per cent of trees infected	Per cent of diseased branches on infected trees
Clay	1	100	10
Lake	1	100	0.5
White	1	+	45.
Hancock	1	trace	trace
	1	100	50
Mercer	1	100	+
McHenry	1	100	20
Putnam	1	2	1
Schuyler	1	100	10
Washington	1	+	40
Massac	1	+	50
	1	+	35
Kane	1	90	3
Kankakee	1	100	1
	1	75	5
Edgar	1	+	40
Wabash	1	+	40
Marshall	1	100	2
Stephenson	1	100	10
Kendall	1	100	5
Will	1	15	5
Jackson	1	+	30
Williamson	1	+	30
La Salle	1	100	2
White	1	+	35
Carroll	1	25	trace
Grundy	1	100	1
Pulaski	1	+	5
	28	Acre av., 50.25%	Acre av., 16.9%

TABLE 39.—Abundance of Pear-Blight Infection in 1923

County	Orchards	Acres	Per cent of trees infected	Per cent of infected branches on infected trees
Clay	2	18	100	25
	1	20	100	45
Marion	2	20	100	25
	1	30	100	40
Randolph	1	1	100	30
	1	10	100	20
Adams	1	+	100	40
Macon	1	+	100	60
Christian	1	1	100	50
Shelby	1	1	100	60
	1	5	100	40
Clinton	1	10	100	25
Richland	1	5	100	20
	1	10	100	60
	16	131	100	43.1

TABLE 40.—Estimated Crop Reductions from Peach Brown-Rot

Year	Per cent reduction	Reduction, bushels	Money loss
1917	12	50,000	$97,500
1918	0	0	0
1919	1	8,000	21,600
1920	1	14,000	44,300
1921	..	.....	.....
1922	1	11,000	19,200
1923	2	14,000	36,000

TABLE 41.—Tabulation of Diseases Discussed in the Text

Crop	Serious diseases	Less serious diseases	Total
Cereals and Forage			
Wheat	5	8	13
Oat	2	1	3
Corn	2	5	7
Rye	3	2	5
Barley	3	2	5
Alfalfa	1	3	4
Sweet Clover	1	1	2
Red Clover	2	3	5
Timothy	1	1	2
Redtop	1	0	1
Fruits, including Small Fruits			
Apple	8	9	17
Pear	4	1	5
Quince	2	3	5
Peach	4	3	7
Apricot	3	0	3
Plum	6	0	6
Cherry	4	0	4
Grape	4	0	4
Brambles (Blackberry, etc.)	8	1	9
Currant and Gooseberry	3	0	3
Strawberry	3	0	3
Vegetable and Field Crops			
Potato	7	0	7
Tomato	3	0	3
Sweet Potato	2	0	2
Cantaloupe	3	0	3
Watermelon	2	0	2
Cucumber	5	0	5
Asparagus	1	1	2
Beet	1	0	1
Cabbage	4	2	6
Cauliflower	1	0	1
Bean	3	0	3
Onion	1	0	1
Lettuce	1	0	1
Rhubarb	2	1	3
Radish	1	2	3
Horseradish	1	0	1
Ornamental plants			
Rose	2	1	3
Lilac	1	0	1
Virginia Creeper	2	0	2
Snapdragon	1	0	1
Carnation	1	0	1
Total for the 44 crops	115	50	165

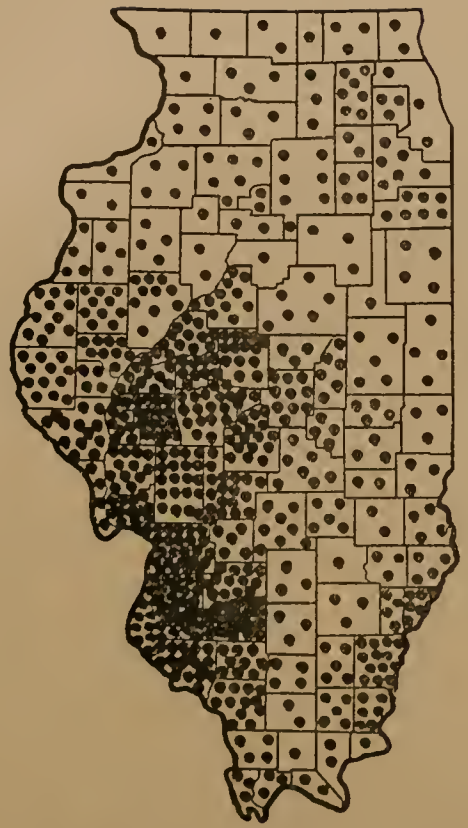
TABLE 42.—Average Annual Estimated Crop Reductions and Money Losses resulting from Disease Attack

Crop and disease	Average annual reduction, bushels	Average annual money loss	Period of record
Wheat			
Leaf rust	1,755,000	$1,975,200	5 years
Stem rust	369,100	533,800	6 "
Stinking smut	1,047,800	1,348,300	7 "
Loose smut	1,274,500	1,828,500	7 "
Scab	3,266,400	6,152,100	7 "
Oat			
Crown rust	3,128,800	1,234,400	5 "
Loose smut	9,692,142	5,245,485	7 "
Corn			
Root-, Stalk-, and Ear-rots	26,893,600	18,719,800	5 "
Smut	8,119,857	6,120,428	7 "
Apple			
Scab	358,160	598,470	6 "
Blotch	286,000	421,830	6 "
Fire-blight	43,660	54,840	6 "
Rust	53,000	62,220	5 "
Blackrot	74,160	103,160	6 "
Peach			
Brownrot	13,850	31,220	7 "
Pear			
Blight	22,900	22,300	2 "
Total	56,398,929	$44,452,053	

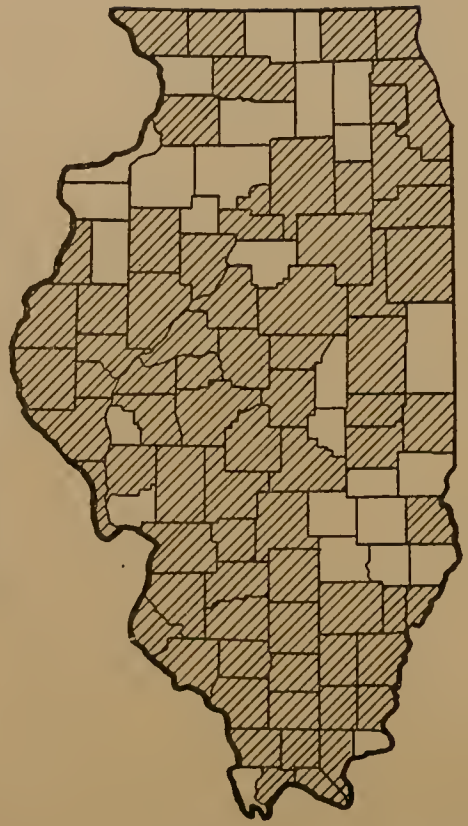
MAPS

Illustrating the distribution of the diseases discussed in the text.

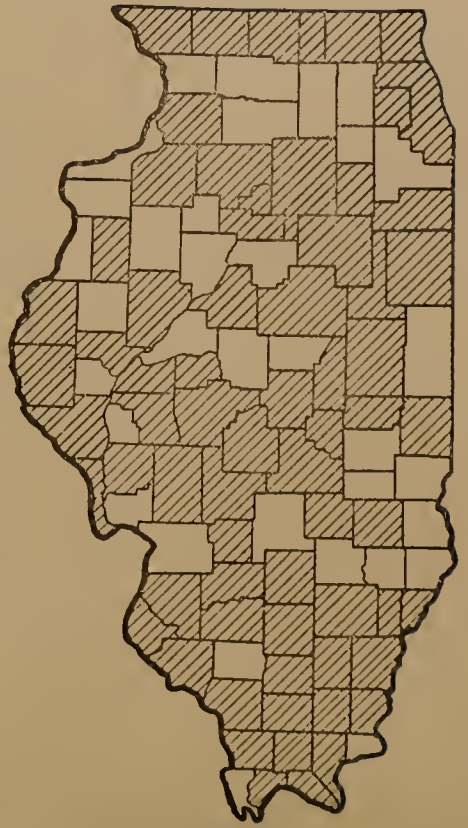
Map of Illinois, with county names for comparison with the following maps.



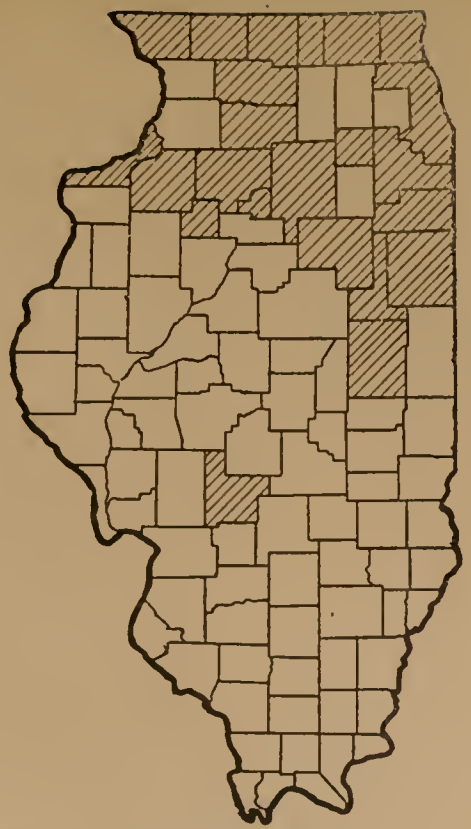
MAP 1.—Distribution of wheat acreage in Illinois in 1922. One dot represents 1,000 acres.



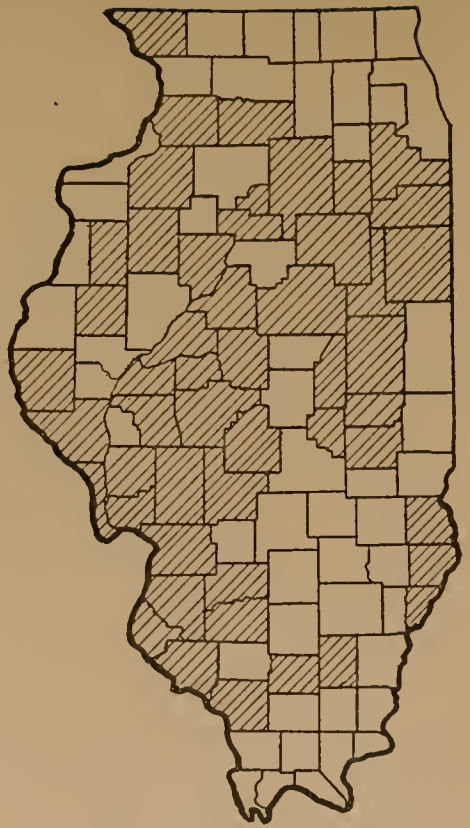
MAP 2.—Distribution of leaf rust of wheat.



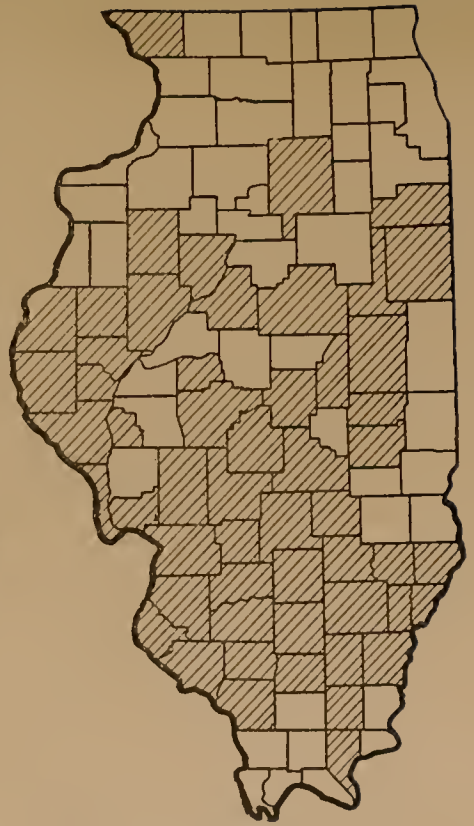
MAP 3.—Distribution of stem rust of wheat.



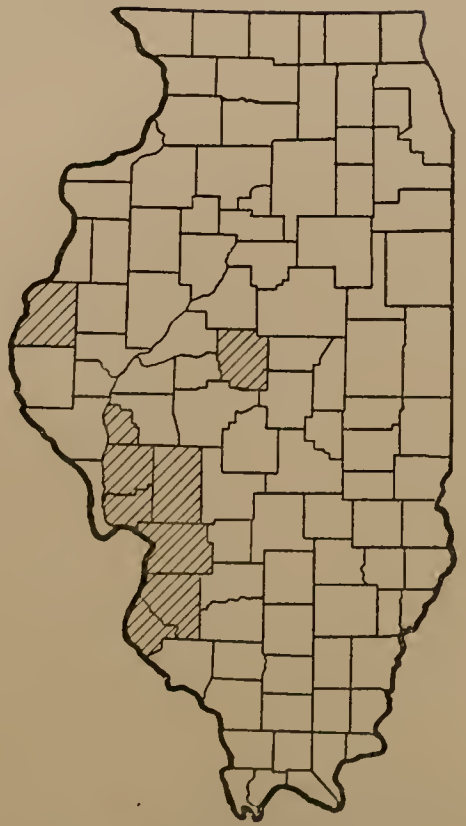
MAP 4.—Distribution of stem rust on the common barberry.



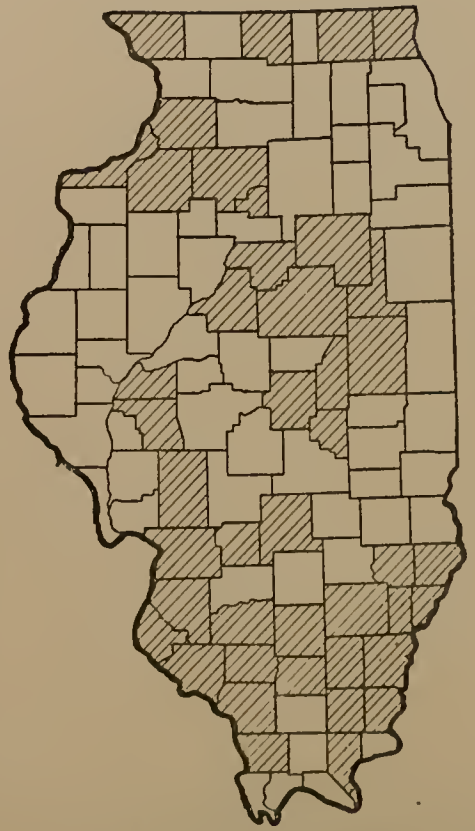
MAP 5.—Distribution of stinking smut of wheat.



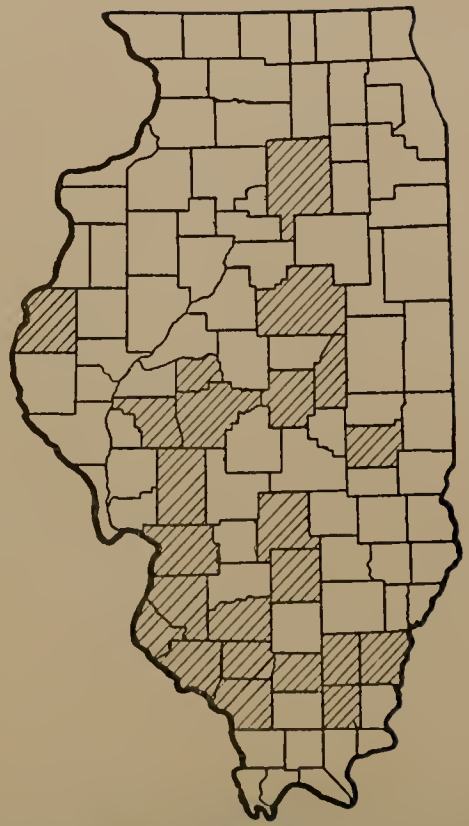
MAP 6.—Distribution of loose-smut of wheat.



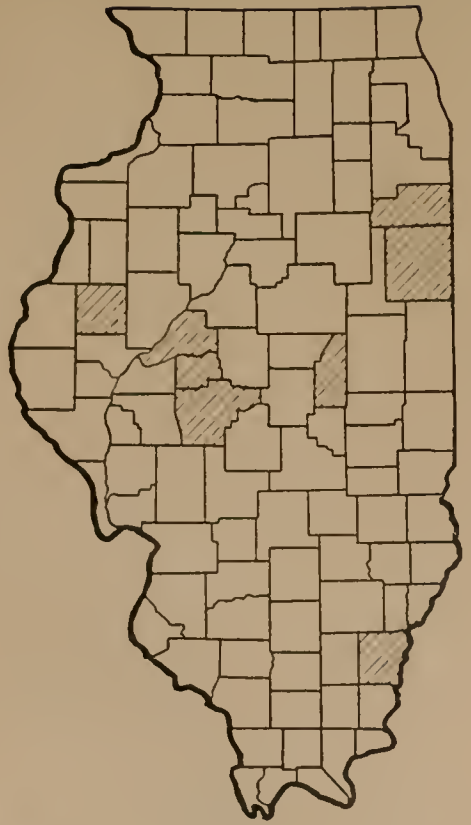
MAP 7.—Distribution of flag smut of wheat.



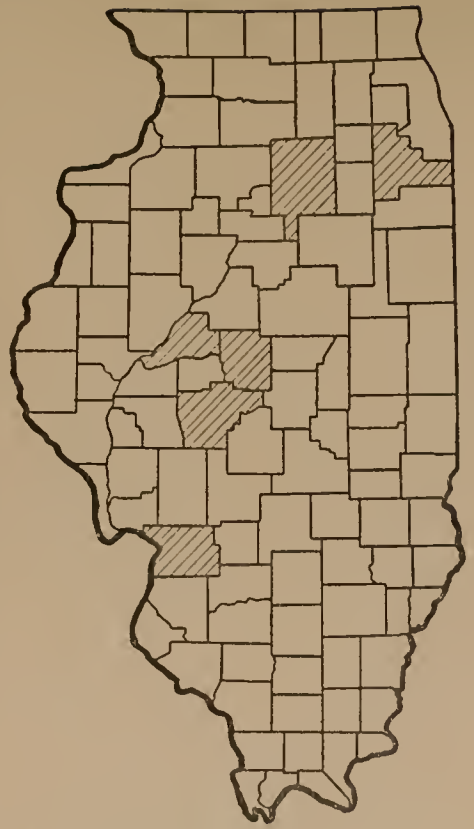
MAP 8.—Distribution of wheat scab.



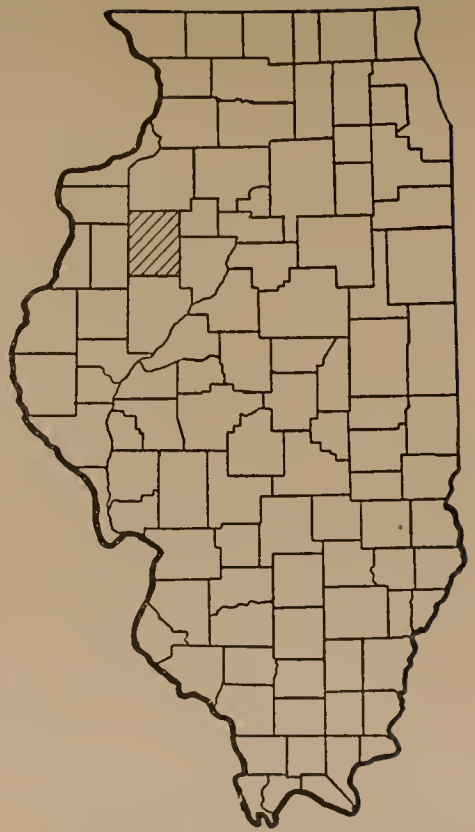
MAP 9.—Distribution of the speckled leaf-blotch of wheat.



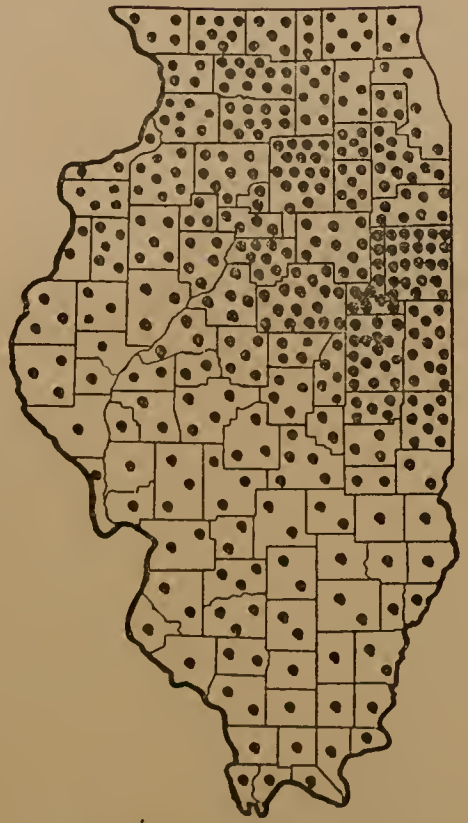
MAP 10.—Distribution of wheat anthracnose.



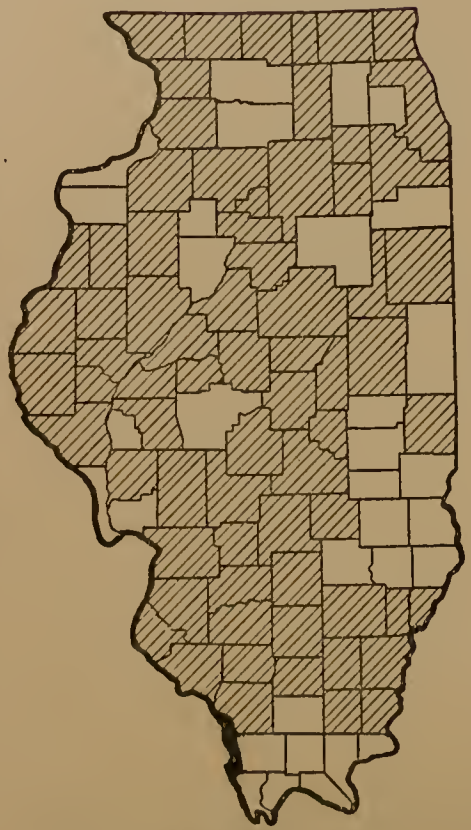
MAP 11.—Distribution of wheat foot-root.



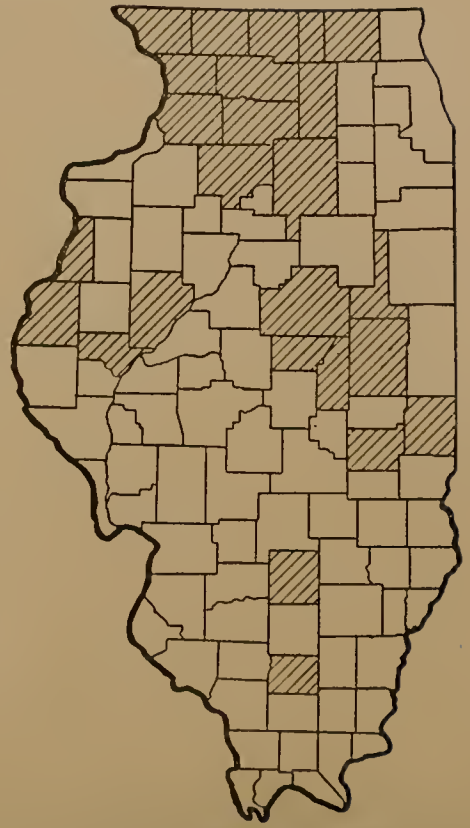
MAP 12.—Known occurrence of the black-chaff disease of wheat.



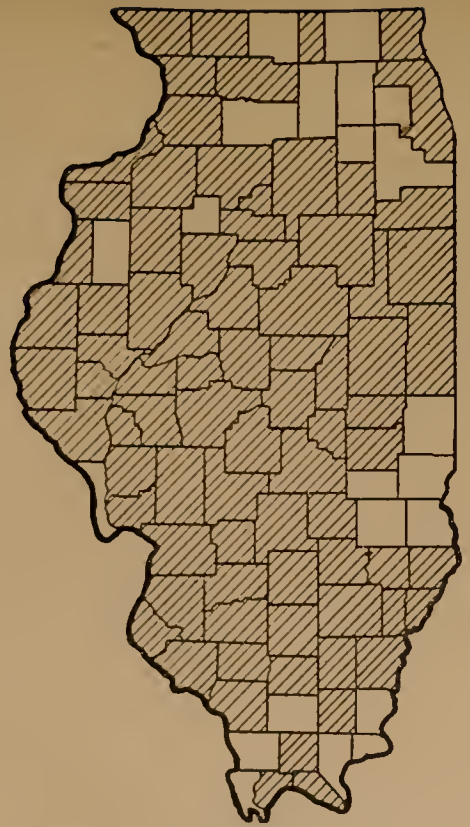
MAP 13.—Distribution of oat acreage in 1922. One dot represents 10,000 acres.



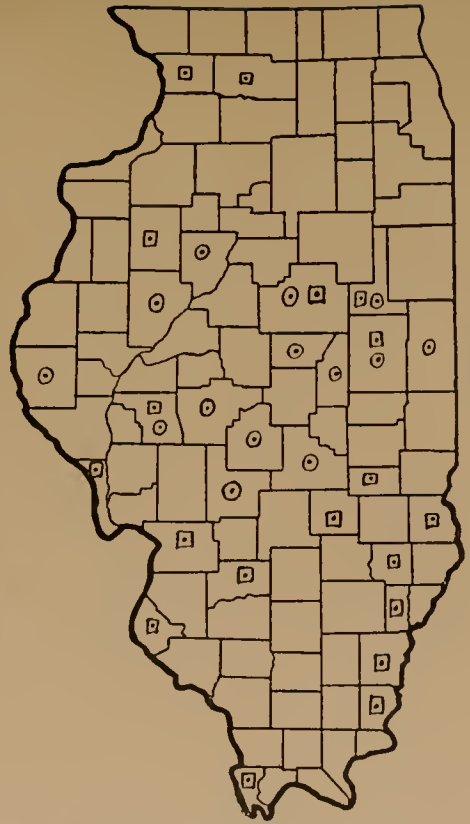
MAP 14.—Distribution of crown rust of oats.



MAP 15.—Distribution of stem rust of oats.



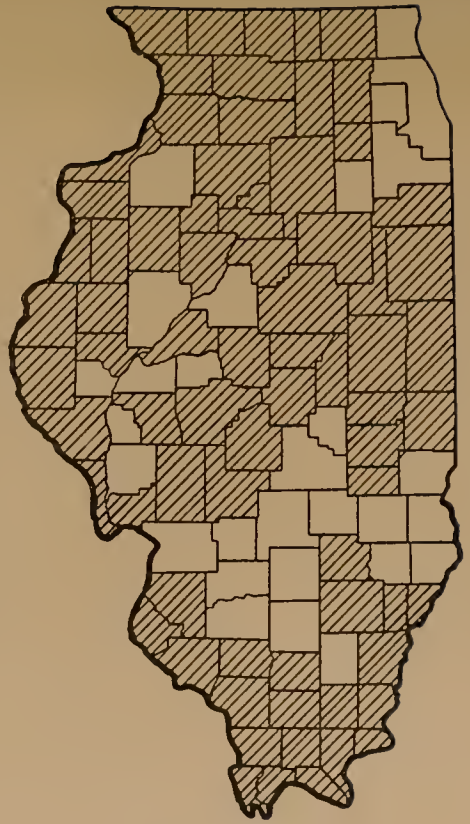
MAP 16.—Distribution of loose-smut of oats.



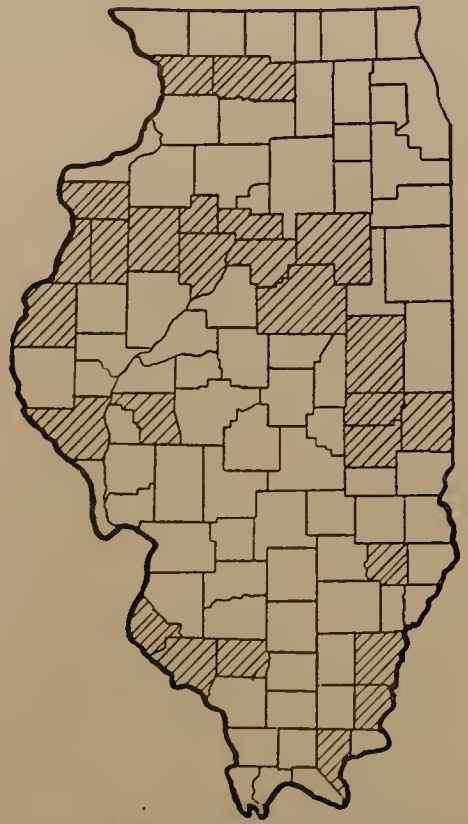
MAP 17.—Distribution of root-, stalk-, and ear-rots of corn.

Dot in circle equals Diplodia rots.

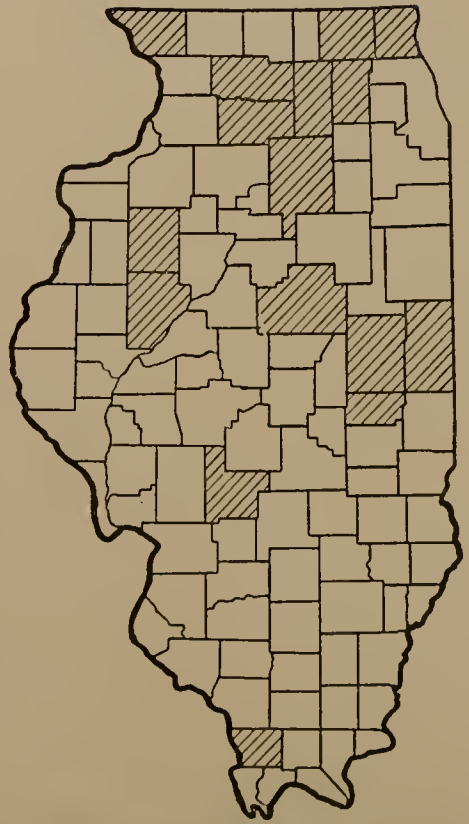
Dot in square equals Gibberella and Fusarium rots.



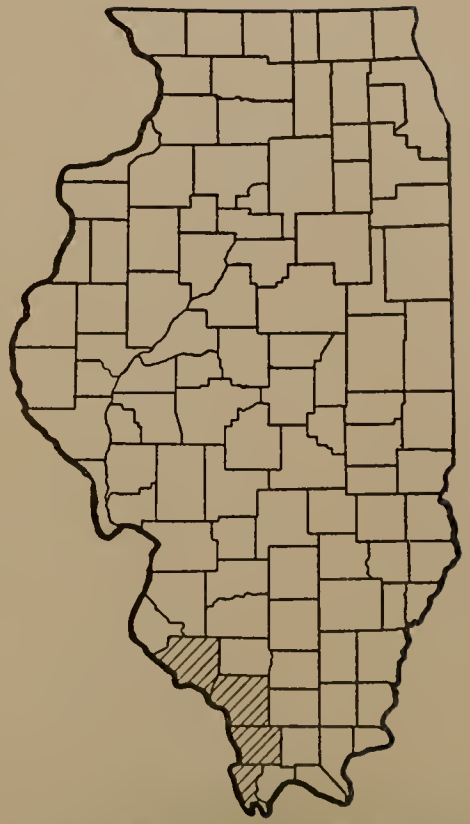
MAP 18.—Distribution of corn smut.



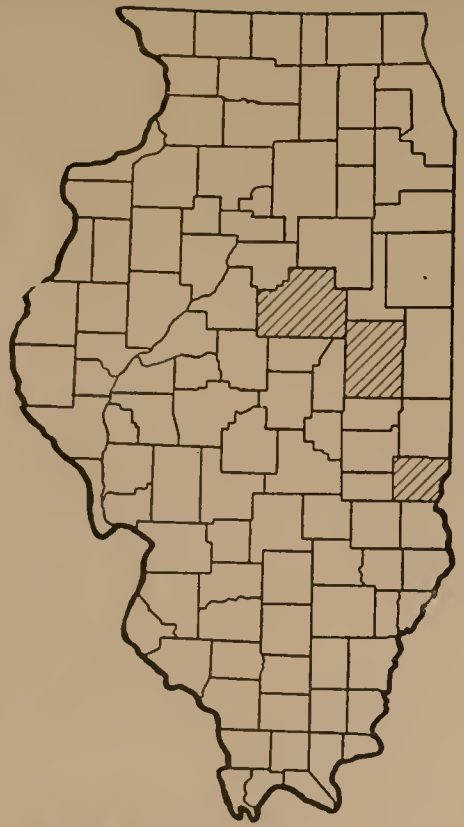
MAP 19.—Distribution of brown-spot of corn.



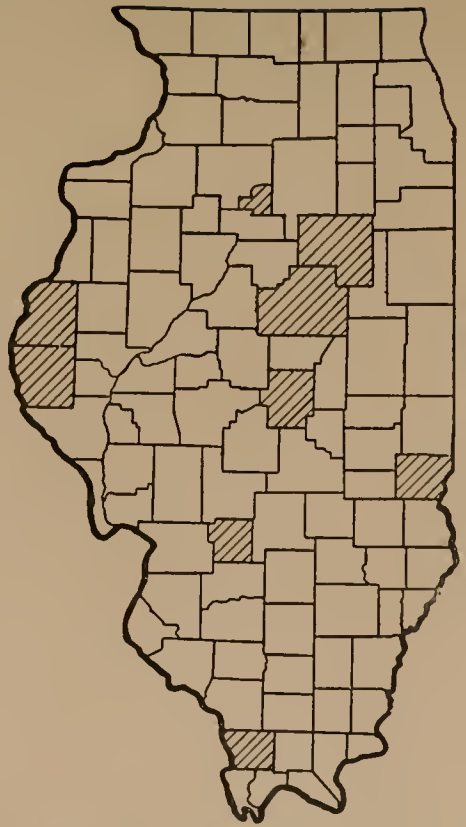
MAP 20.—Distribution of corn rust.



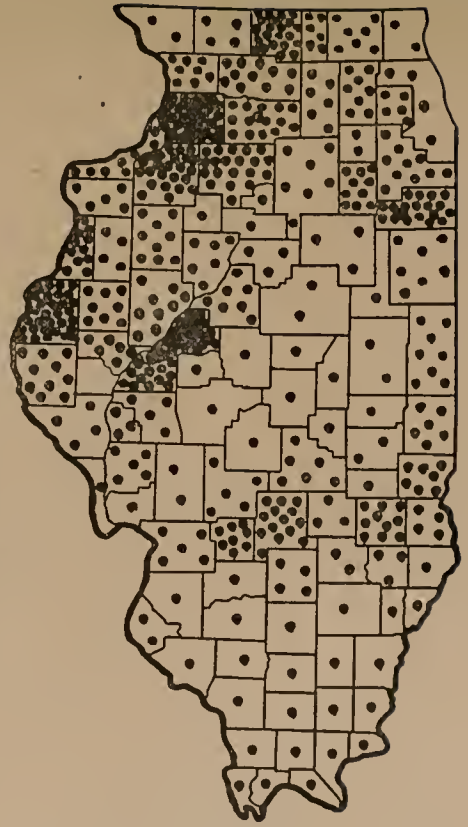
MAP 21.—Distribution of Rosen's disease of corn.



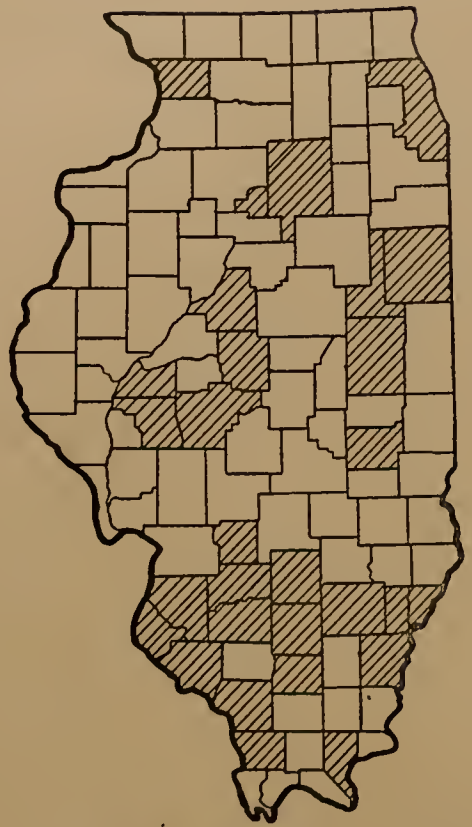
MAP 22.—Distribution of the black-bundle disease of corn.



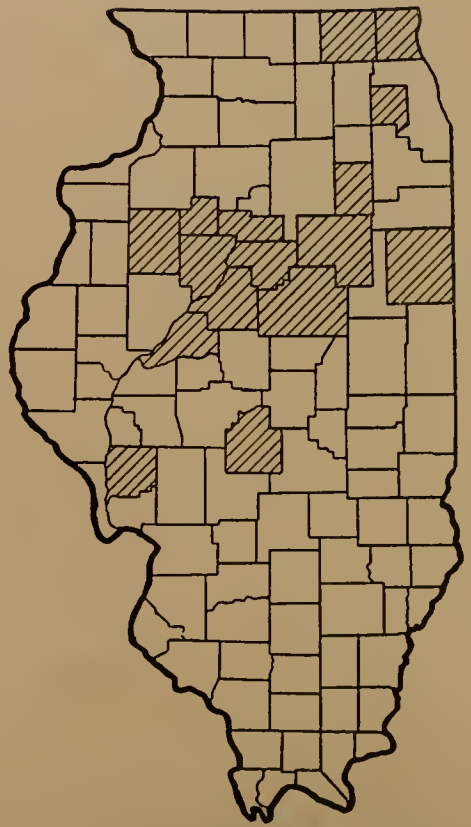
MAP 23.—Distribution of Stewart's disease of corn.



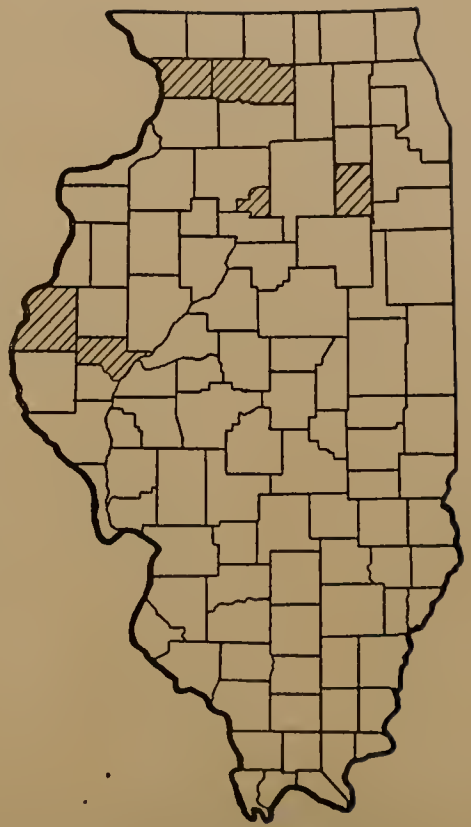
MAP 24.—Rye average in 1922. Each dot represents 500 acres.



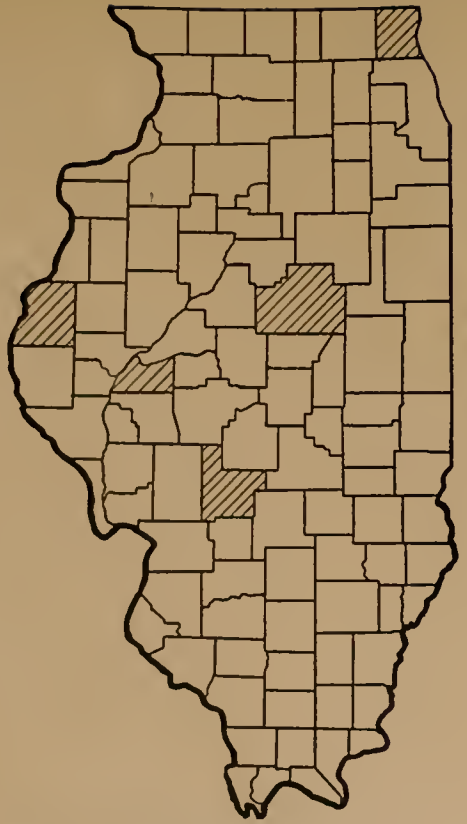
MAP 25.—Distribution of the brown rust of rye.



MAP 26.—Distribution of stem rust of rye.



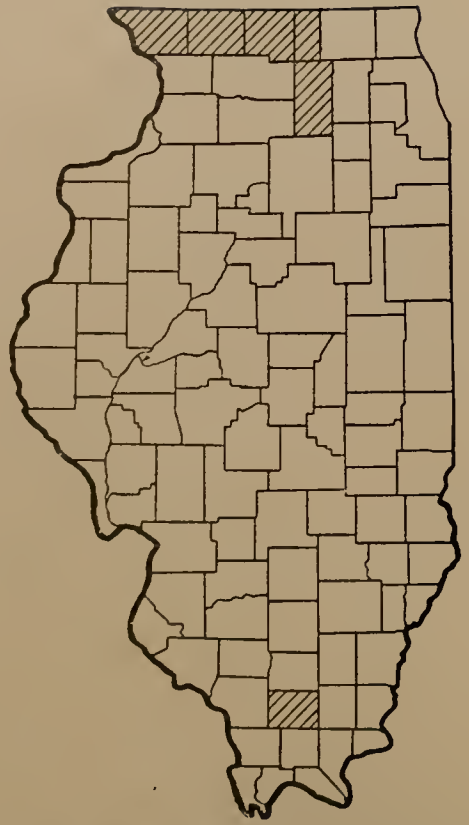
MAP 27.—Distribution of ergot of rye.



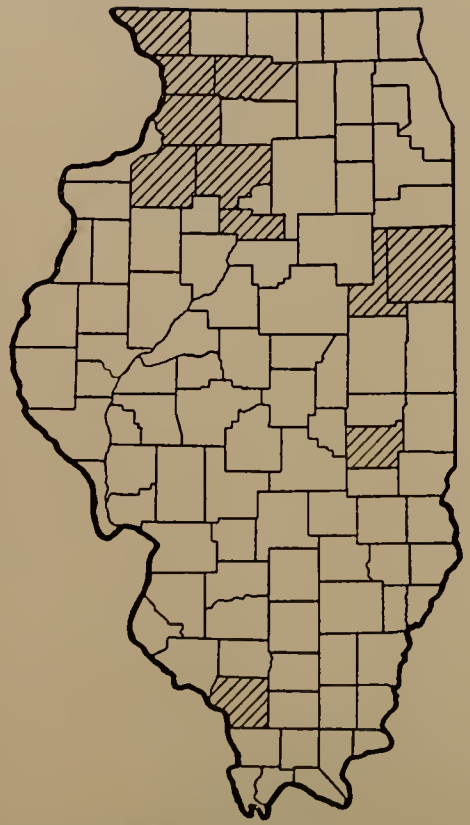
MAP 28.—Distribution of leaf smut of rye.

MAP 29.—Barley acreage in 1922. Each dot represents 500 acres.

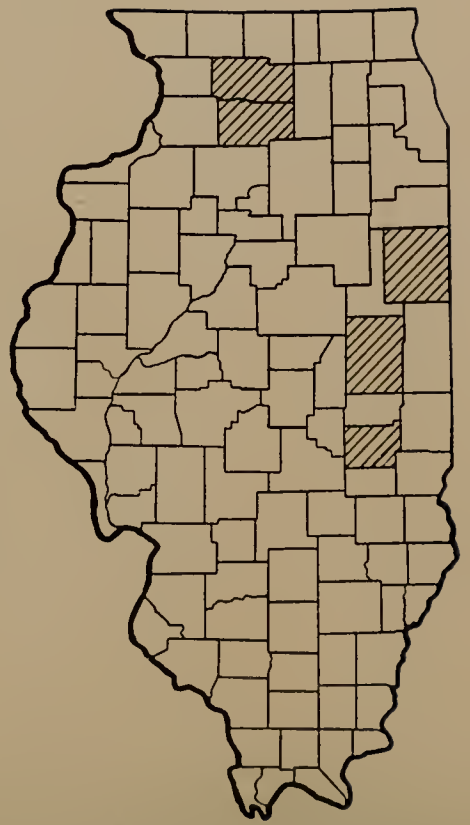
MAP 30.—Distribution of leaf rust of barley.



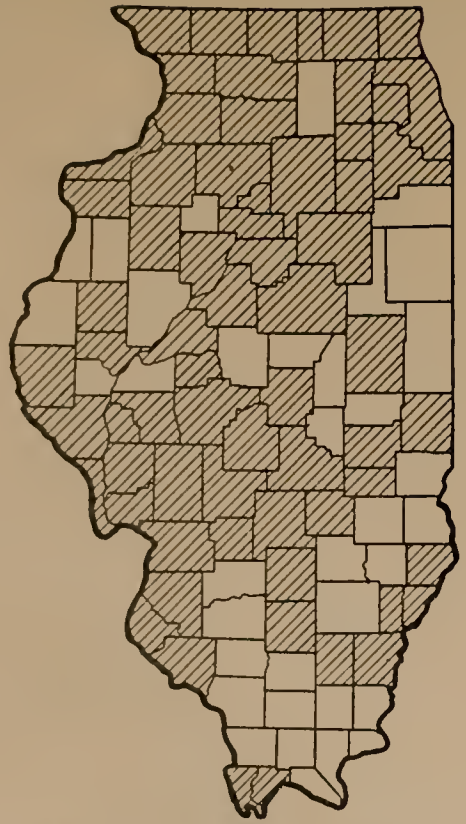
MAP 31.—Distribution of stem rust of barley.



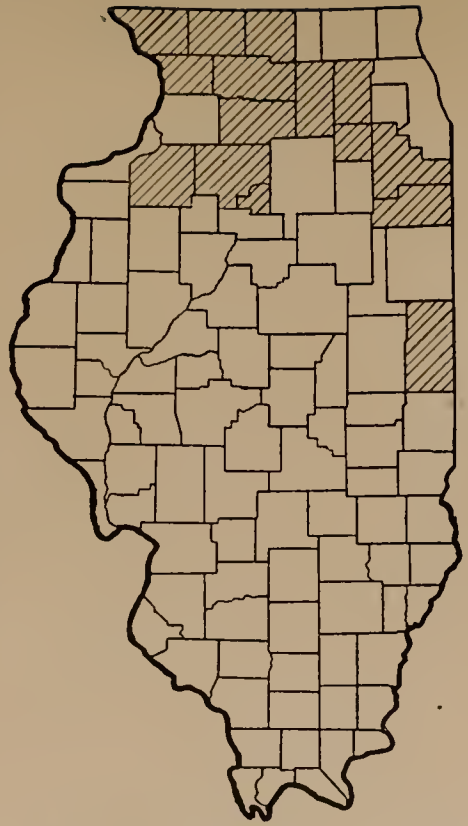
MAP 32.—Distribution of loose-smut disease of barley.



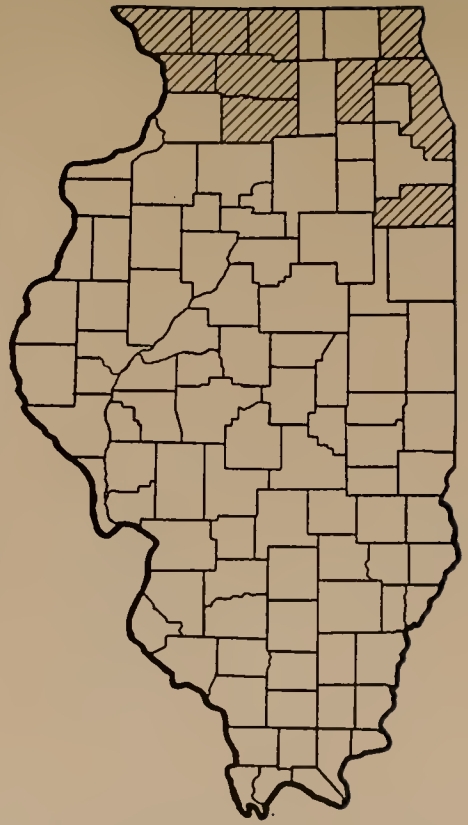
MAP 33.—Distribution of barley stripe.



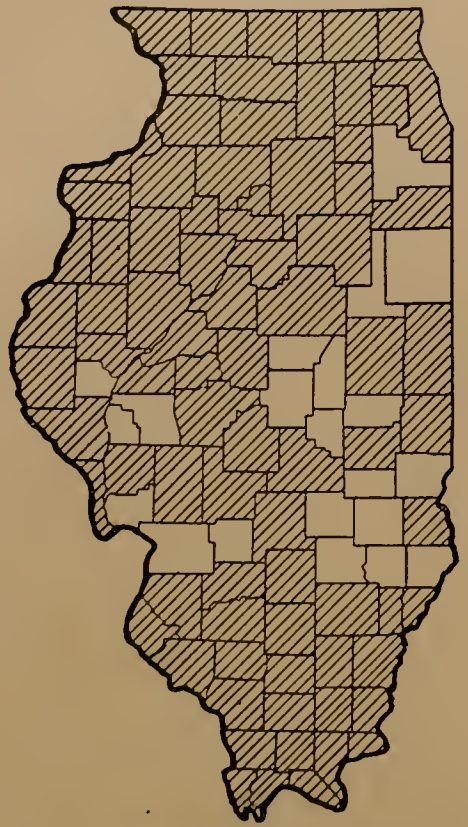
MAP 34.—Distribution of alfalfa leaf-spot.



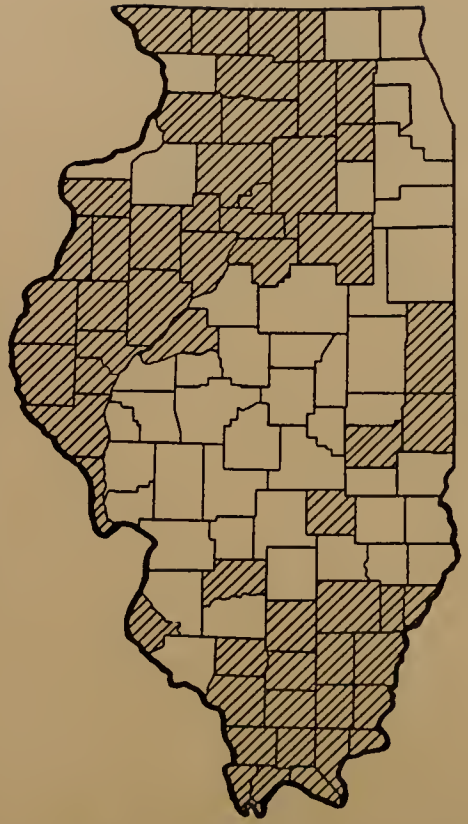
MAP 35.—Distribution of sweet clover anthracnose.



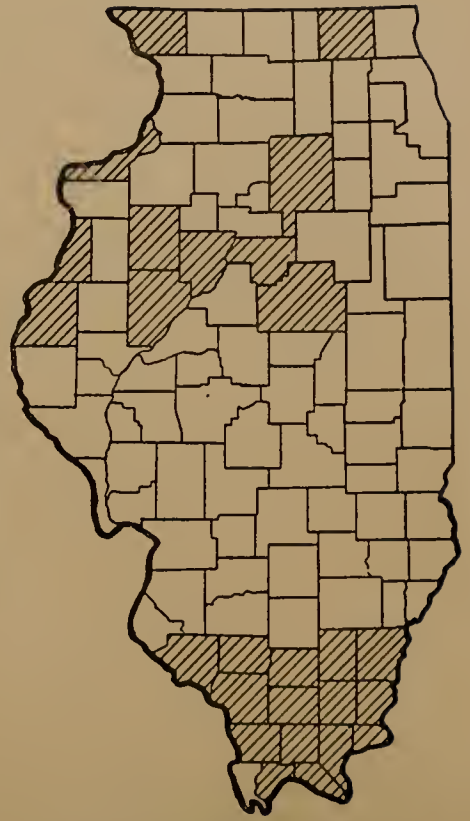
MAP 36.—Distribution of red clover anthracnose.



MAP 37.—Distribution of powdery mildew of red clover.

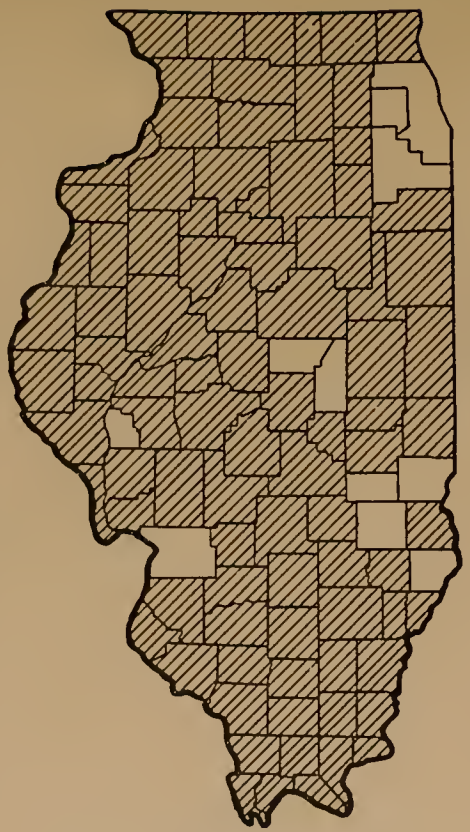


MAP 38.—Distribution of stem rust of timothy.

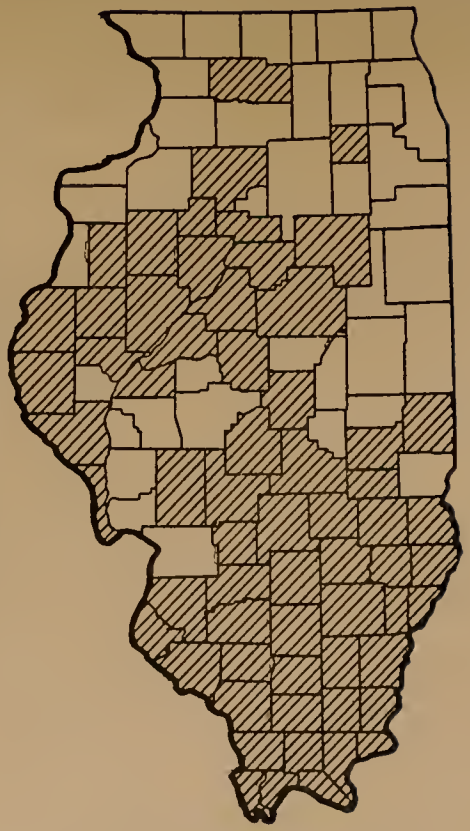


MAP 39.—Distribution of stem rust of redtop.

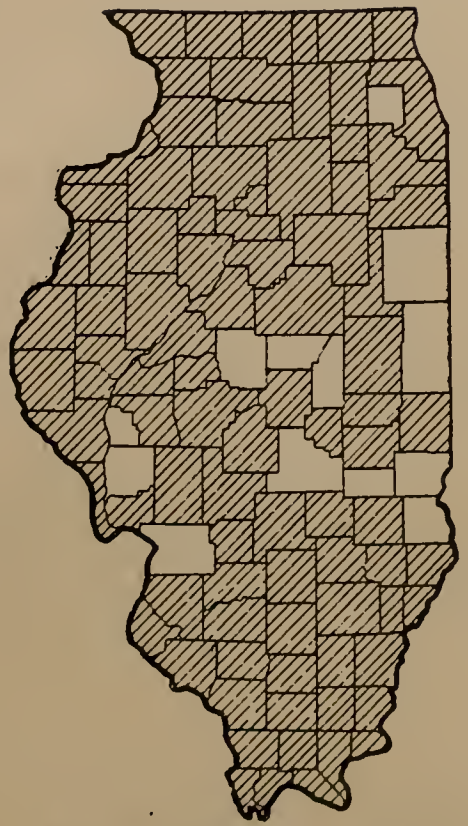
MAP 40.—Apple production. One dot represents 10,000 bushels harvested in 1919.



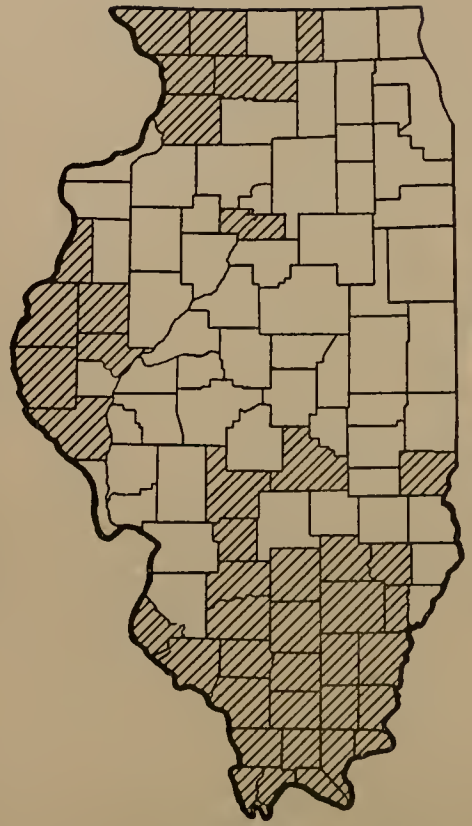
MAP 41.—Distribution of apple scab.



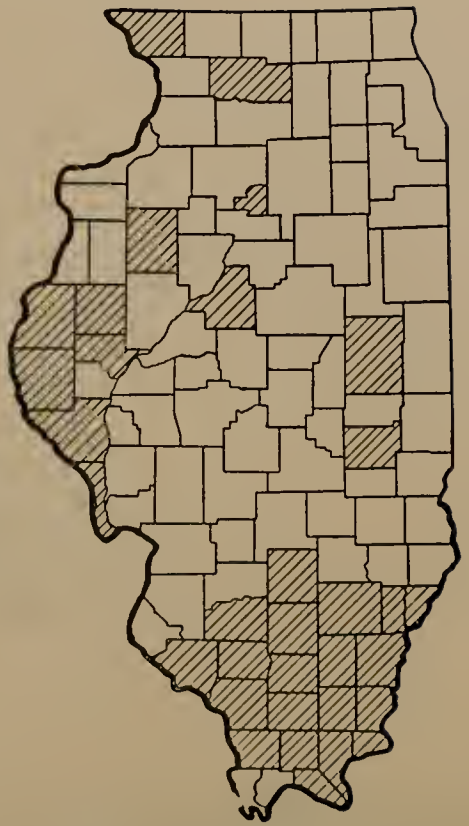
MAP 42.—Distribution of apple blotch.



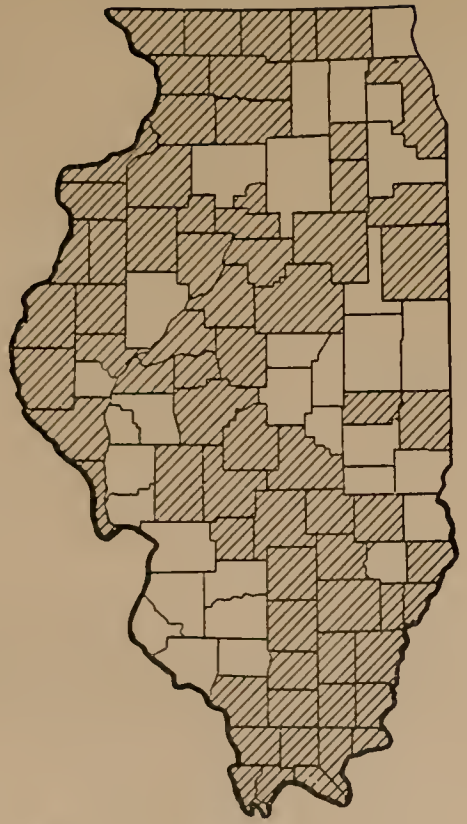
Map 43.—Distribution of fire-blight of apple.



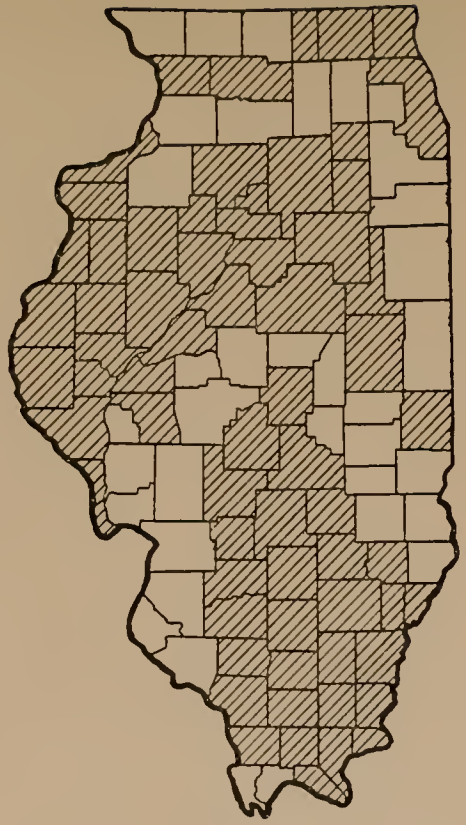
Map 44.—Distribution of apple rust.



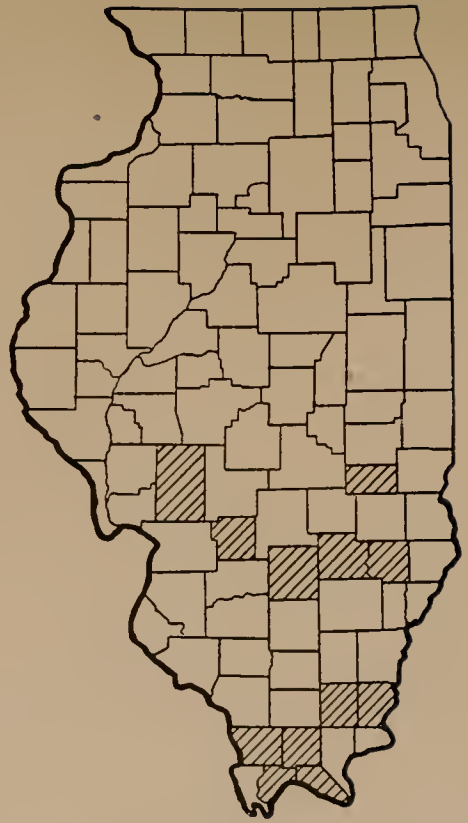
Map 45.—Distribution of cedar rust, the alternate stage of the apple rust.



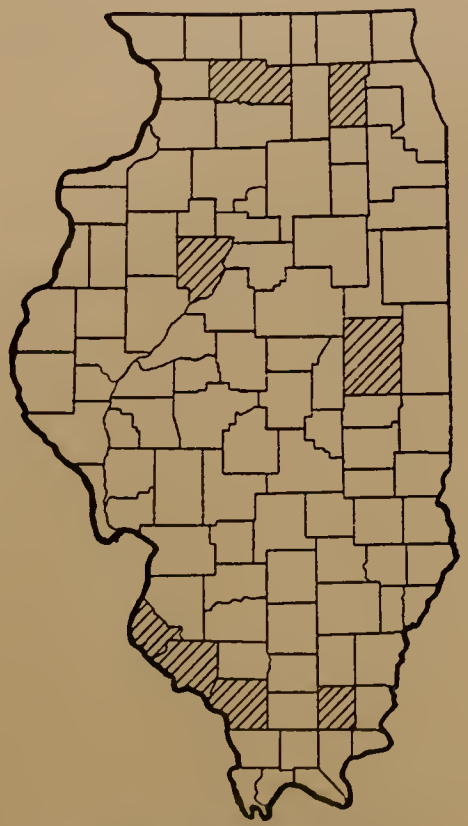
MAP 46.—Distribution of black rot of apple.



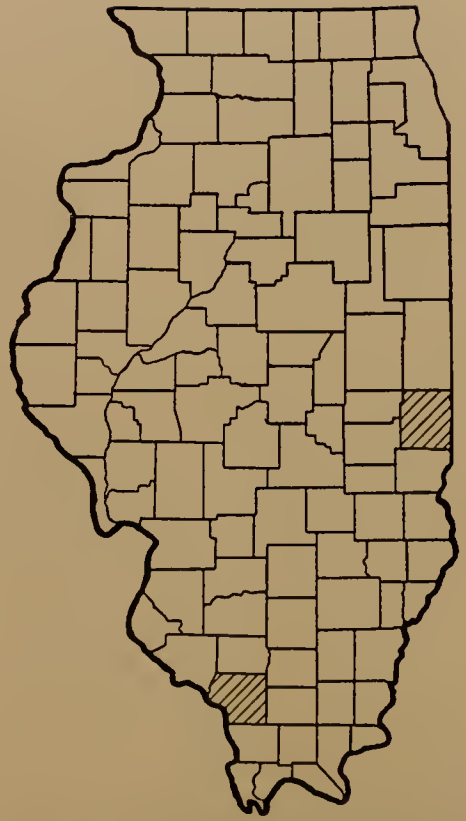
MAP 47.—Distribution of the blister canker of apple.



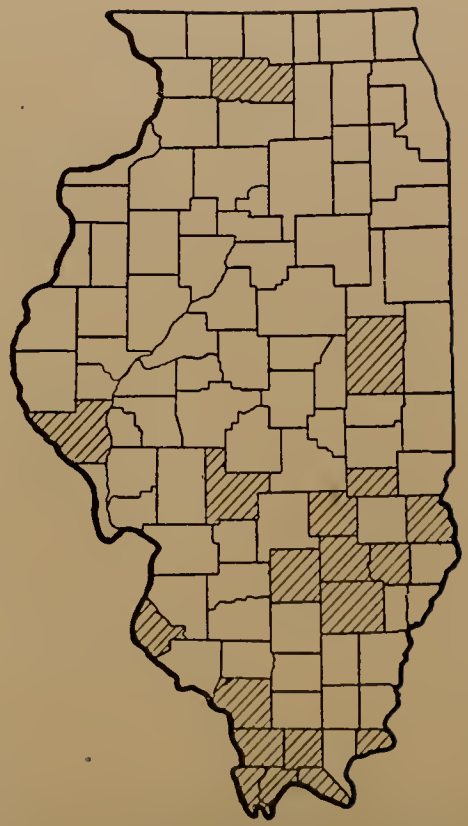
MAP 48.—Distribution of the bitter-rot of apple.



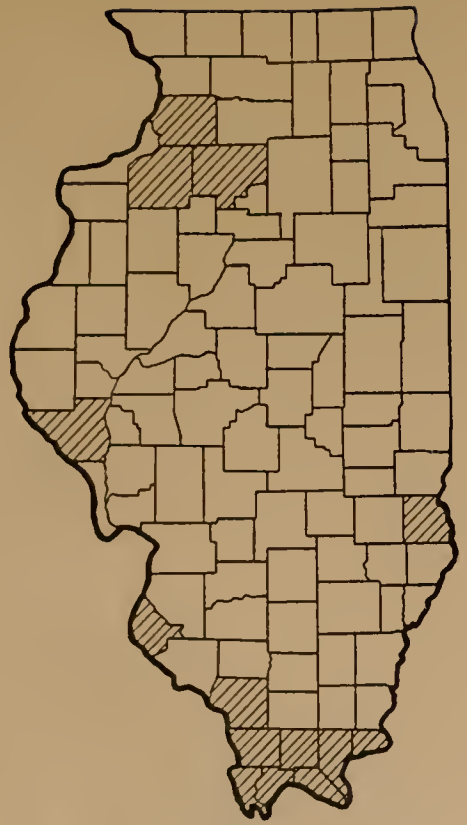
MAP 49.—Distribution of brown rot of apple.



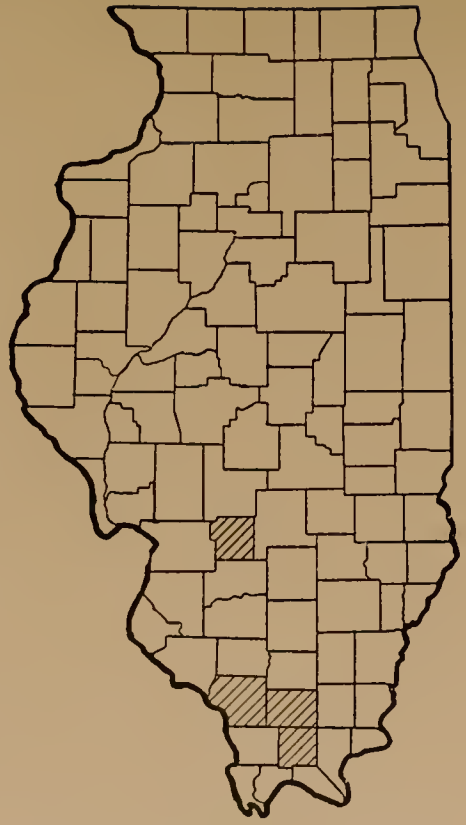
MAP 50.—Distribution of the powdery mildew of apple.



MAP 51.—Distribution of sooty blotch of apple.



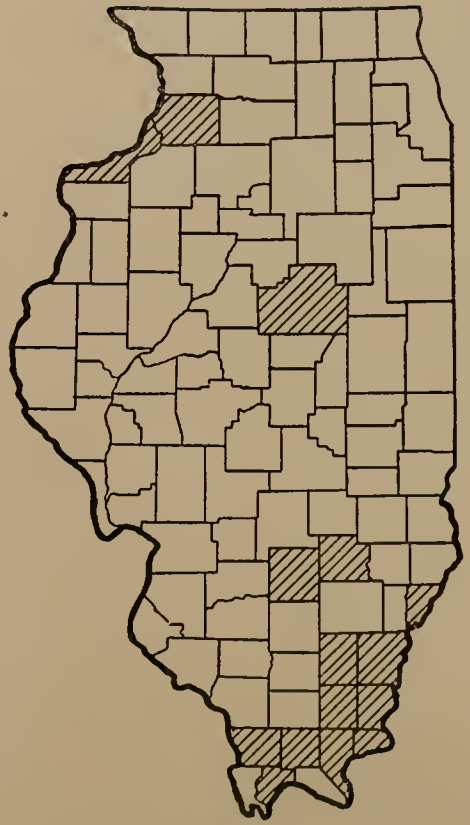
MAP 52.—Distribution of fly-speck of apple.



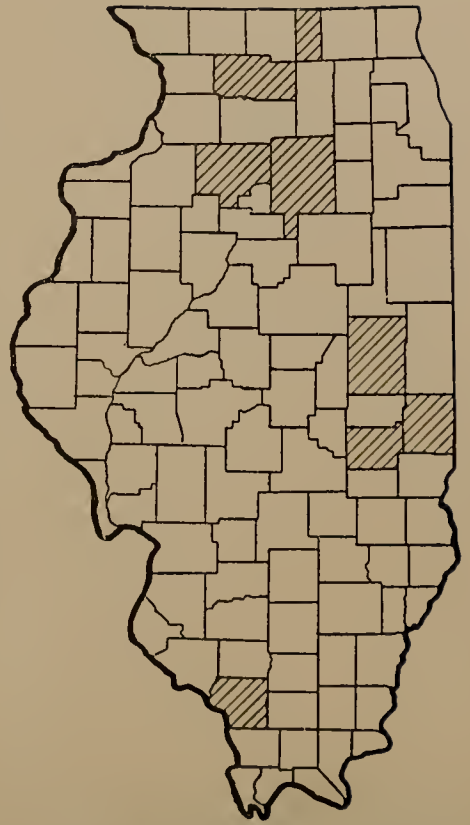
MAP 53.—Distribution of crown-gall of apple in orchards.

MAP 54.—Pear production. One dot represents 1,000 bushels, harvest of 1919.

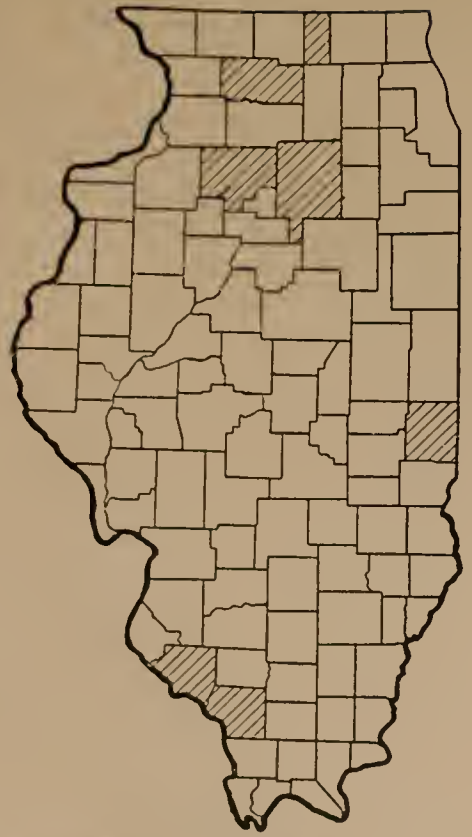
Map 55.—Distribution of pear blight.



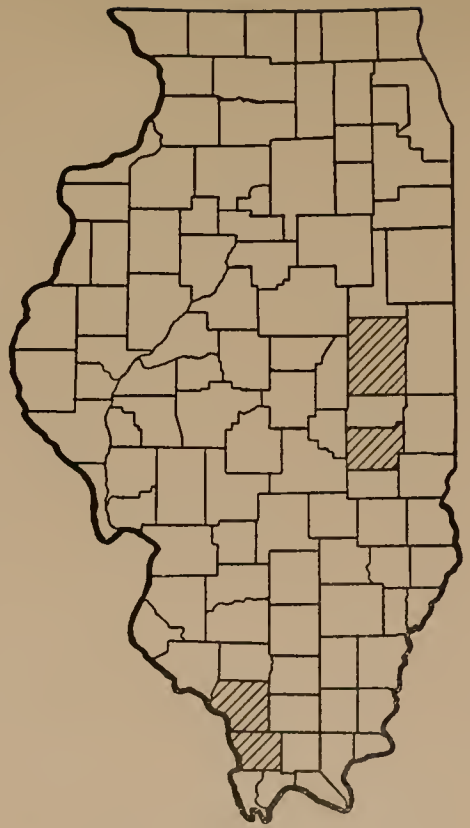
Map 56.—Distribution of leaf blight of pear.



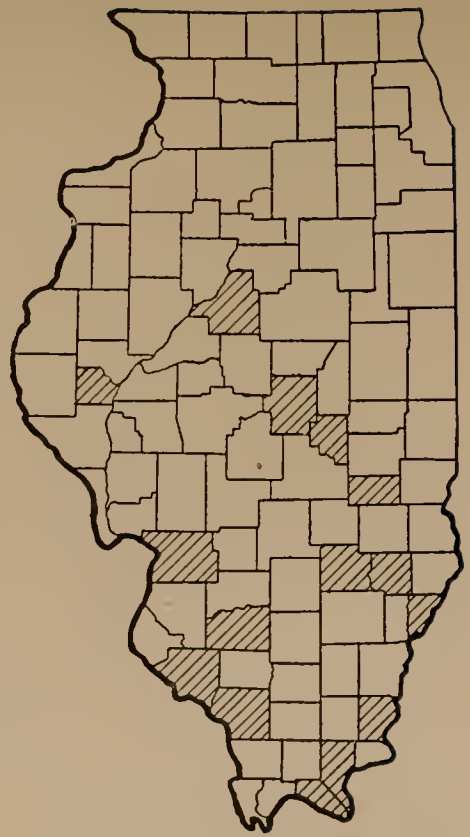
Map 57.—Distribution of pear scab.



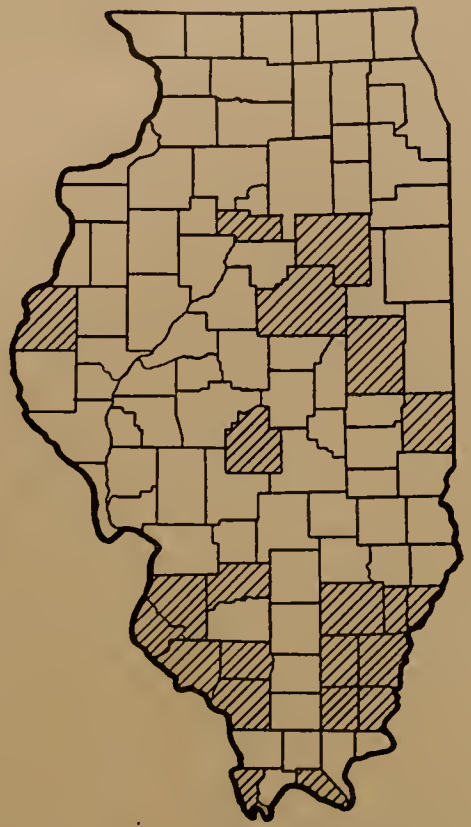
MAP 58.—Distribution of black rot of pear.



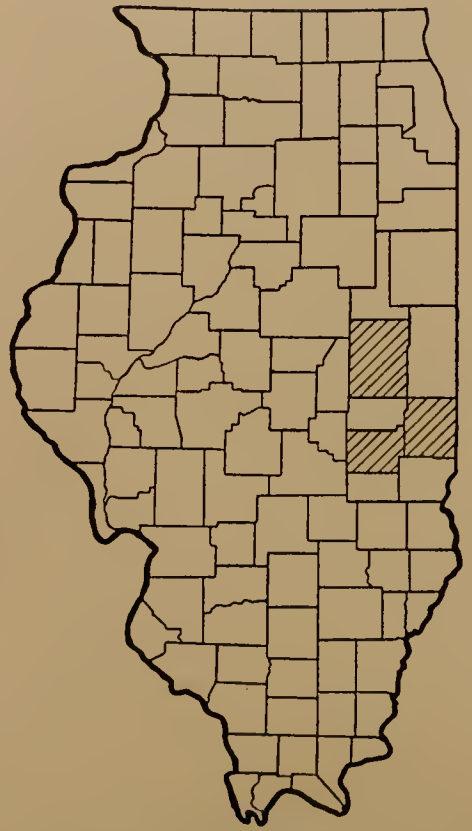
MAP 59.—Distribution of pear leaf-spot.



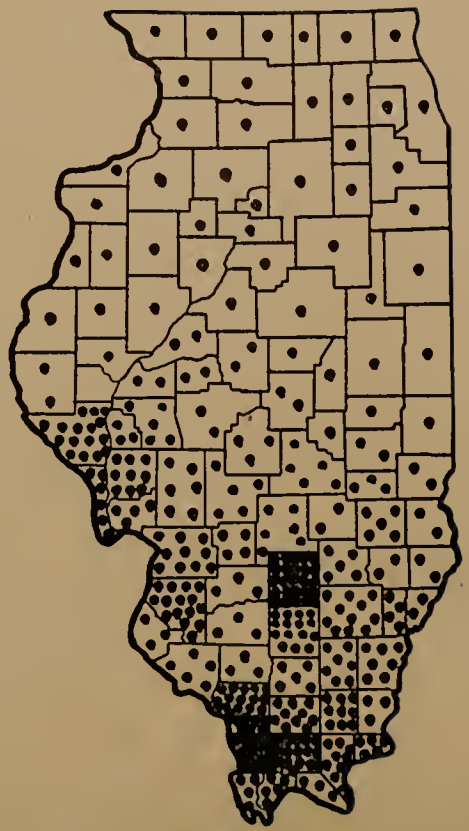
MAP 60.—Distribution of leaf blight of quince.



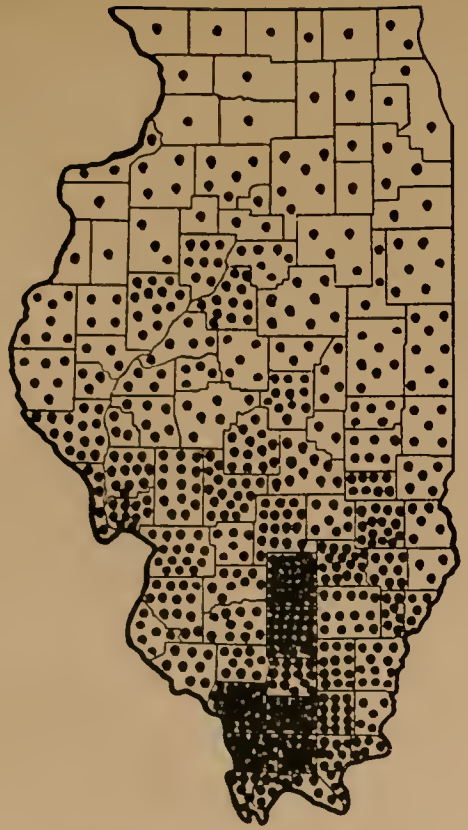
MAP 61.—Distribution of fire-blight of quince.



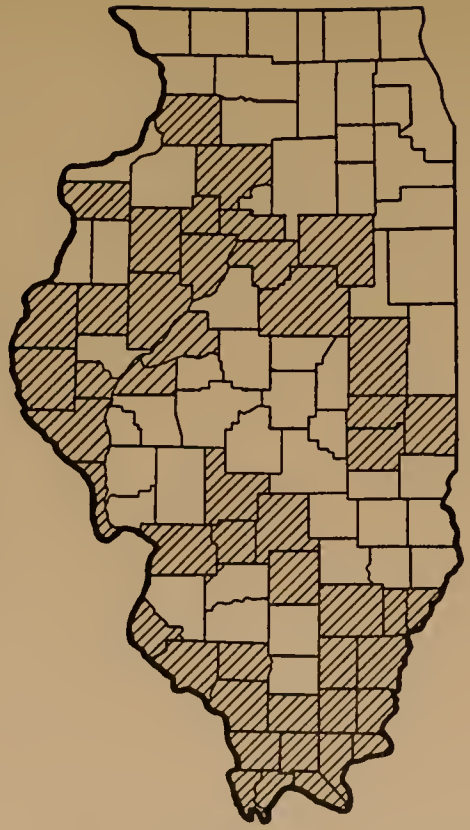
MAP 62.—Distribution of powdery mildew of quince.



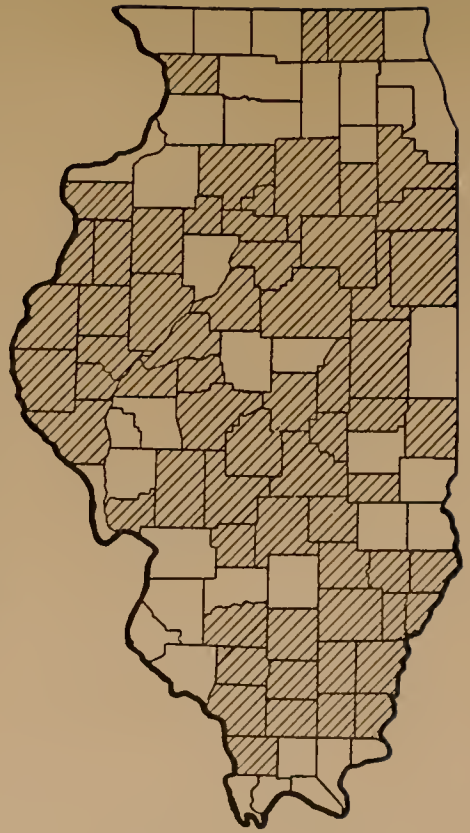
MAP 63.—Peach production. One dot represents 1,000 bushels—harvest of 1919.



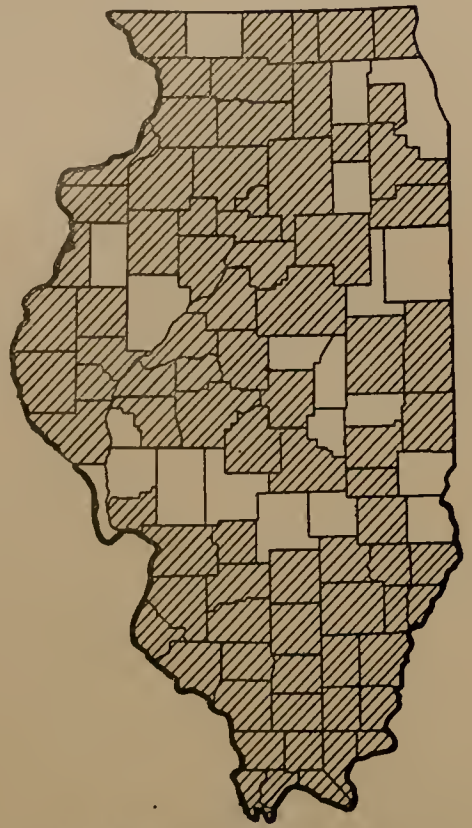
MAP 64.—Distribution of peach trees in 1923. One dot represents 2,000 trees.



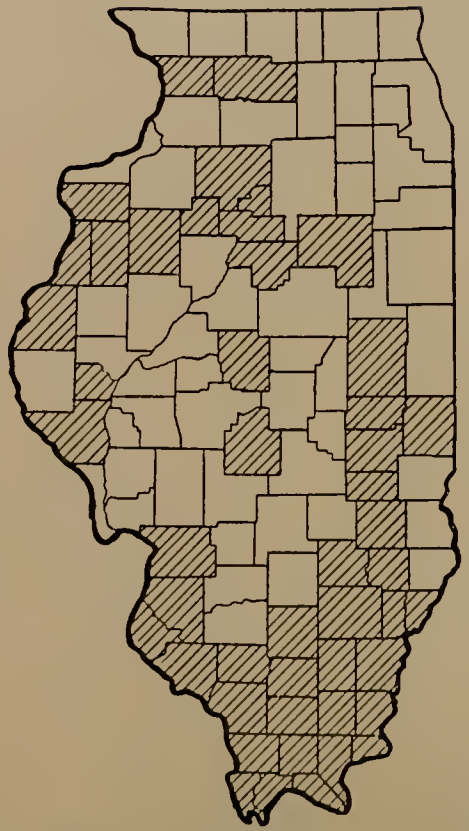
MAP 65.—Distribution of brown rot of peach.



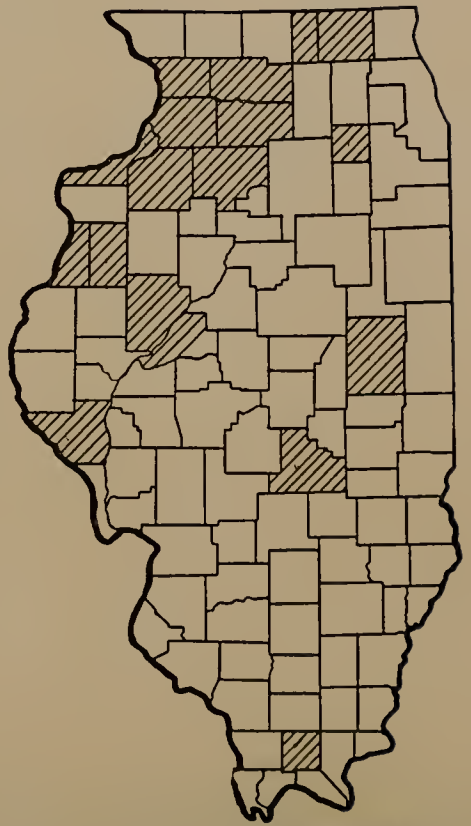
MAP 66.—Distribution of peach leaf-curl.



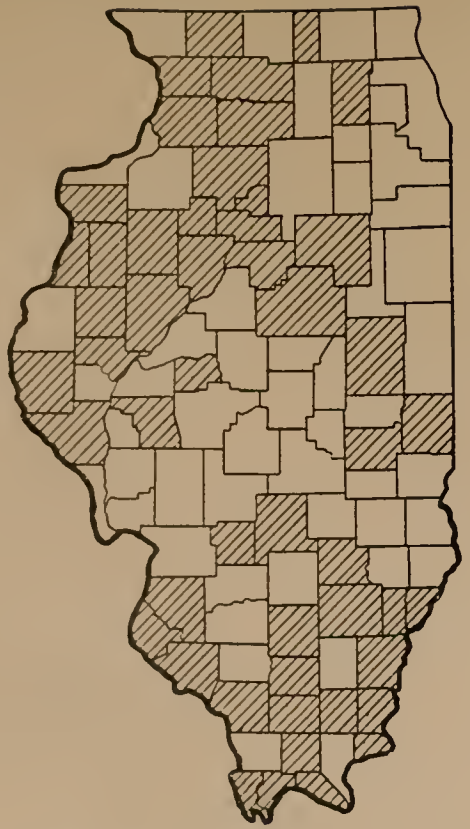
MAP 67.—Distribution of bacterial shot-hole of peach.



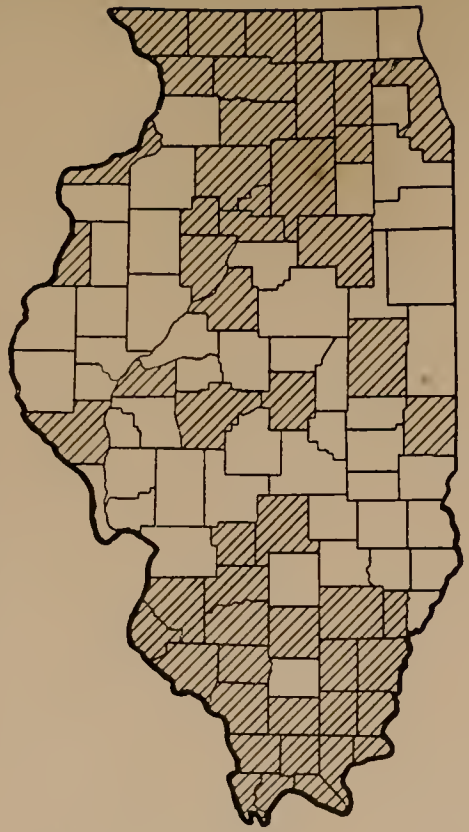
MAP 68.—Distribution of peach scab.



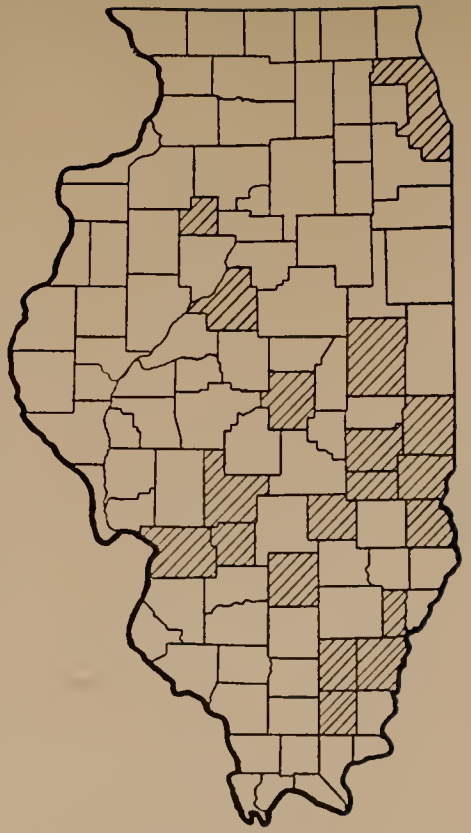
MAP 69.—Distribution of peach die-back.



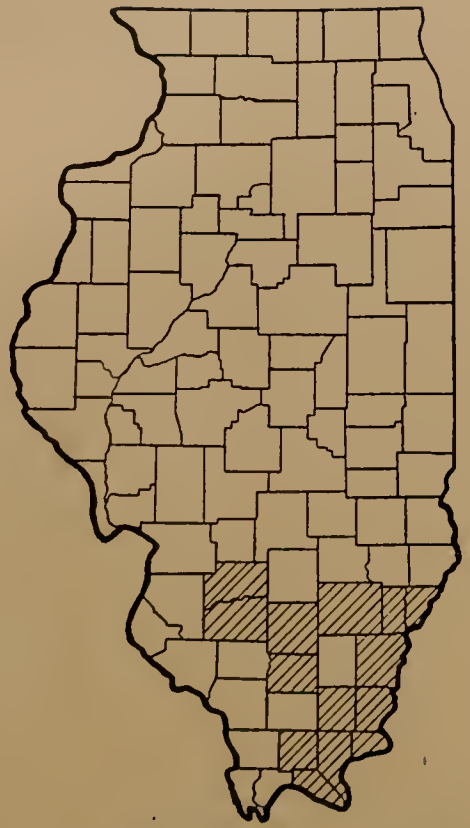
MAP 70.—Distribution of brown rot of plum.



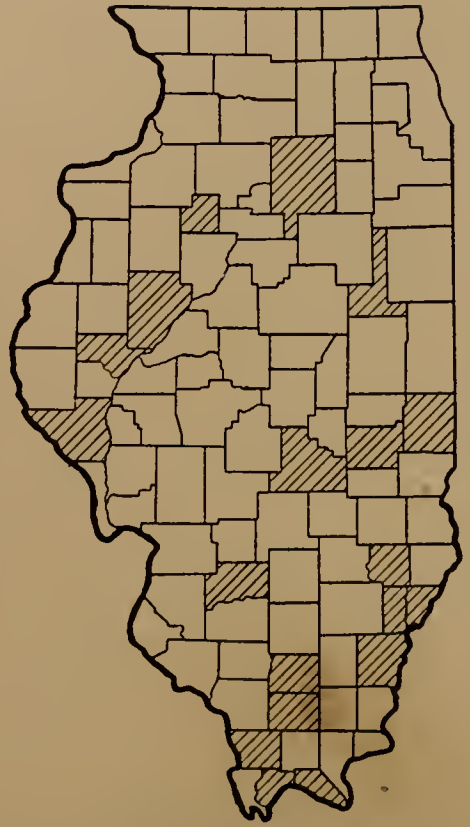
MAP 71.—Distribution of leaf blight of plum.



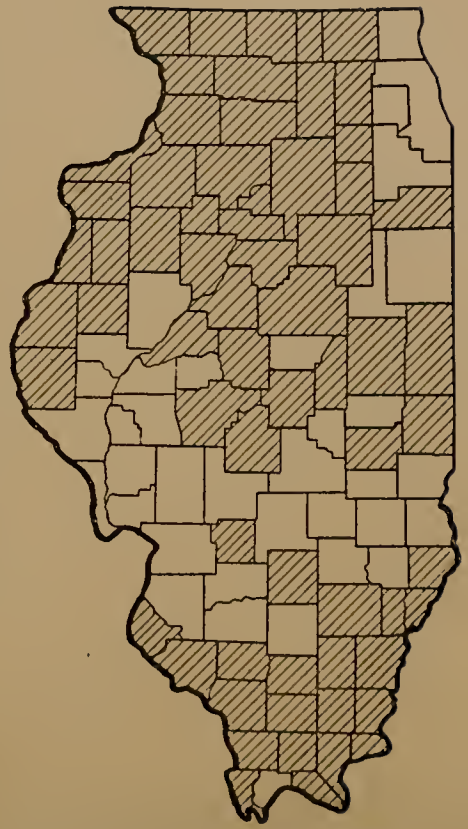
MAP 72.—Distribution of black-knot of plum.



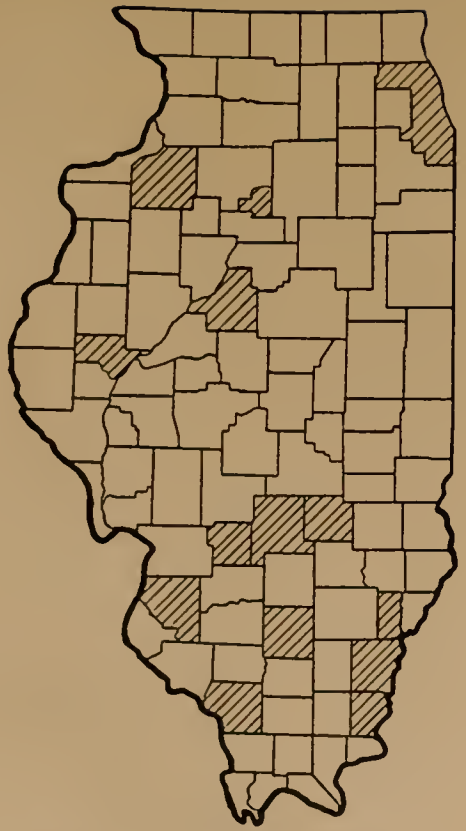
MAP 73.—Distribution of the bacterial shot-hole of plum.



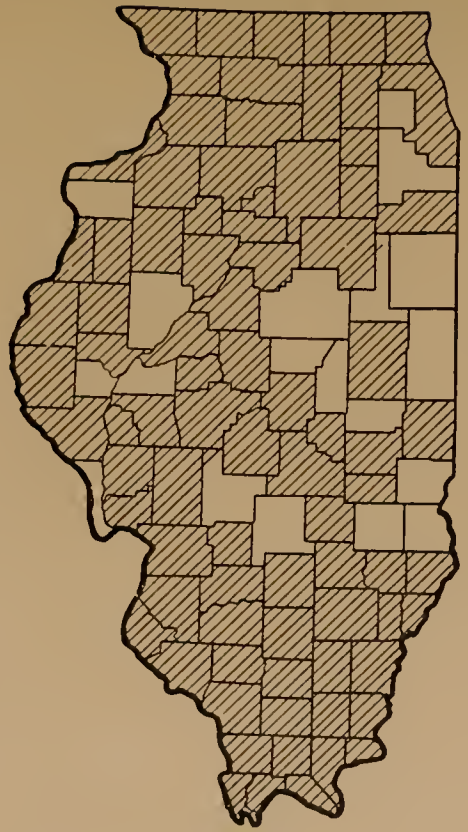
MAP 74.—Distribution of leaf-curl of plum.



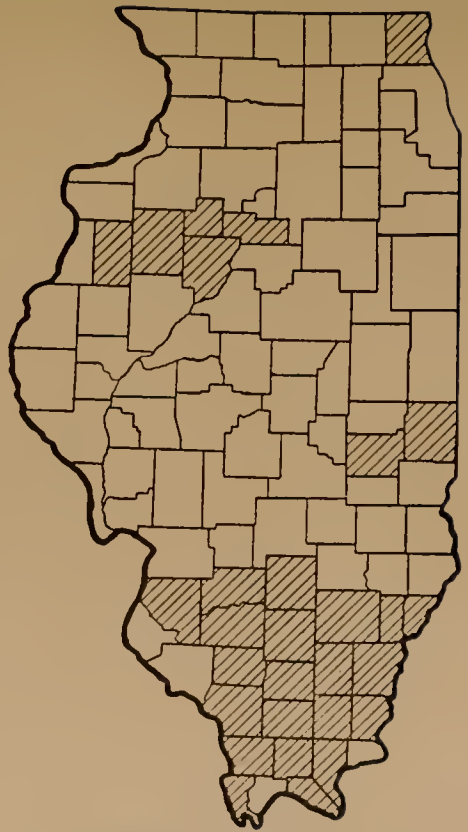
MAP 75.—Distribution of powdery mildew of cherry.



MAP 76.—Distribution of brown rot of cherry.

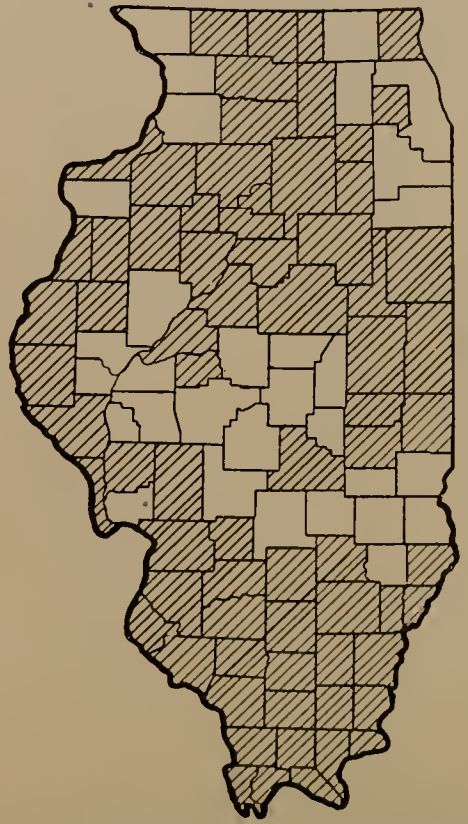


MAP 77.—Distribution of cherry leaf-blight.

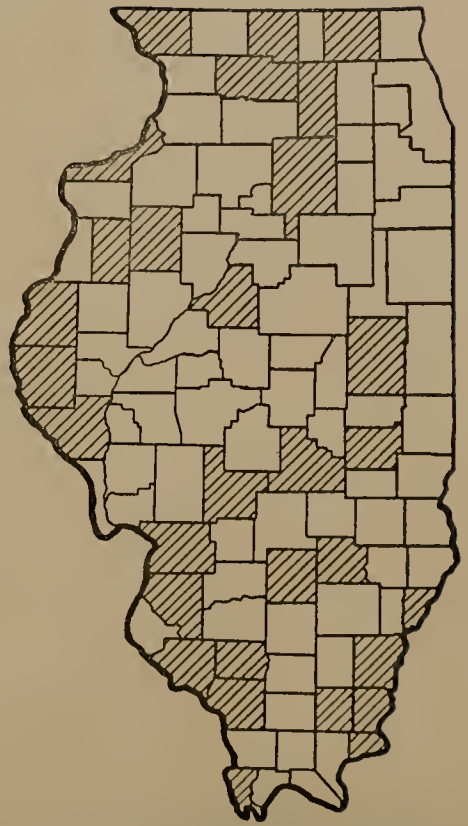


MAP 78.—Distribution of the leaf blight of black cherry.

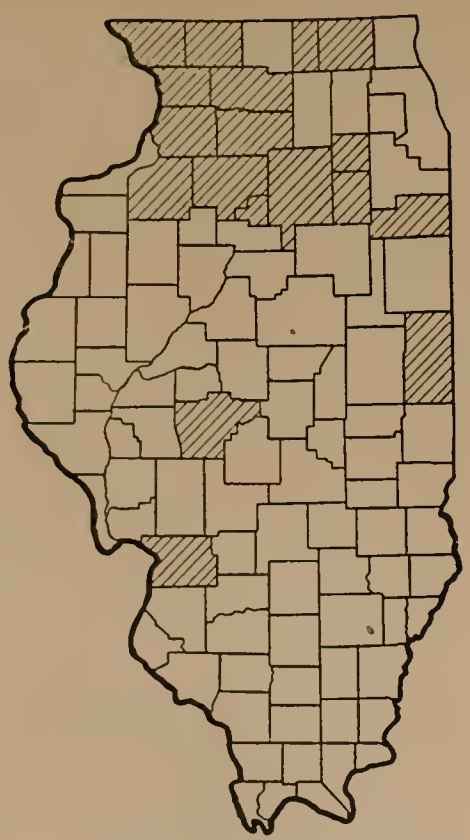
MAP 79.—Grape production. One dot represents 1,000 vines.



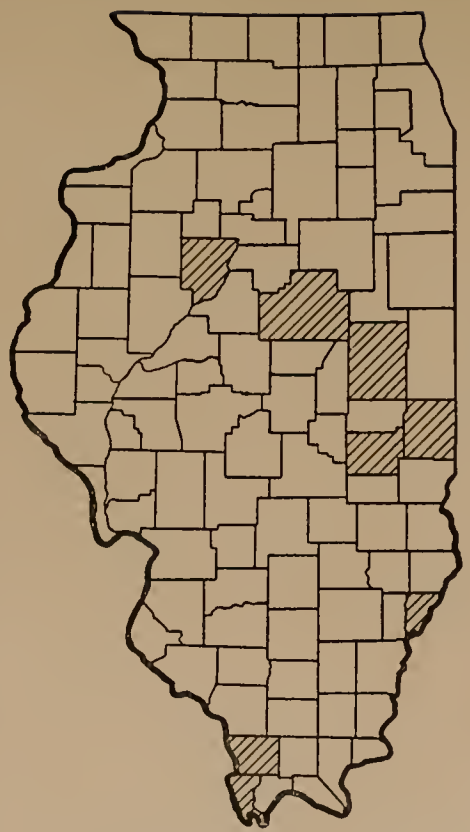
MAP 80.—Distribution of black rot of grape.



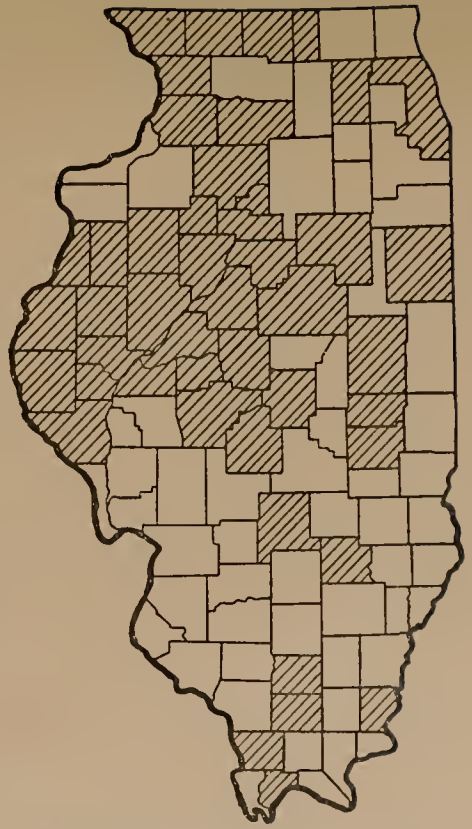
MAP 81.—Distribution of downy mildew of grape.



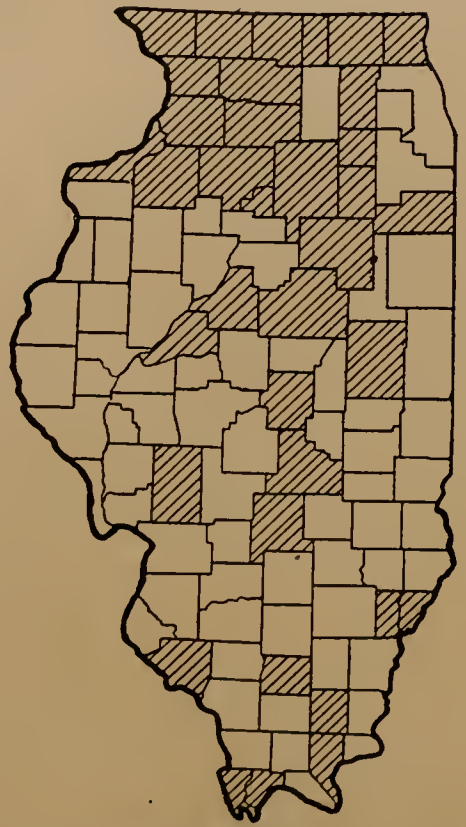
MAP 82.—Distribution of grape anthracnose.



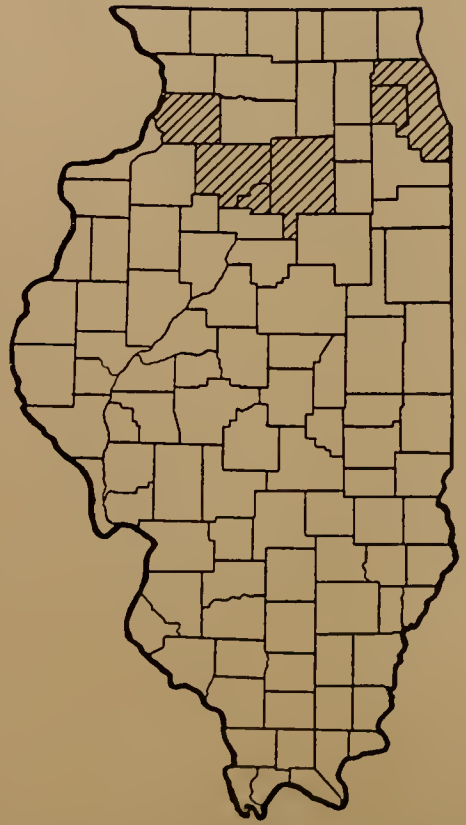
MAP 83.—Distribution of powdery mildew of grape.



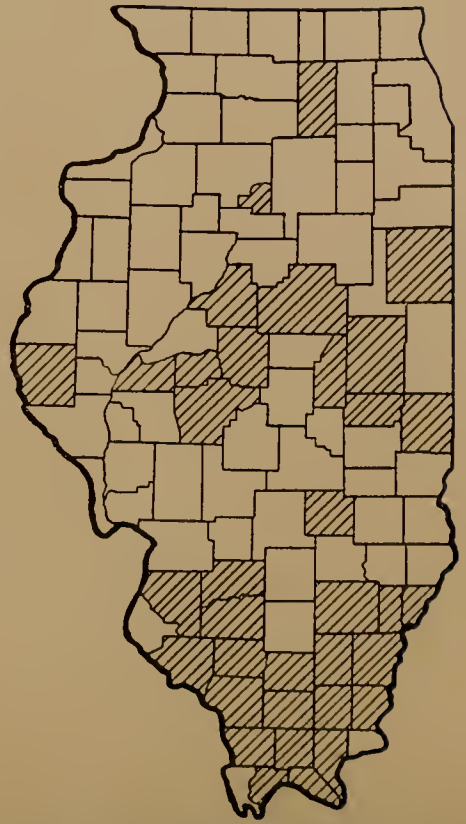
MAP 84.—Distribution of anthracnose of blackberry and raspberry.



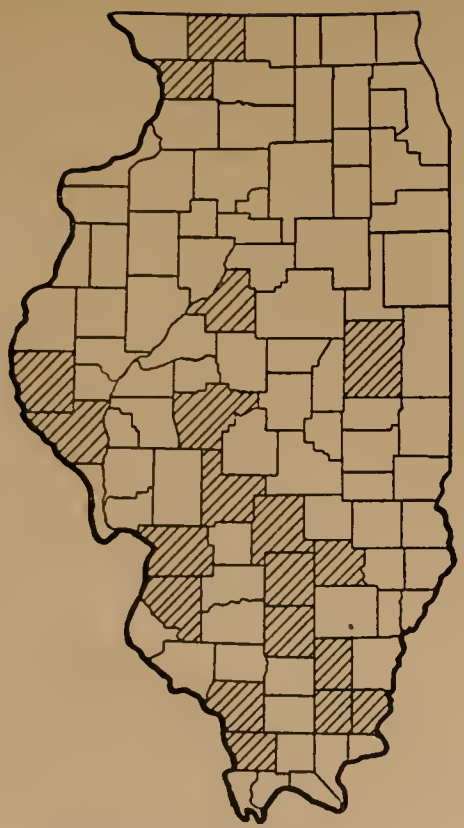
MAP 85. — Distribution of raspberry cane-blight.



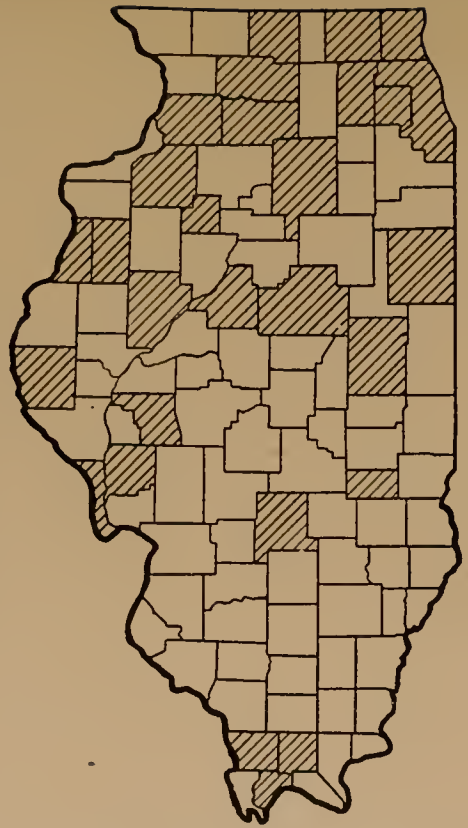
MAP 86. — Distribution of raspberry spur-blight.



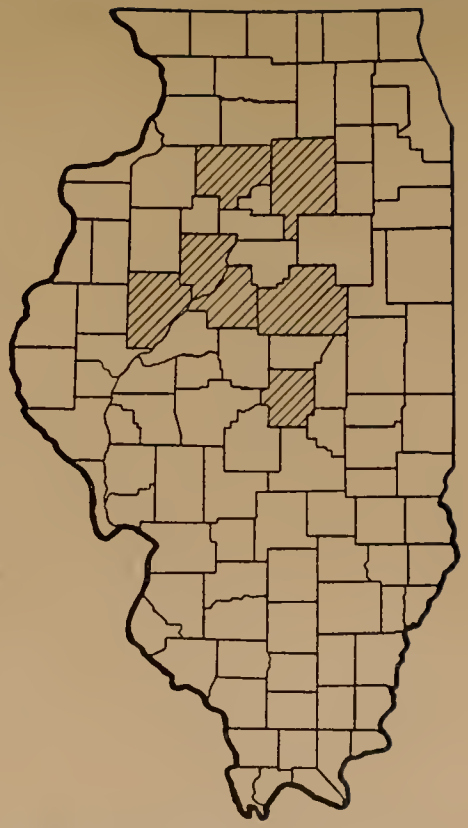
MAP 87.—Distribution of leaf spot of raspberry and blackberry.



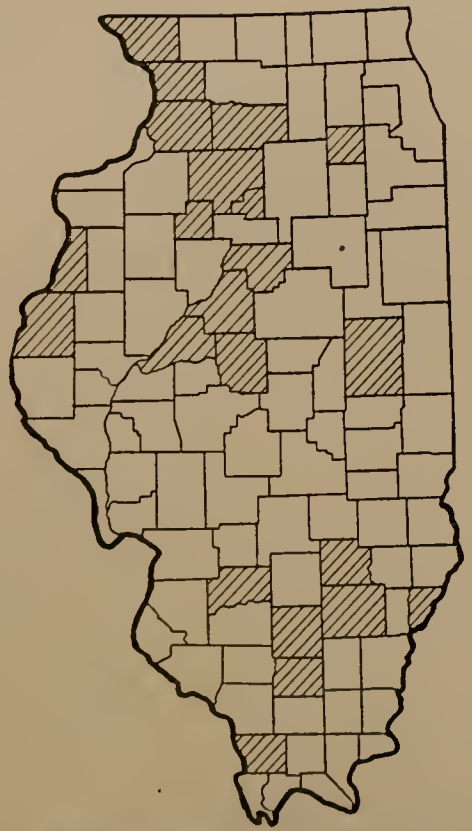
MAP 88.—Distribution of orange rust of brambles.



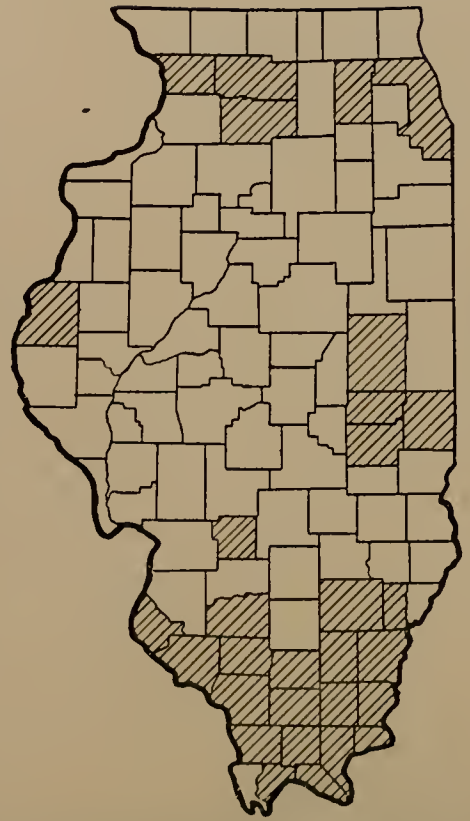
MAP 89.—Distribution of crown-gall of brambles.



MAP 90.—Distribution of bramble-streak of black-cap raspberry.

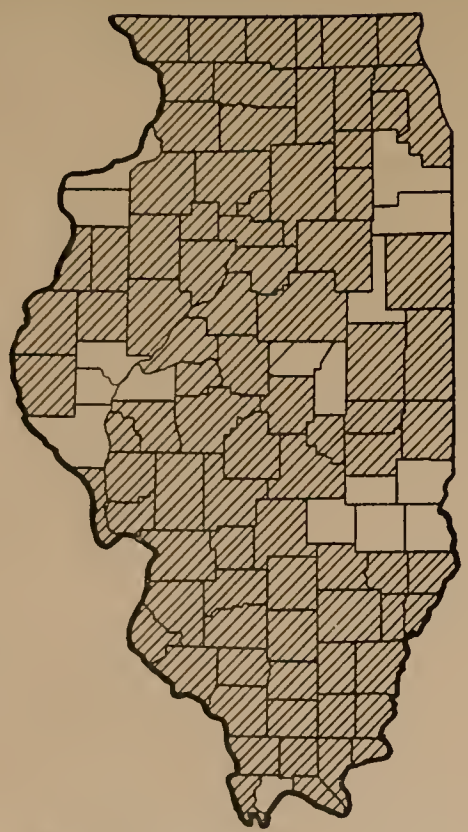


MAP 91.—Distribution of anthracnose of currant and gooseberry.

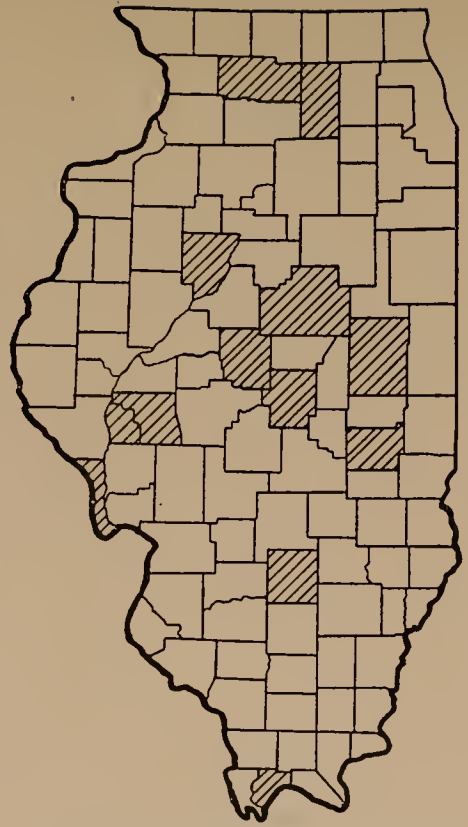


MAP 92.—Distribution of currant and gooseberry leaf-spot.

MAP 93.—Distribution of strawberry acreage. One dot represents 10 acres.

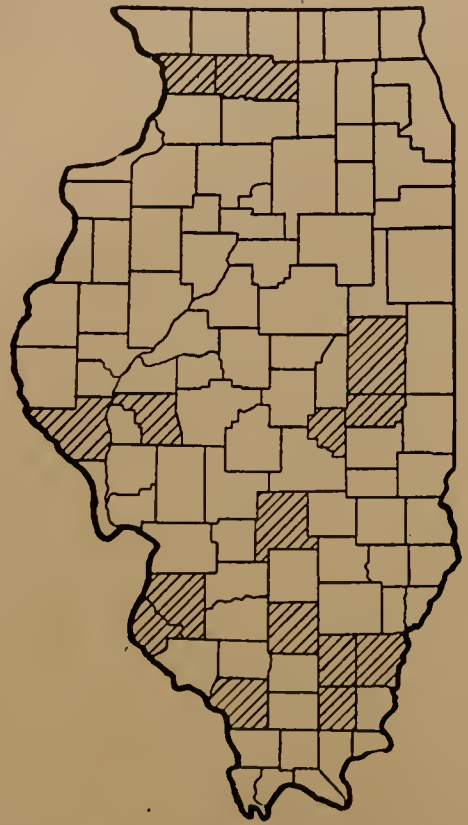


MAP 94.—Distribution of the Mycosphaerella leaf-spot of strawberry.

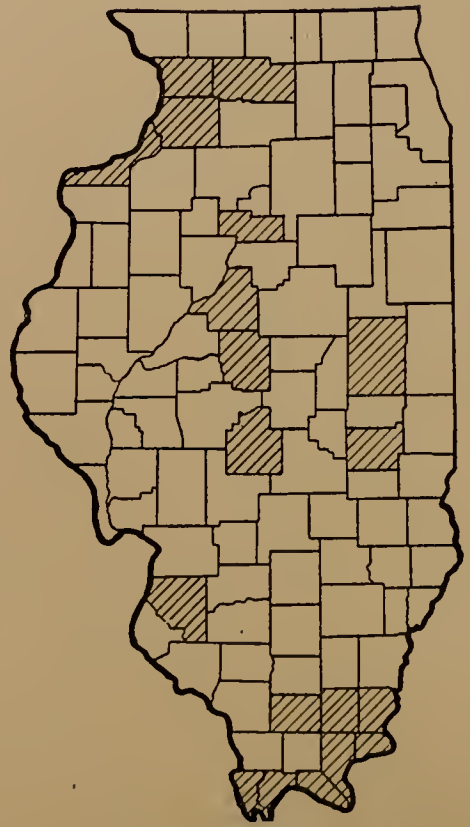


MAP 95.—Distribution of the Dendrophoma leaf-spot of strawberry.

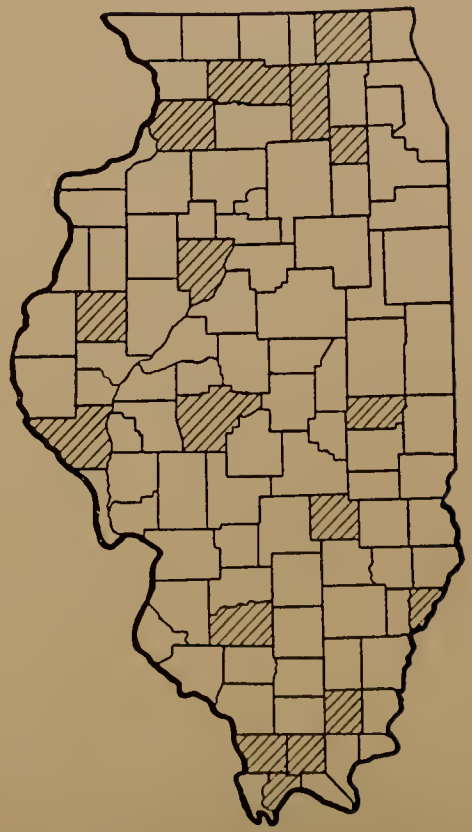
MAP 96.—Distribution of potato acreage in 1922. One dot represents 500 acres.



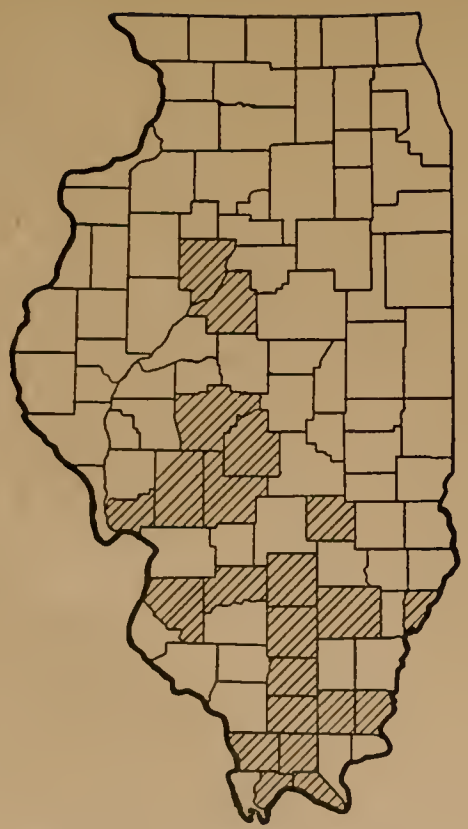
MAP 97.—Distribution of early blight of potato.



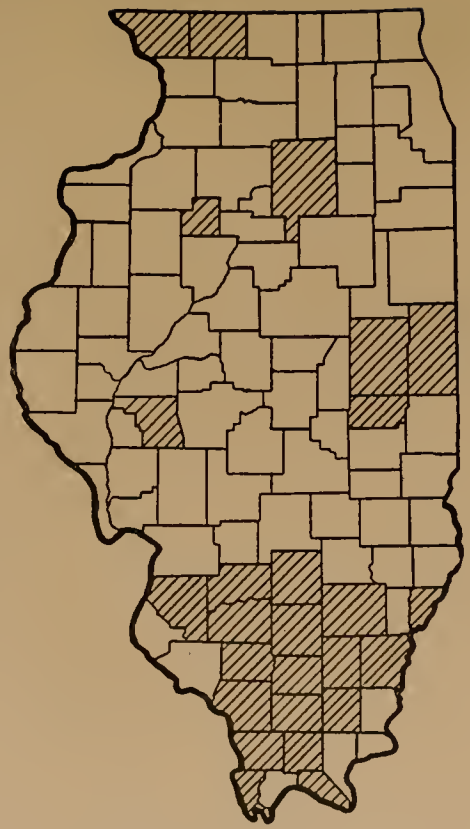
MAP 98.—Distribution of potato scab.



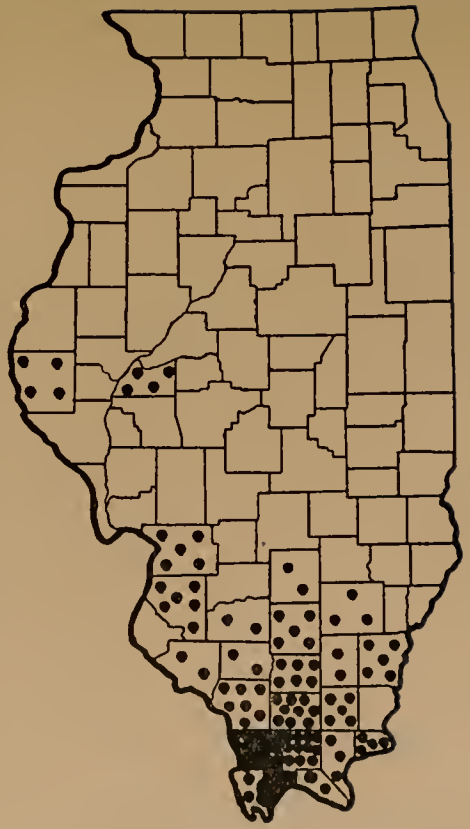
MAP 99.—Distribution of early blight of tomato.



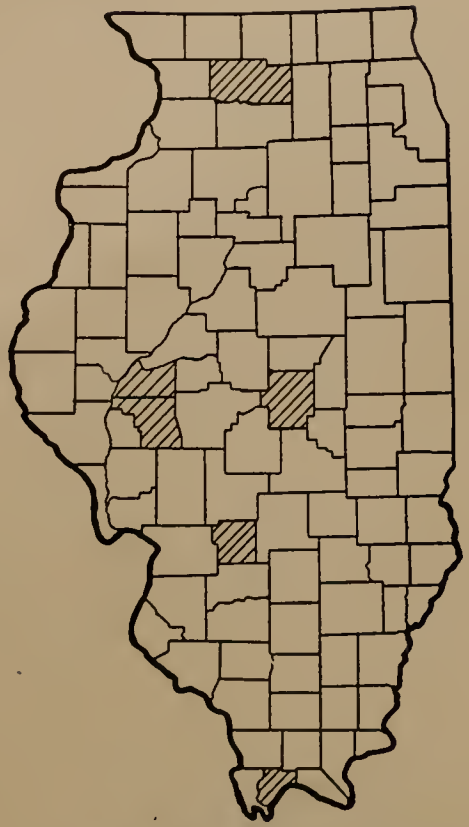
MAP 100.—Distribution of tomato wilt.



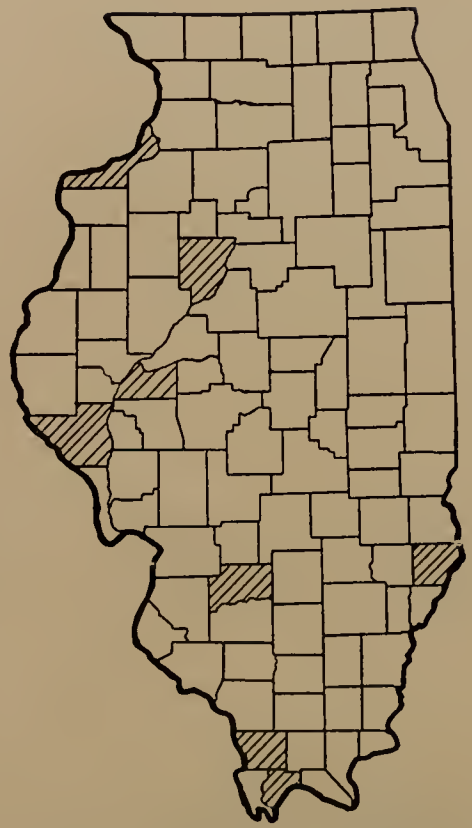
MAP 101.—Distribution of tomato leaf-spot.



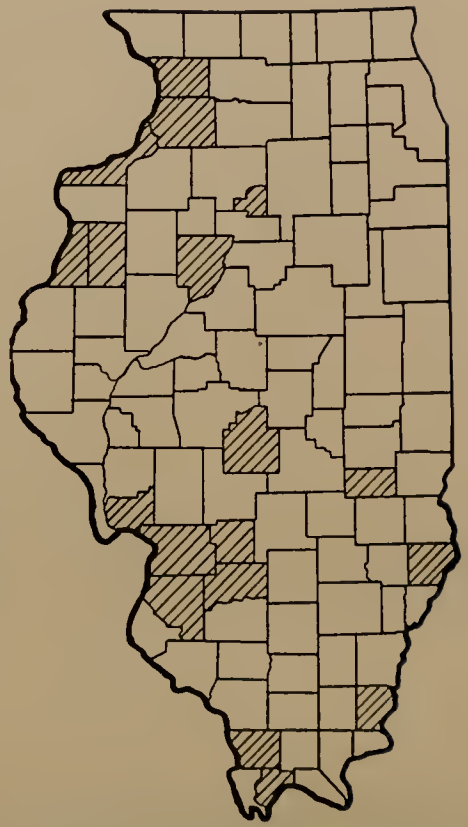
MAP 102.—Distribution of sweet-potato acreage. One dot represents 50 acres.



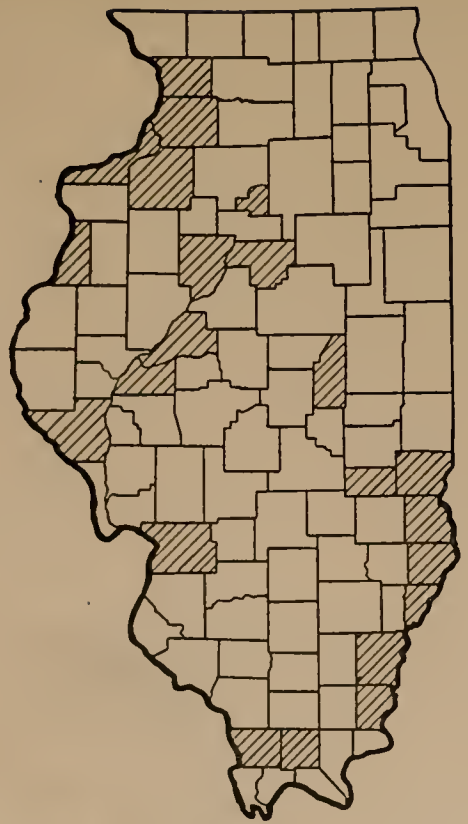
MAP 103.—Distribution of the black rot of sweet potato.



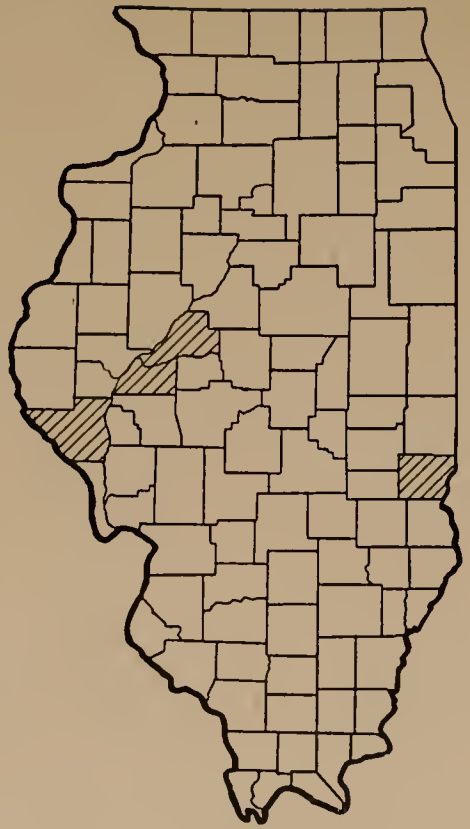
MAP 104.—Distribution of sweet-potato wilt.



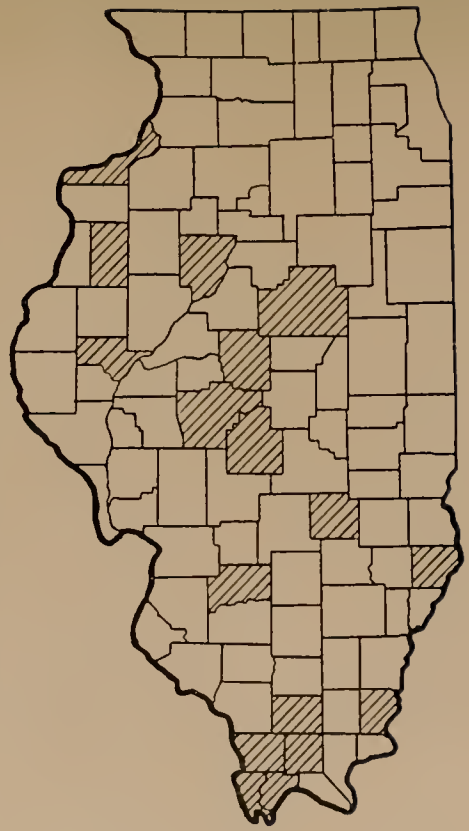
MAP 105.—Distribution of cantaloupe wilt.



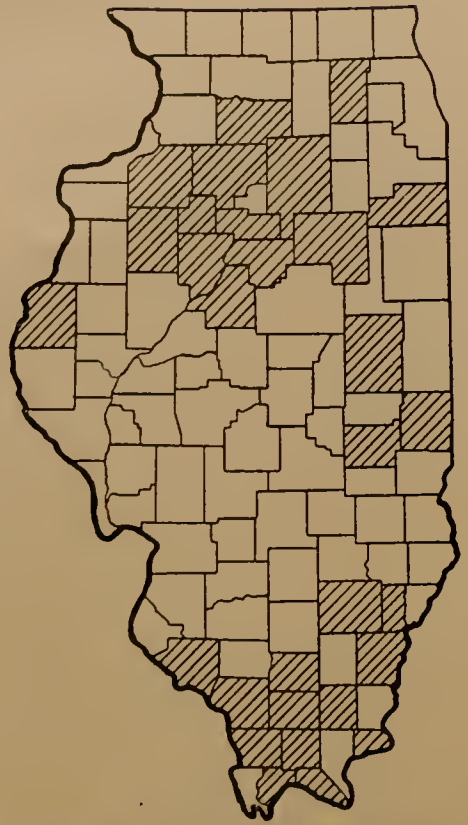
MAP 106.—Distribution of watermelon wilt.



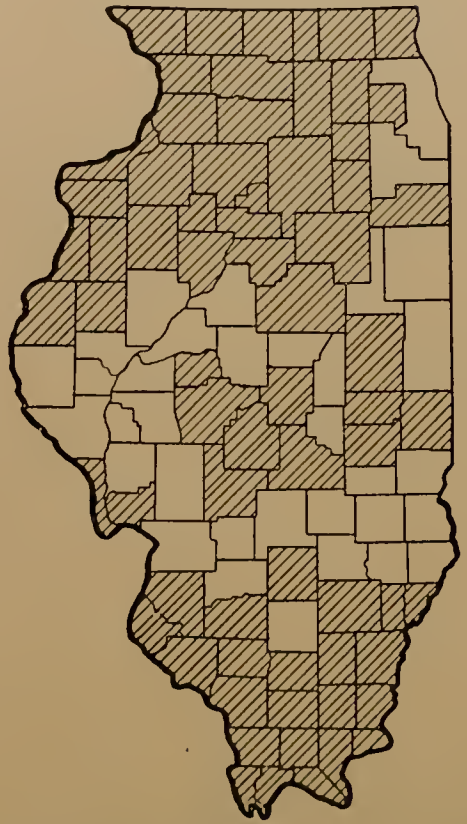
MAP 107.—Distribution of watermelon anthracnose.



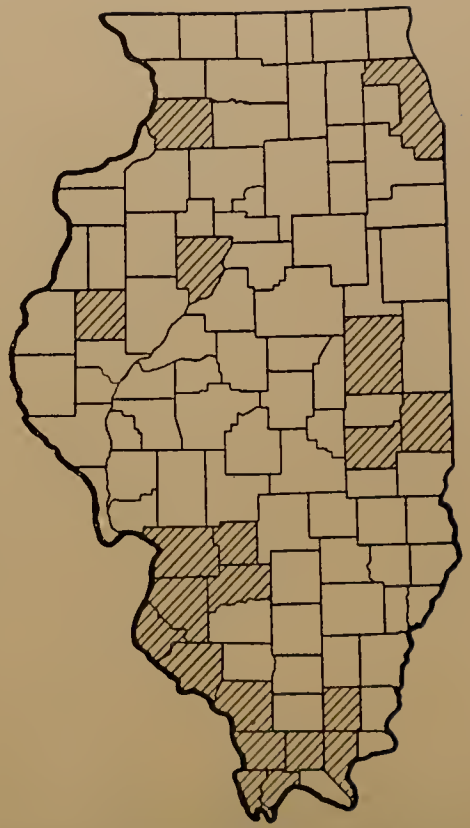
MAP 108.—Distribution of cucumber wilt.



MAP 109.—Distribution of asparagus rust.

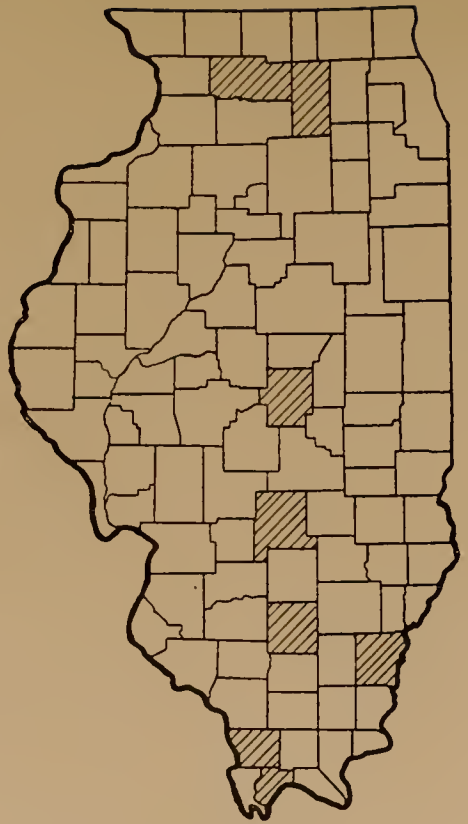


MAP 110.—Distribution of leaf spot of beet and Swiss chard.

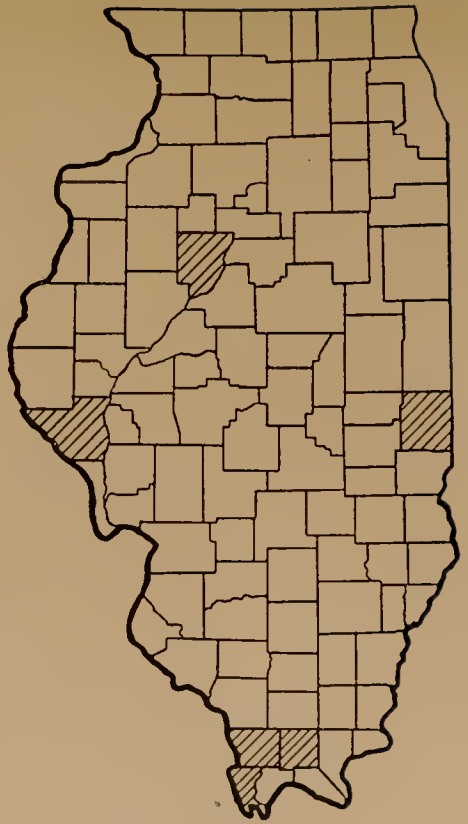


MAP 111.—Distribution of cabbage yellows.

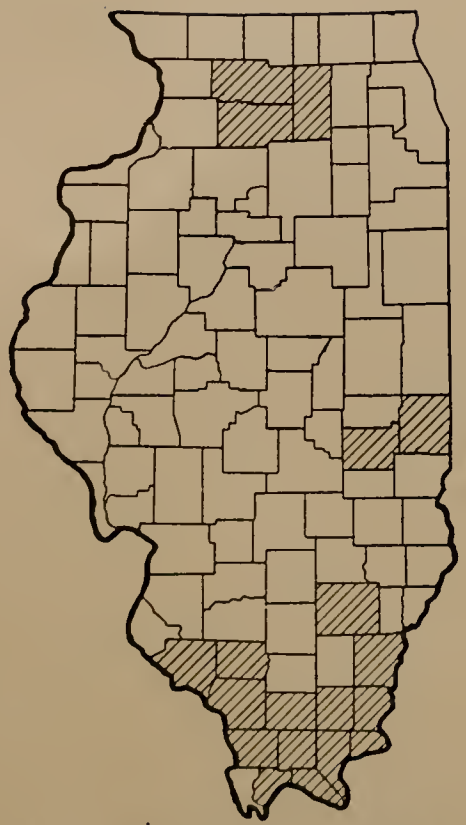
MAP 112.—Distribution of black rot of cabbage.



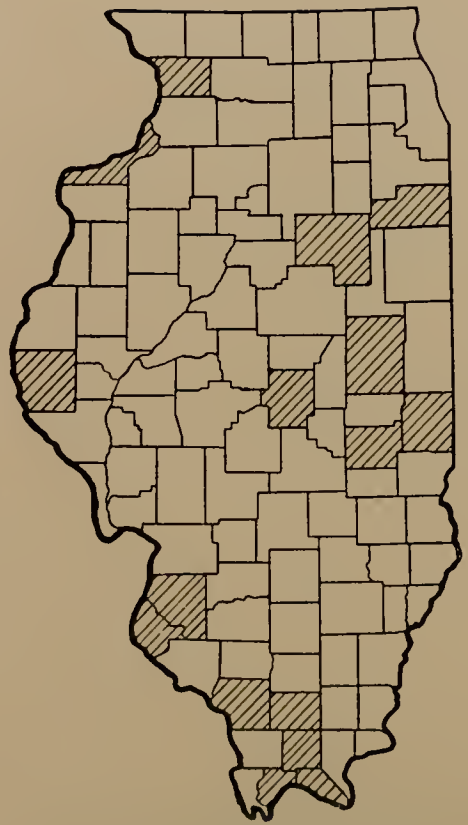
MAP 113.—Distribution of bean blight.



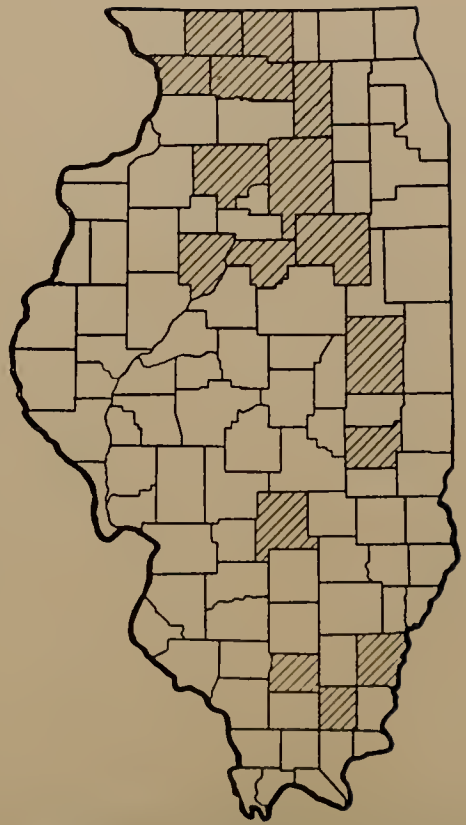
MAP 114.—Distribution of bean rust.



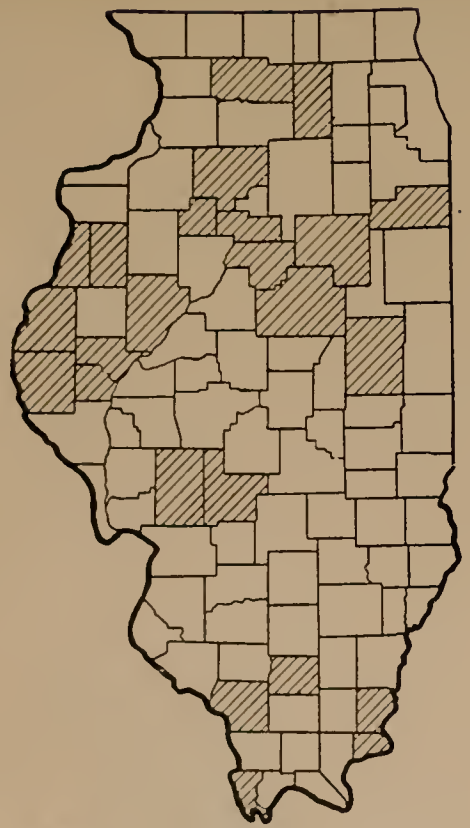
MAP 115.--Distribution of lettuce blight.



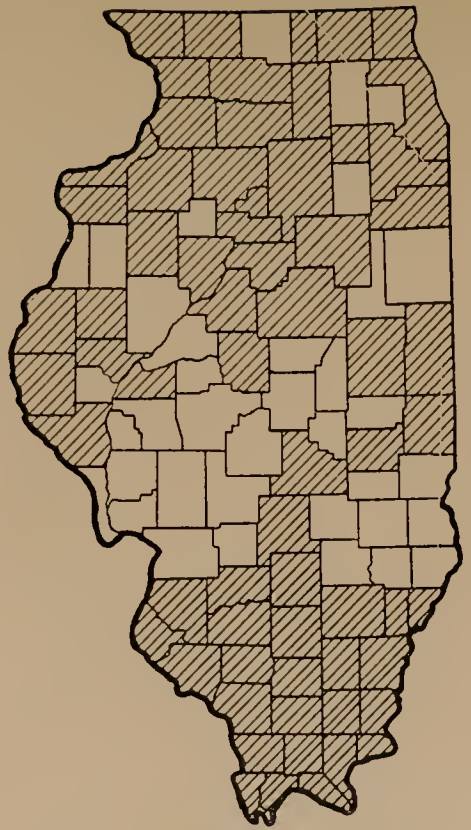
MAP 116.—Distribution of rhubarb leaf-spot.



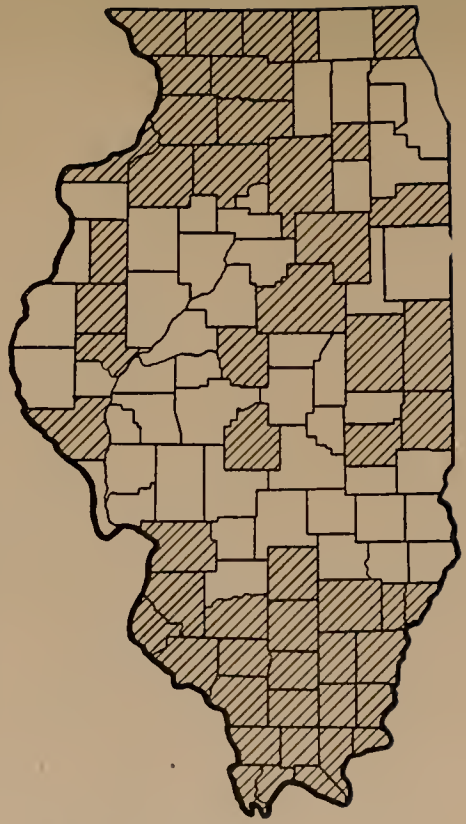
MAP 117.—Distribution of white rust of radish



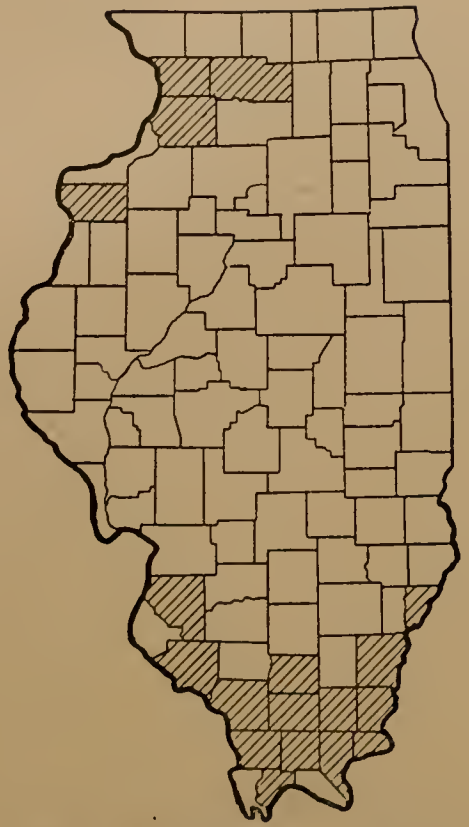
MAP 118.—Distribution of horseradish leaf-spot.



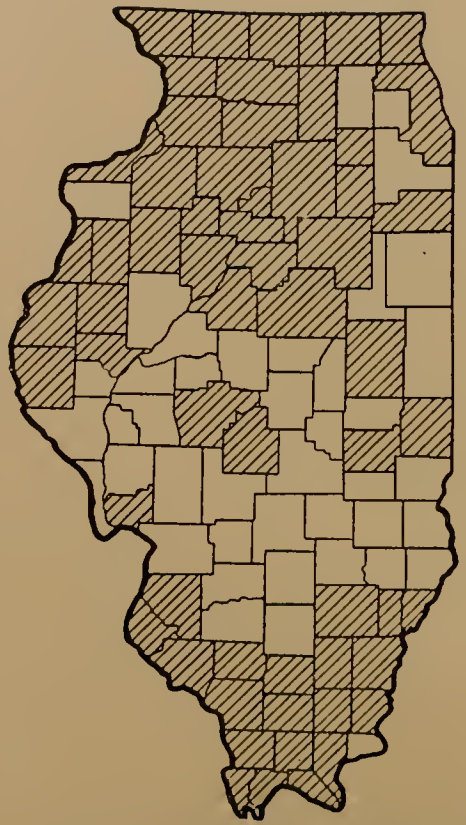
MAP 119.—Distribution of powdery mildew of rose.



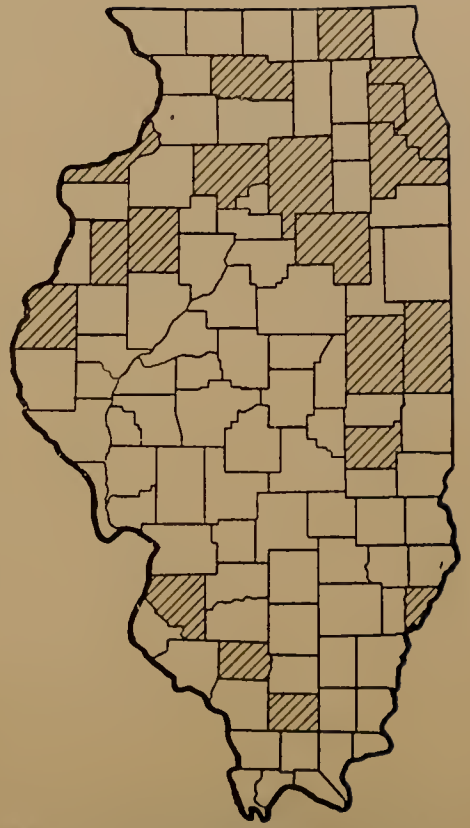
MAP 120.—Distribution of black spot of rose.



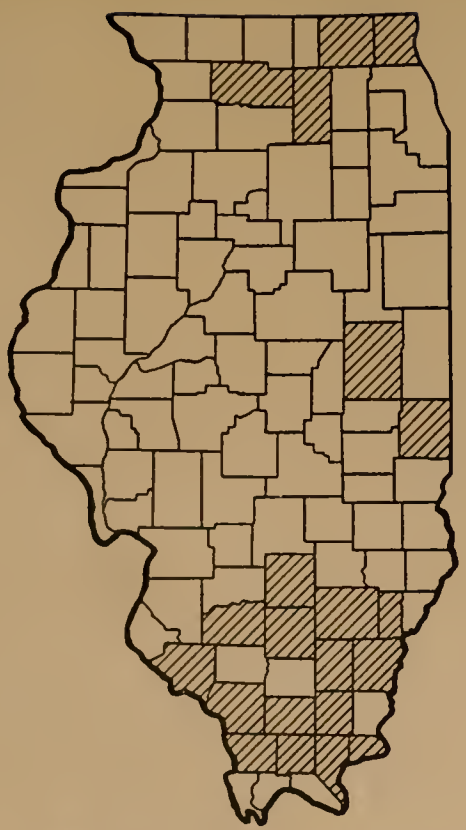
MAP 121.—Distribution of rose leaf-spot.



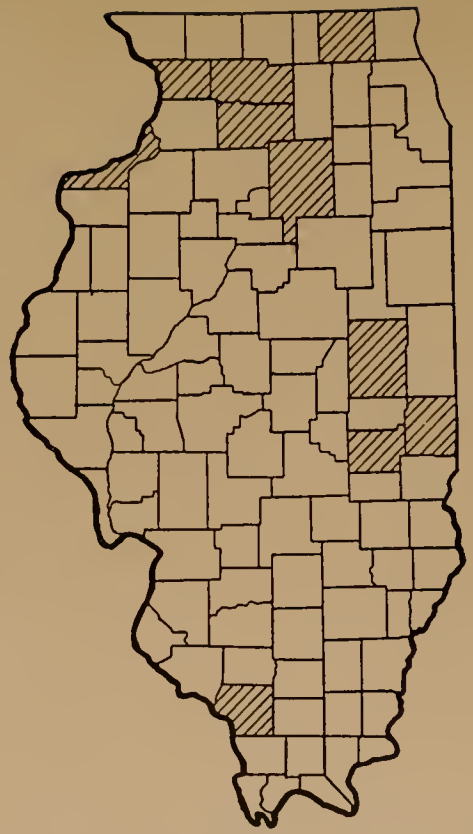
MAP 122.—Distribution of powdery mildew of lilac.



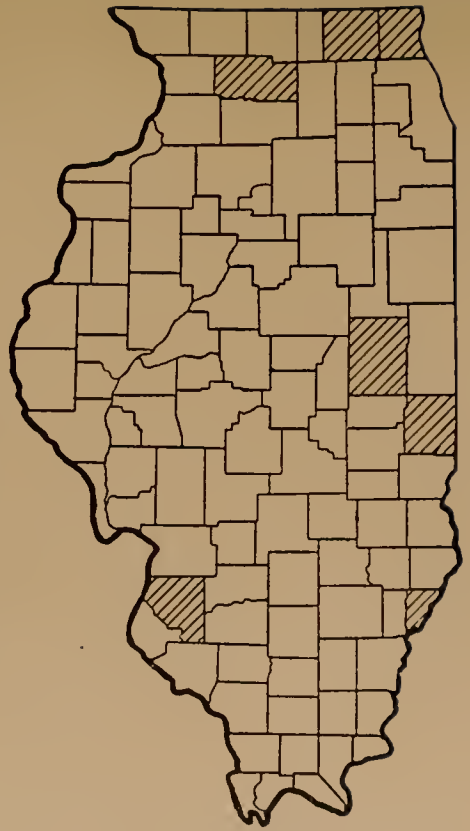
MAP 123.—Distribution of carnation rust.



MAP 124.—Distribution of leaf spot of Virginia creeper.



MAP 125.—Distribution of powdery mildew of Virginia creeper.



MAP 126.—Distribution of snapdragon rust.