Kernel rots, the ravages from which are pictured in the upper illustration on the preceding page, are one cause of the heavy losses that Illinois growers experience from corn diseases. In corn cribbed long enough to be dry, damage from these rots is the factor that usually determines the commercial grade.

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H. W. Mumford, Director, Extension Service in Agriculture and Home Economics, University of Illinois
Combating Corn Diseases in Illinois

By BENJAMIN KOEHLER and JAMES R. HOLBERT

No cornfield is entirely free from corn diseases. To estimate the losses that corn-belt farmers suffer every year as a result of them would be a difficult task. It is safe to say that the toll runs into hundreds of thousands of dollars. Whether the losses are severe, moderate, or slight depends not only on weather conditions, but also on the measures that farmers take to prevent them, for most of these diseases can be dealt with by well-tried methods of prevention. Disease control thus becomes an important part of any corn-improvement program.

The principal measures for combating diseases are the selection of a good strain of corn for planting, the proper care and treatment of the seed, the maintenance or building up of a balanced fertility of the soil, securing proper drainage, practicing crop rotations, and making thorough seedbed preparation. This circular discusses particularly the selection of the strain for planting and the care of the seed. It also describes and illustrates the principal diseases that occur in Illinois corn, and points out their causes, thus making it possible for farmers to recognize them and combat them more effectively.

Some corn diseases are very conspicuous and easy to recognize. Every grower is well acquainted with ear rots and smut, the presence of which he usually considers to be inevitable. But he often does not notice the diseases, many of them important, that have no conspicuous external symptoms—those that are of an insidious nature, or cause a general weakening of the plant. Growers should know about these inconspicuous diseases, as well as the better-known ones, so that they can take the necessary measures to reduce the losses that result from them.

CHOOSING THE STRAIN FOR PLANTING

Obviously the first step in a program for controlling corn diseases is to choose a strain for planting that offers a high degree of resistance. The development and use of disease-resistant hybrids in so far as re-

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sistance can be obtained, is the most desirable method for controlling all the corn diseases. Good progress toward the control of certain diseases by this method has already been made. In so far as the corn plants themselves, because of inherited characteristics, are able to resist disease invasion, the expense of time and labor used in other methods of control may be lessened.

Many hybrid corns and strains of open-pollinated corn that offer varying degrees of disease resistance are available. To choose intelligently, a grower should know his own soils, the diseases it is necessary to combat on his farm, the characters desirable in a good corn strain, the adaptability of the several strains available, and the relative possibilities offered by open-pollinated and hybrid corns.

Disease Resistance Not Only Quality to Look For

Tho disease resistance in corn is in itself a very complex matter, it is only one of the important characters that the grower desires in a corn strain, and unless it can be combined with other desirable characters it is of little value. Some of the more important of the desirable characters are the following:

1. Adaptation to the length of growing season where the corn is to be planted.
2. High yield of good quality grain.
3. Resistance to the fungi and bacteria that cause diseases. (The factors that make for the resistance of each disease are, for the most part, inherited independently, so that a strain resistant to ear rots may nevertheless be susceptible to stalk rots, or vice versa.)
4. Ability to repel chinch bugs and other destructive insects, or at least not to suffer serious injury from them.
5. A strong root system that holds the plant erect even under heavy rains and wind.
6. A firm stalk—one that will not break down.
7. Ability to germinate and grow in cold soil at planting time, and to continue growth in cool weather in the fall.
8. Ability to withstand heat and drouth.
9. Capacity to use soil minerals and moisture efficiently.
10. Location of the ear at a convenient height on the stalk.

No strain of corn is likely to possess all of the above characteristics in equal degree, nor are the characteristics equal among themselves in economic importance. In choosing a strain for planting, therefore, a grower should decide which characteristics are most desirable, and he should then match the strains of corn in question against the desirable list.
Open-Pollinated Strains Limited in Improvement

Many farmers in Illinois have improved their own strains of open-pollinated corn by selecting seed from the best and most disease-free corn plants in the field. After drying the ears under as good drying conditions as could be obtained on the farms, they have culled the ears according to weight, luster, horny endosperm, freedom from discolorations, and other characteristics of good corn. Those who have tried to do the best possible job have followed the culling by a germination test in which ears were further selected for vigor of germination and freedom from disease.

That improvements in certain directions were obtained by this selection method has been amply demonstrated by repeated experiments. Judged by increases in stand and yield obtained by seed treatments, seedling diseases are only half as prevalent when the seed is carefully selected according to the above standards as when it is not so selected. Ear rots in corn grown from the selected and from the unselected seed, carefully measured for ten years, show about 50 percent less Fusarium ear rot in the improved corn and 37 percent less total damage from ear rots (Table 1). Some improvement apparently has been obtained also in the control of some other important diseases; and there has been a consistent, although moderate, increase in yield.

But improvement in open-pollinated corn could not be made cumulative indefinitely. After an initial improvement over several years,

<table>
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<td>3.4</td>
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Acre-yields of sound corn

<table>
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<th>1933</th>
<th>1934</th>
<th>1935</th>
<th>1936</th>
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<td>67.7</td>
<td>32.2</td>
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</table>

*The old show corn type was slightly larger in ear diameter, rougher in indentation, and somewhat more "starchy" in endosperm composition than the Improved Reid Yellow Dent.
further improvement in yields obtained and in resistance to the diseases under consideration become difficult or impossible to attain. This was true because close selection means close breeding, which in turn directly defeats some of the objectives being sought. Furthermore, some characters that are desirable in corn cannot be selected at all in open-pollinated corn, because they cannot be recognized merely by looking at the plants, ears, or sprouts.

Hybridization Offers Superior Possibilities for Disease Resistance

Recently a new and better method of corn breeding has been developed whereby closest possible selection is practiced by self-pollinating corn plants and their progeny for a period of years and selecting and fixing the characters desired in these inbred lines until they breed true. Crossing then restores the vigor of growth lost by inbreeding.

![Open Pollinated Variety](Image)

![Ear Rot Resistant Hybrid](Image)

**Fig. 1.—Damage From Ear Rots Can Be Reduced by Growing Resistant Hybrids**

The shelled corn in the bucket and jars at the left was a good open-pollinated utility type, but it tested 10.5 percent rot-damaged grains and in June graded No. 4; whereas the kernels of the resistant hybrid (Hybrid 172, Table 1) tested only 5 percent damaged and graded No. 2. The price of No. 2 yellow corn at Chicago in June from 1933 to 1937 averaged 1 cent a bushel higher than for No. 3 and 2½ cents higher than for No. 4.
Smut infections were several times more numerous in the open-pollinated strain than in the hybrid. Selection for disease resistance can be made with more certainty in inbred lines and their crosses than in open-pollinated strains because in the inbred lines and hybrids inheritance is more closely controlled.

The advantage of this method lies in the fact that the inbreds breed true, and when superior strains are produced they can be reproduced year after year.

Much experimentation is needed to determine which inbreds, when combined by crossing, will produce the best hybrids. Four inbreds go into the production of a double cross. No inbred having all the characters desirable in a good corn strain is known; but by using four inbreds, each of which introduces desirable dominant factors into the cross, a fairly satisfactory result may be obtained. Thus one or more of the inbreds may introduce heat and drouth resistance, another ear-rot resistance, another stalk-rot resistance, another high yield, etc. Those inbreds which carry several desirable dominant factors are most valuable.

Altho still in the developmental stage, good hybrids superior to open-pollinated corn in ear-rot resistance (Fig. 1), smut resistance (Fig. 2), standing ability (Fig. 3), and yield of grain (Table 1) are already commercially available for various parts of Illinois.
Choose Hybrids of Known Characters and Adaptation

The mere fact that a corn is a hybrid is no assurance that it has value. Growers in selecting a hybrid for planting should take care that it possesses the characteristics they are looking for. Information on the behavior of many hybrids with respect to yield of grain, resistance to ear rots and to lodging, and maturity (percentage of moisture at harvest) is available in the results of the cooperative corn-performance tests conducted in different temperature zones and on several soil types in Illinois. The Agronomy Department, University of Illinois, Urbana, will supply any interested person with the latest results from these tests. "Strip tests" of corn conducted by farm bureaus in many Illinois counties offer another source of information on the performance and adaptability of hybrids.

![Image of corn fields showing resistance to lodging and stalk breaking](image)

**Fig. 3.—Resistance to Lodging and Stalk Breaking Is Inherited**

The open-pollinated corn (*left* and *center*) failed to stand up under winds and rain; whereas the strongly rooted hybrid (*right*) was resistant to lodging. In the Illinois cooperative corn-performance tests most of the hybrids stood up better than the best open-pollinated varieties.
After determining which hybrid he wishes to plant, a grower should make sure that the seed he buys is true to name, has been produced in a well-isolated field in which the detasseling has been thorough, is well developed and mature, properly cured, nearly free from discoloredations or seed-coat injury, and possesses good germination. The ability, training, and reliability of the seed grower and the facilities at his command for producing hybrid corn seed, are important considerations in evaluating the seed. Certification of seed by the Illinois Crop Improvement Association offers some assurance that satisfactory standards have been met.

Corn grown from hybrid seed should not be saved for seed, for this second-generation seed will not perform like the first-generation hybrid from which it came; in fact the results are more likely to be like those of an ordinary open-pollinated strain. The extra vigor of hybrid corn is confined to the first hybrid generation.

CARING FOR THE SEED

Avoid Injury to Seed Coats

Seed ears should be so handled as not to bruise the seed coats. The more moisture in the grain, the easier the seed coats will bruise. Ears with a rough indentation bruise easily even after they are well dried.

The reason for care at this point is that kernels with broken seed coats produce weak, diseased plants, many of which die even before coming up thru the ground. Under favorable growing conditions, seed treatment with a good dust disinfectant will protect against this kind of seedling disease, but under unfavorable growing conditions a broken seed coat is detrimental even when the seed is treated.

Dry Seed Ears Promptly

In order to retard seed infection, and for best all-round results, the seed ears should be gathered from the plants just as soon as they are mature, well in advance of freezing temperatures. Usually they are ready during the first two weeks of October in central Illinois. Then the seed should be dried promptly to a moisture of not over 14 percent. The drying stops all mold growth and puts the seed in a dormant condition.

Farmers producing only a small amount of seed may be able to dry it properly by placing it in hangers in a heated ventilated room. Hybrid seed corn, however, usually is produced in quantities that cannot well be handled in hangers. Bin drying by forced hot air at 105° to 110° F.
is the most satisfactory way of handling large lots. When a great deal of corn is to be dried, a series of bins, one of which is filled each day, is best. When the seed in the first bin is dry, usually after about a week, the bin is emptied, and refilled with fresh corn. For smaller lots ranging up to 150 or 200 bushels, the slatted floor drier (Fig. 4) is satisfactory. With this arrangement corn can be dried satisfactorily in two weeks.

![Diagram of slatted floor corn drier]

**Fig. 4.—Cross-Section of a Slatted-Floor Corn Drier**

This type of drier will take care of 100 to 200 bushels of ear corn piled 1 to 2 feet deep on the slatted floor. Some of the essential features are: a tight building with ample and properly located ventilators, a furnace or large stove, and a sheet-metal baffle located at least 18 inches below the slatted floor. (Designed at Wis. Agr. Exp. Sta.)
For further information concerning the building and operation of drying equipment, write to the Department of Agricultural Engineering, University of Illinois, Urbana.

**Discard Undesirable Ears**

In open-pollinated corn the ears should be carefully culled in order to maintain high quality in the strain. In hybrid corn the heredity is fixed, and a seed grower producing double crosses need not be concerned with maintaining a given type of ear or improving the strain. Hybrid seed ears, however, like open-pollinated ears, should be culled to remove those infected with rot.

Ears are undesirable for seed when they show a rotted shank attachment or rot anywhere on the ear. The kernels should be free from discoloration and streaks, and should show a bright clear germ. Sometimes when the rot is localized on a small part of the ear, it may possibly be satisfactory to remove the rotted or discolored part plus an additional inch of apparently good kernels, and then use the remainder for seed provided the remaining kernels are entirely free from discolorations.

As yet experiments on the extent to which culling should be practiced in hybrid corn are very meager.

**Make Composite Germination Test of Hybrids**

The individual-ear test for vigor and freedom from disease, used extensively for seed selection in Illinois, has probably been effective in improving the resistance of open-pollinated corn to seedling diseases, but it apparently is not worth the expense in hybrid seed. In hybrids, breeding for disease resistance is accomplished by other more direct methods, and so far as avoiding infected seed is concerned, there are now some substitutes for the germination test. Early seed selection and prompt, rapid drying help to avoid some infection that might otherwise take place; and seed treatment helps to control seedling diseases where the seed infection has not progressed too far. The worst hazard to good germination is an early and severe cold wave before the corn is picked. A Diplodia epidemic may also cause trouble.

After hybrid seed has been dried, culled, and shelled, a composite germination test should be made. The Illinois Crop Improvement Association considers that corn germinating 90 percent strong plants is good enough for certification, provided the seed has passed in other respects. This allows for a maximum of 10 percent of kernels with poor germinability—weak sprouts and dead kernels.
Treat Seed With Good Disinfectant

The treatment of seed corn with good seed disinfectants offers, under usual conditions, considerable protection against the seedling diseases discussed on pages 15 to 17. These diseases cause most injury when corn planting is followed by cold weather. Under critical conditions seed treatment may save the necessity of replanting.

Hybrid seed benefits from seed treatment just as much as open-pollinated seed.

Only those disinfectants especially prepared and sold for treating seed corn should be used. Not all materials sold for this purpose are worth while. Some commercial products tested by this Station proved decidedly inferior to the better ones, or were even entirely worthless. Those listed by trade names in Table 2 have proved effective.

<table>
<thead>
<tr>
<th>Treatment used</th>
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<td>bu.</td>
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<td>Heated building</td>
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<td>7.2</td>
</tr>
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<td>1.1</td>
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<td>4.7</td>
</tr>
<tr>
<td>Open shed</td>
<td>.5</td>
<td>2.0</td>
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<tr>
<td>Merko</td>
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<td>Heated building</td>
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<td>78-91</td>
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<td></td>
<td></td>
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<tr>
<td>Barbak 111*</td>
<td>1</td>
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<td>2.0</td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
<td>Heated building</td>
<td>51 bu. yield</td>
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*Barbak 111 has now been replaced by Barbak-C, which from limited tests appears to be an improvement.

At an outlay of about 2 cents an acre for the disinfectant, farmers of the northern and central sections of Illinois may, under average conditions, be fairly confident of an increase of 2 or more bushels an acre in their yields of dent corn by applying a good seed treatment. This statement is based on tests of samples of corn which were obtained from more than 400 farmers in central Illinois in the seasons 1928 to 1932, composited and grown under several different soil conditions. The best seed treatments used in the test gave an average increase of about 3 bushels an acre (Fig. 5). In the Illinois corn-performance tests distributed throughout the state during 1935 and 1936, the average increase in yield from seed treatment with New Improved Semesan Jr. was 2.6 bushels an acre.
Storage of treated seed in a dry building has caused no injury to the seed in experiments with three corn-seed disinfectants (Table 2). However, when storage was in a shed with open sides but a good roof, and the grain stored in sacks up close to the roof, there followed some reduction in stand and yield of grain as compared with that from seed freshly treated. In other experiments treated seed stored for a year gave results nearly identical with seed stored untreated and then treated just before planting. All these experiments were conducted with first-quality seed that had been dried to 12 percent moisture before the treatments were applied.

Seed treatment is not, of course, a remedy against all corn diseases—it does not control smut, ear rot, stalk rot, or root rot directly—but the better vigor and the more advanced development of the plants from treated seed may tend slightly to check such diseases.

Claims have been made by some manufacturers that their disinfectants not only protect corn seedlings against disease infection but that they also control insects that attack corn in the ground shortly after planting. Tests of some of such compounds in Illinois have failed to substantiate these claims.
Applying the Seed Treatment

The commercial seed disinfectants mentioned in Table 2 should be applied at the rate of 1 1/2 to 2 ounces to a bushel of shelled corn. Any excess of disinfectant not adhering to the seed should be screened off (but not fanned), or the application should be so adjusted that there will be no excess. A barrel churn does very well for small quantities of seed, but should be filled only one-third full of grain. A good mixing machine, handling a bushel of seed at a time, can be made from a 30-gallon metal oil drum (Fig. 6). A concrete mixer answers the purpose if a tight lid can be fixed over the opening. Various commercial mixers are on the market.

Use care to AVOID INHALING THE CHEMICAL DUST used in treating seed. Do the mixing out of doors, or place the apparatus on a barn floor with the doors open on both sides. Respirators that fit over the mouth and nose so as to protect the operator are low in price and can be purchased in some drug stores. Mixing the dust with the grain by means of a shovel should never be attempted, for three reasons: (1) a good coating of the seed cannot be obtained; (2) too much of the dust is lost in the air, and (3) the method is extremely dangerous to the health of the operator. All the disinfectants recommended here for
treating seed corn contain mercury—a CUMULATIVE POISON. Even small amounts inhaled from time to time accumulate in the system and if continued reach dangerous proportions.

Seed Treatment Reduces Danger in Early Planting
Treated seed can be planted early with greater safety than untreated seed because there is less danger of damage should unfavorable weather delay sprouting. It has often been demonstrated that when seed of good quality from full-season varieties is used, the early-planted corn (May 1 to 10 at Urbana) usually yields the best.

Seed Treatment Not a Substitute for Good Seed
Seed treatment, it should be emphasized, is not a substitute for good seed, but is usually worth while as an additional measure. This is true for hybrids as well as for open-pollinated varieties.
Growers of sweet corn will be interested in knowing that some of the same treatments that have proved beneficial on dent corn have caused substantial increases in the yield of prime canning corn also.

NO PART OF PLANT IMMUNE FROM ATTACK
From the time the kernel sprouts in the soil until the ear is mature and has become dry enough to “keep,” the possibility is ever present of disease organisms gaining foothold and checking the vigor of the corn plant and its ability to yield normal amounts and quality of grain. Any part of the plant may be attacked; no part is immune.
Fungi are the most common causes of diseases in plants, tho bacterial infection, insect infestation, and unfavorable environmental conditions all contribute to the losses in Illinois cornfields.

Seedling Diseases
About seven different seedling diseases are recognized in Illinois, and no doubt more exist. They cause poor stands and blighted and weak plants. The weak plants usually remain alive thruout the season, but are handicapped and do not yield well.
Seedling diseases may be caused by ear-rot fungi. Ears that have been lightly attacked by ear-rot fungi are often selected for seed if the attack has not gone far enough to rot the kernels noticeably. Unless the seed from such ears is treated with the proper chemicals, the fungi may injure the seedlings after the kernels sprout. The effect of
one of these fungi, Diplodia, is shown in Fig. 7. Early picking of seed corn and prompt drying of the grain to 14 percent moisture helps to prevent some of the kernel infections from taking place.

Organisms present in the soil before the seed is planted are another important cause of seedling diseases. When the seed coat is broken or partly removed from the crown (damage by mice or corn ear

Fig. 7.—Seedlings Grown From Diplodia-Infected Seed Are Stunted and Weak

All four of the infected seeds (left) germinated, but when the picture was taken one of the sprouts was dead, one was dying, and another was so badly rotted at the base that it is doubtful whether it would have grown to maturity. A seedling like the one at the extreme left probably would not die as a result of the infection, but the mature plant would lack vigor; note rot at lower end of mesocotyl near the kernel, and the poor vigor compared with that of the healthy seedling (extreme right).
FIG. 8.—SEED-COAT INJURY INCREASES DAMAGE FROM SOIL INFECTION

The same ears supplied the seed for these two plots of corn plants, but from the crowns of the kernels planted at the left parts of the seed coats had been removed, whereas the kernels planted at the right were sound. If a good seed treatment had been used, there would have been comparatively little difference between the two groups.

worms, or by rough handling), the fungi from the soil can enter the seed at once, without waiting until the seed coat is ruptured during the germination process. Considerable loss to stand and plant vigor may thus occur (Fig. 8) even under favorable germinating conditions. Even the seedlings from well-matured kernels that are protected by sound seed coats may be damaged by soil infection when the corn germinates slowly because of a period of cold weather following planting.

Infections remaining in the seed after prompt drying or coming from organisms in the soil can be overcome to a large extent by treating the seed with a good corn-seed disinfectant. Such disinfectants are readily available commercially.
Common Smut

Smut may occur on any of the above-ground parts of the corn plant (Fig. 9). The swellings are irregular, and vary from the size of a pea to that of a large double fist.

At first the swellings are nearly white in the interior and are covered by a glistening white membrane. But soon the galls turn dark as the mass is converted into black smut spores, and the membrane becomes more fragile and finally breaks. The millions of tiny smut spores of the fungus *Ustilago zeae* are then released and blown about by the wind.

Losses from smut are influenced by differences in inherited resistance of the variety or hybrid used and by environmental factors. Some of the leading hybrids of which seed is now available are more resistant than are open-pollinated varieties. Data taken by the Illinois Natural History Survey indicate an average loss of 2.3 percent to the Illinois corn crop from smut for the years 1917 to 1937 inclusive. The variation ranged from less than one-half of 1 percent in each of the years 1925, 1927, and 1937 to 8 percent in 1934. In the latter year chinch bug damage also was more severe, for the state as a whole, than at any other time during the period 1917-1937.

Altho the environmental conditions conducive to smut development are complex and not fully understood, smut seems to be least injurious when growing conditions are favorable throughout the season so that the corn grows steadily and normally. Late planting, poor soil, or soil especially rich in nitrogen tend to increase smut losses. Drouth, slashing of the leaves, and other decidedly unfavorable factors—especially before the plants have tasseled—also often increase smut. Removal of the ears in the early milk stage, or failure of pollination, may encourage smut development.

Investigations carried out in several different states reveal that smut causes considerable barrenness and reduction in the size of ears, that galls on the stalk above the ear are more injurious than those below the ear, and that galls on the ear are usually more destructive than in any other location. Damage depends also on the size and number of galls present. Small galls on leaves or tassels appear to cause little or no damage, but tassel smut, as shown in Fig. 9, or galls 2 or more inches in diameter on the stalk above the ear, may be expected to reduce the yield of infected plants 30 to 100 percent. Galls of the same size below the ear cause about half that damage.
What infection with common smut will do is shown here on the leaf (A), on the tassel (B), on the stalk (C), and on the ear (D). The spores are not seed-borne, as are the smuts of the small grains, but are carried to the plant by the air. This smut attacks only corn.
Black Bundle Disease

The black bundle disease is characterized by barrenness, poor ear development or multiple ears at the same node, and often a reddish-purple discoloration of the plant after the ears are in the dent stage. At this stage in such plants blackened vascular bundles¹ (Fig. 10) may usually be observed in some part of the stalk. Plants sometimes exhibit outwardly an appearance of the black bundle disease, yet when the stalks are cut the blackened bundles cannot be found; or the stalks may contain black bundles without showing outward symptoms.

The black bundle disease has been reported to be caused by attack by the fungus *Cephalosporium acremonium*, or by heritable responses to several different environmental conditions. Some doubt still remains concerning the exact nature of this disease.

¹"Vascular bundle" is a technical name applied to strands scattered throughout the stalk and other parts of the corn plant through which the sap flows.
Combing Corn Diseases in Illinois

Bacterial Wilt
(Stewart's Disease)

Bacterial wilt is most destructive to early varieties of sweet corn, popcorn, and flint corn, but it may also attack late sweet corn and dent corn. Sweet-corn plants in any stage of development are subject to attack by this disease. Some infected plants succumb when only 6 inches or a foot high, while others live long enough to produce ears.

Young sweet-corn plants infected with this disease may wilt very much as tho they had been cut off beneath the soil. When such plants are cut open longitudinally, the interior of the base of the stalk is likely to be dark. Plants a foot or more tall may show, previous to wilting, one or several broad light green or yellowish streaks down the leaf blades.

Fig. 11.—Sweet Corn Severely Infected With Bacterial Wilt (Left)

Bacterial wilt causes great losses in the early varieties of sweet corn. It also occurs in dent corn, but is not so important in that crop, and the wilted condition is not so likely to develop. The plant at the right showed no symptoms of infection.
The tassels of older plants that are infected may die soon after elongation and appear nearly white. Many infected plants are stunted, some being at tasseling time only half as large as the healthy plants (Fig. 11). A gradual dying and drying out of the leaves often takes place, progressing from the tips of the blades downward and from the margins inward. This type of the infection thus acts as a blight rather than as a wilt.

The surest indication of bacterial wilt is the bacterial ooze that exudes from the vascular bundles when the stem is cut crosswise. This test should be tried before the plant has completely wilted. In a few minutes after the stem is cut, very small droplets of the yellow or

![Fig. 12.—Blighted Leaves and Rotted Stalks of Dent Corn Caused by Bacterial Wilt](image_url)

In dent corn bacterial wilt occurs chiefly as blighting of the leaves and internal rotting of the stalks. The streaking along the veins of these leaves was caused by localized infections. In badly infected stalks, especially in the lower parts, the hollow condition here shown is common. A healthy stalk split longitudinally is shown at the right. These symptoms of bacterial wilt are sometimes confused with leaf blights and stalk rots resulting from other causes.
white slime ooze out of the bundles. If the point of a pencil or other object is touched to one of these droplets and then pulled away, the slime can be stretched some distance. In advanced cases the bundles themselves turn brown.

In dent corn definite wilting as a result of this disease rarely occurs, but some cases of extreme stunting have been observed where the plants were not more than half their usual height. A hollowing out of the stem (Fig. 12) as a result of wilt infection occurs more commonly in dent corn than in sweet corn. This condition may be accompanied by more or less firing of the leaves. Late infections directly on the leaves also may occur in dent corn (Fig. 12).

Wilt infections have been found to be likely to occur after mild winters. The occurrence appears to be related, at least in part, to winter survival of flea beetles, in which the wilt bacterium passes from one season to the next.

Some sweet-corn hybrids resistant to bacterial wilt and of excellent quality have been produced. The one in most general use at the present time in Illinois is Golden Cross Bantam. As yet no extra-early resistant hybrids are available.

Stalk Rots

Diplodia fungus, which readily attacks and rots the stalks of susceptible corn plants (Figs. 13 and 14), is common in Illinois cornfields. Extensive damage is more common when the green surface of the leaves has first been diminished by other diseases, by insects, by drought, firing, hail, or early frost injury. Some of the hybrids are very resistant to Diplodia stalk rot. These same hybrids may or may not be resistant also to Diplodia ear rot. Apparently different factors are responsible for resistance to Diplodia invasion in these two regions of the plant.

Diplodia rot seldom becomes noticeable in the stalks until the ears are in the milk stage, and usually not until after the kernels have dented. Some of the infection comes from spores that have washed down behind the leaf sheaths; and recent experiments in Iowa have demonstrated that infection at the crown may come from infected soil or from the planting of Diplodia-infected seed. While proper seed treatment controls Diplodia seedling disease, it fails, according to those experiments, to stop crown infection.

The areas affected by Diplodia on leaf sheaths and stalks range in surface appearance from a dull brown to a deep straw color at first, the later the central part may turn gray, especially on the leaf sheaths. Infected stalks frequently die prematurely, and after that the little black
These stalks were cut open when the ears had reached maturity. The outer surface over the rotted areas is discolored, and in advanced cases the stalks can easily be compressed with the fingers. Infections usually start near the ground but may start at any of the joints.
Fig. 14.—Dipodilia Stalk Rot Is One Important Cause of Down Corn

Much of the open-pollinated corn shown in the plot at the right was broken down. The hybrid corn shown at the left was resistant to Dipodilia stalk rot and stood erect. (Test plots on Claire Golden farm, Rock Island county)

Fruiting dots (pycnidia) appear somewhat similar to those shown on the husks in Fig. 18. Where the nodes or joints of the stalk are close together, as at the crown or in the shank, infection readily passes thru several nodes; but where they are widely separated the rot more often than not is limited to the node where the infection started.

Other kinds of stalk rot—Fusarium and two kinds of bacterial rots—occasionally do considerable damage in Illinois. Still another kind of stalk rot is sometimes met on soils where the available potash is low but nitrogen is plentiful (Fig. 16).

Finally, stalks that are killed by frost when they are still very sappy are readily invaded by various rotting and fermenting organisms that cannot enter healthy, growing plants.

Root Rots

Corn plants infected by root rots, more or less common in Illinois, produce ears that are lacking in lustre and in weight. Such plants also, because of their weakened roots, are liable to lodge (Figs. 15 and 16).

The cause of the rotted condition often cannot be readily determined. A pythium root rot, which is known to occur in Illinois, probably is responsible for some of the trouble. When there is a lack of
potash in relation to nitrogen in the soil, corn roots and the lower ends of the stalks may become susceptible to rots (Fig. 15), being attacked by organisms which under other conditions seem practically harmless.

In no case now known are rots of the major root system of the corn

![Root and Stalk Rot](image)

**Fig. 15.—Root and Stalk Rot That Developed When Potash Was Deficient**

The blackened areas show the rot invasions. The dark color develops early in the growth of the plant, but rot usually does not develop until later. Plants weakened as this one is usually go down, as is shown in Fig. 16.
The corn plants at the left have been severely attacked by stalk rots and root rots. The reason for the severity of the attack at the left was apparently too little potassium in the soil in proportion to nitrogen. On both plots legumes had been plowed under to supply nitrogen, and rock phosphate had been applied. Potassium fertilizer was added to the right plot but not to the left. (Test plots on R. L. Murray farm, Marion county)

A number of leaf diseases of corn are prevalent in Illinois, but ordinarily none of them cause any considerable damage. Rust (Fig. 17) and several other fungi and bacteria cause leaf spotting and blotching. Firing and blighting of leaves as a result of heat, cold, faulty nutrition, or because disease or insects have weakened the stalks or roots, are not usually considered to be leaf diseases.

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Ear Rots

Several kinds of ear rots cause much damage to Illinois corn. The ears may be either partially or entirely rotted in a conspicuous manner,
In summer the spots of corn rust are reddish brown. The epidermis breaks open as the spores mature, and in the fall the spots become nearly black. This rust is distinct from the rusts of the small grains, and so does not cross over to other crops. (Courtesy E. B. Mains, formerly with U. S. Dept. Agr., and Purdue Univ. Agr. Exp. Sta.)

(Plate I) or they may appear fairly normal from surface inspection but the kernels, when shelled, may show discolorations or rot in the germ area (see front cover and Fig. 19). The effect of rot-damaged kernels on commercial grades is shown in Table 3.

Some infections may start as early as the first appearance of silks, but most of them start later. Often the fungi that cause ear rots produce only very slight infections which cannot be seen even when the kernels are shelled, but the seedlings grown from such kernels are likely to become diseased. (See discussion, pages 15 to 17).

Diplodia ear rot. The Diplodia fungus (*Diplodia zeae*) appears on the ears as a dense white mold between the rows of kernels (Plate I, Ears E, F, and G). When the infections start early, the ears become completely rotted and are of a dull-brown color, weighing less than half as much as healthy ears. The husks, too, are penetrated by the fungus and joined tightly to the ear. In the husks of such ears and imbedded in the kernels (Fig. 18) black fruiting bodies which contain numerous microscopic spores are usually abundant.

In infections that start later, from either the base or the tip of the
Table 3.—Official Grade Requirements for Yellow Corn, White Corn, and Mixed Corn

<table>
<thead>
<tr>
<th>Grade No.</th>
<th>Minimum test weight per bushel</th>
<th>Maximum limits of—</th>
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<tbody>
<tr>
<td></td>
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<td>Moisture</td>
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<tr>
<td>1</td>
<td>54</td>
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<tr>
<td>2</td>
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<td>3</td>
<td>51</td>
<td>17.5</td>
</tr>
<tr>
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<td>48</td>
<td>20.0</td>
</tr>
<tr>
<td>5</td>
<td>44</td>
<td>23.0</td>
</tr>
</tbody>
</table>

Sample grade

Sample grade shall include corn of the class Yellow Corn, or White Corn, or Mixed Corn, which does not come within the requirements of any of the grades from No. 1 to No. 5, inclusive; or which contains stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor; or which is otherwise of distinctly low quality.


Fig. 18.—Completely Rotten Ears Resulting From Early Infections With Diplodia

The black fruiting bodies have developed within the ear and in the husks. Each contains many microscopic spores which pass the winter safely outdoors and in the following summer are carried by the wind to growing corn plants.
FIG. 19.—LATE INFECTION WITH DIPLODIA OCCURRING AFTER THE KERNE LTS WERE NEARLY MATURE

Both the ears from which these kernels were taken appeared to be sound before they were shelled. When they were shelled, however, the ear from which the kernels in the lower row were taken was found to be damaged by Diplodia rot. The rot discoloration occurred primarily in the germ, leaving the crowns relatively sound. Such rots are a factor in determining the commercial grade of the corn.

ear, the rot often does not involve the whole ear. In this case the kernels may retain their normal appearance at the surface of the ears, but when the grain is shelled the germs show more or less rot appearing as a dark discoloration (Fig. 19). In such cases white mold may or may not show between the rows of kernels.

Fusarium ear rot. On most farms more ears of dent corn are damaged by the fungus *Fusarium moniliforme* than from any other cause. The number of damaged kernels per infected ear, however, is not on the average so great as on ears rotted by Diplodia, because Fusarium rot nearly always involves only a part of the kernels on an ear, as shown in Fig. 20 and Plate I, Ears A and B. Fusarium rot usually occurs where seed coats become broken while the moisture in the grain is still high, tho the rot sometimes occurs where there has been no seed-coat injury. The Fusarium fungus is pale pink, and sometimes it brings about a reddish color in the kernels.
Three kinds of ear rot: A, B—A pink rot caused by *Fusarium moniliforme*; sometimes only a few scattered kernels are affected, sometimes the major portion of the ear. C, D—*Gibberella* infection (pink) usually starts at the tip and involves all kernels as it progresses toward the butt of the ear. E, F, G—*Diplodia*, a white mold, advances thru the ear either from butt or tip; completely rotted mummies result when infection starts early.
When only the tip end of the ear is rotted, it is usually because birds, worms, or other insects have previously injured the kernels. When the rotted kernels are scattered over the ear, it is often because the seed coats have previously burst open at the crown as a result of sap pressure. From these crown-cracked kernels scattered at random over the ear, the infection may extend to neighboring kernels and thus sometimes rot a rather large portion of the ear.

Some of the good hybrids are practically free from cracked crowns and consequently from this type of Fusarium rot.

**Gibberella ear rot.** Gibberella rot, caused by *Gibberella zeae*, usually starts at the tip end of the ear and proceeds thru all the kernels as far as the rot extends. Seldom is an entire ear rotted. The fungus produces a characteristic reddish color, as shown in Plate I,

![Fig. 20.—Fusarium Ear Rot](image)

The rotted tip in A probably followed injury by birds. In B the rot has become severe in a localized area and is due possibly to high moisture conditions in that part of the ear at the critical period. Often the rot occurs on scattered kernels, as in C. In a season favorable for the growth and maturity of corn some kind of seed-coat injury usually, but not always, has occurred before the ear is attacked by *Fusarium moniliforme*. 
Ears attacked by Nigrospora rot may present a fair external appearance even tho the cobs and tips of the kernels are rotted. Nigrospora ear rot is therefore often called "cob rot." Note the shredded appearance of the end of the shank (lower right), and the black spores around the place where the shank broke off (arrow) and at the tips of the kernels (upper left).
Ears C and D. On ears rotted by Gibberella, as well as by Diplodia, the husks are tight on the ears, for the fungus has grown thru them and joined them tightly to the kernels.

Only in occasional years is Gibberella rot extensive in Illinois. It will not usually be confused with Diplodia rot, being distinguished by its reddish color; nor will it ordinarily be confused with Fusarium rot, for Gibberella rot progresses rather uniformly down the ear, while Fusarium rot is more irregular.

**Nigrospora ear rot** (cob rot). The cobs of ears badly infected by Nigrospora ear rot break very easily both crosswise and longitudinally. The rot most often starts at the base of the ear. The shank usually breaks off in a shredded manner (Fig. 21), tho this is not an invariable sign of the rot, for shredded shanks may also be produced by other causes. The kernels on Nigrospora infected ears are often more or less shriveled, depending on how early the infection took place. Mold between the rows of kernels is sparse to absent.

Nigrospora infection is best identified by the black spores around the place where the ear was broken off from the shank (Fig. 21), by spores within the ear when broken crosswise, and by spores at the tips ends of the kernels. The lower half of the kernels of yellow corn often are bleached to a streaked whitish color, and the lower end of the germ may have a yellowish-brown discoloration.

**Other ear rots occurring in the field.** A high percentage of the ears in some fields are occasionally found to be infected with blue mold (*Penicillium*). Apparently most of this infection comes as a result of previous injury to the kernels by birds or ear worms. The position and appearance of the mold is very much like that on Ear A, Fig. 20, except that the mold is a dull blue and is covered with dusty blue spores that come off easily in large quantities.

Rhizopus is another mold occurring on corn ears in the field. This fungus is common over the surface and between the rows of kernels under some conditions, but it seems to cause little rot damage. The untrained observer sometimes might confuse this mold with Diplodia infection. The two can, however, easily be differentiated (1) by the more grayish appearance of the Rhizopus mold due to the presence of many small black spore capsules mingled with the white mold, and (2) by the fact that when kernels are removed from an ear that is infected with the Rhizopus mold they do not show rot discoloration.

There are a number of other ear rots that are found in Illinois.

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1The fungus causing this ear rot was formerly called Basiosporium and Coniosporium, but it has been shown that the name Nigrospora has priority.
occasionally, but they are found so infrequently that they need not be mentioned here.

**Storage rots.** Moisture in the corn, length of time in storage, and temperature are the important factors in the development of storage rots. The lower the moisture and the lower the temperature, the longer the time necessary for rots to develop. At freezing temperatures fungus growth stops altogether.

All fungi causing rots in the field may also cause storage rots if moisture in the grain is above 22 to 23 percent and the temperature is mild. But some molds are active enough to be harmful until the corn is much drier than that. *Penicillia* (Fig. 22) may cause damage until the moisture is as low as 19 or 18 percent, and *Aspergilli* until it reaches 15.5 or 15 percent.

Tho very little corn is dry enough at husking to prevent rots, no appreciable commercial damage from storage rots is likely if the temperature is low, if the crib is a good one, and if the corn is husked clean. Because of better ventilation, rots usually develop less rapidly in ear corn than in shelled corn.

Farmers often inquire whether corn having storage rots is likely to be injurious if fed to livestock. So far no injury from the fungi
causing storage rots (except Gibberella, page 31) has been observed. Nevertheless corn showing a considerable amount of storage rot is always under suspicion by feeders, because of other organisms which may be present. When conditions have been favorable for the fungi causing rots to develop, harmful tho unnoticed bacteria may also have gained a foothold.

**SUMMARY**

Serious losses in yield and quality of grain occur throughout the corn belt as a result of diseases that attack the corn plant. Many of these diseases are common in Illinois. To seedling diseases can be attributed many poor stands and blighted and weak plants. This is particularly true when the weather is cold after planting and germination is slow. Other diseases which take serious toll of Illinois corn are common smut, black bundle disease, bacterial wilt, root rots, stalk rots, and ear rots. The severity of attack by these diseases depends, in general, upon the care with which the seed is chosen or selected, stored, and treated for disease infection, and the kind of weather during the growing and maturing season.

*Breeding.* Some improvement in disease resistance has been made in open-pollinated varieties of corn by careful breeding. Further progress in disease control, not possible by open-pollinated breeding, has recently been attained by selecting disease-resistant inbred lines and using these lines in the production of hybrids.

To be truly valuable a hybrid must have not only such desirable characters as high yield, resistance to lodging, and resistance to damage from insects, but also resistance to the important diseases. The Illinois cooperative corn-performance tests made in different parts of the state are helping to determine which hybrids have the most desirable characters and in which localities they should be grown.

*Care of seed.* Even tho the hybrids are bred to resist disease it is important that the seed be properly cared for. Seed corn, especially hybrid seed ears, should be picked as soon as mature, and should be fire-dried promptly in order to check disease invasion.

*Seed treatment.* After the seed corn has been dried thoroughly and shelled, it should be treated with a good chemical dust disinfectant to check or retard the development of seedling diseases after the seed is planted. Treated seed may be stored safely in a dry building. A little heat in the building is advisable during very cold or prolonged damp weather.
FOR GOOD CORN YIELDS the careful selection of a proven variety or hybrid, and the careful preparation, storage, and treatment of seed for the prevention of diseases must go hand in hand with farming practices that build up or maintain a fertile soil. Neither good seed nor fertile soil will alone assure a farmer good yields in return for his efforts, but together they will enable him to take full advantage of favorable weather and the various other factors entering into crop production that are not under his control.

This circular describes the most important diseases that attack Illinois corn, both in the field and in storage, and discusses methods which farmers may use to combat them.