The Control of Corn Diseases in Illinois

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COLLEGE OF AGRICULTURE AND AGRICULTURAL EXPERIMENT STATION
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RESISTANCE TO DISEASE is inherited. Selection for disease-resistant seed therefore starts with the plant. The illustration on the outside cover shows (*A*) a plant prematurely dead on account of disease, (*B*) a healthy, firmly rooted plant maturing normally. In the diseased plant the leaves are either dying or are already dead and the ear is hanging down as the result of a crumpled and rotted shank. Corn produced on such a plant is light or chaffy. While few farmers would select such ears for seed purposes, there are intermediate stages between plants *A* and *B* in which the ear may have a good appearance superficially and even test free from disease, yet carry factors that will make the resulting plants more or less susceptible to diseases that ordinarily occur in the cornfield.

On a healthy plant such as *B* the ear matures normally while leaves and stalk are still green. Ears from such plants should furnish the stock from which seed for planting will ultimately be selected.

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Control of Corn Diseases in Illinois

By Benjamin Koehler and James R. Holbert[1]

CORN, Illinois' most valuable grain crop, is subject to attack by many diseases. Losses to dent corn in the state as a whole, resulting from disease conditions, have been conservatively estimated to average more than one-fifth of the annual crop.

Some corn diseases are very conspicuous. In fact, every corn grower is well acquainted with ear rots and smut. He usually considers these inevitable. A considerable number of other equally important diseases that weaken the plant and reduce yields of grain but cause no conspicuous external symptoms usually escape his notice. Many well-known diseases cause injury of such nature that losses in yield of grain are very hard to estimate; there are other diseases that have as yet received little study.

Complete control of all corn diseases probably can never be attained, but knowledge whereby a considerable part of the loss can be prevented is available. In fact, a farmer can carry out an effective general program of disease control without being acquainted with the various manifestations of individual diseases. This circular outlines certain measures which, if carefully and consistently followed, may be expected to materially reduce losses from corn diseases. Only some general remarks about disease symptoms are included here; those who wish more detailed information on this subject are referred to Bulletin 354 of this Station, "Corn Diseases in Illinois."

DISEASES ATTACK ALL PARTS OF CORN PLANT

No part of the corn plant is immune from attack by disease organisms, and furthermore 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 plant and its ability to yield normal amounts and quality of grain.

Surveys indicate that probable losses from seedling diseases average about 9 percent annually, losses from ear rots about 7 percent,

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from root rots about 5 percent, from smut about 3 percent, and from stalk rots about 2 percent.

Fungi are the most common causes of diseases in plants, tho bacterial infection, virus infection, insect infection or poisoning, and unfavorable environmental conditions all contribute to the losses in Illinois cornfields.

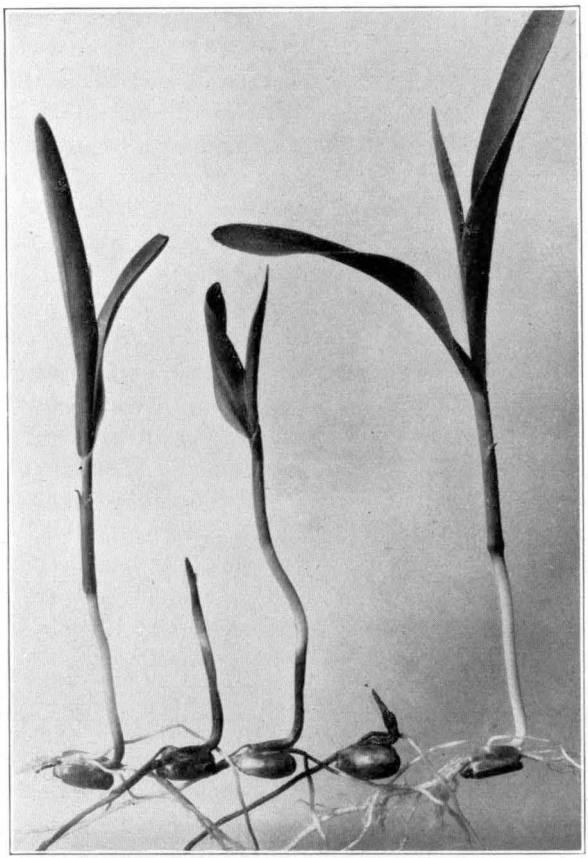


FIG. 1.—SEEDLINGS GROWN FROM DIPLODIA INFECTED SEED COMPARED WITH HEALTHY SEEDLING (RIGHT)

All four of the infected seeds germinated, but at the time the picture was taken one of the sprouts was dead, one was dying, and another was so badly decayed at the base that it is doubtful whether it would have grown to maturity. Such a seedling as the one shown at the extreme left probably would not die as a result of the infection but the mature plant would lack vigor (note the rot at the lower end of the mesocotyl near the kernel and the poor vigor compared with that of the healthy seedling).

Seedling Diseases Result in Poor Stands and Weak Plants

About ten different seedling diseases are recognized in Illinois, and no doubt more exist. They cause poor stands and blighted and weak plants. The effect of one of these diseases, Diplodia, is shown in Fig. 1.

Plants affected by seedling diseases are, in the majority of cases, weakened but remain alive and continue growth during the season. So far as known, this kind of infection in field corn does not pass up the sprout farther than the crown. Actual infection may not extend more than an inch away from the kernel, but it occurs at a very critical time and in a most vital place. Weak seedlings usually develop into plants that are handicapped and do not yield so well as plants from strong seedlings.

The extent of losses from seedling diseases depends largely on seasonal and climatic conditions, strain of corn, care used in plant and ear selection, accuracy of the germination test if one is made, effectiveness of seed treatments, thoroness with which old corn refuse is plowed under or otherwise disposed of, frequency of corn in the rotation system, and the kind of soil management practiced.

Ear Rots Common in Field and Crib

The corn grower is well aware of ear rots. At least five kinds are normally recognizable in the field, and still others are common in frosted corn and in cribbed corn. Some rots that are very common at husking time are shown in Plate 1. Another kind of infection that often results in a dry rot and chaffiness of the ear is shown in Fig. 10.

Some infections may start as early as when the silks first appear, 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 seedlings grown from such kernels are likely to become diseased, as mentioned above under seedling diseases.

Partial control of ear rots can be obtained by attention to strain of corn used, by plowing under old corn refuse, by allowing two or three years between corn crops, and by proper soil management. The prevalence of ear rots is influenced also by moisture and temperature conditions.

Three General Diseases of Above-Ground Parts

Three important diseases are rather general in their attack of the above-ground parts of the corn plant. Common smut may attack leaf, tassel, stalk, or ear (Fig. 2). Black bundle disease causes barrenness,

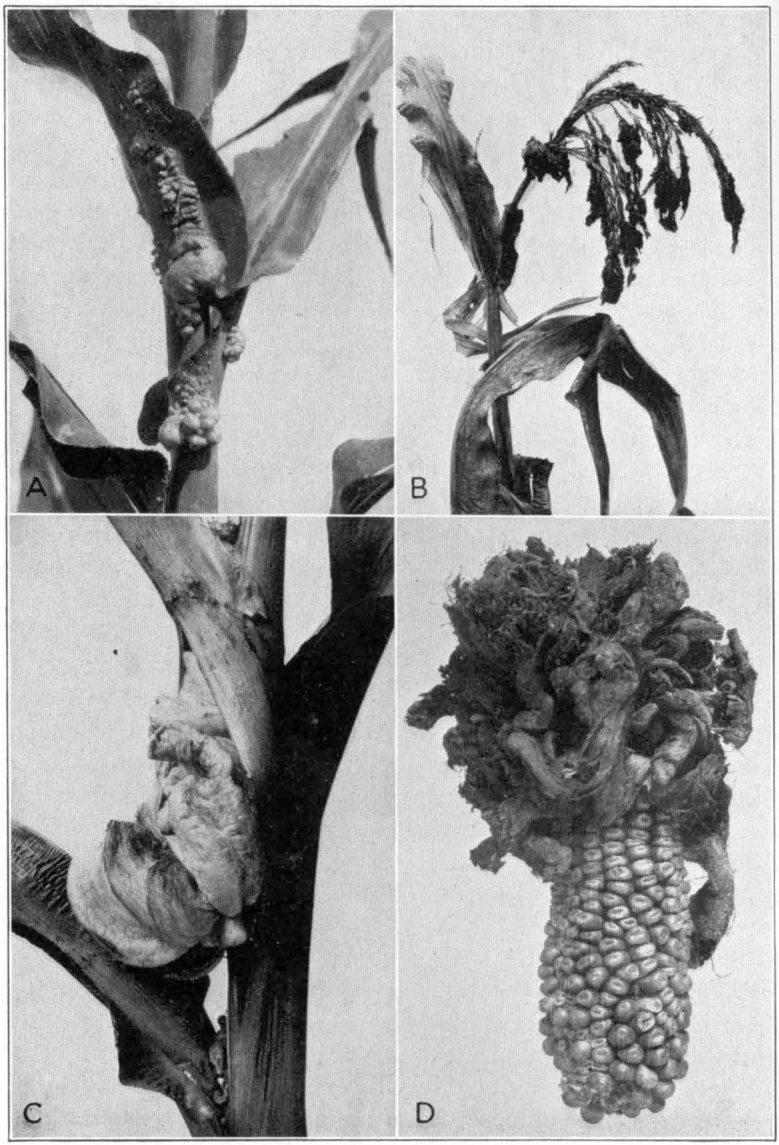
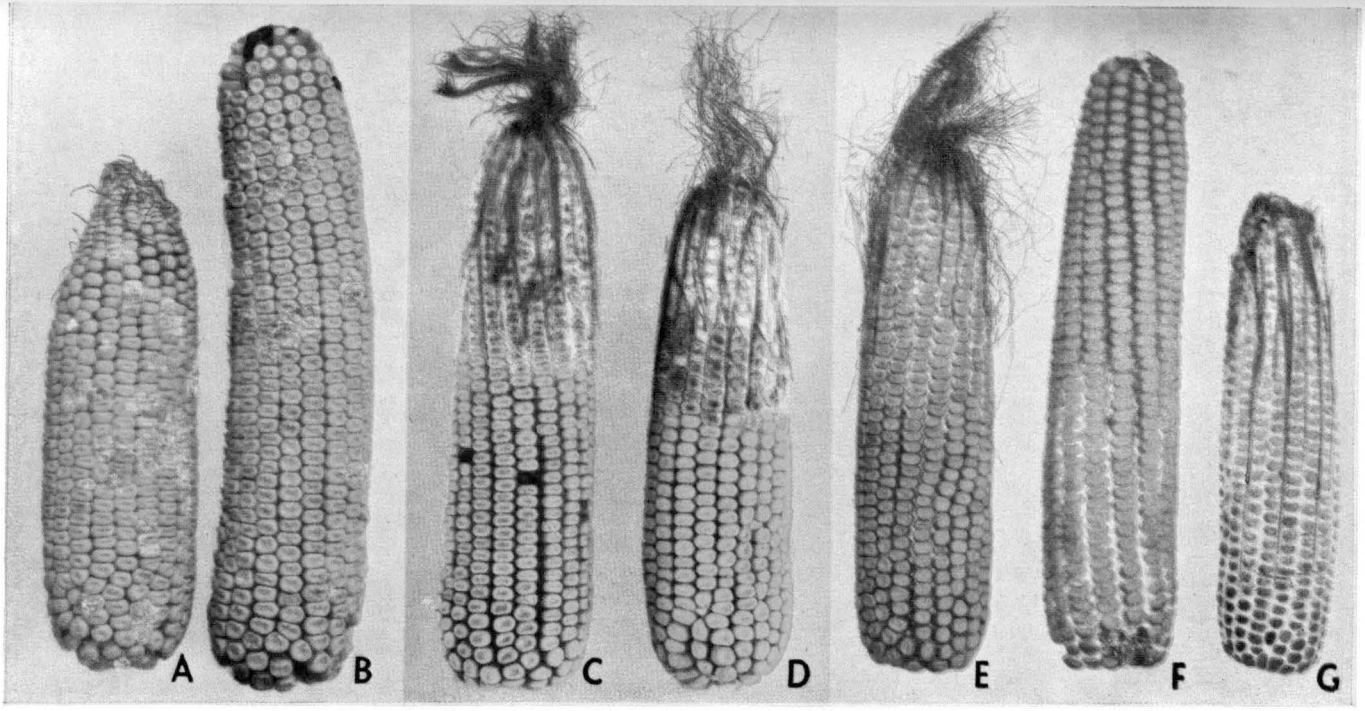


FIG. 2.—COMMON SMUT ON LEAF (A), ON TASSEL (B), ON STALK (C) AND ON EAR (D)

Common smut may occur on any of the above-ground parts of the corn plant. It attacks only corn. The spores are carried to the plant by the air; they are not seed-borne, as are the smuts of the small grains.



Three kinds of ear rot. *AB*, a pink rot caused by *Fusarium moniliforme*; sometimes only a few scattered kernels are affected, sometimes major portion of ear. *CD*, Gibberella infection (pink) usually starts at tip and involves all kernels as it progresses toward butt. *EFG*, Diplodia, a white mold, advances thru ear either from butt or tip; completely rotted mummies result when infection starts early.

poor ear development, or multiple ears (Fig. 3), and often a purple coloration of the plant, especially of the upper portion. The third disease, bacterial wilt, is not of much importance in field corn but is often very disastrous in early varieties of sweet corn. Plants may be attacked by this disease at any time from the seedling stage until after tasseling. Some affected plants wilt and die quickly; the leaves of others gradually become dry and show a blighted condition.

These diseases can be controlled best by the use of resistant varieties, selection of seed from plants free from infection, plowing under of old corn refuse, crop rotation, and proper soil management.

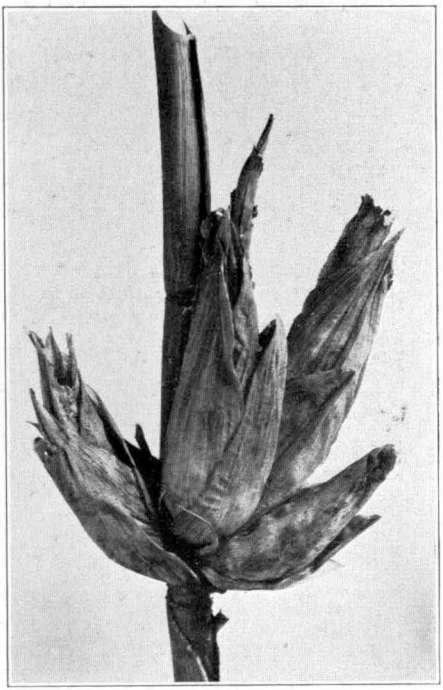


FIG. 3.—MULTIPLE EAR DEVELOPMENT CAUSED BY BLACK BUNDLE DISEASE

In ordinary field corn this condition, together with considerable purple discoloration of the stalks and leaves, indicates that the plant probably is infected with *Cephalosporium acremonium* (black bundle disease). This disease, however, does not always cause multiple ears, nor are multiple ears invariably a sign of this disease.

Root Rots Very Prevalent

Root rots of corn are very prevalent in Illinois. Typical rotted roots are shown at the left in Fig. 4. In many cases the cause of the rotted condition cannot readily be determined. A Pythium root rot, which is known to occur in this region, probably is responsible for some of the trouble. When certain nutritional elements of the soil are out of balance (when there is a lack of potash in relation to nitrogen), corn roots may become extremely susceptible to rots, being attacked by organisms which under other conditions seem practically harmless. This condition has been called by the writers "malnutritional root rot."

In no case now known are rots of the major root system of the corn plant caused by seed infection.

FIG. 4.—SUSCEPTIBILITY AND RESISTANCE TO ROOT ROT

Portions of two root systems, the one on the left having been damaged by root rot and the other showing practically no injury.

Careful selection of seed from resistant plants, crop rotation, and proper soil management are effective measures for holding root rots in check.

Several Kinds of Stalk Rots

A bacterial stalk rot and Diplodia stalk rot are recognized in Illinois. Some other fungi also seem to be able to cause stalk rot. Several kinds of stalk rot are shown in Fig. 5.

As in the case of root rot, certain malnutritional conditions may render stalks very susceptible to a certain kind of stalk rot. After plants are severely injured by low temperatures, the stalks are readily invaded by various organisms, some of which are ordinarily considered harmless.

Control measures should include the use of resistant varieties, plant

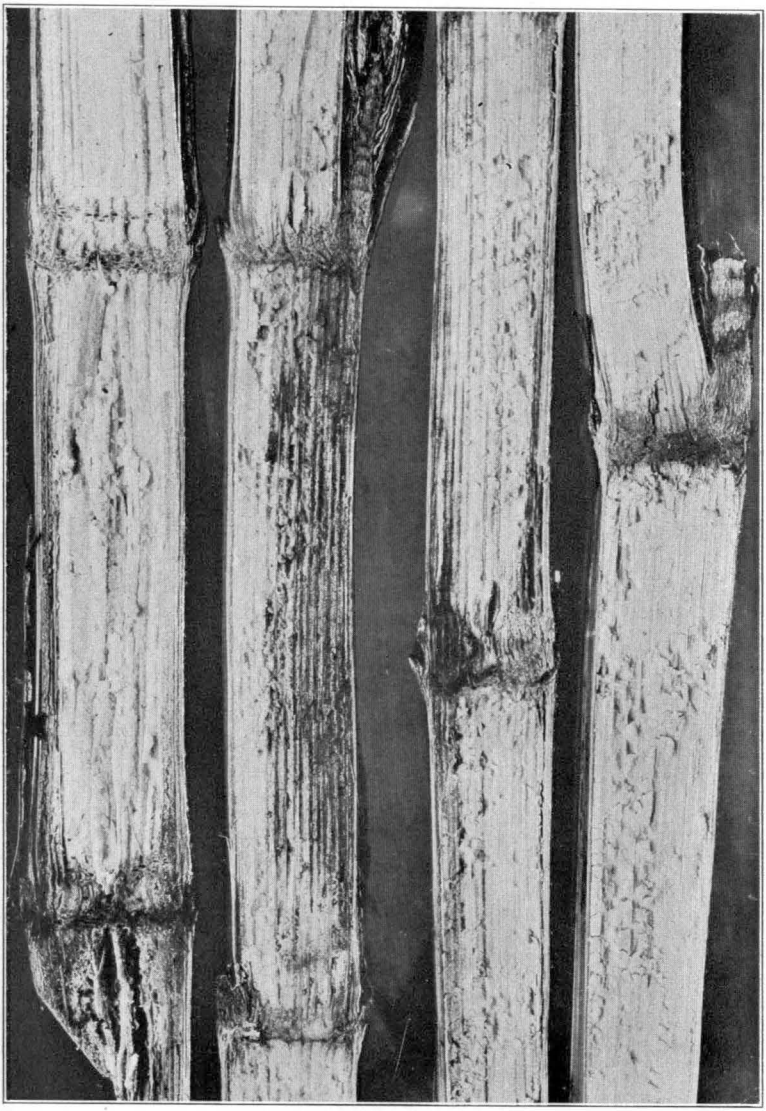


FIG. 5.—STALK ROTS OF CORN AS SEEN WHEN THE STALKS ARE SPLIT OPEN

The dark areas are affected by rot. The stalks are especially subject to attack thru the bud which occurs behind the leaf sheath at every joint from the ground up to the ear. Stalk rots are usually localized at the joints, altho they sometimes extend from one joint to the next.

selection, plowing under of old corn refuse, crop rotation, and proper soil management.

Leaf Diseases Not So Serious

A number of leaf diseases of corn are prevalent in Illinois but fortunately none of them are ordinarily of any considerable commer-

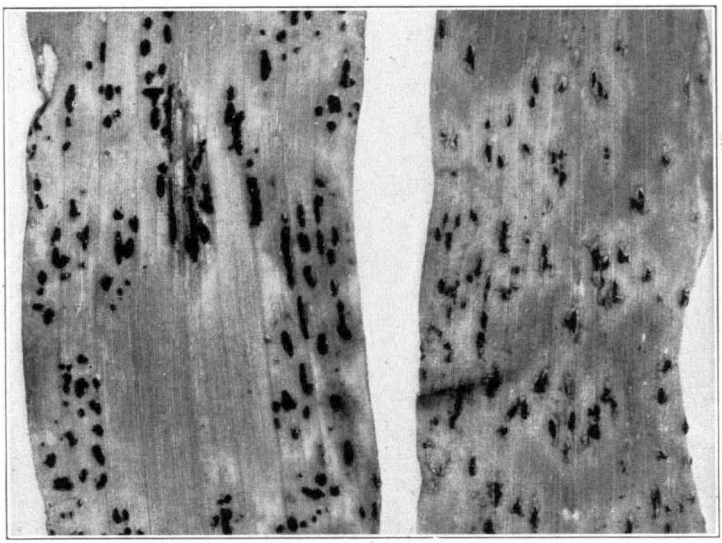


FIG. 6.—CORN RUST ON LEAF BLADES

In summer the spots of corn rust are rusty 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 from one kind of crop to the other. (*Courtesy E. B. Mains, U. S. Dept. of Agriculture and Purdue University Agricultural Experiment Station.*)

cial importance. The most common leaf disease in the state probably is rust, which is illustrated in Fig. 6.

GENERAL PROGRAM OF DISEASE CONTROL

Not all corn diseases can be controlled in the same way, nor does any one disease ordinarily appear sufficiently destructive to warrant extensive application of control measures. Total losses from all corn diseases are, however, large enough to be of serious economic importance, as has been pointed out. Fortunately most of the major corn diseases can be held in check by a well-rounded program of control,

which includes certain sanitary measures (such as the complete removal or turning under of old corn refuse), crop rotation, soil management, breeding for disease resistance, plant and ear selection, seed treatments, and where feasible, a germination test. Some of these measures have merits aside from their effectiveness in controlling disease, and their application is therefore of double benefit.

Completely Remove or Plow Under All Corn Refuse

Corn ear rots, smut, and some other corn diseases are caused by spores produced on old corn refuse and carried by air currents to the new crop. When the old refuse is covered with soil, the disease-producing organisms cannot get out into the air to infect the stalks and ears of the new crop. Complete removal or turning under of all cornstalks and rotten ears before the new season opens is therefore recommended to corn-belt farmers as a measure that without doubt will prove of great help in reducing the losses from several corn diseases.

One difficulty in turning under crop refuse is that of keeping it actually under the soil surface. If some of the undecayed stalks or ears are returned to the surface by the next year's plowing, there may possibly still be some danger of their being a source of infection to the new crop. However, even tho the turning-under of all corn refuse cannot always be perfectly done, this measure is recommended as an important help in reducing losses from corn diseases.

When stalks and cobs from corn that has been fed are thrown into the manure and the manure is returned to the soil, the same precautions should be observed as are suggested for refuse left in the cornfield. The manure and corn refuse should be well turned under or used only where corn is not to be planted that same year.

There is little or no danger that spores that have been eaten will, when passed out in the dung of cows or horses, cause further infection.

Allow Two or Three Years Between Corn Crops

While an interval of two or three years between corn crops may sometimes be undesirable for other important reasons, there is no doubt of the value of such a plan from the standpoint of disease control.

Extensive observations leave no doubt that many corn diseases are aggravated by the frequent cropping of corn on the same land. The organisms that cause these diseases are able to live in the soil or on the soil surface for some time. Some of them are dependent on the presence of corn refuse for growth and propagation, and as soon as the corn refuse has decayed, they seem to disappear.

From the standpoint of disease control, therefore, a crop rotation that includes corn only once in three or four years has important advantages over a rotation that includes corn more frequently, for the old corn refuse has time to decay before another corn crop is planted. It has been demonstrated fairly satisfactorily that corn plants grown in such a rotation are much more firmly rooted than are corn plants grown in fields where the crop is planted more frequently. Ear rots, as well as root rots, have been reduced by the practice of allowing two or three years between corn crops, and very likely some other diseases are to some extent held in check by this practice.

Maintain Fertility Balance

Not only do nutritional factors have a large influence on the vigor and growth of corn plants and the yield of grain, but they also are closely connected with the prevalence of disease and the extent of the losses caused by disease. Altho the relation between soil fertility and the presence or absence of corn diseases is not yet well understood, several general statements can be made.

Lack of sufficient available phosphorus retards the maturing of the grain. Where phosphorus is low, there is more likelihood of ear rot developing. The prevalence or severity of some other diseases also is apparently related to the supply of available phosphorus.

Shortage of potassium in relation to other plant-food materials hinders the proper maturing of the plant and thus increases the ear-rot hazard. When the potassium shortage is extreme, severe pathological conditions are likely to develop. Under some conditions the ears may even fail to develop properly and dry out early in a loose, chaffy condition. Under some other conditions a lack of potassium may result in extensive root rot and sometimes also in stalk rot, the plants becoming stunted and falling to the ground during the latter part of the summer. In most instances the application of potash salts or strawy barnyard manures has remedied the difficulty.

Lack of balance in the supply of plant-food materials in the soil is a great handicap to the development of healthy corn plants. An excessive supply of available nitrogen, for example, when the amount of potassium is inadequate, is especially conducive to the development of certain diseases. The cure is usually found in increasing the supply of available potassium.

Agricultural limestone appears to be of considerable importance in correcting certain conditions favorable to disease development that sometimes occur in poorly drained soils that have an acid reaction and

perhaps sometimes in sour soils even tho they are well drained. There no doubt are toxic substances in sour soils that are converted by the limestone to an insoluble or an inactive condition in which they are harmless. Very frequently liming causes corn plants to stand up better than they do on similar land that is unlimed.

While fertility balance is of prime importance in reducing the prevalence and severity of many corn diseases, it must be said that there are some corn diseases that seem to be aggravated by a high degree of fertility, as for instance, smut and certain stalk rots. Some seedling diseases also are very active in highly productive soil. This is shown by the fact that seed treatments nearly always give the best increases in yield in corn that is grown on such land. It thus becomes clear that it is only thru a well-rounded program of disease control that satisfactory results are to be obtained in reducing losses in Illinois cornfields.

Other publications of the Experiment Station are available that give more detailed information on how to maintain the fertility balance in Illinois soils. The authors, in this circular, desire merely to point out how lack of proper balance induces conditions favorable for disease.

In addition to the fertility of the soil, proper soil drainage and tillage also are of importance from the standpoint of disease control.

Choose a Desirable Strain of Corn

Two considerations are of special importance in the selection of a strain of corn to be grown on any farm: the strain should be adapted to the length of season in the locality where it is to be grown, and it should be of a high-yielding, disease-resistant type. Such strains are produced by breeding. This process is no magic; it is simply a matter of patiently selecting seed from plants showing the desired characters. Many years of work are required to produce satisfactory results.

If one has an unsuited or unimproved strain, it is by far a wiser plan to discard it and buy the best seed obtainable for the conditions under which it is to be grown than to spend years in trying to breed up the original strain. To make an intelligent purchase, it is necessary to know with what ideals and care the corn has been selected. Such terms as "Smith's Yellow Dent" or "Jones' White Dent" have no meaning except as it is known that Smith and Jones put desirable qualities into the strain and that these qualities have been maintained or improved up to the time of purchase. The term "utility type" has been applied to corn ears possessing certain characteristics associated with disease-resistance and high-yielding ability (Fig. 7). This term is in

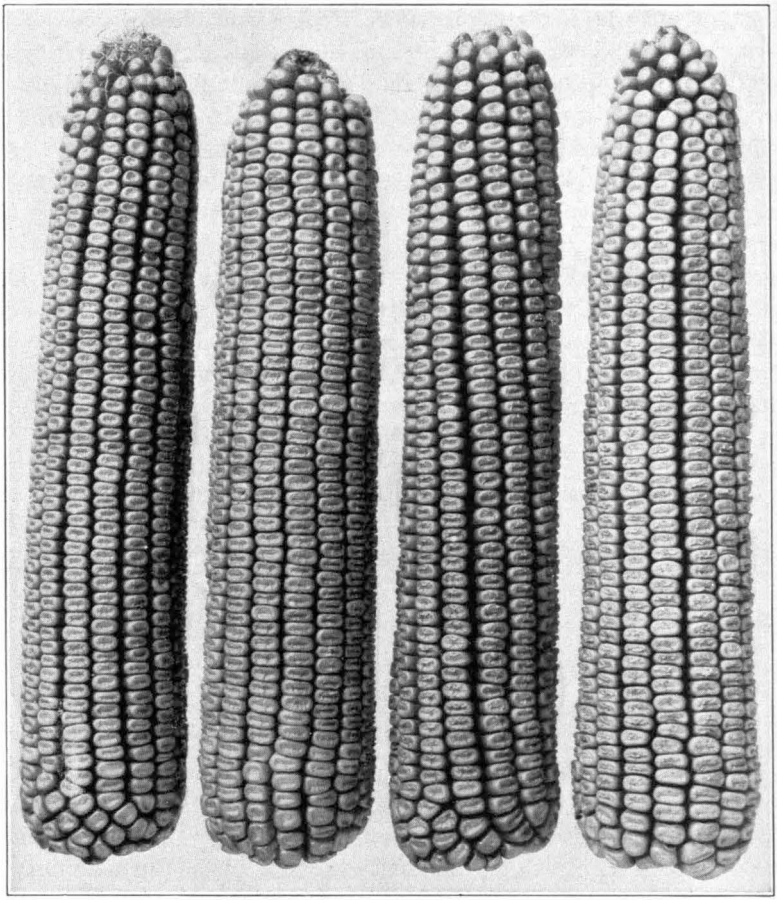


FIG. 7.—UTILITY EAR TYPES

Some of the important characteristics of utility ears are good length, medium diameter, heavy weight in proportion to size, medium-smooth indentation, bright luster, horny kernel composition, a shank attachment that breaks off smoothly and is free from rot, freedom from weathering and mold, and plump, bright kernels with well-developed germs.

itself, however, no *complete* assurance that the corn is good seed corn; other qualities than those that can be seen by inspection of the ear must also be considered.

Open-Pollinated or Cross of Inbred Strains?

Another important question when securing new seed stock is whether an open-pollinated strain or a cross of inbred strains should

be obtained. No definite answer to this question that will cover all cases can be given at present. At Urbana the highest yields in the Station's variety tests have been obtained from single crosses and double crosses of inbreds. This type of breeding, however, is in the experimental stage. Crosses suitable for all soil and climatic conditions have not yet been developed. Anyone wishing to try out such crosses should do so at first on a small scale, comparing the results with these obtained from locally adapted open-pollinated strains.

If a good, open-pollinated strain is chosen, a farmer can well afford thereafter to take the pains to select his own seed corn. It is important, however, that he recognize that the good qualities cannot be maintained without considerable effort on his part. Desirable qualities do not become fixed; without careful attention to selection year after year the strain will gradually "backslide." Furthermore, no strain is so good for any set of conditions but that it can be improved. Every farmer should aim to make such improvements. The directions given a little later in this circular will help to do this.

The maintenance or improvement of inbred strains from which crosses are produced is necessarily a job for the professional seedsman or corn breeder. If a farmer finds it of advantage to grow crossed corn, he need not be concerned much about seed selection, for it will be to his advantage to buy fresh seed every year, or, if double crosses are used, *at least once in every two or three years.* In single crosses of inbreds, that is, in first-generation crosses, the best yield is produced in the first year after the cross is made. Continued selection from such crosses is not recommended, for it will surely result in low yields. The same statement probably also is true for double crosses (a cross of two first-generation crosses), altho in that case regression in yield is considerably slower.

Select Seed Ears From Healthy, Vigorous Plants

Plant selection is of value in any program of corn improvement only in proportion to the care and intelligence exercised in making it. Unfortunately many farmers pay too much attention to type of ear when selecting corn in the field and take too little time to scrutinize the plant on which it is borne. Altho corn is cross-pollinated and one can examine the mother plant only, still by careful selection year after year considerable progress can be made.

Given a strain of corn well adapted to local conditions, the first important consideration in the selection of disease-resistant and nearly disease-free seed is the selection of *plants* that possess desirable characters. Many important hereditary qualities, including resistance to

certain diseases and structural weaknesses that allow disease organisms to enter, can be observed in the mother plant but not in the ear. Not too much attention, therefore, should be given to ear characters at this time; they can be taken care of better after the ears have been cured.

FIG. 8.—RESISTANCE TO STALK BREAKING IS INHERITED

Two inbred lines of corn as they appeared at harvest time are shown above. The one on the left is very susceptible to stalk breaking, every ear usually being on the ground by the first week of November. The one on the right for the most part remains erect thruout the winter. Continuous selection in open-pollinated strains is also effective in increasing the tendency of corn to stand erect until husking time.

Allow Corn to Mature Well. The corn should be allowed to mature well, in so far as weather conditions permit, before seed selections are made. The selections should be made before there is excessive damage from cold weather, altho a temperature just low enough to kill the leaves of plants more susceptible to cold injury, occurring before selections are made, may be of distinct advantage, for then selections can be made for resistance to cold injury as well as for resistance to disease. It should be borne in mind, however, that even tho immature plants usually are less subject to damage by low temperature than are the more mature plants, they should *not* be selected for seed purposes. When a plant is injured by low temperature, the leaves or the affected

portions of them have a dull, pale bluish-green color, as if they had been scalded. If examination is made shortly after the injury occurs, such leaves can be clearly distinguished from those that have died earlier, but usually after a few days have elapsed the "frosted" leaves, or portions of them, turn straw color, and it is not so easy to discern the exact cause of their death. However, even after practically all the leaves have been killed by low temperature, considerable difference in the health of a plant and its resistance to cold is indicated by the greenness of the stalk and by its firmness when pressed between the fingers.

Select Plants With Erect Stalks. As husking by machinery is increasing in popularity, it becomes of greater importance than formerly to select strains that stand erect in the field until husking time. Selections for erect stalks can no doubt be made to best advantage late in the season, possibly in November (Fig. 8). Such late selections should be made in addition to those made earlier in the season and, for breeding purposes, the seed of these late selections should be planted separately from the earlier selections, for one cannot depend on getting good seed corn so late in the season every year. A breeding project cannot be completed in one year, and it will be necessary to reselect for stiff stalks every season in which weather conditions are favorable.

Important Points in Making Plant Selections

1. The plants should be well anchored by the roots; they should stand erect. Plants that lean over are likely to have either considerable root rot or a weak root system. It is undesirable to propagate the tendency toward either one of these defects.

2. The stalk and parts of the leaves should be green while the husks have turned straw color. Plants showing firing or dying of the leaves or any considerable reddish or purplish discoloration of leaves or stem, or plants severely injured by low temperatures should be avoided. Some of these conditions may be an indication of disease or may be associated with susceptibility to disease.

3. The plants should be free from smut. Susceptibility to this disease is inherited.

4. The ear should be supported by a sturdy, unbroken shank. Broken shanks frequently are diseased and the infection may extend into the ear.

5. It is of some advantage to have the shank so curved that the tip of the ear is inclined downward. Then the water will run off the husks as from the shingles of a roof. Less infection has been found in such ears than in those that stand upward. Care must be taken to see that they are inclined in natural growth and not because the shank is broken.

6. The husks should cover the ear well. This reduces the chances for ear infection. In some fields it is difficult to find well-covered ears.

After several years of careful selection for long husks, it no longer becomes so hard to find them.

7. The ears themselves should not be very large in circumference, as such ears dry slowly and therefore are open to disease infection for a longer period. Ears showing mold or insect injury should not be taken, for they would be culled out later.

There are still other characters in type of plant and type of ear that the grower will want to consider, such as color of grain, length of ear, height and number of ears on stalks, etc., but as these are not directly concerned with disease-resistance or the presence or absence of disease, they are not within the province of this circular.

Cure Seed Ears Carefully

After the seed ears have been selected they should be dried rapidly. Under some seasonal conditions when the corn is rather high in moisture and the weather conditions are not favorable for drying, proper drying facilities are a serious problem on the average farm. Under such conditions a heated and well-ventilated drying room is almost imperative. In some houses the room above the kitchen answers fairly well for this purpose. Hanging the corn in a shed is risky, for the disease molds spread rapidly in the damp ears and, furthermore, in case of a hard freeze the seed may be injured or killed. Some commercial equipment which assures forced ventilation at 100° to 110° F. seems very satisfactory. This temperature checks mold growth and is not hot enough to injure the seed. Under favorable seasonal conditions, on the other hand, there is no difficulty in curing the ears properly under ordinary farm conditions if good judgment is exercised.

Weak light is desirable in the drying and storage room. Bright light, especially direct sunlight, bleaches the ears so that it is impossible to take kernel luster into consideration when doing the final selecting. Hangers in which the ears are laid are preferable to those that have prongs, for the shank attachment is considered when the ear is re-examined and it should not be marred.

During the time of curing and subsequent storage until planting time, the ears should be well protected against mouse and insect injury. Kernels with the crown eaten off do poorly when planted. Much corn is damaged in this manner every year.

Select Ears of High Quality

After the seed ears have been dried or cured, they should be further selected for certain definite characteristics that have been

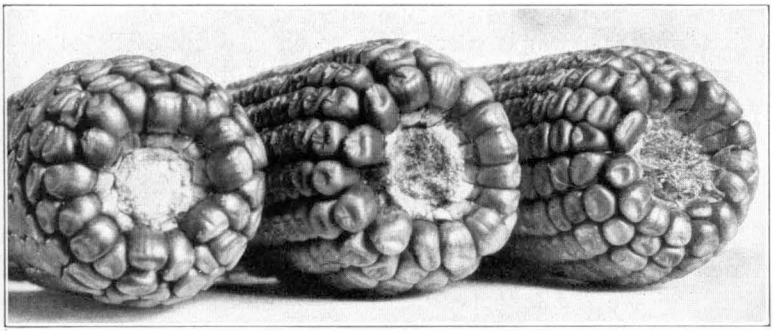


FIG. 9.—ONE GOOD (LEFT) AND TWO UNDESIRABLE SHANK ATTACHMENTS

A clean break of healthy tissue indicates that the shank was healthy and that probably no diseases have entered the ear by that route. A rotted or shredded shank attachment indicates a probability either that diseases have entered the ear at that place or that diseases or other unfavorable circumstances have caused the whole plant, or possibly only the shank, to die prematurely. The kernels of such ears are likely to carry infection, or at least may be susceptible to infection when planted.

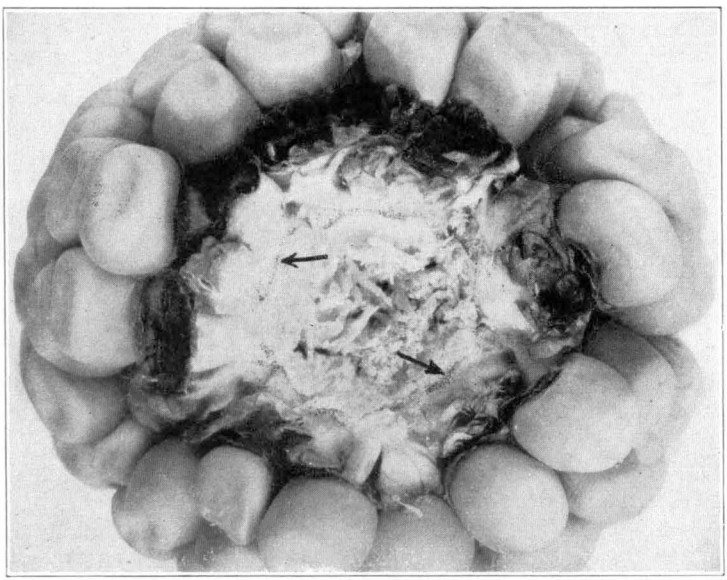


FIG. 10.—BASISPORIUM SPORES AROUND THE SHANK ATTACHMENT

The tiny black spores appearing here in a broken ring are the result of Basisporium infection. The majority of the kernels on such an ear are infected. The spores are often much more numerous than here shown. Ears with a sound shank attachment are not likely to show these fructifications.

shown to be associated with health and vigor. While not every ear that is diseased or is susceptible to disease can be detected and removed in this culling process, the seed lot can be greatly improved.

Points to observe in ear selection are briefly listed below. Nos. 1, 2, 3, 6, and 7 are concerned primarily with complete maturity of the ear. As disease infections, whether of the root, the stalk, or the ear, frequently arrest the final maturing stages, the completely matured ears are more likely to come from relatively disease-free plants than are the less mature ears. The new crop when grown from such seed has a much better chance of being resistant to certain diseases. Points 4, 5, and 8 are more directly concerned with disease symptoms.

Important Points in Making Ear Selections

1. The kernel indentation should not be very rough (Fig. 7). In addition to indicating immaturity and the probability of a high percentage of soft starch, the outer tips of the rough kernels usually become broken in handling and this also is undesirable.

2. The ear should be outstanding in weight and solidity. Some practice is required in order to estimate the comparative weights of ears with sufficient accuracy to be of value in making selections.

3. Good luster of the ear is highly desirable. This means a bright, polished, waxy finish regardless of color.

4. The whole ear, including the tip, should be free from all molds, weathering, and discolorations of every kind. Also the seed coats of the kernels should not be broken, as they sometimes are, either from natural causes, rough handlings, or mouse and insect activity. Mouse damage may be confined to certain parts of the ear only, and if the ear is otherwise satisfactory, it may sometimes be saved by removing and discarding the injured kernels.

5. The butts should show a clean break of healthy tissue. Ears with shredded butts (Fig. 9), or those having yellowish or dull brownish discolorations, are especially to be avoided. Look for the presence of Basisporium spores (Fig. 10).

6. After the ear has been examined as a whole, a number of representative kernels should be removed for examination or, if no germination test is to be made, it is best to shell each ear individually after it has passed the tests just mentioned and then to thoroly examine the shelled kernels. There are two kinds of starch in the endosperm—hard horny starch, which has an amber-like appearance in yellow corn, and soft floury starch. The difference can be noted from the exterior of the kernel (Fig. 11), the horny being semitranslucent and the floury being opaque and, in yellow corn, lighter in color. Selection should be made for a high percentage of horny starch. Ears that pass the germi-

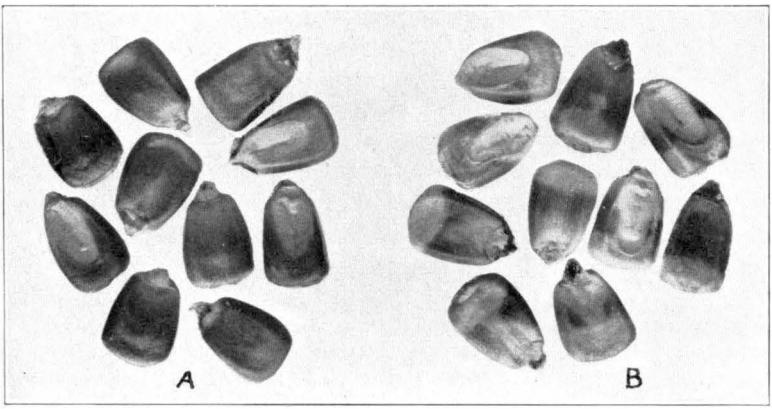


FIG. 11.—HORNY KERNELS OF CORN (A); FLOURY, OR STARCHY, KERNELS (B)

In good seed the horny, amber-like endosperm should extend down to the tip of the kernel and should extend up very nearly to the cap or dent. In dent corn, floury endosperm may be a varietal characteristic or it may be an indication of immaturity of the grain. Corn kernels with a marked degree of floury endosperm are usually undesirable for seed.

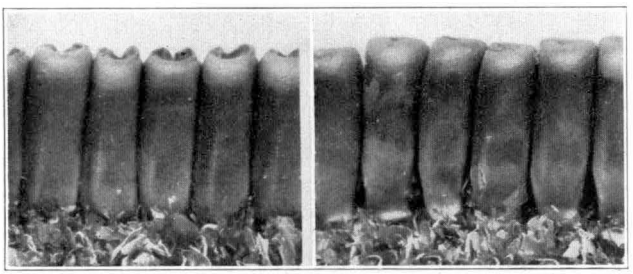


FIG. 12.—MATURE AND IMMATURE KERNELS IN THEIR NATURAL POSITIONS ON THE COB

Mature grains carry their full thickness down to the very tip of the kernel (left). Grains that have dried and hardened while still decidedly immature (right) are not filled out at the tip, altho there may be no indication of this condition in the unshelled ear. When shelled, the undeveloped condition at the tip of the kernels, together with lack of horny endosperm in this region, is easily recognized. This lack of development may be caused by disease or by the occurrence of low temperatures before the ear is mature.

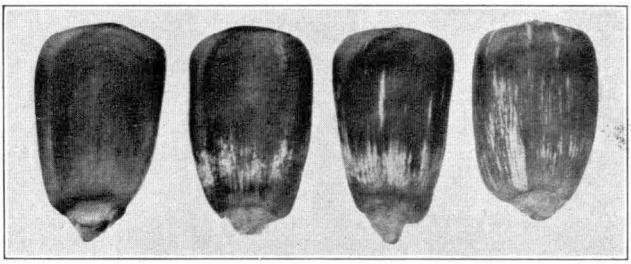


FIG. 13.—ONE SOUND AND THREE INFECTED KERNELS

White streaks as here shown, as well as black streaks, are a good sign of fungous infection, and ears showing such a condition should not be taken for seed. A yellow or brown discoloration at the lower end of the germ is another indication of infection. By observing such signs as these and others described in the text, many undesirable ears can be eliminated from the seed lot. Even tho such ears appear free from disease in a germination test, yet field experiments have shown such seed to be inferior in performance.

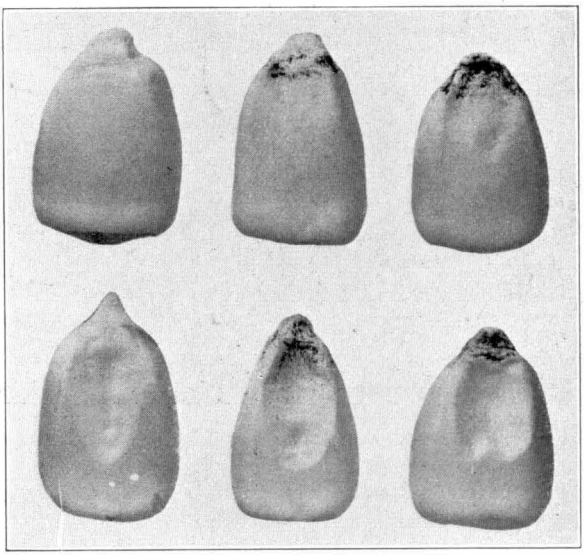


FIG. 14.—KERNELS INFECTED WITH BASISPORIUM

The tiny black spores of this fungus are observable on four of the above kernels. They are not always abundant enough, however, to be readily noticed with the naked eye. Many infected kernels show no spores at all.

nation test should afterwards also be shelled individually and carefully reinspected for horniness as well as for the following points.

7. The kernels should be well developed, carrying their full thickness to the point or tip of the grain (Fig. 12).

8. The kernels should be free from any streaks (Fig. 13), spores (Fig. 14), and whitish, grayish or brownish discolorations. The latter are especially apt to occur toward the tip end of the kernel.

9. Cracked seed coats may occur on the sides of the kernels, where they are not noticed until the ears are shelled (Fig. 15). Such ears should be discarded.

10. When the grain is shelled from the cob, in most corn-belt varieties, the tip cap of the kernel should remain on the kernel and not on the cob. These tips breaking off may or may not be a sign of disease infection, but at any rate if they break off, the grain lacks this protection and is open to infection as soon as it is planted.

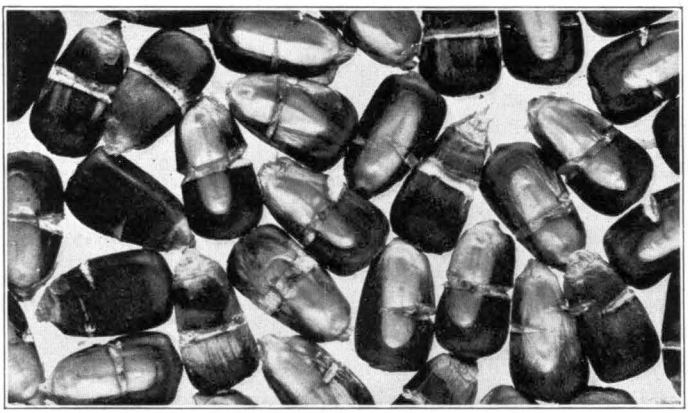


FIG. 15.—SO-CALLED "SILK CUT" OF CORN

In the unshelled ear this kind of injury often is not noticeable. For the detection of this, as well as other kernel defects and discolorations, every ear should be shelled separately and the kernels carefully examined before deciding to use the ear for seed.

Germination Test Third Step in Seed Selection

The germination test must be regarded as a measure that is valuable primarily as a supplement to plant and ear selection. It cannot, even under the most ideal circumstances, take the place of these other measures.

In the first place plant and ear selection take into consideration certain important characters that cannot possibly be covered

by a germination test. In the second place the germination test, so far as it concerns disease, gives information only about diseases that are seed-borne, and to a considerable extent such diseases can be dealt with by reliable seed treatments. Furthermore, few farmers have the equipment or training needed to operate the test so as to develop visible signs of such diseases as may be present or to interpret such symptoms of disease as appear. It is not an easy matter to maintain proper temperatures within the germinator, good aeration, the right degree of atmospheric humidity, and a film of water of proper thickness surrounding the kernels—all of which conditions are highly important in obtaining a reliable disease test.

People who fail to make careful plant and ear selections will, of course, profit more by the germinator test than those who follow such practices, but they will not get as good net results in the long run.

There are other uses for the germination test besides that of detecting disease. It is of special value in years when there is question concerning the vigor and viability of seed corn.

Apply Reliable Seed Treatment

Certain seed disinfectants now available are effective in protecting the young corn seedling against seed-borne infections. Furthermore they seem to offer some protection against infection from the so-called "saprophytes," or "weak parasites," that occur abundantly in the soil and cause much of the damage that is suffered by young corn seedlings.

The average farmer of the northern and central sections of Illinois, under average conditions, may be fairly confident of an increase of 2 or more bushels an acre in his yield of dent corn by applying a good seed treatment at an outlay of about three cents an acre for the disinfectant. This statement is based on tests of samples of corn which were obtained from 285 farmers in central Illinois in the seasons 1928 and 1929, composited, and grown under several different soil conditions. As a result of seed treatment, an average increase of about 3 bushels an acre was obtained (Fig. 16). As yet no seed-treatment experiments have been conducted under the soil and climatic conditions of the southern section of the state.

Some very striking increases in stand, vigor, and yield of grain have been obtained from seed treatment. Even with the very

best seed obtainable seed treatment, in Illinois experiments, has usually proved worth while. Benefits from seed treatment ordinarily cannot be detected by field inspection, but accurate determinations of yield disclose the differences.

Seed treatment is not, of course, a remedy against all corn diseases. It does not control smut, ear rot, stalk rot, or root rot di-

FIG. 16.—DIFFERENCES IN THE VEGETATIVE GROWTH OF DENT CORN CAUSED BY SEED TREATMENT

This striking difference in size occurred in 1929, when planting was followed by three weeks of cool, rainy weather. Ordinarily when fairly good seed is used, the effect of seed treatment cannot readily be detected until the husked corn is weighed.

rectly, 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 such compounds in Illinois have failed to substantiate these claims.

Directions for Applying Seed Treatment.—Effective commercial seed disinfectants should be applied at the rate of 1½ to 2 ounces to a bushel of shelled corn. 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

of a 30-gallon metal oil drum (Fig. 17). A concrete mixer answers the purpose if a tight lid can be fixed over the opening. Various commercial mixers are on the market.

Care must be taken to avoid inhaling the chemical dust used in seed treatments. The mixing should be done out of doors or the apparatus may be placed on a barn floor with the big 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

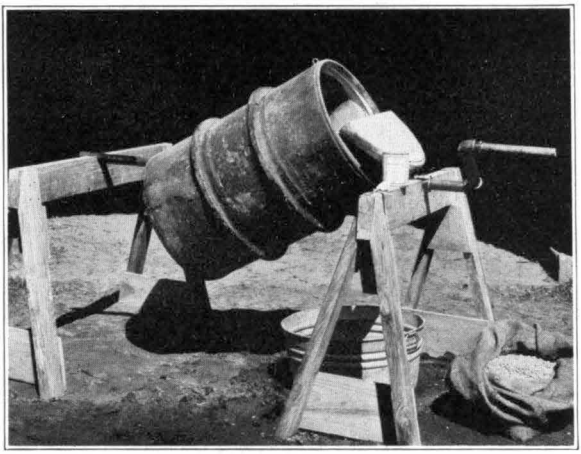


FIG. 17.—A SEED-TREATING MACHINE MADE FROM A STEEL OIL DRUM

One half of one of the drum heads is cut out and a tight-fitting hinged lid is put in its place. A shaft made of one-inch iron pipe is fastened in a diagonal position thru the drum. One or several baffle boards should be fastened on the inside. This size treats one bushel of seed at a time. It is suitable for all kinds of farm seeds.

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.

After the corn is treated it should be stored in a dry place. Leaving it in an open building where the humidity of the air is similar to the humidity out of doors is a risk under some weather conditions. Such exposure is not very apt to kill the seed but it may have a depressing effect on the vigor of the resulting plants and consequently on yields.

Seed Treatment Reduces Danger From Early Planting.—Treated seed can be planted early with greater safety than untreated seed, for there is less danger of damage because of unfavorable weather conditions in case it should lie in the ground for a long time before sprouting. It has often been demonstrated that when seed of good quality from full-season varieties is used, the early-planted corn (May 1 for Urbana) usually yields the best. Seed treatments may also be of special benefit in case the soil is wet when the corn is in the seedling stage.

Altho seed treatments sometimes have proved of no benefit, yet in the event of unfavorable environmental conditions during the germinating period the treatments become highly beneficial and may even prevent the necessity of replanting. They have given enough return, on the average, to allow a good profit on the investment.

Seed Treatment Not a Substitute for Good Seed

Seed treatment, it should be emphasized, is not a substitute for good seed. Physical selection, when well done, is more important than seed treatment, but a good seed treatment may be worth while as an additional measure. In fact, farmers who have been giving careful attention to plant and ear selection for a number of years are in many cases getting more benefit from the use of a good seed disinfectant than are farmers who have spent comparatively little time in selecting their seed ears.

Some of the same treatments that have proved beneficial on dent corn, when applied to sweet-corn seed, have been found to cause a substantial increase in the yield of prime canning corn.

Reducing Losses From Corn Diseases

ILLINOIS FARMERS can greatly reduce their losses from corn diseases by carrying out certain control measures described herein. Practices important in such a program are:

1. Sanitation, that is, the removal of all old corn refuse from the field or the thoro plowing under of such refuse so as to remove it from the surface of the ground. Such refuse carries spores which otherwise are scattered by the wind and reinfect the next crop.

2. Crop rotation, in order to prevent the accumulation of disease organisms in the soil.

3. Soil management, including proper tillage, drainage, and soil fertility, in order to provide conditions favorable to the vigorous and balanced growth of the corn plant.

4. Development of disease-resistant strains in open-pollinated and inbred stock by careful plant and ear selection for freedom from disease, for characters found to be associated with resistance to disease, and for other desirable plant qualities.

5. Seed treatment, in order to check seed-borne diseases and protect the kernel or young seedling against infection from the soil, especially when the environmental conditions are unfavorable for germination.

6. In addition to the above control measures, the germination test for vigor and freedom from disease usually is of value. In seed lots that have poor viability, a germination test of the ear is very important. The value of seed treatment and the germination test only partly overlap. Neither can entirely take the place of the other and each has advantages not covered by the other.

No one step in these general measures for controlling corn diseases is very effective without attention to all. It is only when a well-rounded program for corn improvement is followed out year after year that satisfactory results are obtained.