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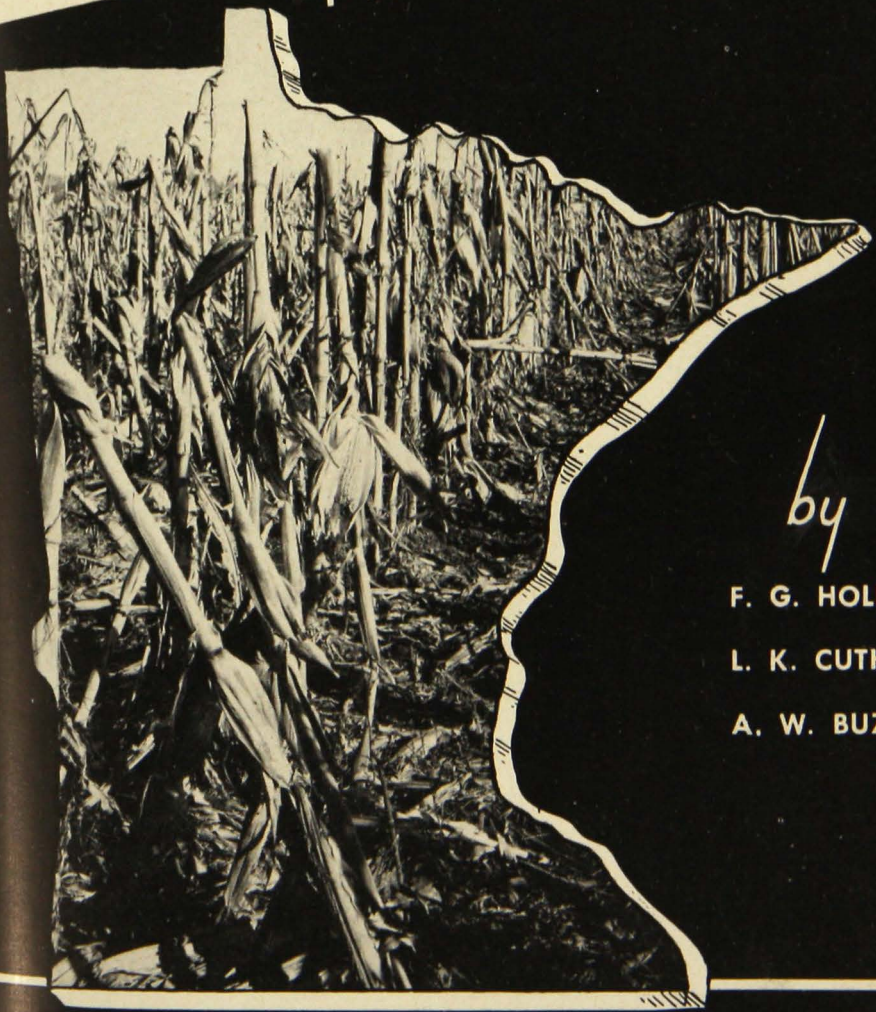
FIGHTING THE European CORN BORER IN MINNESOTA



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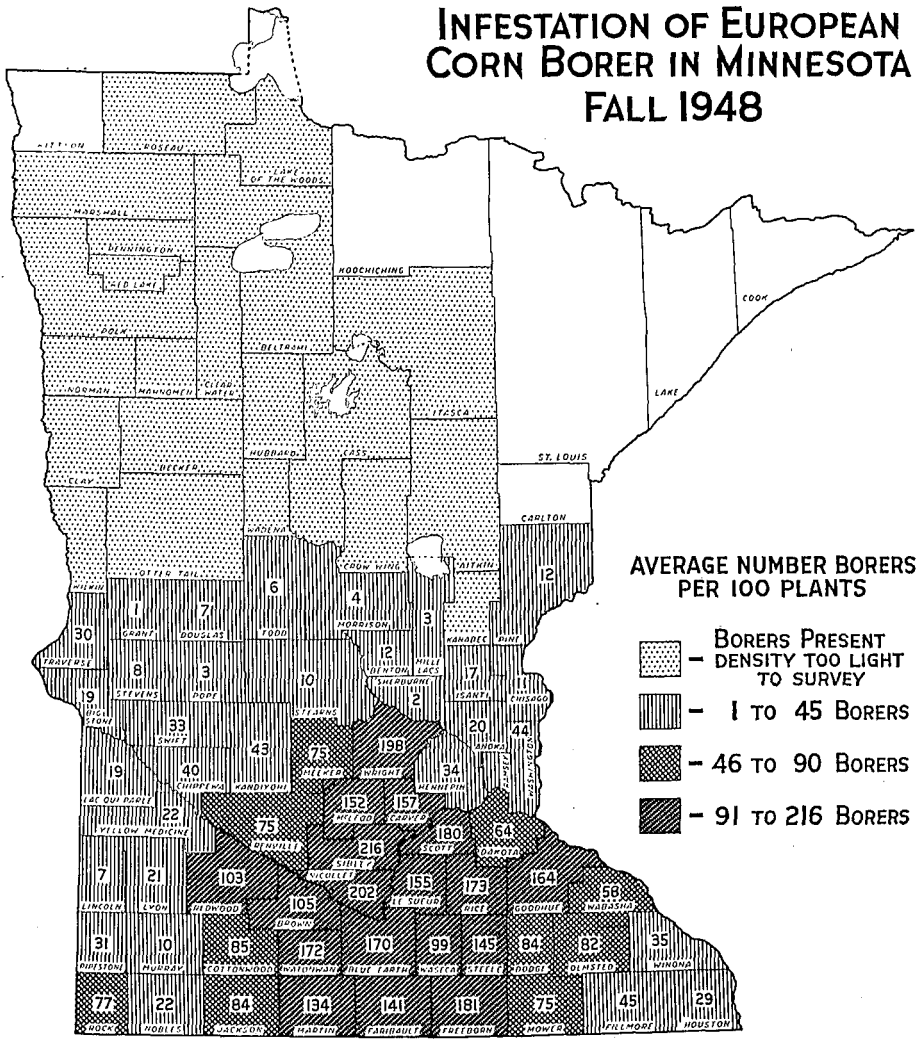

When Is There Danger of Damage?

In areas where borers average more than 100 per 100 stalks in the fall, the infestation in the following season is likely to be very severe. In areas where they average from 10 to 100 per 100 stalks, infestation may be severe. Counties with less than 10 borers per 100 stalks may have some damage. Corn borer moths can fly 25 to 50 miles, so an area adjacent to a region with a heavy infestation could be heavily infested by moths from a distance.

Fighting the European Corn Borer in Minnesota

F. G. Holdaway,[1] L. K. Cutkomp,[2] and A. W. Buzicky[3]

A FEW YEARS AGO the European corn borer was just a curiosity in Minnesota. Today, it is the greatest single menace facing corn production in the state. First found in Houston County in 1943, only six years ago, it has now spread to every one of Minnesota's corn-growing areas.

In their few years of experience with the corn borer, Minnesota farmers have found that borer losses can be large. In both 1947 and 1948 losses of field corn were estimated to be about 6,000,000 bushels. Additional losses to sweet corn and seed corn were estimated at $700,000 in 1947 and $2,000,000 in 1948. With corn at $2.30 per bushel in 1947, the total loss was estimated at $14,000,000. With corn at $1.25 per bushel, the total loss in 1948 was estimated to be $9,600,000.

The borer damages corn in four ways:

1. Newly hatched larvae feed on the young leaves, causing a "shot-hole" condition.

2. Larvae bore into the bases of leaves and in the stalk. The injury to the leaves reduces the ability of the plant to produce food; the injury to the stalk prevents the plant from getting all the food it needs for growth. The plant may be so weakened that it breaks, while the boring in the stalk, even when breakage does not occur, often results in nubbins and light chaffy ears.

3. Larvae may attack the ears themselves.

4. Larvae boring in the stalk and ears open avenues of entrance for rots which may cause additional damage. In individual plants this may be more serious than the borer itself. Records obtained by Dr. J. J. Christensen and C. L. Schneider of the University of Minnesota's Division of Plant Pathology during 1947 and 1948 indicate that 80 to 90 per cent of the borer tunnels showed evidence of rots.

When borers average one per plant at the end of the growing season, the yield of field corn may be reduced by 3 to 4 per cent. When borers average three per plant, yields may be reduced 10 per cent. Heavier infestations of 10 to 20 borers per plant have caused complete loss.

To appreciate the following control recommendations, it is important to be able to recognize the borer in its four stages—egg, larva or borer, pupa, and adult or moth.

Larva—The full-grown corn borer is about one inch long and about three-sixteenths inch thick. Its head is dark

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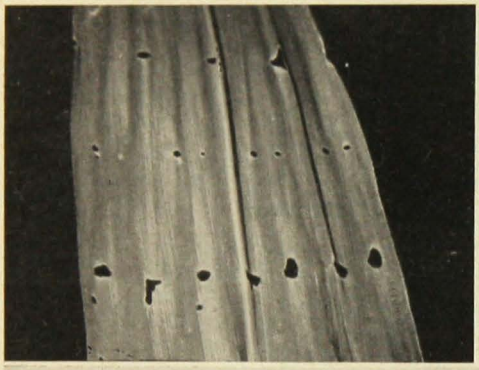
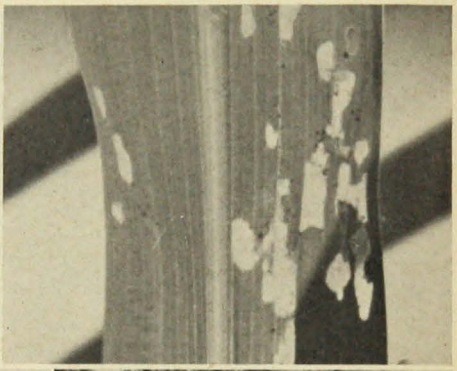
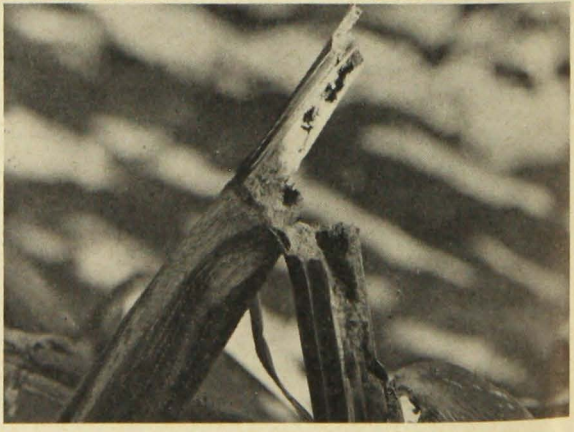






DAMAGE DONE BY BORER

UPPER LEFT—shot-hole condition caused by feeding on leaves while still rolled up; UPPER RIGHT—later leaf injury; CENTER LEFT—broken tassels resulting from borer feeding within stalk; CENTER RIGHT—borings on the outside of the stalk; BOTTOM LEFT—tunneling or burrowing within stalk showing larva and pupa of the first brood; BOTTOM RIGHT—broken stalk caused by tunneling.

brown to nearly black, with the rest of the body usually dirty grey. The general body color may range from pinkish to light brown. It has rows of small brown spots along its back, but has no stripes. The borer goes through the winter in this stage.

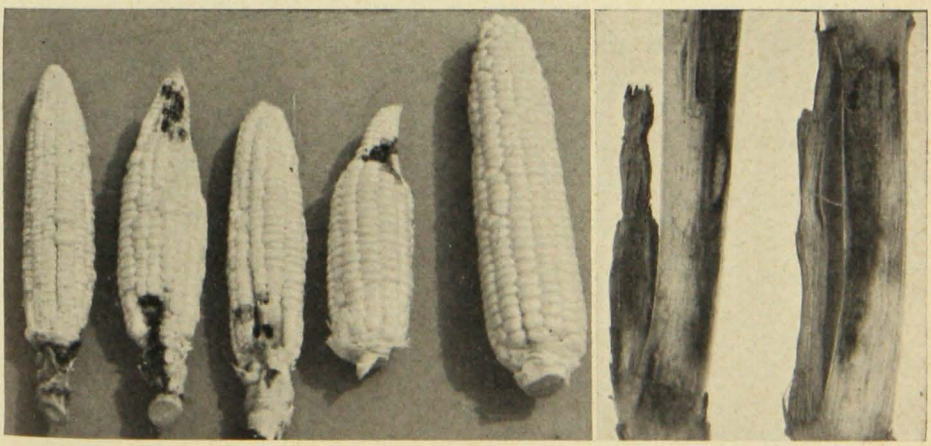
Pupa—In late May the larva which has passed through the winter changes to a pupa. This stage lasts 10-14 days. The pupa is about one-half to three-quarters inch long, spindle shaped, and a light to dark reddish brown.

Moth—In late June the moth comes out of its pupal case. Usually tan, the moth may range from light brown to pale yellow. There are zig-zag lines on the outer half of the front wing. The moth is seldom seen during the day; it usually remains hidden in weeds or grass, or more rarely, on the underside of corn leaves. Ordinarily the moths leave the corn fields at dawn and return after twilight.

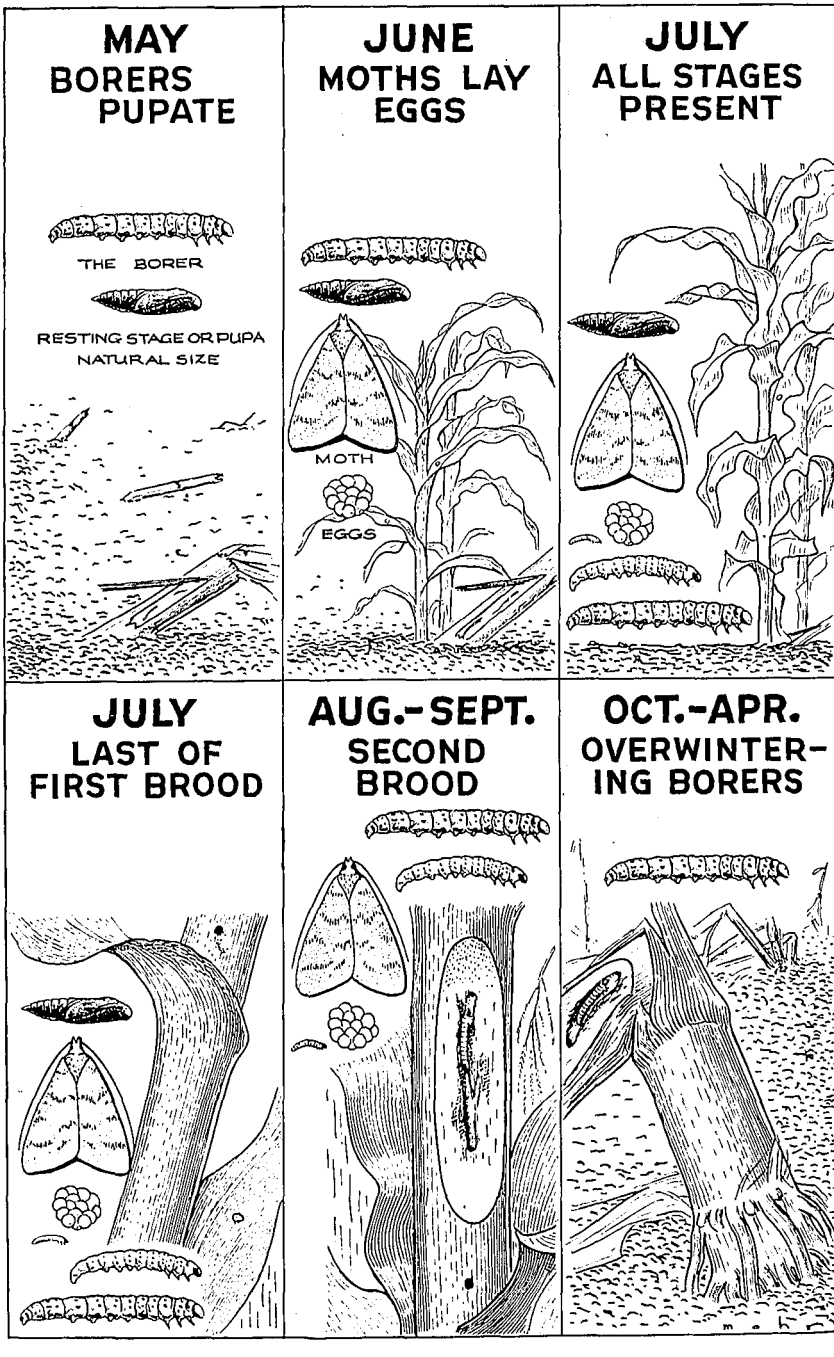
Eggs—The moths mate and lay eggs within two to five days after leaving their pupal case. They lay their eggs at night, usually on the underside of the corn leaf, in clusters of 5 to 50 overlapping like fish scales. The average number of eggs per egg mass at Waseca has been found to be 14 in the first brood and 17 in the second brood.

Each female lays about 400 eggs. Egg laying begins in the latter part of June and continues during early July. These are the eggs of the first brood. Most of these eggs are laid on the most advanced corn available to the laying moths. It is possible, however, to get a heavy infestation in a field which is not as advanced.

At first the eggs are milky white. After four to seven days, and just be-



Left—Ears attacked directly and nubbins and light chaffy ears resulting from borer preventing normal development; ear on right came from an uninfested field.
Right—Stalk rot developing around borer tunnels; note borer in left stalk.



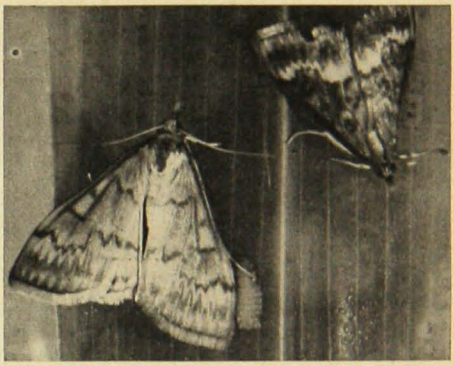
LIFE HISTORY OF EUROPEAN CORN BORER
Modified for Minnesota conditions from Illinois Natural History Survey Publication.

fore hatching, a black spot develops on each egg. This spot is the head of the young larva showing through the shell.

The larvae which hatch from the eggs are tiny, glassy-white caterpillars with dark heads. Larvae from eggs of the first brood, laid when the corn is in the whorl stage, move from the exposed leaves on which the eggs were laid into the whorl, where they feed on the young leaves.

Life History—Both a single-generation strain and a two-generation strain of the borer occur in Minnesota. Borers of the first brood are a mixture of single-generation and two-generation individuals. The single-generation strain completes its larval development in August and remains as a larva for the rest of the summer and through the winter.

The larvae of the two-generation strain change to pupae in August and produce a second brood late in the summer. The eggs of the second brood are laid from the middle of August to early September. The borers which develop from moths appearing late in August or early in September belong to the two-generation strain.

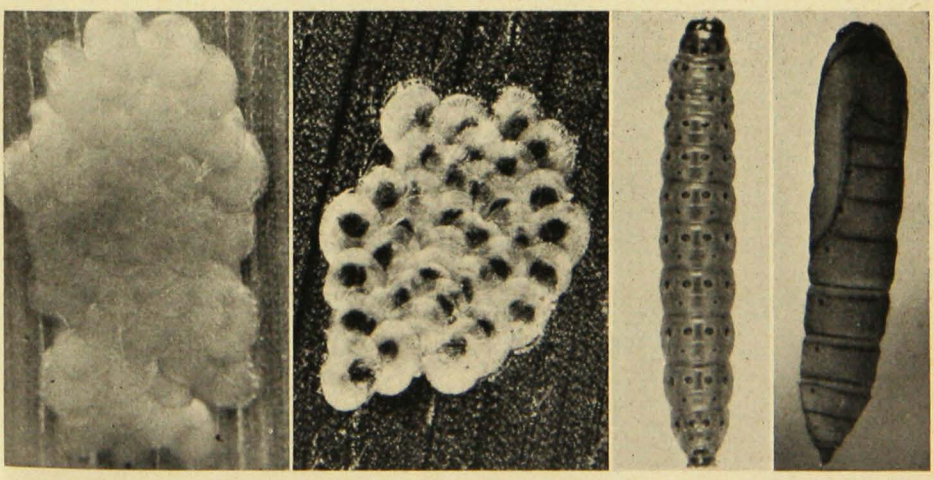


Corn borer moths (magnified about twice). The female, larger and lighter, is near an egg mass. The male is smaller and darker.

The details of this life history are important in understanding control recommendations.

There are three types of control available to farmers: cultural, mechanical, and insecticidal methods.

There are two other types of control, but these do not rest primarily in the hands of the farmer. These methods, biological control and development of resistance in corn, are in the hands of state and University officials who are actively working on them.



STAGES IN BORER'S LIFE—from left to right, a fresh egg mass, an egg mass in the "black head" stage, larva, pupa. All stages enlarged, the egg masses much enlarged.

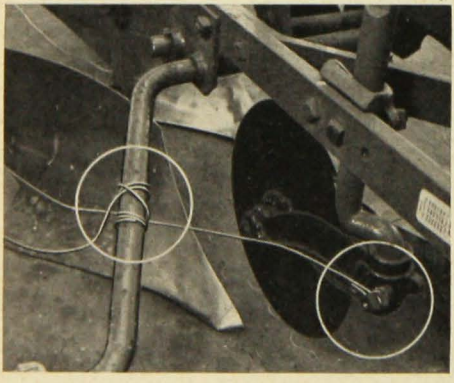
Clean Plowing Destroys Borers

VALUABLE in borer control is any farm operation that destroys borers, improves the crop, and leads to a better yield.

Destroy Overwintering Borers

The corn borer overwinters as a larva in old corn-stalks, stubble, ears and shelled cobs, and in coarse-stemmed weeds. Plowing these under completely and cleanly, preferably in the fall, will destroy most of the borers. Clean plowing also adds the crop remains to the soil, thus maintaining its fertility and structure. Use any tillage equipment that will completely cover the crop remains.

Stalk shredders and crushers attached to mechanical corn pickers, field ensilage harvesters, hammer and roughage mills, and stalk choppers all destroy borers. Such equipment also breaks up the crop remains, so that they will be decomposed more easily and be more satisfactorily worked into the soil.



Attaching a 10- or 12-foot length of No. 9 wire to front of plow and allowing the wire to drag in furrow helps guide stalks into furrow.

Moldboard plows and disc plows will cover the trash or mix it with the soil. A 16-inch bottom moldboard plow covers stalks and trash somewhat better than a 14-inch bottom plow or a disc plow. If the moldboard plow is to do its best job, it should be operated with attention to several details.

A large 16- or 18-inch rolling coulter (either notched or smooth) attached to moldboard plows aids materially in cutting trash and preventing clogging. Jointers of either the disc or moldboard type are essential in obtaining good coverage.

A simple home-made device attached to the plow will help cover the trash and stalks completely. Such a device is a 10- or 12-foot length of No. 9 wire attached to the coulter shank or to the front of the plow, as shown in the illustration. The free end is allowed to drag free in the furrow and is covered and held down by the furrow slice, guiding the stalks down under the furrow. For better results in very trashy fields, two wires can be used per bottom.

Many farmers do not obtain the most from their plows because they are poorly adjusted or sprung. A well-adjusted plow will give better coverage with less draught. Local implement dealers or county agents will help in plow adjustment problems.

Adapt Controls to Farm Practices

On many farms recommended practices for corn borer control might interfere with other soil management operations related to soil erosion control and maintenance of soil fertility. The decision whether or not to adopt clean plowing will depend on the risk of soil erosion.

The completeness with which the stalks have been broken up, the kind of soil, and the depth of the top soil all influence the choice of plowing equipment and the depth to plow. Complete coverage of the crop remains will be more difficult on heavy soils than on loams or sandy loams. With the heavier clay soils, complete coverage probably should not be attempted.

The individual farmer must decide whether he can use clean plowing as a measure for corn borer control on his farm. With the special knowledge of the farming practices which can be adopted under his particular conditions, the farmer must be the final judge.

Keep Feed Lots Clean

Feed lots become a source of infestation if corn stalks are not disposed of in some satisfactory way. The stalks should be hauled into a field and plowed under completely before the last week of May.

Burning corn stalks destroys valuable organic matter and is not recommended in borer control.

Insecticides Protect Corn Plants

DURING THE PAST four years insecticides have proven to be an effective tool for control of the corn borer. Custom operators can apply DDT sprays or dusts for $3.00 to $4.00 per acre per application. Farmers can reduce this cost by using their own equipment for the treatment. When correctly timed, insecticide applications result in considerable savings in heavily infested fields.

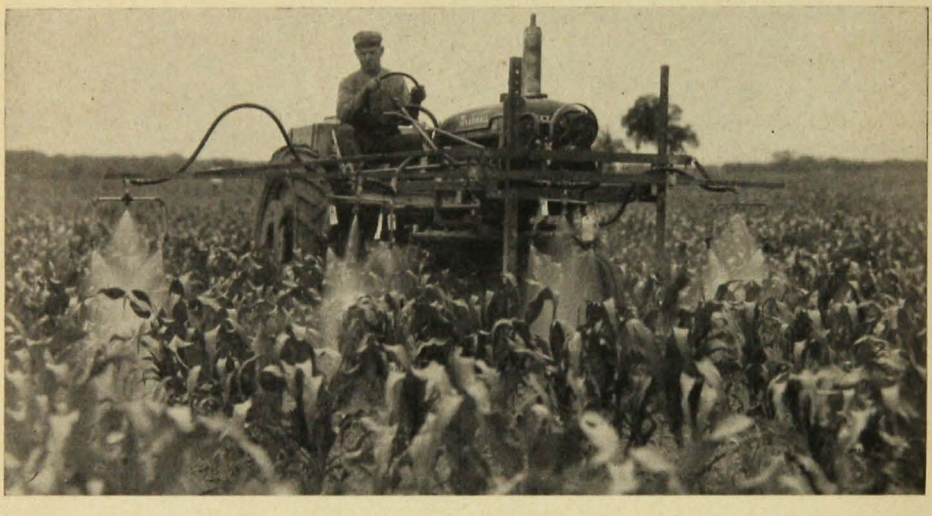
Do Insecticides Pay?

A decision on whether or not insecticides should be applied to corn will depend on a number of factors. The value of the sweet corn crop and the need for thorough protection of the ear makes the use of insecticides on sweet corn justifiable if the infestation is likely to be high. It may not, however, be quite so easy to justify use of insecticides on field corn, especially if the price goes lower than it is at the time of writing ($1.25 per bushel). The farmer should consider the anticipated return per acre, for the grain, and whether the stover will be used for fodder. There is also the factor of the anticipated level of infestation as indicated by the counts of egg masses.

Time Applications Correctly

Correct timing of treatment is essential in chemical control of the borer. Young corn borer larvae can be reached more easily by the insecticide before they have gone into the leaf axils, stalks, and ears. Once within the plant, the larvae are relatively safe from insecticides.

Larger larvae occasionally leave their burrows and move to other parts of the plant, but they are not as readily killed as smaller larvae. For best control of first-brood borers, the layer of insecticide should reach between the leaves of the whorl, around the developing tassel, and in the leaf axils at the time the larvae are hatching. If ears are to receive special protection, as when treating sweet corn, the region of the developing ear and the ear itself should receive sufficient insecticide at the time of the second brood.



Power sprayer, tractor-mounted. Note the arrangement of the nozzles illustrated also on page 14.

Count Egg Masses

Knowledge of the egg-mass count in a field will enable a farmer to tell if an application of insecticide will pay. The count can also indicate to him **when** to make the application.

The grower should start examinations for egg masses when his tallest corn is 15-18 inches high, and he should re-examine twice a week thereafter during the moth flight. The number of egg masses which indicates a need for control measures is given below in the sections on field corn and canning sweet corn. If spring and early summer observations indicate that moth emergence might be prolonged, the egg-mass count recommended for treatment of field corn and sweet corn may be reduced.

When to Apply

Field corn—Protection of field corn should be directed especially at first-brood borers. Eggs of the first brood appear when the plants are in the whorl stage.

If 50 egg masses or more are found on 100 plants, applications of insecticide will usually pay. One or two treatments are recommended, depending on the intensity of infestation and the degree of control desired.

For the two-treatment schedule, the first application should start one week after the first few egg masses hatch in those plantings where egg counts reach 50 masses per 100 stalks. If eggs continue to be present at this rate or higher, the second application should be made 7 to 10 days after the first.

When only one application is to be made, the treatment should begin 10-12 days after first hatch in plantings having 50 egg masses per 100 stalks. In general, it does not pay to apply insecticides for control of second-brood borers in field corn.

Canning sweet corn—Protection of canning corn should be directed especially at borers of the second brood, although applications may also be necessary for the first brood. When 25 or more egg masses are found on 100 plants of sweet corn in late June and

July, treatment with insecticides may be profitable. Usually only the earliest planted corn will require treatment for control of first-brood borers. Late-planted sweet corn may sustain ear injury from second-brood borers in September.

Eggs of the second brood are concentrated in the vicinity of the developing ears and especially on the flags of the ears. These egg masses will appear on the plants in August and September. Treatments should be made if corn borers are known to be present in the area. Applications of insecticide should be made as soon as eggs begin hatching and should be repeated at five-day intervals until ten days prior to canning.

What to Apply

DDT is at present the most economical and most readily available insecticide which is highly effective against the corn borer. Ryania is about equally efficient, but it is difficult to obtain and is more costly. Its principal virtue is that it does not harm animals which may eat recently treated corn plants, and does not accumulate in the fat or milk. (See also pp. 12 and 16.)

DDT emulsion spray, 25 per cent—For the first-brood borers, apply 2 quarts of the concentrate, diluted with water, per acre. For treatment of second-brood borers, 3 quarts per acre are desirable since the plants are larger and it is important to get sufficient DDT through the foliage to the region of the ear.

At least 50 gallons of water will give best results. With low-gallonage weed sprayers, a range of 5 to 25 gallons per acre is practical. The higher rates give best control.

Some DDT emulsions may be injurious to the foliage, largely because of the leaf penetration by the oily solvent. The solvent should have a low boiling point, and the dealer should give an assurance that the recommended strength of emulsion will not injure corn plants. Some solvents produce damage more easily than others, but several factors influence the injury. Large drops of the emulsion spray will cause more harm than small ones, but very fine drops are not desirable because they cannot be driven into the whorl and leaf sheaths as easily.

Foliage damage is often worse when application is made on a hot and sunny day. Less vigorous corn is more liable to be injured. These factors may cause variable plant injury even with the use of a single type of emulsion.

DDT wettable powder, 50 per cent—DDT powders in water may be applied by spray machines with good agitating devices, proper nozzles, and pressures of 100 pounds per square inch or greater. A rate of 3 pounds of the 50 per cent wettable DDT, or 1½ pounds actual DDT, in at least 15 gallons of water per acre, will give good control when a spreading agent such as *Ultrawet E* or *Areskap* is added at the rate of ⅓ pound per 100 gallons (about 1 ounce per 15 gallons).

Other spreading agents should not be used unless there is evidence to show that corn plants will not be injured at the concentration required for spreading action. The use of more than 15 gallons of spray material per acre is desirable since the efficiency of corn borer control becomes greater as the quantity is increased to 100 gallons per acre.

Pure ground Ryania—The application rate is 6 pounds per 100 gallons of water per acre. It is possible to reduce the amount of water to 30 gallons, although the larger amount of liquid will give more satisfactory control. The type of sprayer can be the same as that used for a DDT wettable powder. An added wetting agent should be used, as with DDT.

Application Rates for Sprays and Dusts on Field and Sweet Corn Grouped in Descending Order of Effectiveness

Insecticide	Additional wetting agent*	Material per acre for each application: Actual DDT, Ryania, or Rotenone	Material per acre for each application: Commercial preparations of DDT, Ryania, or Rotenone	Material per acre for each application: Final volume or weight	Equipment
	(Pounds per 100 gallons)	(Pounds)			
High gallonage sprays					
DDT, 50 per cent wettable powder	⅓	1 to 1½	2-3 pounds	50-100 gallons	Ground
DDT, 25 per cent emulsion‡	None	1 to 1½	2-3 quarts	25-50 gallons	Ground
Ryania, 100 per cent powder	⅓	6	6 pounds	50-100 gallons	Ground
Low gallonage sprays†					
DDT, 25 per cent emulsion‡	None	1 to 1½	2-3 quarts	5-15 gallons	Ground
DDT, 50 per cent wettable powder	⅓	1 to 1½	2-3 pounds	Not less than 15 gallons	Ground
Ryania, 100 per cent powder	⅓	6	6 pounds	Not less than 30 gallons	Ground
Dusts					
DDT, 5 per cent		1¾ to 2	35-40 pounds	35-40 pounds	Ground
Ryania, 40 per cent		14 to 16	35-40 pounds	35-40 pounds	Ground
Rotenone-containing cubé or derris, 1 per cent rotenone		1/3 to 2/5	35-40 pounds	35-40 pounds	Ground
Rotenone spray					
Rotenone-containing cubé or derris, 4-5 per cent rotenone	⅓	¼ to ⅓	6 pounds	25-100 gallons	Ground
Low gallonage sprays					
DDT, 25 per cent emulsion‡	None	1½ to 2	3 quarts to 1 gallon	2-4 gallons	Aircraft
Dusts					
DDT, 5 per cent		1½ to 2	35-40 pounds	35-40 pounds	Aircraft
Ryania, 40 per cent		14 to 16	35-40 pounds	35-40 pounds	Aircraft
DDT, 10 per cent (free flowing only)		2	20 pounds	20 pounds	Aircraft

* Ultrawet E and Areskap have been found satisfactory.

‡ Use only emulsions that have been tested and found to be safe on growing corn at the approximate gallonage and pressure you expect to use.

† An additional spray material, DDT, 40 per cent colloidal, may be used in ground equipment at the rate of 1½ quarts of the product in 15 to 25 gallons per acre, but nozzle clogging may occur if no mechanical agitator is employed, or if fine screens are used in the line. This product does not injure the plants, and provides more efficient control than dusts.

DDT dust, 5 per cent—This is an easily applied and widely used strength for ground dusting equipment and airplane application. Each treatment should be made at a rate of about 35 pounds of dust per acre. Although dusts which contain certain sticking agents appear somewhat more efficient, increased costs may make them less economical. Impregnated dusts have not given better control than mechanical mixed dusts.

DDT dust, 10 per cent—A free flowing dust of this strength can be used in aircraft to increase the pay-load. The rate of application should be about 20 pounds per acre.

Ryania dust, 37-40 per cent—Application should be at a rate of 40 pounds per acre and may be made from either ground equipment or aircraft.

How to Apply

The efficiency of application can be rated as follows:

Ground spraying gives best results. Ground dusting applications and aircraft spraying rank second, and aircraft dusting third. However, certain conditions may make it more practical to use the somewhat less efficient methods.

Ordinary tractor-drawn or mounted dusting and spraying machinery can be used up to the time the corn is about three feet high. If the corn is this height, plant breakage can be reduced by making the application on a warm evening. After the corn has reached 3 feet, special high-clearance equipment is necessary.

Sprayers—Standard row-crop sprayers which develop pressures of 40-120 pounds per square inch or more can give excellent results with the wettable powder or the emulsion type of DDT under the conditions recommended.

Ordinary weed-spraying machines are not adapted to spraying wettable DDT powders. Generally they produce insufficient pressure and have inadequate agitation. The weed-spraying nozzles do not withstand abrasion well and may not provide a sufficiently coarse spray.

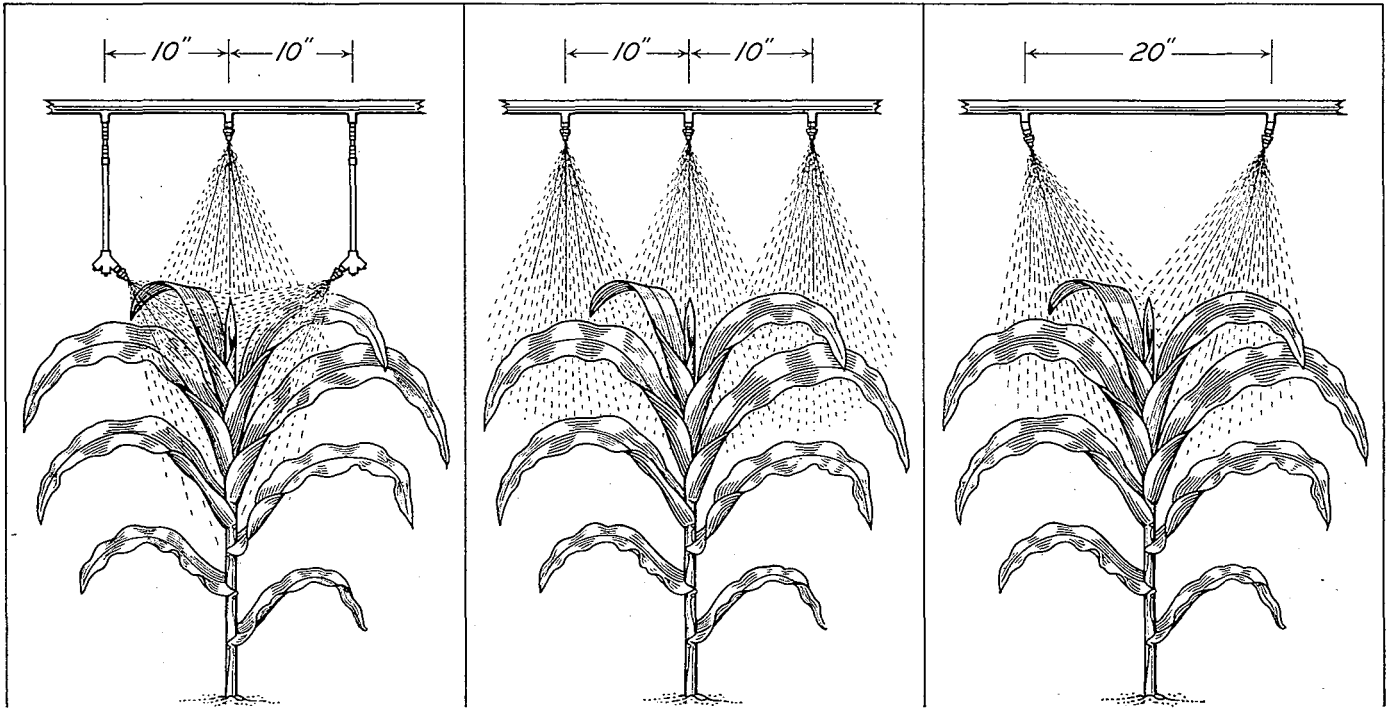
The low-gallonage weed-sprayer type of spray machines can, however, be used for DDT emulsions if proper conversion is made. The boom should be fitted with nozzles arranged for row-crop spraying. The three-nozzle arrangements are preferred (see figure on following page).

Solid cone nozzles appear most desirable, but hollow cone nozzles or fan-type nozzles can be used satisfactorily. Nozzle adjustment should provide a maximum concentration of spray on the upper leafy portions including the whorl and leaf axils, and, in treating the second-brood borers, the developing ears. Pressures of 40-120 pounds per square inch are desirable. Only the DDT emulsion type of spray should be used in the converted low-gallonage weed sprayer.

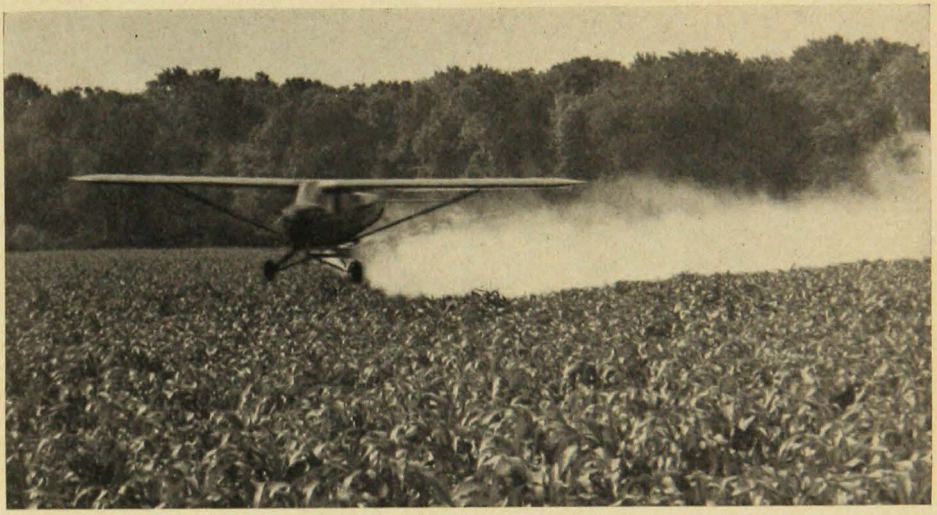
Dusters—Crop dusters of the row type can easily be adapted with two dust nozzles per row to cover corn plants thoroughly. Nozzles should be placed about 5 inches above the corn plant when it is in the whorl stage. The machine should have a gauge so that the operator can determine the dust output of the apparatus and make the proper adjustments.

Airplanes—Airplanes can be used when large areas need to be covered rapidly, when wet fields prevent the use of ground equipment, when corn plants are lodged, or when plants are too high for the ground equipment available.

Spray booms on airplanes should have multiple nozzles arranged to give



SATISFACTORY NOZZLE ARRANGEMENTS—three satisfactory nozzle arrangements for application of sprays to control first-brood borers. Wherever extension pipes are needed, as in the drawing on the left, flexible synthetic rubber connections should be used. The stage of growth illustrated, with eight leaf blades visible, is the "whorl" stage at which applications of insecticides should be made for the control of first-brood borers.



Airplane dusting aids in the control of the borer.

a uniformly-distributed swath when flying a few feet above the corn.

Dust applications should be made through a conventional venturi-type distributor on the aircraft. The effective swath width for dusts and sprays will vary depending upon equipment, but will not be greater than the airplane wing span, and in many cases will be less. Airplane treatments will be spotty and less efficient if wind movement is greater than 4 miles per hour during dusting and 8 miles per hour during spraying operations.

Feeding Warning

The University of Minnesota Agricultural Experiment Station recommends that corn plants bearing DDT should not be fed to animals. Ill effects are not apparent in the livestock which consume the small quantities of DDT occurring as residues on the treated corn. Traces of DDT can, however, accumulate in the fatty tissues of animals and in the butterfat of the milk. The United States Food and Drug Administration considers DDT a contaminant when present in human food. Therefore DDT-treated fodder should not be fed to animals, unless it is known to be free of DDT residues.

Other Controls Being Developed

Borer-Resistant Corn

The University of Minnesota Agricultural Experiment Station has already made considerable progress in the breeding of corn varieties which are resistant to, or tolerant of, the borer and which have desirable commercial characteristics. This work is being undertaken by the Division of Agronomy and Plant Genetics with the assistance of the United States Bureau of Entomology and the Division of Entomology and Economic Zoology of the University of Minnesota.

It will be some years before new commercial varieties resistant to the borer can be released to growers.

In general, hybrid field corn stands up to corn borer attack better than open-pollinated field corn. Minnesota farmers should use hybrid varieties which are well adapted in maturity, which possess desirable stalk characteristics, and which are best suited to each grower's locality.

Biological Control

The State Entomologist's Office of the State Department of Agriculture and the University of Minnesota Agricultural Experiment Station are cooperating with the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture in introducing natural enemies of the borer into Minnesota. In the study areas where the parasites were originally released, collections of borers indicate that some species are still present in the state and are likely to establish themselves permanently. The State Entomologist's Office will continue to release parasites.

LATE DEVELOPMENTS

If milk or meat of livestock shows traces of DDT, it may be condemned by the U. S. Food and Drug Administration. This means that there may be a risk in feeding DDT-treated fodder and silage (but not ear corn) to milk cows or fattening livestock. This is what can be done in fields needed for feed:

1. **Don't use DDT unless egg counts indicate a definite need.**
2. **Substitute Ryania or Rotenone for DDT, especially on sweet corn.**

If your field needs DDT, lessen the chance of DDT residues by using the dust instead of the spray. Limit dusting to the whorl stage. If DDT-treated corn is to be fed to livestock, the only safe procedure is to know from an analysis of the fodder or silage that DDT is not present.

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