



*How to Know
and Control*
**STORED-GRAIN
INSECTS**



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Farm storage of grain presents a serious problem of insect control. Wooden bins with loose sides and open tops make grain fumigation difficult. Mice and rats often add to the problem by gnawing holes in the bottoms and sides of these bins. Steel bins, one type of which is shown in the upper right-hand picture, are the most practical and economical. They are easy to fumigate and are practically rat and mouse proof.

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How to Know and Control Stored-Grain Insects

By M. D. FARRAR, T. F. WINBURN, and W. P. FLINT¹

IF NO PREVENTIVE or control measures are taken, grain held for any time in farmers' bins is almost sure to become infested with insects, which damage the grain and lower its value for seed, for feeding, and for market. Germinability, weight, quality, all are reduced when grain is infested.

Serious damage to whole grain in Illinois bins is done by comparatively few insects, but these few destroy or spoil thousands of bushels of grain each year. They are not difficult to recognize; in fact any careful observer can usually identify them by comparing them with the illustrations and descriptions in this circular.

Where these insects have gained foothold, fumigation is the only effective way to rid grain of them. This circular describes a safe, effective, inexpensive fumigant that farmers can apply. Preventive measures must be taken before the grain is in the bins.

TO PREVENT INFESTATION

See that bins and grain are clean. Much insect damage is due to the fact that bins are not cleaned before the grain is stored. Bins should be thoroly cleaned out, and all waste grain removed from the cracks, corners, and floors of the bins, on the outside as well as the inside.

Grain that is to be placed in the cleaned bin should be free from dirt, chaff, cobs, rodent excrement, and other foreign materials. The cleanup load of grain from the sheller or thresher, which is usually very dirty, should not be put with the rest of the grain. In fact this load often ruins a whole binful of good grain.

Keep moisture content down. The moisture content of corn, wheat, oats, and barley should not exceed 13.5 percent; soybeans should not exceed 15 percent. In good bins, if the grain is clean, if it is not in storage more than a year, and if the moisture content is checked

¹M. D. FARRAR, Research Entomologist, Illinois State Natural History Survey; W. P. FLINT, Chief Entomologist, Illinois State Natural History Survey and Illinois Agricultural Experiment Station; and T. F. WINBURN, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

three or four times during the year, 14 percent may be safe for the first four grains; but rancidity will increase faster with the higher moisture content and in time will affect the grade.

Spray infested empty bins. If a bin has been infested, spray it thoroly with deodorized kerosene or a spray consisting of the following ingredients:

	<i>10 gallons</i>	<i>100 gallons</i>
Dormant-tree spray oil.....	1 gallon	10 gallons
Lye.....	3 ounces	2 pounds
Water.....	9 gallons	90 gallons

A gallon of this spray will cover adequately about 50 square feet of bin surface.

Do not leave small grain in field. In order to reduce infestations in the field, small grain should be combined or threshed as promptly as possible. In southern Illinois, in years following mild winters, a considerable amount of grain in the shock may be infested in the fields if it is not promptly threshed.

TO CONTROL INFESTATION

Fumigate with ED-CT mixture. Once grain in the bin has become infested with insects, fumigation is the only practical method of stopping damage. The problem has been to find an effective fumigant that would not be dangerous to use. A 3-to-1 mixture of ethylene dichlorid and carbon tetrachlorid (ED-CT for short) seems to be the best answer at present.¹

No fire hazard. The gas created by this colorless, sweet-smelling liquid is deadly to all forms of insect life if used in sufficient strength and at temperatures in which the insects are active, but it creates no fire hazard. It is the best fumigant, all things considered, that the authors have found for farmers' grain bins, or for piles of feed that can be kept in a tight container. When exposed to the air at ordinary temperatures, the mixture evaporates slowly and forms a penetrating gas, which is heavier than air and sinks to the bottom of any container in which it is used.

Bins must be tight. The effectiveness of this fumigant depends on the tightness of the storage bin—a bin with large cracks or open-

¹There are commercial fumigants on the market that are effective when a heavy enough dosage is used. In tests made by the authors, however, few of these other fumigants were as effective as the ethylene-dichlorid and carbon-tetrachlorid mixture when used in amounts representing equivalent cost. Such materials should be used only as directed by the manufacturers.

ings in the bottom or sides cannot be successfully fumigated. All cracks and openings must be completely closed so the fumigant will not escape. Lining the bin with a heavy building paper or sheet metal is the most satisfactory way to seal it. Sometimes the open parts can be covered from the outside with heavy building paper. If a bin cannot be tightened without too much expense, the grain should be transferred to one that is tight, before the grain is treated.

Level off grain. Before treating the grain, level it off and leave at least 6 inches of side wall extending above the grain surface. This much free space above the grain is needed to hold the gas until it has a chance to sink down thru the grain. If there is not enough free space here the gas will flow over the edges of the bin before it can penetrate the grain.

To prevent surface evaporation. Loss of fumigant thru surface evaporation can be reduced by throwing a canvas or tarpaulin over the surface of the grain after the fumigant has been applied. This extra precaution is especially effective where the grain is stored in bins that have large open spaces or drafts above the surface of the grain.

Break up moldy layers. When a bin of grain is heavily infested with insects, the surface grain becomes solid; and a damp, moldy layer may extend an inch to several feet below the surface. Heating (grain becomes warm to the hand) usually takes place in such bins. The solid surface layer of grain must be thoroly broken up before fumigation starts.

All grain that is sprouted or badly molded should be removed before the surface is stirred.

Amount of fumigant needed. The following amounts of ethylene-dichlorid and carbon-tetrachlorid mixture, properly applied to the surface of the grain, will penetrate to the bottom of all ordinary farm bins:

<i>Bin content</i>	<i>Amount of mixture per 1,000 bushels</i>
Less than 500 bushels.....	8 gallons
500 to 1,500 bushels.....	6 gallons
1,500 to 3,000 bushels.....	5 gallons

Grain placed in unusually shallow bins will need more fumigant.

This liquid can be bought in 5- to 50-gallon lots. It costs from 75 cents to \$1.25 a gallon, depending on quantity purchased.

Add oil for shelled corn. Insects are bound to reinfest shelled corn even when it has been well fumigated. But such reinfestation can



Never try to fumigate grain that lies unevenly in the bin. The gas will sink to the lower parts of the surface and penetrate down into the grain in those areas, but the grain under the higher parts will not get enough of the gas to insure a kill of insects.



Level off the surface of the grain before starting treatment. No matter what kind of bin or fumigant is used, this step must not be omitted.

be reduced by adding oil to the fumigant, using 2 to 3 quarts for each 1,000 bushels of corn. The oil should be either technical white or some unsaturated oil of 100 to 200 seconds viscosity (Saybolt 100° F.) and be free from objectionable odors. *Do not use kerosene or waste crankcase oil.*

Have grain temperature above 60° F. The best results with the ethylene-dichlorid and carbon-tetrachlorid mixture are obtained when the grain registers a temperature above 60° F. During extremely hot weather, however, fumigation is best done during the cooler parts of the day. It should not be attempted when there is a strong wind blowing—anything above 15 miles an hour is too strong.

Use a spray pump. The easiest and best way to distribute this fumigant is to spray a 1/8-inch stream uniformly over the surface of the grain, using some form of force pump. This may be a small inexpensive bucket pump or a higher-priced garden sprayer. If there is only one bin to treat and no pump is available, a sprinkling can may be used but it is not so satisfactory as a sprayer and not so safe for the operator (see *caution* paragraph below).

To fumigate small lots. Tight barrels, drums, or glass jars are satisfactory containers for fumigating small quantities of seed. Use 1/2 pound of the liquid fumigant to a 50-gallon barrel. When it is desired to retain good germination, seeds should not be fumigated longer than 72 hours.

Fumigation stops heating by insects. Stored grain heats because of excessive moisture. Excessive moisture may be due to the moistness of the grain when it went into storage or to insect infestation or to both. If it is due to insects, effective fumigation will stop the heating, but it will have no effect if the grain was put into storage too moist.

CAUTION: This gas is not highly toxic to man but is irritating to the eyes and throat. Therefore always leave the bin or room as quickly as possible after applying the liquid. And before entering any place that has been fumigated be sure that it has been ventilated thoroly. Because it is heavier than air, there is little likelihood of harm from the use of this gas if it is properly handled.

Frequent contact of the liquid with the skin of the hands may cause sores.



A bucket pump is the easiest method of applying the fumigant. The liquid is poured into a pail or large can and pumped thru a hose to the man on the bin, who sprays it over the leveled surface of the grain. This equipment costs only \$10 to \$12 and can be used by a number of neighbors since one treatment a year is usually enough.

INSPECT BINS ONCE A MONTH

An abundance of insects in grain or an abnormally high temperature justifies immediate fumigation. In fact the only safe thing to do with any grain about which there is question is to fumigate it. The cost is small compared with the loss that may otherwise be incurred.

Since grain that has been stored for some time may go out of condition at any season as the result of the presence of insects, bins should be inspected once a month thruout the year. A bushel of grain sifted over a gravel screen (8 meshes to the inch) will roughly indicate how much infestation there is. The grain for this purpose should be taken from below the surface in the center of the bin.

In a heavily infested bin, as elsewhere noted, the surface grain becomes solid; and damp, moldy grain may extend for some distance into the bin. Heating usually occurs in such bins.

The damage to be expected from an infestation will depend on the number and kinds of insects present and the length of time they persist.

OTHER PROTECTIVE MEASURES

Hydrated lime for beans and peas. Beans of all kinds and cowpeas, that are held over from one year to another, may become infested by one of the pea or bean weevils or by one or two of the common grain moths. Larger quantities of such seed, piled in bins, can be protected by covering the seed with a half-inch layer of hydrated lime. Small quantities can be protected by mixing the lime with the beans in the proportion of one part of lime to four parts of beans or peas, by weight. The mixing or covering should be done immediately after harvesting.

This treatment will not injure germination.

Oil emulsion for ear corn. Ear corn may be protected from insects by dipping the ears in an oil emulsion containing 8 percent of technical white mineral oil dispersed in water. The dipped ears should not be handled after they are dry. The treatment does not injure germination.

Mercury fungicides. Seed stocks of corn or small grains that have been treated with a fungicide containing mercury (such as Ceresan or Semesan Jr.) are relatively safe from attack by insects. Seed so treated may be carried from one season to the next without injury by insects. *Do not feed this treated seed to livestock or poultry.*

Carbon bisulfid. This chemical has been successfully used for many years as a fumigant for farm-stored grain. It is very effective against grain insects but has a definite fire and explosive hazard. A lighted lantern, cigarette, cigar, or pipe, or sparks from an electric switch coming in contact with the gas in a bin or barn will ignite it and may cause serious damage or even loss of life.

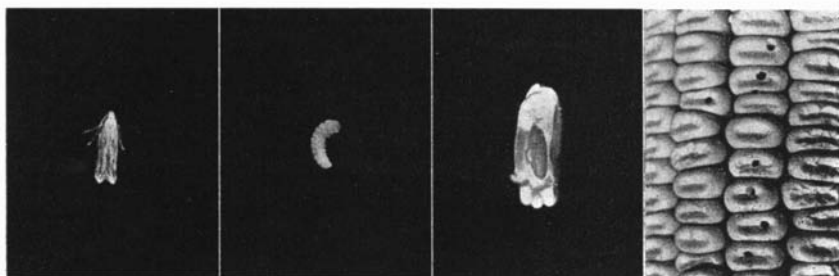
This material is used as a fumigant in the same way as the ethylene-dichlorid and carbon-tetrachlorid mixture (ED-CT). Recommended dosages are:

<i>Bin content</i>	<i>Amount of liquid per 1,000 bushels</i>
Less than 500 bushels.....	4 gallons
More than 500 bushels.....	3 gallons

INSECTS TO WATCH

Not all insects found in stored grain are destructive. Those from which trouble may be expected are shown or described here. Some of these are a much more serious menace than others, tho even those ordinarily considered of secondary importance may become abundant enough to put grain out of condition. So all bear watching. Fortunately the same fumigant will kill all of them. Mites are an exception; they are most effectively controlled by moving, cleaning, and drying the grain, as indicated on page 15.

ANGOUMOIS GRAIN MOTH



Adult
Mottled gray
¼" to ½" long

Larva
Feeding stage
Gray to white
Up to ½" long

Pupa
Changing stage in
corn kernel
Light brown

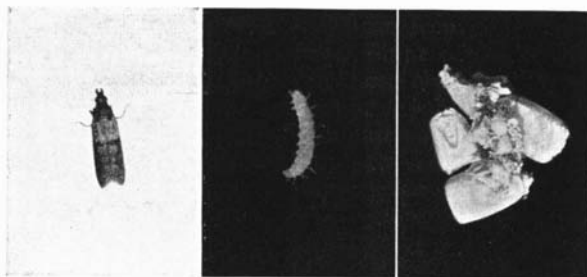
Damage
Typical exit holes
in corn kernel

This light-gray mottled moth does more damage to ear corn in cribs than any other insect. It also attacks wheat, rye, and other small grain. Tho found thruout Illinois, it is most destructive in the southern half of the state.

The eggs are deposited on the kernels of wheat or grains of corn by the adult moth. The tiny worms (*larvae*) hatching from the eggs bore into the grain, complete their growth, and go into a resting or changing stage (*pupa*); then finally emerge thru the holes they eat in the grains. They eat out most of the inside of the grain. A brood is matured in about 35 to 40 days. In southern Illinois there may be as many as six broods a year.

Corn, wheat, and other grains in the field are frequently infested, and losses running up to 50 to 75 percent of the value of the cribbed corn are sometimes incurred in the course of a single season in the southern fourth of Illinois.

INDIAN MEAL MOTH



Adult
Light brown banded
with chocolate
 $\frac{1}{3}$ " to $\frac{1}{2}$ " long

Larva
Feeding stage
White to pink
Up to $\frac{1}{2}$ " long

Damage
Typical webbing
in corn kernels

This moth is a common and destructive pest of all kinds of stored grains as well as soybeans, nuts, dried fruits, and many other food products. It occurs throughout the state, laying its eggs on the outside of grains. It is easily identified by the dark chocolate-colored area on the hind part of the wings.

The young worm (*larva*) spins a thread of silk wherever it goes and webs the food material together. It eats out the inside of damaged kernels but does not bore into sound kernels. In corn it frequently eats out the germ. On becoming full-grown the larva forms a thin cocoon, goes thru a changing stage, and emerges as a moth.

Broods of this moth mature in about 30 to 40 days, and there may be as many as four to six broods a year. Under warm conditions this insect breeds continuously throughout the year.

MEALWORMS

Yellow mealworm
Feeding stage



Light brown
Up to 1" long

While common throughout Illinois, mealworms are of secondary importance as grain pests. They are often found in stored wheat or shelled corn but are of little importance in cribs of corn.

These worms closely resemble wireworms in appearance. They feed on the outside of the grain, being too large to bore thru it. The black adult beetles also feed on the grain. There is probably never more than one brood a year.

RICE WEEVIL



Adult
Brown to black
 $\frac{1}{8}$ " to $\frac{1}{4}$ " long

Adult
Side view

Damage
Corn kernels eaten
out by the grub

This small dark-brown snout beetle, slightly smaller than shown here, is the most common grain weevil found in Illinois, and one of the most destructive. It feeds on all kinds of grains, particularly on corn and wheat. It is found thruout the state but is common only in the southern half.

The female insect makes a small hole in the side of the kernel of corn or grain of wheat by biting into the grain with her strong jaws. She then turns around and deposits an egg in this cavity. The footless grub hatching from this egg eats out the interior of the grain, consuming a large part of it. Within this cavity the grub changes to a resting stage and comes out later as an adult weevil.

Under the most favorable conditions there may be a brood of these insects every 30 days. In southern Illinois broods probably average six a year. The insect has wings and frequently infests grain and corn in the field.

LESSER GRAIN BORER



Adult
Brown
 $\frac{1}{8}$ " long

Adult
Side view

Damage
Wheat kernel completely
destroyed

This small cylindrical brown beetle, shown here about twice its actual size, is one of the most destructive of all the beetles feeding on stored grains. Both adults and young feed on the interior of the grain. Where infestation occurs, immediate steps should be taken to clean it up.

In the northern half of Illinois this insect is not so generally distributed as are most of the common grain-infesting insects. Four to six broods a year may be produced.

GRANARY WEEVIL

Often associated with the rice weevil (*page 12*) is a slightly larger and darker-brown weevil which also has a short snout projecting from its head. This is the true granary weevil. It has much the same range and life history as the rice weevil and likewise causes serious damage. The adult cannot fly and does not infest grain in the fields.

CADELLE

Adult
Black, $\frac{1}{2}$ " long



Feeding stage
White tipped with black
Up to $\frac{3}{4}$ " long

This rather large black beetle is only of moderate importance as a grain pest in Illinois. It is usually associated with the other grain-infesting insects; and while it may become abundant enough to do considerable damage, it will not of itself usually require fumigation.

The adult female usually lays her eggs on the grain next to the bottom and sides of the bin. The white, black-headed larvae feed on the outside of the grain, never boring into it. In wooden bins or cribs they frequently bore into the wood, especially where it is soft or doty. About one generation occurs each year.

FLAT GRAIN BEETLE



Adult
Light brown
 $\frac{1}{16}$ " to $\frac{1}{8}$ " long

This tiny flat brown beetle, shown here about 3 times its actual size, infests all kinds of grain and grain products. It is of secondary importance in stored grain. It feeds on cracked grains or broken kernels, not on the entire kernel; and both adults and their small worm-like larvae always feed on the outside of the grain.

This beetle occurs thruout the state. Tremendous numbers of both adults and larvae may be found in grain that is heating, and frequently they are responsible for this condition.

SAW-TOOTHED GRAIN BEETLE



Adult
Brown
 $\frac{1}{8}$ " long

This tiny brown, very active beetle, shown here about twice its actual size, is not a primary feeder on whole or undamaged grain, but chooses cracked and broken kernels. Both adults and larvae feed on the damaged kernels. Bins of oats and barley, shelled corn, and less frequently wheat, are its principal feeding ground. When present in large numbers, these insects may cause the grain to heat, and it is this that makes them a threat to stored grain.

The larvae are small, thread-like worms about $\frac{1}{4}$ inch long when full-grown, and they are found thruout the grain where the adults occur.

This beetle is about as common in northern as in southern Illinois. In the warmer parts of the state it breeds thruout the year, probably averaging two or three broods.

CONFUSED FLOUR BEETLE.

Adult
Reddish brown
 $\frac{1}{4}$ " long



Feeding stage
Light brown
Up to $\frac{1}{3}$ " long

This small mahogany-brown beetle is one of the most common insects wherever grain is stored in elevators, mills, bins, or cribs, but fortunately it causes very little damage. Both the beetles and their grayish-colored larvae feed principally on the outside of cracked or broken grain. Two to four broods mature each year.

Fumigation or turning the grain will usually control this insect. Generally known as "bran bugs," confused flour beetles do more damage in ground feed than in grain stored whole.

HAIRY FUNGUS BEETLE

Damp moldy grain is especially attractive to fungus beetles, of which there are several kinds. The most common is a hairy, dark-gray-to-brown insect $\frac{1}{12}$ to $\frac{1}{8}$ inch long in the adult stage. These insects feed on the molds and fungi in the spoiled grain.

Few bins are free from fungus beetles. When present in large enough numbers, they may cause the grain to heat.

FOREIGN GRAIN BEETLE



Adult
Light brown
1/16" long

This small light-brown beetle, shown here about 3 times its actual size, is one of the most common species of stored-grain insects in Illinois. It breeds in all stored grain. Grain containing large amounts of cracked kernels and foreign material is very subject to attack.

The full-grown beetle is very active, running or flying when disturbed. Reproduction is rapid under favorable conditions. Tremendous numbers of both adults and larvae may be found in grain that is heating, and in many cases they are responsible for the heating.

BOOK LICE



Adult
Flesh color
1/16" long

This tiny gray insect, shown here about 6 times its actual size, is found in most stored grain. It causes no direct injury to the grain, as it does not feed on it but on foreign materials. Grain that is out of condition may contain large quantities of adults and their wingless young.

These lice are often very abundant in bins infested with other grain insects.

GRAIN MITES



Clusters
of grain
mites

Several kinds of very tiny white grain mites, measuring only about 1/32 inch in length, are to be found in most stored grain. Grain that is damp or molding or includes a large proportion of cracked kernels or foreign material is an ideal breeding place for these mites.

Moving, cleaning, and drying the grain is the best control procedure. Dry, clean grain is seldom infested.

CARPET BEETLES

Feeding stage
Dark brown
Up to $\frac{1}{2}$ " long



Feeding stage
Brown
Up to $\frac{1}{3}$ " long



Several kinds of small gray-to-brown, distinctly hairy worms may be found in stored grain or grain products, especially in wheat. These are the young of some of our common Dermestid beetles or, as they are called when we find them in our houses, carpet beetles. These beetles feed on a wide variety of food and animal products and occur in all parts of Illinois in about equal numbers.

Occasionally these beetles become numerous enough in old grain—grain that has been held over for several seasons—to warrant fumigation, but usually they are of secondary importance. The larvae feed on the outside of the grain. Adults feed on the pollen of flowers and are not of any importance as grain pests.

ENEMIES OF STORED-GRAIN INSECTS



Adults
Black
 $\frac{1}{16}$ " to $\frac{1}{8}$ " long

There are several kinds of tiny wasps that attack and destroy stored-grain insects, particularly the larvae of the two grain moths (*pages 10 and 11*). Two of these wasps are illustrated here magnified to about twice their actual size. Where these wasps are found in stored grain, there will be less damage from destructive insects.

These wasps are strongly attracted to lights and are frequently to be seen on the windows of cribs or buildings in which grain is stored.

FARMERS WHO FIND in their stored grain insects which they suspect are destructive but which they cannot identify with certainty are urged to send specimens to: CHIEF ENTOMOLOGIST, ILLINOIS NATURAL HISTORY SURVEY, URBANA, ILLINOIS.

The insects will be examined without charge and recommendation given for treatment.