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Insect Control in Forages, Field Corn and Small Grains

Michigan State University

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Farm Science Series

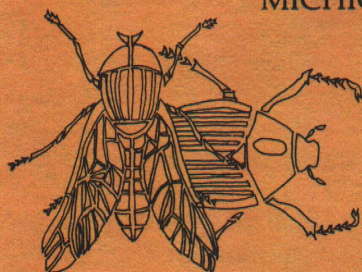
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Insect Control

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In the past ten years, there has been a major increase in the threat of insect damage to forages, field corn, and small grains in Michigan. The cereal leaf beetle, first found in Berrien County in 1962, has spread and requires control in most of the small grains in the Lower Peninsula. The alfalfa weevil, first found in Livingston County in 1966, has similarly spread and is threatening our alfalfa. The increase in acreage in corn-after-corn has intensified the problems with corn rootworms in field corn. These changes mean a greater investment in time and money spent by the grower to protect his crops from insects than in the past. Means of obtaining maximum protection from the many insects that attack these crops are presented here.

Planning Control

The object of controlling an insect pest is to *protect* the crop from losses caused by the insect. Insect damage must be anticipated and measures taken to protect the crop *before* it is damaged.

An accurate prediction of damage is possible for only a few insects of forages, small grains, and field corn. Most of the pests of these crops appear in a few fields each year and in many fields during some years. It is impossible to determine what insect may appear in a field during a season. Most losses from insects are caused because the pest appears unexpectedly. Stay alert to insect problems as the first step in effective insect control:

1. Review past problems that you or your neighbors have had with pests and anticipate more trouble.

2. Familiarize yourself with the insects and their damage—what they look like, where and when they are found. The pests are not damaging every year, but some can be found every year. Examine them so that you can identify them with certainty. They are generally most abundant in wet, weedy areas of the field. These areas should be especially closely examined for insects that may be scarce in the rest of the field. Descriptions of the pests are given in this bulletin. Your County Agricultural Extension Agent can help you identify a pest.

3. Service and calibrate your insecticide application equipment (see the section on "Calibrating Equipment") and check for available sources of insecticides to be sure they will be ready to go before the insects actually appear.

4. Become familiar with the safe, effective use of insecticides. Some pointers are offered later. Specific instructions and warnings on the use of the insecticide are stated on the label of the insecticide. **Read the label** before using any insecticide.

5. The most important step—the critical point in effective insect control—is to **check the fields** regularly for appearance of the pest, stage of development, and numbers. Suggestions on what to look for are

given in this bulletin. Warnings on the appearance of insects will be issued by the County Agricultural Extension Agent. These warnings are possible, however, only if you alert him to the presence of the pests. Check your own fields in order to be ready to *protect* them from the insects before the damage is done.

Selecting an Insecticide

Careful consideration should be given to choosing a specific insecticide. The first point, of course, is that the particular insecticide be effective against the insect pest. Insecticides recommended in this bulletin are known to be effective and are suggested for general use against specific pests. Some insecticides are not recommended, usually because they have not been tested in Michigan. The label on the container lists the pests that insecticide controls and instructions for safe and effective use. If a non-recommended insecticide is used, check the label very carefully to be sure that insecticide can be used effectively for the desired pest and crop.

Insecticides generally kill more than one species of insect. Where two or more pests are threatening the crop, the choice of an insecticide that will kill both pests is desirable. Check the recommendations to see if one or a mixture of insecticides can be applied at the same time to save on application costs.

Formulation depends on the type of application equipment available and recommendations for specific formulations. If a duster or granular applicator is all that is available, or if a dust or granule is all that is recommended, there is no real choice. Sprayers can use either dry or liquid insecticide concentrates (wetttable powders, flowables, or emulsifiable concentrates). In general, liquid formulations tend to remain in suspension better and cause less nozzle blockage in weed-type sprayers than wetttable powders. This is because weed-type sprayers do not have mechanical agitators. Some wetttable powders suspend well without heavy agitation, and jet-agitation fittings are available for weed-type sprayers. Wetttable powders can be used in weed-type rigs with care in their selection or provision for better agitation in the tank. Either wetttable powder or liquid concentrates can usually be used in row-type sprayers with mechanical agitators.

The number of days between application and harvesting or grazing will also influence the selection of an insecticide. Some insecticides can be applied only at planting time; others may be used up to the day of harvest. These limitations are placed on the use of the insecticide to avoid undesirable residues on the crop. They are noted in the recommendations and also on the label of the insecticide. An insecticide residue on a commodity could make it unsalable. The residue from persistent insecticides (such as DDT, dieldrin, aldrin, heptachlor, chlordane, BHC, and

lindane) will remain in the soil several years after application and could contaminate later crops. Avoid using persistent insecticides whenever possible. Do not use them at all if there is a possibility that crops for which the persistent insecticides are not recommended may be planted later.

Insecticides are poisons and some are highly toxic. In spite of this, sickness and death are seldom caused by insecticides. Insecticides can be used safely but they must be handled carefully. **Read the label** on the container for safe use of that insecticide, even if the insecticide is relatively safe. Select an insecticide that, without doubt, can be used safely. An insecticide should not be used if there is any question of its safe use—such as lack of adequate storage, lack of safety equipment for handling and application, danger of drift, or danger of people or livestock entering the treated field.

Price per acre and availability are two other factors to consider when selecting an insecticide. Usually, only a few insecticides are stocked by a farm store. They can be obtained easily if their use is anticipated far enough ahead to order them. Check with your farm supply dealer in advance of the season for the specific insecticide needed. Cost of the insecticide should be calculated on a per acre and not per pound or per gallon basis. One insecticide may cost more per gallon than a second insecticide, but require less per acre. Discounts are sometimes given for sales of large containers or case lots of insecticides. These should be investigated when a large amount of insecticide is to be purchased. Similarly, per acre costs for aerial applications are low if the aerial contractor is assured of a large acreage in an area.

Amount of Insecticide

Insecticides are sold as dry (granular or wetttable or soluble powders) or liquid (flowable and emulsifiable concentrates) formulations. The amount of active insecticide in a formulation is given on the label as the percentage, by weight, of the dry formulation and as pounds per gallon of the liquid formulations. The recommended amounts of an insecticide are given as the weight, in pounds, of active insecticide to be used per acre. The recommended amount must be transformed to the amount of formulation needed for the proper amount of active insecticide. This transformation can be made for dry formulations using the equation:

$$\text{pounds of formulation} = \frac{100R}{P}$$

... where R is the recommended amount of active insecticide per acre in pounds, and P is the percentage of actual insecticide in the formulation. For example, if you are using a 50 percent wetttable powder

(P = 50), and want to apply 1-1/2 pounds of active insecticide per acre (R = 1.5):

$$\text{pounds of formulation} = \frac{100 \times 1.5}{50} = 3 \text{ pounds}$$

A similar transformation can be made for liquid formulations, using the equation:

$$\text{pints of formulation} = \frac{8R}{P}$$

... where R is the recommended amount of active insecticide per acre in pounds and P is the pounds of active insecticide in a gallon of formulation. For example, if you have an emulsifiable concentrate containing 5 pounds of active insecticide per gallon (P = 5) and want to apply 1 pound of active insecticide per acre (R = 1):

$$\text{pints of formulation} = \frac{8 \times 1}{5} = 1.6 \text{ pints (about 26 liq. oz.)}$$

Calibrating Equipment

1. *Granular applicators*—The amount of active insecticide to apply per acre is determined directly by the amount of formulation applied when granular insecticides are used. The granular applicator must be precisely calibrated to deliver no more than the amount of insecticide necessary to control the insect. This calibration can be done by:

- adjusting the feed indicator to the approximate setting;
- taping plastic bags to the drop spouts of the granular applicator to collect the granules dropped by the applicator;
- running the tractor for a measured distance, in feet, at normal speed with the granular applicator going;
- recovering and weighing (in ounces) the weight of the granular insecticide delivered by the applicator into the plastic bags;
- determining the pounds of granular insecticide delivered per acre by using the equation:

$$\text{lbs of granules per acre} = \frac{2723A}{LW}$$

... where A is the ounces of granules per spout; L is the feet traveled during the test; and W is the width of the swath in feet covered by the nozzle. For example, if the nozzle is placing granules in 32 inch rows of corn (W = 2.67) over a distance of 400 feet (L = 400) and 5.5 ounces of granules are delivered at the spout (A = 5.5):

$$\text{lbs/A} = \frac{2723 \times 5.5}{400 \times 2.67} = 14.02 \text{ lb. of granules per acre}$$

f. readjusting the feed indicator in the granular applicator and repeating the test until the desired amount of granular insecticide is delivered per acre;

g. checking the calibration of the granular applicator by recording the actual amount of insecticide delivered over a measured acreage, and re-adjusting when needed.

2. *Sprayers*—The amount of active insecticide supplied by a sprayer per acre is determined by the amount of water applied per acre and the amount of insecticide formulation in that amount of water. The amount of water needed per acre will vary with the crop and the insect to be controlled:

a. *About 10 to 15 gallons per acre for:*

- 1) sprays applied to open soil prior to planting
- 2) small corn, small forage crops, and all small grain crops
- 3) control of leaf feeding insects on tall corn

b. *About 20 gallons per acre for:*

- 1) tall forage crops
- 2) whorl-feeding insects on small corn

c. *About 40 gallons per acre for a single nozzle centered over the row for whorl-feeding insects in taller corn.*

Determine the amount of water that should be delivered per acre and only the amount of insecticide formulation needed to control the insect should be added (see the section "Amount of Insecticide"). To determine the amount of water sprayed per acre:

- Measure, in feet, the distance traveled in one minute by the tractor at the normal spraying speed; 88 feet per minute is equal to 1 mile per hour.
- Select nozzles, strainers, and a spraying pressure that should deliver the required amount of water per acre; this information is available in spray equipment manuals or can be furnished by the equipment dealer.
- Collect and measure, in liquid ounces, the amount of spray delivered by a nozzle in one minute; check several nozzles and use the average amount delivered per nozzle.
- Determine the gallons of water delivered per acre by using the equation:

$$\text{gallons per acre} = \frac{340AN}{LW}$$

... where A is the liquid ounces delivered per nozzle per minute; N is the number of nozzles in the boom; L is the distance in feet traveled in one minute, and W is the width in feet covered by the spray from the boom. For example, if the tractor travels 260 feet in one minute (L=260), the spray covers 21-2/3 feet (W = 21.67), there are 13 nozzles on the

boom (N = 13), and an average of 16 liquid ounces of water are delivered per nozzle per minute (A = 16);

$$\text{gal/A} = \frac{340 \times 16 \times 13}{260 \times 21.67} = 12.55 \text{ gallons of spray per acre}$$

e. Readjust tractor speed or spraying pressure and repeat the test until the amount of spray desired per acre is obtained.

f. Check the actual amount of spray applied to a measured acreage and readjust the sprayer as needed to apply the exact amount of spray required.

Methods of Application

In *seed treatment*, the seed is coated with an insecticide to protect it from insects. Seed treatment with insecticides is best done by the seed dealer at the same time fungicides are applied. Some ready-treated seed is available, but it is not easily obtained in Michigan. Seed treatment dusts should be applied by the grower at planting time when treated seed is not available. Follow the instructions on the label of the seed treatment to be sure to obtain an even coating on the seed.

Preplant broadcast applications, as their name implies, are sprays or granules of insecticide spread over the entire field before planting. This is best done immediately before final discing or dragging so that they are worked into the soil surface. A spreader-type granular applicator, weed-type or row-type sprayer can be used. Adjust the granular applicator or sprayer for uniform coverage of the soil. Work the insecticide into the soil immediately after it has been applied.

A *planting or cultivation band application* is a spray or granule applied in a band centered over the row. Granular applicators or sprayers can be used. Special equipment is available for this type of application, or equipment can be adjusted for this use. Place the nozzles on your planter so that they cover a 7 to 10-inch band over the row. The insecticide should be applied at planting between the seed shoe and the covering wheel to place it out of contact and above the seed. In cultivation band application, use two nozzles with each covering a three-inch band on either side of the plants. The insecticides in both planting and cultivation applications should be covered with soil immediately after application.

Granular foliage applications are especially effective against insects that feed in the whorl of corn or that are in the soil surface of many crops (cutworms, billbugs, armyworms, common stalk borer, and European corn borer). Center the nozzle directly over the row and adjust its height so that the granules cover most of the plant; that is, concentrate the granules on the plant itself and do not try to cover the open ground between the plants.

Foliage spray applications are of two types; sprays applied with weed-type or row-type equipment in smaller plants, and "Hi-boy" applications in tall plants such as tasseled corn. Weed-type or row-type sprayers can be used effectively against leaf feeders in smaller plants (especially flea beetles, slugs, cereal leaf beetle adults, and grasshoppers). Center one nozzle on the row at a height that will cover most of the plant (as in a granular foliage application) and use 15 to 20 gallons of spray per acre. The sprays are also effective against the whorl feeding insects of corn before the pests become hidden in the whorl, using this lower rate of application. The rate of application must be increased to about 40 gallons of spray per acre to get the insects hidden in the whorl, especially in taller corn.

"Hi-boy" type sprayers are high clearance tractors with several nozzles on drops between the rows to completely cover the tasseling plants. They are not used much in Michigan field corn, but are available and used in sweet corn. They are especially effective against ear pests (sap beetles and corn earworm) and late-season pests (corn leaf aphid, grasshoppers, European corn borer). The amount of spray used per acre will depend on the kind and number of nozzles used.

Aerial sprays are effective against the leaf feeding insects including those that appear late in the season. Aerial sprays are also effective against whorl or ear feeders before the pests become hidden in the whorl or ear. If aerial sprays are to be used to control whorl or ear feeders, the spray should be timed to hit the pest before it becomes hidden. The amount of spray to apply per acre will depend on the equipment used. The effectiveness of an aerial application depends on the pilot's skill and thoroughness, and care should be taken to select a reliable air contractor.

Safe Use of Insecticides

Many insecticides are highly toxic to man and other animals and some retain their potency long after application. They should be stored, handled, and applied with respect for their dangerous nature. The label of the insecticide container, by law, clearly lists the precautions needed for the safe use of that insecticide. Read the label to be sure that these precautions are understood and that they can be followed before buying an insecticide. Nearly all cases of direct poisoning from insecticides result from careless storing and handling of the concentrate insecticide. Store all insecticides where they cannot possibly be contacted accidentally by children, livestock, or feed.

A sturdy, locked cabinet in a machine shed is a good place to store them. Handle the insecticides with care; the label on the container will list any special equipment needed for handling or applying. Wash and change clothes after using an insecticide and wash immediately if concentrate insecticide is spilled onto the skin.

Use care in applying the insecticide to avoid drift onto adjacent fields or waters and to avoid exposure of bees, livestock, and wildlife to insecticides. Apply sprays only when winds are soft (generally less than five miles per hour) and cover soil insecticides immediately after application. Advise neighboring beekeepers when insecticides are to be applied so that they can move their hives, if necessary. Honey bees work the flowers of many crops. Do not apply an insecticide to flowering crops without giving the beekeepers special notice. Honey bees are very important to Michigan's agriculture and beekeepers de-

serve accommodations to protect the bees from unnecessary kill.

Insecticides, such as DDT and dieldrin, persist as pollutants in our soils, streams, and even our bodies long after they have been applied. The actual threat that these residues pose is disputed, but the fact that they exist is not. Their continued use should be reduced to a minimum, and the insecticide recommendations are based on this. Insecticides can also kill wildlife and insects other than the pests for which they are applied. Use the insecticides only when they are needed to protect the crop and then use the least amount of insecticide in the safest way possible. The costs, dangers, and difficulties in using insecticides make them poor means of controlling insects. Research on other, non-chemical means of control are underway. For the near future, however, chemicals are the only reliable means of control. They must be used safely.

FORAGE INSECTS

Livestock is Michigan's biggest farm business. This makes the feed crops for these animals—especially hay, forage, and pastures—especially important to the economy of the State. There is a wide variety of insects that can lower both yield and quality of hay, forage, and pasture crops. A few of these pests appear in damaging numbers over large areas during some years and some of them damage a few scattered fields each year. The use of chemical insecticides in these crops has been very minor in the past. The appearance of the alfalfa weevil, a severe pest of alfalfa in 1966, and its subsequent spread and increase have changed this. Growers must check their fields for this pest and apply an insecticide for its control when needed. The other pests are still present and growers must continue to be alert for them as well as the alfalfa weevil. Notes on the biology and identification of these pests are presented below and some suggestions on how to check fields for them are summarized in Table 1. Recommendations for insecticides to use for control are summarized in Tables 2 and 3.

MEADOW SPITTLEBUG

The spittlebug overwinters as eggs in alfalfa, clover, and other plants. These eggs hatch early in the spring. The yellowish nymphs suck the sap of the plants, weakening them. When the nymphs are abundant, they can stunt the plants. Damage has been especially severe on lighter soils. The nymphs form a spittle-like froth around themselves and feed within its protection. Check your fields for these spittle masses every few days, starting after the first warm

days of spring. If about 1/5 of the stems on sandy soils, or 1/3 of the stems on heavier soils show spittle masses, insecticides are needed. Note that these are the stems that arise from a plant and not each plant. The nymphs change to the adult stage in June. The adult spittlebugs are stout, oval-shaped insects that jump when disturbed. The adults range in color from light gray through red and brown to nearly black. The adults suck sap from many crops but need control only if they are extremely abundant. Insecticides should be applied as sprays to cover the foliage of the plants.

SWEETCLOVER WEEVIL

The sweetclover weevil adult chews crescent-shaped holes in the leaves of sweetclover. The grubs of the pest feed on plant roots, but greatest damage is caused by the adult feeding on the small plants early in the spring. They can severely damage newly seeded and second-year stands of sweetclover when abundant. Begin searching for the feeding and adults of

Honey Bees

Honey bees are frequent visitors of forage crops and are easily killed with insecticides. Advise neighboring beekeepers that you are going to apply an insecticide far enough in advance that they can protect their bees from the spray. Do not spray forage crops during bloom. Use special care to avoid drift of insecticides into areas where bees may be foraging.

the pest when plants first germinate or start new spring growth. The adults are gray beetles with a broad "snout" and are about 3/16 of an inch long. They may be found feeding on the leaves or hidden near the bases of plants. An application is needed if field damage is easily seen. Insecticides should be applied as sprays to cover the small plants. The weevil can defoliate small plants rapidly—do not delay spraying if the weevils are abundant.

PEA APHID

There are several species of aphids that attack forage crops. The pea aphid is the most common species in alfalfa and clovers. The pea aphid is a small, soft, green, inactive insect usually found in colonies on the new stems and leaves of the plants.

It sucks the sap of a plant. Heavy infestations cause a curling of the new leaves and weaken and stunt the plant. The aphid is usually most abundant in the cool, early and late parts of the season. The aphids are attacked by many natural enemies (lady beetles, small parasitic wasps, diseases, and others) that usually keep their numbers down. However, they do appear in damaging numbers in some fields each year and the grower should check the tips of the stems for aphids each time he checks for other insects. A spray for their control is needed only if nearly every stem has a colony of aphids. The insecticide should be applied as a spray to fully cover the plants. Use at least 15 gallons of spray per acre in small plants and at least 20 gallons per acre in tall alfalfa if ground sprayers are used. Aerial sprays should be applied at one gallon per acre to small plants and two gallons per acre to larger plants.

ALFALFA WEEVIL

Alfalfa weevils overwinter as adults at the bases of alfalfa plants or in other sheltered places. Adults are gray to brown snout beetles that are about 1/4 inches long. They can be identified by their slender "snout" and by a broad, black band that extends to the middle of the wings. They become active with the first warm days of spring, feeding on the young leaves of alfalfa at night and hiding near the bases of the plant during the day. Rounded, yellow to brown eggs are laid inside the hollow stems of alfalfa. The small grubs that hatch from the eggs feed on the small leaves at the tip of the stem and move out to feed on the leaves as they grow larger. Grubs have a black head but lack legs. They are whitish when small, but change to green with a prominent white stripe down the length of their backs as they grow older. They are about 3/8 of an inch long when fully grown. The grubs make a rough cocoon of silk either on or near

the bases of the plant and transform into a quiet pupal stage. Adults that emerge from these cocoons feed on the leaves of the alfalfa for a week or so and then move into cool, sheltered areas out of the alfalfa fields. A few adults return to the alfalfa field, feed, and lay eggs in the fall while most adults stay out of the field until the following spring. The fall feeding is slight and few of the eggs survive the winter.

Check new alfalfa growth for feeding and the bases of the plants for the adults of the alfalfa weevil each time you check for other insects early in the spring. Fields that show feeding and presence of adult weevils should be checked especially frequently. Tips (buds) and upper leaves of plants should be checked for grubs and their damage starting with the first warm spell (about 60°F or more) in the spring. A critical point is reached when about 1/4 of the tips show damage from the grubs. In the few years that the alfalfa weevil has been in Michigan, this has occurred at bud to first flower stage of alfalfa development—just about the time of the first cutting. Cut, *without* spraying, if the cutting will be made within a week or ten days after 1/4 of the stems show damage. A spray *should be applied* immediately if the first cutting will be made later than this. Since there is danger of bad weather delaying the first cutting, this factor should be considered in making the decision to spray the first cutting. A spray should be applied immediately to the stubble if grubs are commonly seen. Check the regrowth if no stubble spray is applied and spray if 1/4 or more of the young tips show feeding of the pests.

Checking the fields to determine if a spray is actually needed is an important element in the present weevil control program. A research program on the introduction and release of natural enemies (small parasitic wasps) of the weevil shows promise for suppression of the weevil in the near future. These natural enemies must be protected from insecticides that will kill them as well as the weevils. Growers may soon have to check for the natural enemies as well as the weevil and other pests in their alfalfa fields. Make field checking for insects a routine now to facilitate the use of the combination of chemical and natural controls in the future. Taking the first cutting as soon as possible is an important element in the control of the alfalfa weevil as well as a sound agronomic practice. Delay in cutting will make control of the pest very difficult and may require additional sprays for satisfactory control. Delay may also result in increased loss to the pest. Cut the alfalfa without spraying and immediately spray the stubble if a heavy infestation of the grubs is not found until the field is already heavily damaged.

The insecticide should be applied at the rate of 15 gallons per acre in stubble or small plants and at 20

gallons per acre in tall plants if a ground sprayer is used. If regular aerial applications are made, apply one gallon per acre in stubble or small plants and two gallons per acre in tall plants. Concentrate malathion in aerial sprays (ULV aerial application) is also recommended for control of the weevil in stubble or small plants. The ULV application must be well done to be effective and reliable air spray contractors should be hired.

ARMYWORMS, CUTWORMS, GREEN CLOVERWORMS

Many caterpillars eat the leaves or clip the stems of forage crops. These worms are cylindrical, lack noticeable hairs on the body, have three pairs of jointed legs just behind the head, and three to five pairs of fleshy legs near the tail end. The worms range in size from 1/2 to nearly 2 inches in length. Cutworms are most common in hay and pasture grasses, and occasionally also damage forage legumes. They are usually most abundant early in the season and in wet or weedy areas. Cutworms feed on the leaves or clip the stems of the plants at night and hide in the soil or the bases of the plants during the day. They vary in color, but are usually dark colored.

The armyworm is also usually a night-feeding pest of grasses, but will "march" in large bands from grasses or grain crops into legume crops and feed during the day when it is abundant. The armyworm is usually most abundant during June and early July. They are greenish to black in color and usually have a broad, pale stripe down each side.

The green cloverworm is a pest of legumes and damages beans and soybeans as well as clovers and alfalfa. It is usually most abundant during July and later during the summer. Green cloverworms feed night and day on plant leaves. The worms are usually found on the undersides of the leaves. They are greenish in color with whitish stripes extending along each side of their bodies.

Areas of cut plants or plants with leaves showing signs of feeding should be examined for the worms on the leaves or hiding under the plants. An insecticide should be used if the worms are easily found. Apply the insecticide in the area infested plus a 20 to 40 foot border if the worms are found only in one area of the field. A 20 to 40 foot swath of insecticide around the margins of an uninfested field will prevent armyworms from "marching" into the field from an infested adjacent field. Notify your County Agri-

Table 1. Guide to checking hay, forage, and pasture crops for insects.

When	Crop	Where	What	Why
First warm spring days	alfalfa & clover	stems	frothy mass of spittle	spittlebug nymphs
	alfalfa	bases of plants	hard shelled snout beetles	alfalfa weevil adults
Germination to 2 inch growth	sweet clover	leaves	crescent shaped holes & snout beetles	sweetclover weevil
Before first cutting	alfalfa, clover, hay & pasture grasses	areas of poor stand	dark, cylindrical worms	cutworms
	alfalfa & clovers	stems & leaves	colonies of soft, green bugs	pea aphid
	alfalfa	tips of stems	greenish, legless grubs	alfalfa weevil grubs
At first cutting & regrowth	alfalfa	leaves, machinery, stubble & regrowth	greenish, legless grubs	alfalfa weevil grubs
Later growth	alfalfa, clover, hay & pasture grasses	leaves & flowers	oval, active running bugs	plant bugs
			stout, hopping bugs	spittlebug adults
			large, jumping insects	grasshoppers
	alfalfa & clover		small, sideways-running bugs	leafhoppers
		leaves & bases of plants	dark, cylindrical worms	armyworms & cutworms
		leaves	greenish, cylindrical worms	green cloverworm
			small, sideways-running bugs	potato leafhopper

cultural Extension Agent if the armyworms appear in damaging numbers so that he can warn others. The insecticides may be applied as either sprays or gran-

ules for armyworm and cutworm control. They should be applied only as sprays for control of the green cloverworm.

Table 2. Insecticides recommended for the control of insect pests of forage, hay, and pasture crops, 1972.

Insect	Crop	Insecticide	Lbs. Active Insecticide/A.	Limits
Spittlebug nymphs	Alfalfa & clover	malathion	1-1/4 lb.	0 days
		methoxychlor	1 lb.	7 days
Spittlebug adults	alfalfa, clover & hay & pasture grasses	malathion	1-1/4 lb.	0 days
		methoxychlor	1 lb.	7 days
		carbaryl (Sevin)	1 lb.	0 days
Sweetclover weevil	sweet clover	malathion	1-1/4 lb.	0 days
		methoxychlor	1-1/4 lb.	7 days
		carbaryl (Sevin)	1 lb.	0 days
Pea aphid	alfalfa & clover	malathion	1-1/4 lb.	0 days
		diazinon	1/2 lb.	7 days for hay; 7 days for clover pasture or forage; 0 days for alfalfa pasture or forage
		demeton (Systox)	1/4 lb.	21 days; apply only once per cutting; hazardous, use full precautions
		dimethoate (Cygon)	1/3 lb.	28 days
Alfalfa weevil (adults & grubs)	alfalfa	methyl parathion	1/2 lb.	15 days; hazardous, use full precautions
		malathion, plus, methoxychlor	1 lb. plus 1 lb.	7 days
		Imidan	1 lb.	7 days
		azinphosmethyl (Guthion)	1/2 lb.	16 days; use once per cutting; hazardous, use full precautions
		Alfa-Tox	2 qt. of the commercial mixture	7 days
		malathion	1-1/4 lb.	0 days
		ULV malathion	6/10 lb.	aerial spray only; 5 days
		methoxychlor	1-1/4 lb.	7 days
Alfalfa weevil (grubs)	alfalfa	carbaryl (Sevin)	1-1/2 lb.	0 days
Cutworms, armyworms, & green cloverworms	alfalfa, clover, hay & pasture grasses	carbaryl (Sevin)	1-1/2 lb.	0 days
		malathion	1-1/4 lb.	0 days
	hay & pasture grasses	parathion	3/8 lb.	15 days; hazardous, use with full precautions
Leafhopper and plant bugs	alfalfa, clover, hay & pasture grasses	carbaryl (Sevin)	1 lb.	0 days
		malathion	1 lb.	0 days
		methoxychlor	1 lb.	7 days
		dimethoate (Cygon)	1/3 lb.	28 days
	hay & pasture grasses	parathion	1/2 lb.	15 days; hazardous, use with full precautions
Grasshoppers	alfalfa, clover, hay & pasture grasses	carbaryl (Sevin)	1-1/4 lb.	0 days
		malathion	1 lb.	0 days

There are several species of both leafhoppers and plant bugs that attack forage and hay crops. These are sucking bugs that weaken and stunt the crops when they are abundant. The two most common species are the potato leafhopper and the tarnished plant bug. Both of these pests inject a toxic saliva into the plant as well as suck sap from the plant. The potato leafhopper is a pest of alfalfa and clovers. It appears in Michigan in early June and is most abundant in the field during mid- to late-summer. Its damage appears as yellowish to reddish leaves with dead tips and is often confused with drought. Potato leafhoppers are small, greenish, wedge-shaped insects that run sideways when disturbed. Other leafhoppers are gray to tan in color and attack grasses as well as legumes. These other leafhoppers have the same side-running habit as the potato leafhopper and are controlled by the same insecticides.

The tarnished plant bug and other species of plant bugs are pests of grasses, clovers, and alfalfa. The plant bugs reach their greatest numbers during late June to late summer. The plant bugs are about 1/8 to 1/4 of an inch long, oval in shape, and are very active runners. They range from greenish to gray or red in color. The tarnished plant bug can be distinguished from the others by a yellow V-shaped mark on the center of its back. Recent studies have shown that periodic cutting of hay tends to keep the tarnished plant bug numbers down. Feeding of the tarnished plant bug on the flowers and pods of seed legumes causes blasting of the seed, and the tarnished plant

bug has been a pest primarily of legumes grown for seed in Michigan.

Check for leafhoppers or plant bugs in areas of hay and pasture crops that appear stunted or droughty or have a slow regrowth following cutting or pasturing during the summer. Periodically check fields of legumes grown for seed, especially when the first flower buds appear. An insecticide should be applied if most of the stems have one or more insects on them. The insecticide should be applied as a spray to cover the foliage of the plants.

GRASSHOPPERS

The well known grasshoppers are normal residents of our hay and pasture fields and rarely appear in large enough numbers to justify the use of insecticides for their control. While called "grasshoppers," they feed mainly on broad-leaved weeds and are pests only when they are unusually abundant and forced to feed on cultivated plants by summer droughts. Grasshoppers were abundant during the late summers of 1965, 1970, and 1971 in recent years, but did not cause much damage to forage crops. Hay and pasture fields should be checked for grasshoppers and their feeding on leaves during periods of drought. Special attention should be given to margins of fields adjacent to large, weedy areas. An insecticide should be applied only if grasshoppers are especially abundant. Notify your County Agricultural Extension Agent if damaging numbers of grasshoppers are seen. Insecticides may be applied either as sprays or as granules.

Table 3. Effectiveness against other pests of alfalfa¹ of insecticides recommended for control of the alfalfa weevil.

Insecticide	Lbs. active Insecticide/A.	Pea aphid	Spittle-bug	Cut-, army-, and green clover worms	Potato leafhopper	Plant bugs	Grasshoppers	Notes
Methyl parathion	1/2	+	+		+	+	+	use with full precautions
Malathion plus methoxychlor	1 1	+	+	+	+	+		
Imidan	1	-			+		+	
Azinphosmethyl (Guthion)	1/2	-	+		+		+	use with full precautions
Alfa-Tox	2 qt. ²	+	+		+	+		
Malathion	1-1/4	+	+	+	+	+	+	
ULV malathion	6/10	+				+		aerial spray only
Carbaryl (Sevin)	1-1/2	-	+	+	+	+	+	
Methoxychlor	1-1/2		+		+	+		safest for honey bees

¹A "+" indicates that the insecticide is known to be effective against the insect pest.

A "-" indicates that the insecticide should not be used if the pest is present in the field.

²"Alfa-Tox" is a commercial mixture containing diazinon and methoxychlor. The quantity of "Alfa-Tox" to apply per acre is given as quarts of the commercial mixture.

SMALL GRAIN INSECTS

Except for occasional outbreaks of armyworm and scattered damage from other insects, small grains in Michigan have been relatively free of insect damage until recent years. The appearance of the cereal leaf beetle in Berrien and Cass Counties in 1962 and the subsequent spread and increase of this pest over the entire Lower Peninsula has changed this. Growers must now check their small grains for the beetle and take measures for its control when it appears in damaging numbers. The other pests are still with us, however, and you must continue to check your fields for them as well as for the cereal leaf beetle.

Some suggestions on how to check for these insects are summarized in Table 4. The checks can be made by walking or driving through the field and looking for possible problems. Many pests of small grains build up on weedy areas of the field itself or in adjacent fields and later damage the grain crop. Check such weedy areas with special care. Notes on identification of the pests and recommendations for

their control are also presented below. Recommended insecticides are summarized in Table 6.

HESSIAN FLY

The small, white maggots of the Hessian fly feed on the stems of wheat from beneath the leaf sheath. These maggots lack both legs and a definite head. The feeding of the fall generation stunts and, when severe, causes winter kill of the plants. The pest overwinters as a hard "flax seed-like" pupa and emerges as the adult fly early in the spring. The adult lays its eggs on the leaves of wheat and the maggots that hatch from these eggs feed on the plants. Their feeding in the spring stunts the plants and causes the stems to lodge. The fully developed maggot transforms to the flax seed stage and the adults emerge from these flax seeds to lay eggs again in the early fall.

Damage from Hessian fly can be avoided by planting winter wheat after the adult fly has finished lay-

Table 4. Guide to checking small grains for insects.

When	Where	What	Why
Before fitting	surrounding fields	sod, weeds & old pasture	expect armyworms, billbugs, and common stalk borer
	field itself	sod, weeds & poor drainage	expect white grubs, wireworms, billbugs and common stalk borer
Fitting	date of planting	fly-free date	Hessian fly
	plow furrow	thick bodied grubs: slender larvae:	white grubs wireworms
Seedling and tillering plants	soil in area of poor stand	thick bodied grubs: slender larvae:	white grubs wireworms
	whorls	dark snout beetles	billbug
	leaf sheaths of stunted plants	legless maggots	Hessian fly
	bases of stems	frassy holes	common stalk borer
	areas of stunted yellowish plants	groups of small, soft-bodied insects	greenbug
	leaves	blue beetles with red necks: small yellowish eggs: black, slug-like larvae:	cereal leaf beetle adult cereal leaf beetle eggs cereal leaf beetle larvae
Taller & headed plants	leaves and head	margins of leaves eaten or heads clipped off	armyworm
	heads	groups of small, soft-bodied insects	English grain aphid
	dried heads or lodged stems	frassy holes in stems: headless maggots in stem: legless grubs in stems: hard pupae in leaf sheaths:	common stalk borer wheat stem maggot billbugs Hessian fly

ing its eggs in the early fall. The "fly-free" dates for Michigan counties are shown in Table 5. Wheat planted after the date given in the table will usually remain free of the Hessian fly. There are some varieties of wheats that are resistant to the Hessian fly. Check with your seed dealer for seed of a good resistant variety if you plan to make an early planting of wheat.

WHITE GRUBS AND WIREWORMS

Adults of the white grubs (called May beetles or June bugs) and adults of the wireworms (called click beetles) usually lay their eggs in grassy fields, sod, old pasture, and weeds. The larvae that hatch from these eggs feed on the roots of grasses, small grains and other crops that may be later planted in these fields. The larvae can persist and cause damage for two years after the sod has been plowed. White grubs have white, thick, soft, cylindrical bodies and curl into a C-shape when disturbed. They have a definite head, six small legs just behind the head, and range up to 1-1/2 inches in length. The wireworms, as their name implies, have tan, hard, thin, cylindrical bodies. They also have a definite head and six small legs just behind the head. Neither the white grubs nor wireworms have fleshy legs near their rear. Look for white grubs and wireworms in the plow furrows while fitting the land and apply an insecticide if they are easily found. Check the roots of wilting seedling plants for feeding and the soil around such plants for the grubs or worms. If there is still time, these affected areas and a margin around them may be disked, an insecticide applied, and the area replanted.

Apply the insecticide as a spray or granule to cover the soil surface. Work it into the upper layer of soil immediately. Applying the insecticide just before final disking of the soil is a good practice.

BILLBUG AND COMMON STALK BORER

These two pests are usually most abundant in weedy areas of the field or in margins along the side of weedy fields. The billbugs feed in new growth of fall planted grains, and, occasionally, spring grains. Their feeding appears as holes in the new leaves and a tattering of the old leaves in the spring. The billbugs are hard-shelled snout beetles. There are two types; one is large, black and often found hiding in the soil near the plant; the other is smaller, gray and usually found deep in the upper rolled leaves of the plant. The larvae are small, white worms with a definite brown head, but without legs. Their tunneling can cause grain to lodge when infestation is heavy.

The common stalk borer is a cylindrical worm with three pairs of jointed legs near its head and five pairs of fleshy legs near its tail end. It can be readily identified by the broad dark "saddle" marking across its middle. The larvae tunnel into the bases of the stems and cause stunting or death of the plants. Their holes in the stems are marked by sawdust-like castings called frass. The borers are most damaging to small plants early in the season, but also damage headed plants. Their damage to headed plants is seen as conspicuous dried stems and heads. The wheat stem maggot also causes dried heads. The maggot is a headless, legless, larvae that tunnels in the upper section of the stem. The wheat stem maggot has not been numerous enough to cause appreciable loss of yield in Michigan small grains. Check fields for the appearance of the billbugs and common stalk borer and apply an insecticide if one-third or more of the plants show feeding by these pests.

GREENBUG AND ENGLISH GRAIN APHID

The greenbug and the English grain aphid are small, soft-bodied, inactive insects that occur in groups (or colonies) on the small grains. The green-

Table 5. Hessian fly-free dates for Michigan.

County	Earliest Seeding Date (Sept.)	County	Earliest Seeding Date (Sept.)	County	Earliest Seeding Date (Sept.)	County	Earliest Seeding Date (Sept.)
Alcona	6	Eaton	16	Lapeer	15	Ogemaw	10
Allegan	20	Emmet	4	Leelanau	8	Osceola	10
Alpena	9	Genesee	17	Lenawee	25	Oscoda	7
Antrim	4	Gladwin	12	Livingston	16	Otsego	6
Arenac	13	Grand Traverse	8	Macomb	18	Ottawa	19
Barry	18	Gratiot	15	Manistee	13	Presque Isle	8
Bay	14	Hillsdale	19	Mason	13	Roscommon	7
Benzie	16	Huron	13	Mecosta	12	Saginaw	16
Berrien	23	Ingham	17	Midland	15	Sanilac	15
Branch	19	Ionia	16	Missaukee	9	St. Clair	16
Calhoun	19	Iosco	7	Monroe	21	St. Joseph	23
Cass	22	Isabella	11	Montcalm	15	Shiawassee	16
Charlevoix	3	Jackson	16	Montmorency	7	Tuscola	15
Cheboygan	4	Kalamazoo	20	Muskegon	18	Van Buren	22
Clare	12	Kalkaska	5	Newaygo	15	Washtenaw	18
Clinton	17	Kent	18	Oakland	16	Wayne	18
Crawford	6	Lake	13	Oceana	16	Wexford	9

bug attacks small grains early in the spring. They suck the juices of the plant and also inject a toxic saliva into the plant. The plants attacked by greenbug are weakened, turn yellow and areas of the plants may die out.

The English grain aphid attacks the larger plants and is especially numerous in the heads. These aphids suck the juices of the plants, and, when numerous, can cause poor seed set and light grain. The English grain aphid also carries the virus for red leaf of oats. These two aphids and smaller numbers of other species of aphids are only occasionally pests of small grains in Michigan. Our spring weather is usually unfavorable for the development of the greenbug, and natural enemies usually keep the English grain aphid down to less than damaging numbers. Chemical control of these aphids is not needed unless most of the plants have colonies of aphids on them. The insecticide should be applied as a spray to cover the entire plant.

CEREAL LEAF BEETLE

The adult cereal leaf beetle is a hard-shelled beetle with a red pronotum (neck) and metallic blue wings. Adults overwinter in a variety of sheltered places. They become active with the first warm days (about 50°F or more) of late winter or early spring

and move first to grasses and then to winter grains. The adults later flock into spring-planted grains when the spring grains come up. They feed on the upper leaves of the crops by chewing a rectangular hole completely through the leaf. Eggs are laid on the upper surfaces of the leaves. The eggs are pin-head size, yellow and laid on their sides either singly or in small chains. The larvae that hatch from these eggs are thick bodied and have a definite head and six jointed legs just behind the head. The larvae are actually whitish in color, but cover their bodies with a slimy black coating so that they look like little slugs on the leaves. The larvae usually feed only on the upper surface of the leaves and the lower surface of the leaves remains intact. The skeletonized leaves give a severely injured field a frosted appearance.

Check your fields for adult feeding and the eggs of the pest every few days starting with the first warm spell of the season. An insecticide should be applied if there are about three eggs and larvae per stem in small plants that have not started to head, or about one larva per flagleaf on plants that have headed. Apply the spray when the eggs are common and the small larvae are first easily seen without searching for them. If you spray at this time, you will be sure that a spray is needed, that you won't be too early, and that the pest will be controlled before much damage is done to the crop.

Table 6. Insecticides recommended for control of insect pests of small grain crops; 1972.

Pest	Application	Insecticide	Lbs. Active Insecticide/A	Limits on Use
Wireworm & white grub	preplant soil	parathion	4	Do not use on rye. Do not enter field for 48 hours after treatment. Do not contaminate ponds or streams.
		chlordane	4	Non-dairy farms only. Do not graze treated fields.
Armyworms	foliage	parathion	3/8	Do not use on rye; 15 days for all other small grains.
		malathion	1-1/4	7 days.
		carbaryl (Sevin)	1	0 days. Do not apply after boot stage.
		trichlorfon (Dylox)	1	Do not use on rye. Grain, 21 days; feed or forage, 3 days.
Greenbug & English grain aphid	foliage	demeton (Systox)	1/4	Do not use on rye; 2 applications per season. Allow 14 days between applications. Grain, 45 days; feed or forage, 21 days.
		malathion	1	7 days.
		parathion	3/8	Do not use on rye. 15 days.
Cereal leaf beetle	foliage	malathion	1	7 days.
		carbaryl (Sevin)	1	0 days.
		azinphosmethyl (Guthion)	1/2	30 days, 1 application per season.
		endosulfon (Thiodan)	1/4	Do not feed treated forage to dairy cattle nor animals being finished for slaughter. Do not apply after heads begin to form.
	ULV aerial spray	malathion	6/10	7 days.
Billbug & common stalk borer	foliage	carbaryl (Sevin)	1	0 days. Do not apply after boot stage.

An attempt is now being made to establish parasites (small wasp-like insects that attack the cereal leaf beetle) to aid in the control of the cereal leaf beetle. Establishment of these parasites will require greater care in checking the fields in the future. Growers are urged to periodically check their fields now both as a guide to immediate control and also to familiarize themselves with checking fields. Timing of insecticide sprays is very important to the establishment of the parasites. **Insecticides should be applied when the small cereal leaf beetle larvae are first easily seen in the field.** This will best protect the crop from losses caused by the cereal leaf beetle. This "early" application of insecticides is also less likely to kill parasites of the pest than applications made later. If most of the larvae of the cereal leaf beetle are large and the field already shows heavy damage before the pest is discovered, do *not* spray the field. The damage has already been done, the insecticide costs will be wasted, and there is danger to parasites that could be helpful in future years.

ARMYWORM

Armyworms are cylindrical worms with a definite head, three pairs of jointed legs just behind the head, and five pairs of fleshy legs near the rear end. They range in color from tan to nearly black, usually with a broad pale stripe down each side. The larvae overwinter in the soil or plant debris. They pupate early in the spring and emerge as adult miller moths. Adults lay their eggs in clusters on the leaves of grains or grasses and fold and seal the leaf over the eggs. They most frequently lay their eggs in dense grasses and heavy stands or lodged areas of grains (especially rye). Such areas in the field or in adjoining fields should be especially well checked for the presence of the worms.

The larvae that hatch from the eggs feed on the leaves of the grasses and grains by chewing the margins of the leaves at night. The armyworm also feeds at the tips of the stems of tall plants and causes the head to dry or fall off. The armyworms hide during the day in the soil and litter around the bases of a plant. Their feeding and pellet-like castings are easily seen, however, and a search in the area where these are common will soon disclose the worms. The worms will feed during the day and "march" in "armies" from field to field when they are abundant. It is this marching habit that has given them the common name of armyworm.

The insecticides may be applied as sprays or granules. The area affected and a generous margin around it (20 to 40 feet) only need to be treated if the worms are found in just one area of the field. A 20 to 40 foot treated band around the field will stop the armyworm from marching into the field from adjoining fields of grasses.

FIELD CORN INSECTS

Every stage of the corn crop in Michigan, from the time the seed is planted, through storage of the harvested grain, *can* be attacked by one or more species of insect pests. These insects are seldom *actually* damaging to a large acreage each year, however. The insects do damage some fields each year and some of them appear in large numbers (outbreaks) during some years. Check your fields of corn periodically for the pests in order to anticipate possible damage and apply controls in time to prevent losses in yields.

Some suggestions on when and what to look for while checking fields for insects are summarized in Table 7. Note that fields should be checked even before planting and that checks should continue even after the grain has been stored. Walk or drive through the fields and look for the problems noted in Table 7. The damage of cutworms and armyworms can occur very rapidly and the timing of insecticides for European corn borer control is extremely important. Be especially careful in checking for these insects. Many of the insects that damage corn build up in wet, weedy areas in adjacent fields or in the corn field itself. These areas should be checked very carefully. Insecticides recommended are summarized in Table 8.

WHITE GRUBS AND WIREWORMS

These insects are discussed in the section on "Small Grain Insects." Their damage to corn is the same as in the small grains; a chewing of the seed and pruning of the roots of seedling plants that prevents germination or causes wilting of the seedling.

SEEDCORN MAGGOT

The seedcorn maggot is a whitish, spindle-shaped larva that lacks both a definite head and legs. The maggots tunnel into the seed and stems of the seedlings. Their damage appears as areas of poor stand or of weak, wilting seedlings. The adults of the maggots are small flies. They lay their eggs in soils high in organic matter (muck soils or fields with a lot of weeds, stubble or manure plowed down). The maggots hatch from these eggs and cause the damage to the corn. Late planted corn is especially susceptible to seedcorn maggot. Start looking for areas of poor stand as soon as the corn begins to germinate. Check the seed and stems of the seedling for the maggots.

Treatment of the seed with an insecticide is recommended for control of the seedcorn maggot. Seed treatment is best done by the seed dealer at the same time the seed is treated with fungicides. Seed treatment formulations of the insecticides are available for use in planting box applications if ready-treated seed is not available. Follow instructions on the label of the seed treatment to be sure an even coating of the seed is obtained.

Table 7. Guide to checking corn fields for insect pests.

When To Look	Where To Look	What To Look For	Insect
Before planting	adjacent fields	small grain, weedy or grassy fields	expect armyworm, flea beetles, billbugs, cutworms, slugs, grasshoppers, or cereal leaf beetle adults.
	the corn field	wet or weedy places	the insects above
		previous sod or meadow in past 2 seasons	expect wireworms and white grubs
		lodging and damage roots of corn last season	expect corn rootworms
Land fitting	plow furrows	muck soil, heavy weeds, or stubble, heavy manure	expect seedcorn maggot
		thick bodied larvae	white grubs
Germination	area of poor stand	slender, tough larvae	wireworms
		roots pruned or seed gnawed	wireworms or white grubs
		seed or seedling tunneled by legless larvae	seedcorn maggot
		plants cut at soil level; cylindrical larvae in soil	cutworms
Seedling & whorl stage	leaves	irregular holes in leaves; soft, slimy animals in soil	slugs
		small round holes and corky spots; small black beetles on leaves	flea beetle
		silvering of upper leaf surface; small, active reddish to yellowish insects in bases of leaves	grain thrips
		white scratches on upper surface; blue beetles on leaves	cereal leaf beetle adult
		holes in leaves and frass in whorl:	
		a. hard shelled snout beetles in soil or whorl	billbug
		b. striped cylindrical worms in whorls, leaves or soil	armyworm
		c. clear or spotted cylindrical worms in whorl or leaves	European corn borer
	stalk near ground of wilting plants	frassy holes; cylindrical larvae with black middle; in stems or leaves	common stalk borer
	roots of wilting or stunted plants	pruned, tunneled roots; small, white cylindrical larvae	corn rootworm
Tasseled plants	leaves	edges eaten; large, active insects	grasshoppers
		scale-like masses under leaves, holes in leaves; cylindrical clear or spotted larvae	European corn borer
	leaf axils, tassel, base of ears	black, sticky honey dew; small, soft green insects	corn leaf aphid
	tassels, silks, and ears	yellow to green beetles with long antennae	corn rootworm adults
		black beetles with yellow or red spots	sap beetles
		striped, cylindrical larvae	corn earworm
		clear or spotted cylindrical larvae	European corn borer
Mature corn	lodged areas	stalks tunneled and broken above ground; spotted larvae in stalk near base	European corn borer
		roots pruned and tunneled	corn rootworm

Table 8. Insecticides recommended for the control of insect pests of corn; 1972.

Pest	Type of Application	Insecticide	Amount of Active Insecticide	Limits on Use
Seedcorn maggot	seed treatment	diazinon	2 oz./bu. seed	do not use seed for food or feed
		dieldrin	1/2 oz./100 lb. seed	do not use seed for food or feed
White grubs and wireworms	preplant, broadcast	parathion	3 lb./acre (mineral soils)	do not contaminate ponds or streams
			4 lb./acre (muck soils)	do not enter field for 48 hours after treatment. Incorporate into top inch of soil.
White grubs, wireworms, and corn rootworms	preplant, broadcast	diazinon	4 lb./acre	incorporate into top inch of soil
		chlordane	4 lb./acre	non-dairy farms only, incorporate into top inch of soil
	planting, 7" band	diazinon	1-1/2 lb./acre ¹	incorporate into top inch of soil
		chlordane	2 lb./acre ¹	non-dairy farms only, incorporate into top inch of soil
Corn rootworms	preplant, broadcast	BUX	4 lb./acre	incorporate into top inch of soil
	planting, 7" band	carbofuran (Furadan)	3/4 lb./acre ¹	incorporate into top inch of soil
		phorate (Thimet)	1 lb./acre ¹	incorporate into top inch of soil
		BUX	1 lb./acre ¹	incorporate into top inch of soil
		Dasanit	1 lb./acre ¹	incorporate into top inch of soil
		Dyfonate	1 lb./acre ¹	incorporate into top inch of soil
		prophos (Mocap, Jolt)	1 lb./acre ¹	incorporate into top inch of soil
	cultivation, 7" band	phorate (Thimet)	1 lb./acre ¹	incorporate into top inch of soil, apply in June
		BUX	1 lb./acre ¹	incorporate into top inch of soil. Apply 30-40 days after planting or when plants are 8-10 inches tall
Corn rootworms	cultivation, 7" band	diazinon	1 lb./acre ¹	incorporate into top inch of soil
		Dyfonate	1 lb./acre ¹	apply at least 45 days before harvest; incorporate 2 to 3 inches into soil
Armyworms and cutworms	foliage application	carbaryl (Sevin)	1-1/2 lb./acre	no time limit
		parathion	3/8 lb./acre	12 days
		trichlorfon (Dylox)	1 lb./acre	28 days. Spray once per season when plants are 3-12 inches tall. Spray only bases of the plants and soil around plants
Billbugs, slugs, flea beetle, common stalk borer, and grain thrips	foliage application	carbaryl (Sevin)	1 lb./acre	no time limit
European corn borer	foliage application	carbaryl (Sevin)	2 lb./acre	no time limit
		parathion	1/2 lb./acre	12 days
		carbaryl (Sevin) plus parathion	1-1/2 lb./acre, plus 1/2 lb./acre	12 days
		diazinon	1-1/2 lb./acre	12 days for forage, no time limit for grain
Corn earworm	foliage application	carbaryl (Sevin) plus parathion	1-1/2 lb./acre, plus 1/2 lb./acre	12 days
		carbaryl (Sevin)	2 lb./acre	no time limit
Cereal leaf beetle adults, and grasshoppers	foliage application	carbaryl (Sevin)	1 lb./acre	no time limit
		malathion	1 lb./acre	5 days
	ULV aerial spray	malathion	6/10 lb./acre	5 days
Corn leaf aphid	foliage application	malathion	1 lb./acre	5 days

¹The amounts of active insecticide per acre recommended for band applications are given for corn rows spaced 40 inches apart. Read the instructions on the insecticide label if other row spacings are used.

There are three species of corn rootworms in Michigan. Their damage and larvae are very similar, but adults can be easily differentiated.

1. The southern corn rootworm adult (also called the spotted cucumber beetle) is yellow with black spots. Adults and larvae of this species feed on a large number of crops. It is not damaging to corn in Michigan.

2. The northern corn rootworm adult is a uniform pale yellow or green. This species feeds exclusively on corn and is presently the principal rootworm in corn in Michigan.

3. The western corn rootworm adult is yellow to red with a black stripe down each wing cover and another black stripe down the center of its wing covers. It, too, feeds only on corn. The western corn rootworm has been moving eastward across the corn belt for the last 20 years. It was first found in Michigan in Allegan and Cass Counties in 1971. It causes even more damage to corn than the northern corn rootworm and is a potential serious threat to Michigan.

All three corn rootworm adults are hard shelled beetles with long antennae. The adults feed on the silks and tassels of corn during August and September and are very active insects. Their trimming of the silks causes poor seed set when adults are abundant. Growers should check their fields for adults when the plants are tasseling. If there is one adult per plant, damage can be expected if the field is to be planted to corn again the following season.

The adult northern and western corn rootworms lay their eggs in late summer only in the soil of corn fields. These eggs overwinter and hatch in late May to mid-June of the following season. Larvae that hatch from these eggs are slender and cylindrical with whitish bodies that range to nearly 1/2 inch in length. The larvae have a tan head, six small legs just behind the head, and no false legs on the abdomen. They feed only on corn, tunneling through roots and pruning small roots of corn. Their damage to the roots causes stunting and an early wilting of plants during periods of drought in June and July. Plants that show stunting or wilting should be examined for the feeding of the larvae. The weakened roots will not support the plant and infested fields become lodged and difficult or impossible to harvest. The lodging is from the soil level and plants injured by rootworms are commonly curved (goose-necked) from their bases. The larvae form immobile pupae in the soil when they have completed their larval development. Adults emerge from these pupa in mid-August to September.

The best control for corn rootworm is to rotate corn with any other crop when this is economically feasible. The rootworm larva that hatch from the eggs

cannot exist on the other crop. Adult rootworms will not lay eggs in the alternate crop. Corn planted in the field following the alternate crop will, therefore, be free of rootworms. The need to have corn after corn should be critically reviewed by the grower if rootworm problems appear. Fields should be rotated unless absolutely necessary to plant corn-after-corn.

Not every field of continuous corn will have problems with rootworms. Many fields in Michigan have been in corn for numerous years without any rootworm damage. Check your fields carefully before deciding to invest in equipment and insecticides for rootworm control:

1. Rootworms persist as pests in fields of constant corn; once a grower has had rootworm damage in an un-rotated field, he can expect continuing damage from the rootworm.

2. Plants that show stunting, wilting, or lodging in June or early July should be examined for the rootworm larvae and their damage to the roots. If found in time, a cultivation application may be made, as described below, to protect the field from further injury.

3. The tassels and silks of plants should be checked for adults of the rootworm when plants are tasseling. As a general rule, one adult per plant means a rootworm problem in corn planted in that same field the next season.

4. Lodged, mature corn should be checked for tunneling of the larvae of the rootworms. Root rots always accompany the rootworm and the smaller roots are often completely rotted off. The tunnels can usually be found in the brace roots, however, even when the rest of the root system is nearly completely gone.

Once you are convinced that insecticides are necessary, plan ahead of planting time to obtain needed equipment and insecticides.

Pre-plant broadcast applications of insecticides are made by spraying or applying granular insecticides to the soil surface of the entire field before planting. Applying the insecticides immediately before final disking is a good practice.

Planting band applications are made by spraying or applying granular insecticides in a seven inch band over the row at planting time. The insecticide should be applied above and out of contact with the seed. The spray nozzle or granular applicator spout should be placed between the seed spout and the covering wheel. It may be necessary to modify the covering wheel so that it will incorporate the insecticide into the upper surface of the soil. If more convenient, insecticides may also be applied in bands over the row and incorporated into the soil after planting, before the plants emerge.

Cultivation band applications are made by spraying or applying granular insecticides in about 3 to 4 inch bands on both sides of rows of growing corn and in-

corporating the insecticide into the upper surface of the soil with a cultivator shoe. This application takes especially modified equipment, but is the only practical means of applying insecticides to growing corn. It is especially recommended if the rootworm infestation is not found until after the corn germinates.

CUTWORMS AND ARMYWORMS

These insects are discussed in the sections "Forage Insects" and "Small Grain Insects." The damage of the cutworms in corn (cutting of the young stems near soil level) is the same in corn as in the other crops. The armyworm feeds in the whorl of the corn as well as on the leaves. Their feeding in the whorl causes elongate holes in the leaves and larval droppings (frass) will be seen in the whorl. Granular insecticides will penetrate into the whorl of the corn better than sprays. If sprays are used, a single large nozzle should be centered over the row of corn and the spray applied at 40 gallons per acre, or more.

BILLBUG AND COMMON STALK BORER

These insects cause the same damage to corn as they do to the small grain crops discussed in the section of "Small Grain Insects." The feeding of the billbug in the whorl of corn causes rounded parallel holes to appear on the leaves as the leaves unroll out of the whorl. Granular insecticides or sprays as recommended for armyworm control should be used when billbugs are in the whorls of corn.

SLUGS, FLEA BEETLES, GRAIN THRIPS

These three distinctly different types of pests feed on the leaves of young corn. They are frequently most abundant in weedy areas of a field, but can spread over the whole field during some years. Slugs are not insects. They are mollusks related to the clam, snail, and octopus. They feed at night by chewing irregular holes through the leaves of the corn and hide during the day in the soil near the bases of the plants. The holes in the leaves and their slimy trails on the leaves are easily seen during the day. A search of the soil and debris near the plants will reveal a soft, dark, slimy rounded-to-elongate animal that ranges from 1/2 to 1-1/2 inches long. Slugs have been most abundant during cool, moist springs and are often damaging only in the wetter areas of the field. They can severely damage small plants when abundant. Thus, a spray should be applied to the area affected if their damage is seen on most plants.

Flea beetles are small, round, dark-colored, hard-shelled beetles that spring into the air when disturbed. The larvae of these beetles live on the roots of grains, grasses, and some weeds. Flea beetles can be expected in corn fields that are weedy or close to grain fields. They are active insects, however, and may

appear in any field. Flea beetles eat small, round "shot-holes" completely through the young leaves of corn or feed on the upper surfaces of the leaves, causing a round, corky spot on the leaf. Their feeding retards the early growth of the plant and can kill small plants when numerous. In addition to the direct damage to corn, the flea beetles also carry the bacteria of Stewart's wilt disease of the corn. A spray should be applied to the area infested when most of the plants in the area show signs of feeding by the flea beetles.

Grain thrips is a very small, ovoid, yellowish to reddish insect that scrapes the upper surfaces of the leaves and sucks up the juices. The thrips feed hidden in the leaf sheaths of the small plants. Its damage appears at first as a silvering of the upper surface of the leaves. Heavily damaged leaves dry up and the whole plant is stunted and retarded in growth when the thrips are abundant. Thrips are usually found in grassy areas of the fields (headlands, for example), but can spread out and damage entire fields during dry weather. A spray should be applied to small corn when most of the plants in an area show the silvering of the leaves caused by grain thrips.

GRASSHOPPERS, CEREAL LEAF BEETLE ADULTS

Grasshoppers have been discussed in the section on "Forage Insects," and the cereal leaf beetle has been presented in the section on "Small Grain Insects." The grasshopper most common in corn is the large, gray to green, differential grasshopper. They chew large areas out of the margins of corn leaves and are generally most abundant in the margins of the fields adjacent to weedy fields and fence rows. Cereal leaf beetle adults feed in late June to mid-July on the upper surfaces of the leaves. Their feeding appears as a whitish scratching on the leaf surface. The scratches fuse and the leaf tatters and dries when adults are numerous. Adults are most common in corn adjacent to small grain fields that have been heavily damaged by the pest. Neither grasshoppers nor cereal leaf beetles need special control unless they are abundant in the field and their damage threatens to retard the growth of small plants.

EUROPEAN CORN BORER

The scale-like rounded eggs of the European corn borer are laid in masses on the underside of corn leaves. The eggs overlap in the mass like shingles on a roof. They are whitish when first laid, but darken and form a definite black spot (the head of the larva) just before hatching. The larvae make small white spots by feeding on the upper surface of the leaves soon after hatching. They move into the whorl within a day or so after hatching. Their presence in the whorl can be detected by their frassy droppings and parallel, elongate holes that appear in the leaves.

Whorl damage looks the same as armyworm damage. The European corn borer larva has the same cylindrical shape as the armyworm—six small legs near the head, and five pair of fleshy legs near the tail. Larvae of the European corn borer, however, are whitish and usually marked with prominent dark brown or black spots.

Larvae of the borer leave the whorl after a few days and bore through the stalk and even into the ear shanks of the corn. Their tunneling weakens the stalk and damaged corn lodges, making harvesting very difficult. Stalks damaged by European corn borer break over at an upper internode, usually not at the base as they do when damaged by corn rootworms. Lodging is most severe, of course, when the stalk is broken below the ears. Larvae pupate within the stalk and adults emerge from the pupae.

There are two generations of the borer per year in Michigan. Larvae overwinter in stubble of corn and in an extremely wide range of other plants. They pupate early in the spring and adult moths emerge to lay the eggs of the first generation in June. Adults are active only at night. They are attracted to light and light traps are maintained in many areas to check the abundance of the moths. The adults of this first generation emerge and lay the eggs of the second generation in August. It is the larvae of this second generation that pass the winter in an inactive (diapausing) state.

Growers should be alert to notices from their County Agricultural Extension Agent of the appearance of the adult European corn borer moths caught in the light traps. This will give them warning of when to check their fields. The undersides of leaves of corn should be examined for egg masses, the upper surfaces of the leaves should be checked for white spots made by the small larvae, and the whorls should be examined for frass and larvae when the fields are checked. An application of insecticides is needed when there is about one egg mass per plant, or when 3/4 of the plants show damage of the larvae. The European corn borer is easily controlled when the small larvae are exposed on the surface of the leaves; more difficult to control when the larvae are in the whorl, and cannot be controlled when the larvae are tunneling in the stalk. The field *must* be checked frequently in order to time the applications to assure protection of the corn from the borer. The ideal time to spray is when the eggs are in the "black head" stage. They will hatch soon and the small larvae will be entirely exposed to the spray. Granular insecticides or a spray applied as described for armyworm control are needed when the larvae are in the whorl. The corn will be tall when the second generation borer appears. An aerial or ground application with a "Hi-Boy" type of applicator will be needed.

CORN LEAF APHID

The corn leaf aphid is a small, inactive, green insect that sucks the juices of corn. They are found in colonies most commonly in the tassels, leaf sheaths, and bases of the ear. Their feeding can retard the growth of the plant and result in poor seed set on the ear. They pump out a sticky liquid (honey dew). A mold forms on this honey dew and gives heavily infested plants a blackened appearance.

The corn leaf aphid is commonly found in all Michigan corn fields. Its natural enemies (lady beetles, lace wings, diseases, and wasp-like parasites) usually keep their numbers below damaging levels. Sprays of some insecticides, such as Sevin, kill the natural enemies without reducing the numbers of the corn leaf aphids. Be especially alert for corn leaf aphid in corn fields that have been sprayed with Sevin. A spray is needed to control the corn leaf aphid only in fields where the seed has not been set and nearly every plant shows appreciable blackened areas of honey dew in the tassels and axils of the leaves. Corn will be tall when the insecticide is applied. An aerial spray or ground application using a "Hi-Boy" type of sprayer will be needed.

CORN EARWORM AND SAP BEETLES

These two insects attack the ears of corn. They are very seldom of any importance in field corn in Michigan. The corn earworm is a cylindrical worm with a tan head, six small legs behind the head, and five pair of fleshy legs near the tail. It ranges in color from pale green, reddish, brown, to nearly black. They have light stripes running the length of their bodies and range up to 2 inches in length. Adult moths lay their greenish, cone-shaped eggs singly on the silks of late planted corn. The young larvae that hatch from these eggs feed on the silks and soft seeds near the tips of the ear. The silks of field corn planted very late should be checked for the eggs and a spray applied to corn that has not yet set seed if the eggs are found on most (2/3 to 3/4) of the silks.

Sap beetles are hard shelled, black beetles that are spotted with yellow or red. They feed primarily on tissues that have been injured and are decomposing. They are frequently found in whorls of corn that have been damaged by armyworm or European corn borer and in the tips of ears damaged by birds or the corn earworm. They will feed on sound, soft kernels in the ear when they are abundant, but their damage is negligible. They are of special importance because they are found feeding on tissues that have been damaged by other causes and are frequently falsely accused of doing the damage. Their appearance in large numbers in a corn field is a good indication that the corn is in poor condition because of injuries from other insects, diseases, or other causes.

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