A 3-Point Program

- Use resistant hybrids
- Delay planting
- Practice clean farming

Circular 521

UNIVERSITY OF ILLINOIS \ COLLEGE OF AGRICULTURE EXTENSION SERVICE IN AGRICULTURE AND HOME ECONOMICS
SERIOUS LOSSES IN ILLINOIS' GREATEST CROP CAN BE PREVENTED
without adding much, if anything, to production costs if farmers will . . . .

- Select the most resistant hybrids that are suited to the area.

- Plant these hybrids late enough so they will escape the eggs of the first-brood corn-borer moths. (This is especially necessary on very fertile soils; on poorer soils the borer is not a serious problem.)

- Practice clean farming, including the plowing under of all infested crop and weed refuse sometime before the first of May.
CORN-BORER CONTROL
A Three-Point Program

By W. P. Flint, G. H. Dungan, J. H. Bigger, and A. L. Young

In spite of quarantines the European corn borer has now not only entered Illinois but has extended its range entirely across the state. Nearly half the farming area of Illinois is now known to be infested. In the eastern section, along the Indiana line from Lake county to Edgar county, the borer is so common that it can be found in almost any cornfield in a five to ten minute search.

While no commercial damage has yet occurred in Illinois cornfields, and none is expected for two or three years, it is time for Illinois farmers to familiarize themselves with well-tested defense practices and be prepared to carry them into effect just as soon as they are needed. For 1942 the only measure that need be adopted is clean plowing.

Farmers in Indiana and Ohio who have had many years of experience with this insect have learned to live with it and produce good crops of corn in spite of it. This is why not much has been heard about borer damage during the past five years. In the most fertile corn-producing areas in Ohio farmers who have consistently followed the practices outlined here have commonly produced 60 to 80 bushels of corn to the acre. But if a farmer neglects any of them, particularly either of the first two, his corn yield is cut seriously, many times it is cut in half, and the corn is of poor quality. In experimental plots in areas where the borer has been a pest for fifteen to twenty years these three practices have made it possible to harvest 60- to 80-bushel corn crops on highly fertile soils.

Altho borers were found within 25 miles of Illinois in 1930, it was not until 1939 that they were actually discovered in the state. Five northeastern counties were then found infested. In 1940 12 more counties were added to the infested list, and in 1941 26 more counties were added, making 43 in all.

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MAY
OVERWINTERING-BORERS CHANGE TO RESTING-STAGE (PUPAE) IN OLD CORN AND WEED STALKS AND SIMILAR SHELTER

JUNE
LAST OVERWINTERING BORERS PUPATE. PUPAE CHANGE TO MOTHS. MOTHS LAY EGGS AND FIRST-BROOD BORERS BEGIN TO HATCH

JULY
SOME FIRST-BROOD BORERS PUPATE AND CHANGE TO MOTHS. MOTHS LAY EGGS. SECOND-BROOD BORERS BEGIN TO HATCH

AUGUST
LAST OF FIRST-BROOD BORERS PUPATE AND CHANGE TO MOTHS. SECOND-BROOD BORERS CONTINUE TO HATCH AND CHANGE TO MOTHS. MOTHS LAY EGGS. EGGS HATCH

SEPTEMBER
SECOND-BROOD BORERS COMPLETE THEIR GROWTH

WINTER MONTHS
OCTOBER THRU APRIL. FULL-GROWN BORERS WINTER. IN CORN STUBBLE AND STALKS OF CORN AND WEEDS

The shorter the corn plants are at the peak of moth flight, which usually occurs in June, the less likely are the moths to deposit eggs on them. That is why delayed planting reduces injury.
TWO BROODS A YEAR IN ILLINOIS

From observations made during 1941 it is estimated that about 60 to 70 percent of the borers in Illinois cornfields in 1942 will be two-brooded. This fact may or may not increase the damage the borer will do, for in many seasons the chances are that weather and other environmental conditions will reduce its numbers and the worms hatching from the second-brood eggs will not become mature enough to survive the winter.

With two broods a year the life cycle of the insect will be approximately as shown in the drawing on page 4.

In May and June the borers that have overwintered in the stems of plants, particularly the stalks of corn and stems of large weeds, change to the brown resting stage; that is, they become pupae.

In June and July the moths emerge from these pupae, lay their eggs, and hatching starts.

During July and early August the first brood of borers continue to hatch, mature, and change to the brown resting stage (the pupa stage) within the stems of the plants where they have been feeding.

In August or early September a second brood of moths emerge from these pupae and lay the eggs from which the second generation of borers hatch.

In September and early October if the weather is favorable, the borers of this second generation become full-grown caterpillars. They bore into the interior of the stems of various plants, mainly cornstalks and large weeds. Thus protected they pass thru the winter and are ready to develop into the next stage when warm weather returns.

SOME STRAINS OF CORN ARE RESISTANT

One outstanding fact emerges from several years of tests in the heavily infested areas of Ohio and Indiana. It is that distinct and consistent differences exist among the different inbreds, hybrids, and open-pollinated varieties of corn in their resistance to borer damage. These differences appear as variations in (1) attractiveness of the corn plants to the moth; (2) ability of the borers to establish themselves in the plants; (3) ability of the borers to survive after they are established; and (4) ability of the plant, even tho infested, to produce a good yield of marketable grain.

The most desirable corn would probably be one on which the moths
would not lay eggs; in other words, the plant would be immune from attack. It is clear, however, that for some years to come Illinois corn growers will have to put up with plants on which moths will lay their eggs but in which the worms will find it difficult to establish themselves and survive, or else plants that will produce good yields of good corn in spite of borer infestation.

The extent to which entries in the Ohio experiments have varied in their susceptibility to borer infestation when grown under identical conditions is shown by the accompanying table, in which the data for four years are summarized. Year after year some of these strains averaged twice as much infestation as others.

### Susceptibility of Nine Illinois Corn Varieties and Hybrids to Corn-Borer Attack When Tested in Borer-Infested Fields Near Toledo, Ohio; and Effect of Delayed Planting

*(Based on records for four years, 1928-1931)*

<table>
<thead>
<tr>
<th>Entry</th>
<th>Percentage of plants infested when seed was planted—</th>
<th>Average infestation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May 4-10</td>
<td>May 18-24</td>
</tr>
<tr>
<td>Illinois Hybrid 365</td>
<td>22.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Illinois Two-Ear</td>
<td>22.5</td>
<td>13.6</td>
</tr>
<tr>
<td>Illinois Hybrid 517a</td>
<td>27.1</td>
<td>13.8</td>
</tr>
<tr>
<td>Illinois Hybrid 250</td>
<td>29.4</td>
<td>14.9</td>
</tr>
<tr>
<td>Champion White Pearl</td>
<td>32.5</td>
<td>19.4</td>
</tr>
<tr>
<td>Illinois Hybrid 334b</td>
<td>37.4</td>
<td>15.1</td>
</tr>
<tr>
<td>Reid Yellow Dent</td>
<td>37.3</td>
<td>20.6</td>
</tr>
<tr>
<td>Hunt White Dent</td>
<td>44.2</td>
<td>18.0</td>
</tr>
<tr>
<td>Clarage</td>
<td>43.0</td>
<td>25.2</td>
</tr>
<tr>
<td>Golden King</td>
<td>51.0</td>
<td>20.4</td>
</tr>
<tr>
<td>Average of 4 hybrids</td>
<td>29.1</td>
<td>13.3</td>
</tr>
<tr>
<td>Average of 6 open-pollinated varieties</td>
<td>38.4</td>
<td>19.5</td>
</tr>
<tr>
<td>Average of all entries</td>
<td>34.7</td>
<td>17.1</td>
</tr>
</tbody>
</table>

*Grown three years only. °Clarage, a standard open-pollinated Ohio variety, was included for comparison. Tests were carried out in cooperation with the U. S. Bureau of Entomology and Plant Quarantine.

Illinois Two-Ear, which is found near the low-infestation end of the list, has the second excellent characteristic mentioned on page 7—slow early and rapid late development.

Owing to rapid changes in available hybrid material during the period when these tests were being made, only a few of the same entries were continued thru all four years.
SEVERAL PROMISING INBREDS

Commercial corn breeders will be interested in the work with inbreds and single crosses which the Illinois Station has been doing in cooperation with the Ohio Station since 1938. As the result of tests made in Ohio the following inbreds now being used in the Illinois corn-breeding program can be definitely classed as resistant or susceptible to corn-borer attack.

**Resistant**
- Illinois R4
- Illinois Hy
- Iowa L317
- Ohio 40B
- Ohio 56
- Wisconsin CC5

**Susceptible**
- Illinois A
- Indiana WF9
- Indiana Tr
- Iowa Os420
- Iowa 1224a2
- Iowa L289
- Iowa Cl 477
- U. S. 187-2
- U. S. 4-8

In a strain of corn in which resistance to attack by the borer is to be developed, three protective characteristics are considered desirable:
1. Delayed emergence of the tassel.
2. Slow early development of the plant and rapid late development.
3. Relatively late maturity.

Altho delayed emergence of the tassel, so noticeable in R4, appears to help in preventing borer establishment, nevertheless there are some inbreds that do not have this characteristic and yet are relatively free from attack.

Breeding for borer resistance made this difference. Grown side by side, the susceptible strain (1028 X WF9) had only 2 good ears and a small number of damaged ears; whereas the resistant strain (Hy X L317) had many good ears and only a few badly damaged ones.
The upstanding stalks at the left show what can be expected of a resistant strain (US187-2 × 28). Only very little breakage occurred. The broken stalks at the right (Os420 × Os426) are typical of susceptible strains under corn-borer attack.

**VALUE OF DELAYED PLANTING**

The reason delayed planting is of so much importance in corn-borer control is that much of the later planted corn will not be high enough to attract the moths until after the peak of the moth flight has passed. The moths prefer the tallest corn on which to deposit their eggs.

In the Ohio tests reported in the table on page 6, 35 percent of the plants of all the varieties planted May 4-10 were infested with borers; whereas only 17 percent, or only half as many, were infested when the corn was planted two weeks later, May 18-24.

In other tests near Van Wert, Ohio,\(^1\) the May 10 planting showed all stalks infested and an average of 14 borers to a stalk; the May 24 planting had 9 borers per stalk; and the June 2 planting only 2 borers per stalk. These three tests were made in 1939 on adjacent plots and were carried on cooperatively by the Illinois Station and Natural History Survey and the Ohio Station.

Fields near Berne, Indiana, planted on May 13, 1939, showed 196

\(^1\)Unpublished data from L. L. Huber, Ohio Agricultural Experiment Station.
It is on fields of high productivity, according to the experience of Ohio corn growers, that delayed planting is most effective. Therefore where corn follows clover or alfalfa, or where the normal corn yield would be 75 or more bushels an acre, it is especially necessary to delay the planting date.

Since date of planting is a matter of such great importance in combating the borer, one of the jobs of the corn breeder is to develop hybrids that will produce efficiently when planted at a medium-late date.

PLOWING IS BEST CLEAN-UP METHOD

Delayed planting of resistant hybrids is good protection for the individual farmer against serious damage to his corn crop by the borer, but the chances of avoiding heavy damage are still better if thorough clean-up methods are used when the crop is harvested and when the ground is being prepared for the next corn crop. To be commercially worth while, however, clean-up practices must be applied to all infested fields over a large area, otherwise the moths will fly from one field to another.

Sometimes the crop can be so utilized that most of the borers will be killed without other effort. Low cutting of the stalks, followed by ensiling or shredding, will kill the borers, as will also the trampling of the stalks into the manure where the stalks are being fed. Some farmers who have had experience in heavily infested areas argue that in livestock sections instead of husking so much corn from standing stalks, more should be cut low, placed in shock, and later shredded for both feed and bedding. This would largely solve the problem of saving the straw from the combine for bedding and would allow more of it to be sold for industrial processing.

The most economical and effective method of destroying borers, all things considered, is to plow under all stalks and other plant material in infested fields. The material must be buried far enough beneath the surface so that none of it will be brought up in later operations to furnish shelter for the borers. Even tho some borers will work their way to the surface, few will survive where there is no plant material in which they can shelter.

1Oral report by G. A. Ficht, Indiana Agricultural Experiment Station.
Burning is of little value. If neither feeding the stalks nor plowing them under is practical, the infested material can be burned, though this practice is not recommended. When the next crop is to be seeded without the ground being plowed, burning the stalks is sometimes resorted to, but to do it completely enough to obtain satisfactory control is difficult and often impossible. Both from the standpoint of borer control and maintenance of soil fertility, it is better to plow this material under.

HOW TO GET GOOD COVERAGE

Plowing, as commonly done, leaves far too much material on top of the ground to give good borer control, but most farmers can get effective coverage by using their moldboard plows if the plows are in good condition, are equipped with the proper attachments, and are properly operated. Many of the later models of plows are designed with extra clearance beneath and between beams, thus providing space for needed attachments and permitting the free passage of large amounts of trash.

A plow capable of doing good plowing can, as a rule, be made to do good covering without much additional expense, if the type of bottom is correct for the soil being handled, the shares are kept reason-

Adequate plow attachments are necessary to do a job like that on the left. Blame for the poor coverage at the right can be laid to lack of the right attachments, for the same plow was used on both areas and it was run at the same depth.
ably sharp and properly pointed, and the entire bottom scours freely. The rolling colter must be sharp enough, large enough, and so set that it will cut thru all trash and leave a clean furrow wall. The hitch must be correct both vertically and horizontally. Excessive wear at any point that prevents the plow from doing a good job should be repaired immediately.

To get good coverage some additional equipment will, as a rule, be needed. Moldboard-type of jointers must be used and must be carefully adjusted to position. They are often combined with the colter but if preferred can be separately mounted on the beams. Unfortunately wear at the point of the jointer often causes trash to lodge between the jointer and the colter. To prevent this, the point may have to be reshaped in a forge.

Wire or trash shields are also usually needed in order to flatten and hold down the trash and force it into the bottom of the open furrow. Many farmers are now using one or more wires to a bottom, commonly No. 9 size and about 10 feet long.

Trash shields have not been used extensively in Illinois; but they have been used in Indiana, and according to the Purdue Station have proved satisfactory. Constructed of sheet metal and hinged above each moldboard, these shields apparently have to be carefully shaped and fitted to each type or model of plow.

Complete coverage of cornstalks is often more easily obtained if the stalks are given some treatment, such as a thoro disking, or rolling in the direction in which the plowing is to be done, before the field is plowed. Double-disking is especially desirable where the ground is considerably ridged; if possible, this should be done sometime ahead of plowing, as a rain between disk ing and plowing is often helpful in securing complete coverage.

INSECTICIDES FOR SWEET CORN

For the present, insecticides will have to be depended upon to control the European corn borer on sweet corn. The cost is fairly high but the outlay will prove profitable in localities where the borer is destroying 25 percent or more of the marketable crop.

Dusting the growing plants with fixed nicotine dusts or spraying them with rotenone has given the best results. Either method care-

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1See Circular 450, “Better Plowing,” for a complete discussion of plow adjustment and operation. Copy will be sent free on request.
fully followed should give 75 percent of the ears borer-free. Three or four applications of the insecticide must be made, starting as soon as the first borer eggs begin to hatch and continuing at approximately 5-day intervals.

The systematic clean-up of crop refuse, if practiced over a large area, will help to keep down the borer population on sweet corn as well as field corn.

The use of resistant varieties will be just as effective for sweet corn as for field corn, but as yet there is not much information on resistant sweet corns. Control by delayed planting is not practicable since sweet corn must mature throughout the marketing season.

That Illinois farmers would some day have to cope with the European corn borer and learn to produce good yields of high-quality grain regardless of its presence in their fields was forecast 15 years ago in Circular 313, *Learning To Live With The European Corn Borer*.

Fortunately this pest advanced more slowly toward Illinois than first seemed probable, thus giving time for research workers in Ohio, Michigan, Indiana, Illinois, and the federal bureaus to test out control measures in advance of its arrival. The foremost accomplishment has been the development of resistant inbreds and hybrids.

Before commercial damage becomes a broad threat in Illinois resistant hybrids should be generally enough available to give good protection where farmers will delay planting and practice clean farming.