

Stored- Grain Insect Control



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Stored-Grain Insect Control

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Stored-Grain Insect Control

At the onset of winter, the value of grain stored on and off farms in Ohio exceeds \$1.25 billion. More than half of this grain is stored on farms managed by tens of thousands of individual growers.

Grain stored on the farm is a significant portion of the total field crop produced the prior growing season, and it must be maintained in good condition if it is to be marketed at full value or fed to livestock.

Like money in the bank, stored grain is a valuable asset. Unlike money in the bank, grain is a living entity susceptible to attack by insects, mites, molds, and rodents. If grain quality is allowed to deteriorate due to the activity of one or more pests, the value of the grain is reduced and significant losses result.

Prevention of post-harvest losses requires implementation of a pest prevention and control program including both chemical and non-chemical methods. Grain pest-management programs include the following basic steps:

1. Storage-facility preparation, including sanitation and chemical treatments of the empty storage facility.
2. Binning of grain in good condition with the application of protective insecticide, especially if long-term storage is anticipated.
3. Periodic monitoring and management of the grain, including a special effort to detect pest infestation.
4. Implementation of corrective procedures when pest-population activity threatens grain quality.

Current Developments

Removal of Malathion from Recommendations

For the past three decades, malathion has been recommended as an empty-bin treatment and grain protectant. Due to current laws regarding re-registration, the Environmental Protection Agency has requested additional toxicological information for continuation of the use of malathion as either an empty-bin treatment or grain protectant. Because the cost of generating the information needed for re-registration of malathion uses on stored grain may exceed potential market benefits, manufacturers have indicated that applications applicable to stored grain will be discontinued. These decisions have also been influenced by factors related to the relative efficacy of malathion in the stored-grain field compared to new products on the market. As a result, listings of products containing malathion have been removed.

It should be noted that existing supplies can be used according to label directions, but new labels of malathion products will not include listings for use on storage facilities or stored grains.

Removal of Dichlorvos from Recommendations

Formulated products including dichlorvos (DDVP, Vapona) have been used in the past as space treatments to control stored-product pests, especially adult Indian meal moths. The most common product used in grain bins was the resin strip formulations. In 1989, a special review concluded that dichlorvos should be classified as a "possible" human carcinogen. The EPA has proposed revoking the food-additive tolerance for dichlorvos in packaged or bagged nonperishable foods in 1992. Therefore, food industries will probably not welcome grain with any residues of dichlorvos.

As a result of these recent developments regarding dichlorvos, grain managers are advised to carefully consider the health risks and potential public concern that may result from the use of dichlorvos products. Dichlorvos products previously listed in this publication for use in stored-grain environments have been removed.

New Chemical Product

Tempo is a new synthetic pyrethroid insecticide labeled for surface treatment of food-handling establishments, including grain mills and granaries, which may be interpreted to include the farm grain-storage facility. At press time of this publication, Tempo product labels do not specify use as an empty-bin treatment. However, labeled uses of Tempo applicable to farm-based grain storage may be forthcoming. The active ingredient of Tempo is cyfluthrin, which exhibits fast knockdown of insect pests and is currently labeled for many stored-product insects. (See "Surface Treatments of Empty Storage Facilities.")

Storage Facility Preparation

Prior to storing new grain, growers should make every possible effort to prepare a pest-free environment to prevent the carryover of established pests to the new grain. Preparations include application of sanitation and insecticide treatments to eliminate established pest populations.

Sanitation

Sanitary practices include measures to remove old grain and other organic matter that may be supporting pest populations in the grain-storage facility. Note the following specific practices:

1. Clean the entire storage facility, preferably to the point that the facility is near its original state. A limited effort includes

sweeping and vacuuming of grain remaining from the previous storage season. Thorough cleaning includes scrubbing and removal of all residue capable of supporting pest populations. If feasible, clean-out of old grain residue should be implemented in metal bins with sub-floor spaces.

2. Clean grain-handling equipment, including that used for field harvesting, transport, and grain handling. In general, any equipment that may hold grain from a previous season represents a source of infestation and should be cleaned thoroughly. Grain-dump hoppers and boot areas require special attention.

3. Remove any grain pest-supporting habitats in the immediate vicinity of the storage facility, including ground or floor accumulations, weeds, old sacks of seed or feed, and any other sources of contamination. **Never store new grain on top of grain remaining from the previous season.**

Sanitation is the first step in stored-grain pest control. The grain-storage facility should be viewed as a food-handling environment and cleaned accordingly. Major food-processing plants implement sanitary practices as a primary method for controlling insect populations that may contaminate food products. If growers implement equivalent procedures in handling stored grain, the incidence of insect problems in farm-stored grain will be significantly reduced.

Surface Treatments of Empty Storage Facilities

After thoroughly cleaning the storage facility, apply an insecticide treatment to eliminate any remaining insect infestations (Fig. 1). This treatment is generally called an *empty-bin spray*. The treatment may also be referred to as a *residual spray before storing grain* where the term "grain bin" may not apply.

The objective of the empty-bin spray or residual spray treatment is to eliminate insect infestations remaining from the previous storage season and to maintain an insect-free environment until the time of storing new grain. This treatment penetrates cracks and crevices that may be impossible to clean and leaves a chemical residue that will presumably come in contact with and kill insect pests remaining in the storage facility. When

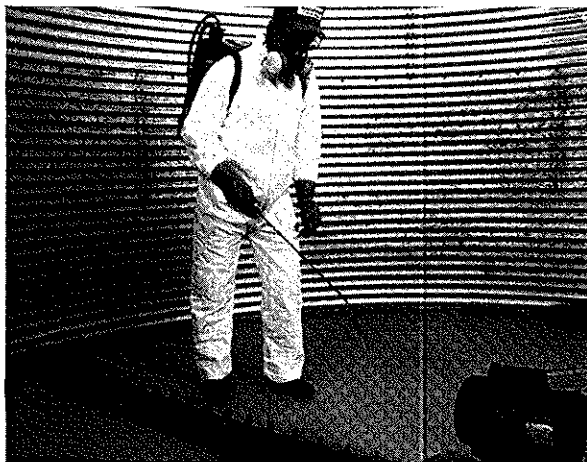


Fig. 1 Application of empty bin spray using protective clothing and respirator.

possible, empty-bin treatments should be applied one to two weeks before binning grain.

The following materials are recommended as empty-bin treatments or as applications to surfaces that will come in contact with stored grain:

MaxKill Mill & Bin Spray (ready to use formulation — Methoxychlor 3%, Pyrethrin .025% + piperonyl butoxide .063%)

Apply approximately 1 gallon to 750 square feet on non-absorbent surfaces. Complete drying is necessary before commodities are placed in bin. Do not spray directly on grain, and do not contaminate any feed or food stuffs.

Douglas Special Mill Spray (ready to use formulation — Pyrethrins 0.14% plus piperonyl butoxide)

Apply 1 gallon per 750 square feet.

Methoxychlor 25% spray (25.4% methoxychlor)

Mix 1 gallon in 10 gallons water. Apply at rate of 1 gallon of diluted spray per 1,000 square feet of bin surface area.

Note: Do not add grain to bin for at least 24 hours or until walls have dried out thoroughly.

Reldan 4E (chlorpyrifos-methyl)

Mix 1/2 pint formulation per 3 gallons of water, then apply 1 gallon of mixture to 650-1,250 square feet of bin surface area.

Tempo 2 (cyfluthrin)

Mix 8 ml (0.27 fluid ounces) in 0.26 gallons (metal surface) to 4.2 gallons (wood or concrete surface) of water and apply mixture to 1,000 square feet of surface area.

Tempo 20WP (cyfluthrin)

Mix 9.5 grams (3.4 ounces) in 0.26 gallons (metal surface) to 4.2 gallons (wood or concrete surface) of water and apply mixture to 1,000 square feet of surface area.

Space Treatments of Empty Storage Facilities

Large bins or warehouse-type storage facilities require a space treatment using a mist blower, ULV generator, or fogging device to disperse an insecticide formulation throughout the structure to eliminate hard-to-reach insect pests. Some formulations labeled for use in grain-storage areas may not have residual properties.

Formulations of methoxychlor provide long-term residual activity. Formulations of pyrethrins provide effective control of present pests, but do not provide residual activity. Some space-treatment formulations may be used as space treatment over unprocessed stored grain. The following formulations are available:

Lethalair A-20 (an aerosol system using synergized pyrethrin)

This system enables automatic and periodic application of synergized pyrethrin throughout the storage airspace to control exposed and flying insects. Use of this aerosol system requires

installation of an aerosol generating system per 50,000 cubic feet of airspace.

Pyrethrin Dispenser A battery-driven dispenser that releases 2% pyrethrin periodically from a 7.5-ounce can. This unit lasts about 1 month and treats 6,000 cubic feet. It is a potential replacement for dichlorvos no-pest strips previously recommended for treatment of adult Indian meal moths. Note: Use of this pyrethrin dispenser should be based on detection of adult Indian meal moth activity with pheromone-baited sticky traps.

Elimination of Sub-Floor Sources of Infestation

A primary source of insect reinfestation in grain bins is the sub-floor area of bins with aeration floors. This area should be periodically cleaned if possible. Once a bin has had an insect infestation, growers should assume that the infestation has become established in the sub-floor area. Empty-bin residual treatments may have some effect on a sub-floor infestation if the treatment can be directed into the sub-floor area.

When constructing new bins, consider design and installation of aeration floors that can be removed sufficiently to enable treatment of the sub-floor area. Easy-access flooring systems are now available to facilitate floor removal and cleaning.

An empty-bin fumigation with chloropicrin is recommended if the sub-floor is suspected of having an insect infestation and the area cannot be cleaned or thoroughly treated with a spray.

Empty-Bin Fumigation with Chloropicrin

Chloropicrin is an extremely toxic, restricted pesticide. It forms a pungent tear gas that is heavier than air and will settle into the bin's sub-floor area, killing insect infestations present. Approved respiratory and gas monitoring equipment is required when using chloropicrin.

No respiratory protection is required if the concentration of chloropicrin in the working area does not exceed 0.1 ppm as measured by a Matheson-Kitagawa detection device using tube No. 172. If this concentration is exceeded at any time, all persons in the fumigation area must wear a NIOSH/MSHA-approved air-purifying respirator (full-face gas mask) approved for organic vapors or a self-contained breathing apparatus (SCBA). Commercial formulations of chloropicrin currently available for use in empty grain bins include Chlor-O-Pic and Quasar. As an empty-bin fumigant, chloropicrin is applied as a space fumigant at the rate of 1 quart per 250 square feet of floor area.

To perform an empty-bin fumigation, apply chloropicrin on a calm day when the air temperature is 65 F or higher. Use commercial-quality duct tape and polyethylene sheeting to seal all bin openings below the level of the side door including fan openings and the auger shaft. Always work in pairs when applying this or any other fumigant. After sealing the bin, pour chloropicrin from the ventilation door of the bin roof. Post warning placards according to label instructions, and wait at least 24 hours before airing out the bin.

Although fumigation of an empty bin with chloropicrin should not require entry into the fumigated area, users should realize that exposure occurs while pouring the liquid fumigant. Use of a full-face gas mask is emphasized during this time given the impact of the tear gas and the precarious position of the applicator at the time of application.

Storage Time Procedures

At binning time, store grain at an optimum moisture level that minimizes the risk of insect and mold development while not causing excessive drying costs or weight loss. Given the factors cited above, the maximum safe moisture-content levels that should be achieved in Ohio are as follows:

Maximum Safe Moisture Content

Planned Storage Period	Shelled Corn	Wheat
Until spring	15%	14%
Up to 1 year	14%	13%
More than 1 year	13%	12%

Another factor affecting insect development in grain is the presence of foreign material. Trash and fines inhibit drying and aeration, contribute to the development of insect populations, and reduce the effect of preventative and rescue treatments applied to control insect infestations. In brief, grain cleaning minimizes the development of storage problems. Therefore, use of a grain cleaning device at binning time is strongly advised.

Application of Grain Protectants

A grain protectant is an insecticide applied directly to whole grain generally at binning time to provide a temporary residue to kill any insects entering the grain at the initial storage period when extended storage of grain is anticipated. Such a treatment may be applied to the entire grain mass by treating the grain stream entering the bin with a liquid formulation at binning time or by mixing a dust formulation into the grain mass. Application of liquid spray formulation is generally preferred for its ease of application and even distribution. Application of a dust formulation is preferred where grain is stored on the cob. Where grain has been dried at high temperatures that may adversely affect a liquid application, application of a dust formulation may be possible following cooling of the grain if mixing is possible.

Protectants may also be applied as a surface treatment, which protects the surface area where infestations often develop initially. The use of a surface treatment is warranted when flow of grain directly from a high-temperature dryer to the bin prevents application of a protectant to the grain stream.

Advantages of using grain protectants over total reliance on fumigants are as follows: (1) an element of insurance is provided by the reduced probability of infestation; (2) protection is offered to some storage situations that might be difficult to fumigate; and (3) protectants are relatively safe to apply compared to fumigants.

Recommended Grain Protectants

Formulations labeled for use as grain protectants include:

Bacillus thuringiensis (B.t.) (Top-Side Dipel, DI-WURMD) or equivalent

B.t. is warranted as a surface treatment for protection against Indian meal moth especially where malathion is the protectant used for protection against other insects. Top-Side Dipel is applied at the rate of 4 pounds per 500 square feet and mixed into the grain surface to a depth of 4 inches. This treatment may provide effective protection against initial infestations, but is limited in controlling established infestations due to decreased efficacy on mature larvae.

Actellic 5E (pirimiphos-methyl) (for corn, field corn or popcorn, and grain sorghum)

As grain-stream treatment, apply 9.2 to 12.3 ounces in 5 gallons of water per 30 tons (60,000 pounds) of grain. As surface treatment, apply 3 fluid ounces with 2 gallons of water to 1,000 square feet of grain surface.

Note: Surface treatment should be used only if grain has not previously received an application of Actellic. Actellic should provide protection against all stored-grain insects, including Indian meal moth, for a prolonged storage period if good grain-management practices are routinely followed.

Reldan 4E (chlorpyrifos-methyl) (for barley, oats, rice, sorghum (milo), and wheat)

As a wheat grain-stream treatment, apply 11.5 fluid ounces in 1/5 gallon of water per 1,000 bushels of grain. (Refer to label for rates on other grain commodities.) As surface treatment on wheat, apply 3 fluid ounces in 2 gallons of water to 1,000 square feet of surface. Half the mixture should be applied and raked into the top 4 inches, then the remaining half should be applied to the raked surface. Reldan provides protection against the total insect complex of stored grain, including the Indian meal moth.

Reldan 3% Dust (chlorpyrifos-methyl) (for barley, oats, rice, sorghum (milo), and wheat)

Apply to grain at the rate of 10 pounds of product per 1,000 bushels as grain is being loaded or turned into final storage. To protect stored grain from Indian meal moth, apply to surface at a rate of 7 pounds per 1,000 square feet of grain surface area.

Grain Protectant Application Methods

A variety of application methods and types of equipment can be used to apply protectants to grain. Protectant spray treatments may be applied using a simple hand-held pump sprayer or applied to the grain stream using accurately metered insecticide drip applicators or pumps. For full-scale grain operations, an insecticide pump that can be accurately calibrated to provide a steady flow of protectant to the grain stream is recommended. The cost of such a pump is approximately \$300. A gravity-flow drip applicator can be set up for less cost where 2 valves are incorporated (1 valve for on/off, and 1 valve for calibration).

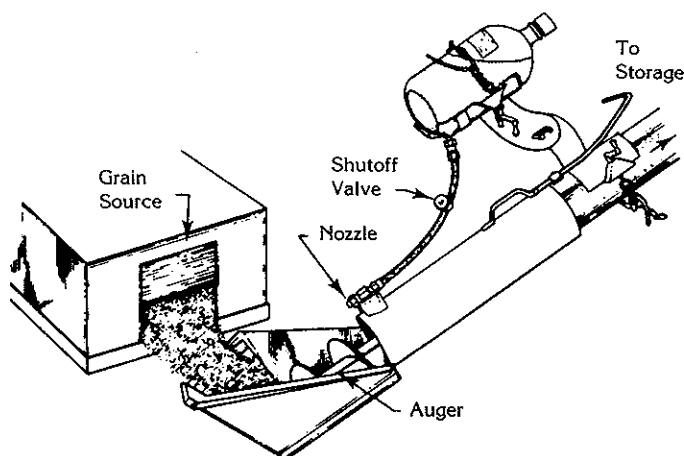


Fig. 2. Gravity feed or "drip on" applicator.

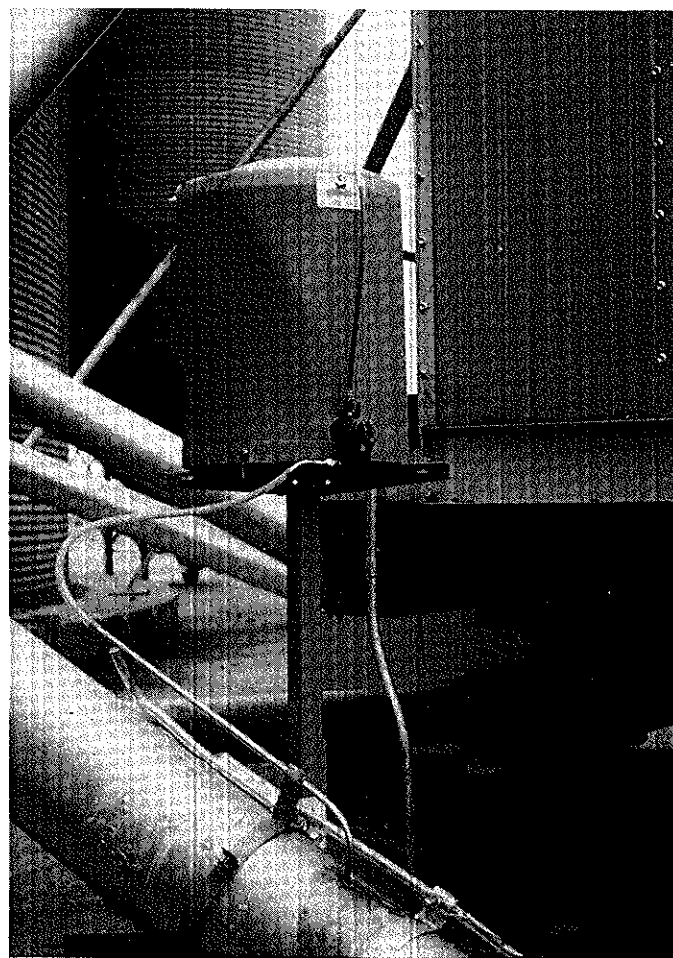


Fig. 3. A commercial gravity flow grain protectant applicator.

Drip applications are generally applied directly into the grain stream by attaching a hose that carries the protectant to a fitting attached directly to the grain auger (Figs. 2 and 3). Preferably, the protectant may be applied to the grain stream using a floodjet or whirljet nozzle when a pump driven or compression-type garden spray system is used (Figs. 4 and 5).

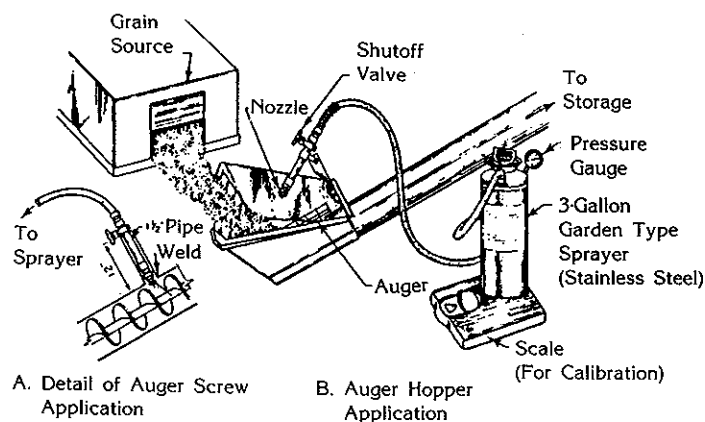


Fig. 4. Components of pressurized liquid application of protectants.

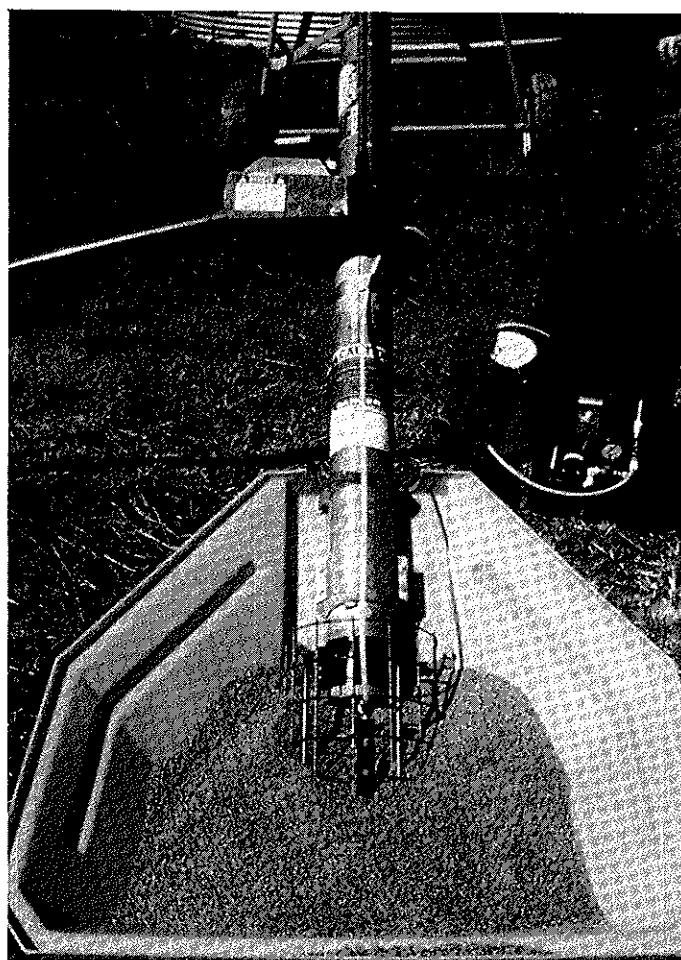


Fig. 5. A commercial pump driven grain protectant application system.

It is important that the application system be calibrated. See "Grain Storage Math" for additional information on calibration.

Note: When treating the grain stream following a high-temperature drying process, application should be positioned to minimize breakdown of the protectant by heat.

Dust formulations can be applied to the grain stream by attaching a specially designed dust applicator to the grain auger.

If a relatively small quantity of grain is to be treated, such as a truck or wagon load, a protectant dust formulation may be applied and mixed evenly to the grain surface assuming that the dust will be mixed throughout the grain mass during unloading.

Protectant Use on Whole vs. Processed Grain

Direct treatment with protectants applies only to whole grain, not processed grain. Processed animal feeds cannot be directly treated with protectants. Grain treated with a protectant should not be fed or processed for 30 days following treatment. Whole grain treated with a protectant that is to be processed shortly afterward should be well-aerated and turned for about 48 hours.

Grain Monitoring and Management

Assuming all preventative measures including sanitation, storage-facility treatment, and protectant application have been properly executed, stored grain requires continued monitoring and management. The stored-grain environment responds to changes in the temperature and moisture of the external environment, and adjustments must be made periodically to maintain a balance and ensure that insects and biological microorganisms do not begin to multiply.

Recent developments in insect-detection methods have established that stored-products pests are present in nearly all stored-grain systems. Thus, the potential for development of economic pest infestations is always present, and grain must be managed to minimize development of such pests.

Temperature Management

Temperature management is a key factor in managing the grain environment. Development of insect-pest populations is directly related to the prevailing grain temperatures. Insects thrive at grain temperatures ranging from 70 F to 85 F. Insect activity declines when grain temperature drops to a range of 50 F to 55 F. Insects start to die at grain temperatures of 35 F or less. In general, cooling grain to temperatures below 40 F arrests insect development and delays resurgence of insect-population development the following spring. Thus, effective manipulation of grain temperature can minimize development of insect populations.

Effectively manipulation of grain temperatures requires a good aeration system to achieve timely and rapid cooling of the grain when the opportunity occurs in the early-season fall months. Because moisture accelerates insect development, aeration should be avoided during long periods of damp or wet weather when cooling grain. It is also important that the grain surface be level and not peaked to achieve effective aeration.

Temperature gradients in grain influence moisture accumulation. The potential for mold and insect development increases if moisture levels become excessive at any location in a grain environment. Hot spots in the grain mass occur when mold and

insect activity becomes significant. Early detection of adverse temperature gradients and problem hot spots is facilitated by installation of temperature sensors, which can be remotely read from the exterior of a bin. In addition, temperature-monitoring systems may assist in economic use of aeration systems. The cost of temperature-monitoring systems should be offset by efficient use of aeration systems and the prevention of losses from molds and insects.

Use of Insect Traps

Indian meal moth activity may be monitored with pheromone-baited sticky traps (Fig. 6). Significant increases in adult-moth activity indicate the need for surface treatment or possibly a rescue fumigation treatment if infestation is severe.

Grain weevils and other beetle pests affecting stored grain can be effectively monitored with grain probe traps (Grain Guard probe trap (Fig. 7) or Storegard WB Probe II). These traps are plastic probes about 15 inches long that function as pit-fall traps for numerous grain beetles and their immature larvae. Placement of two to four probe traps into the grain surface over a 48-hour period will detect insect presence. Periodic increases in the number of beetles collected indicate development of a pest problem. The traps may collect hundreds of specimens if insect populations are well-established.

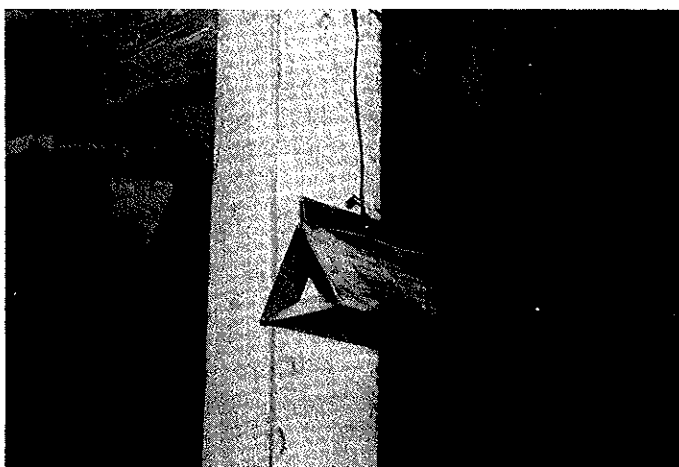


Fig. 6. A sex pheromone baited sticky trap used to monitor Indian meal moth.

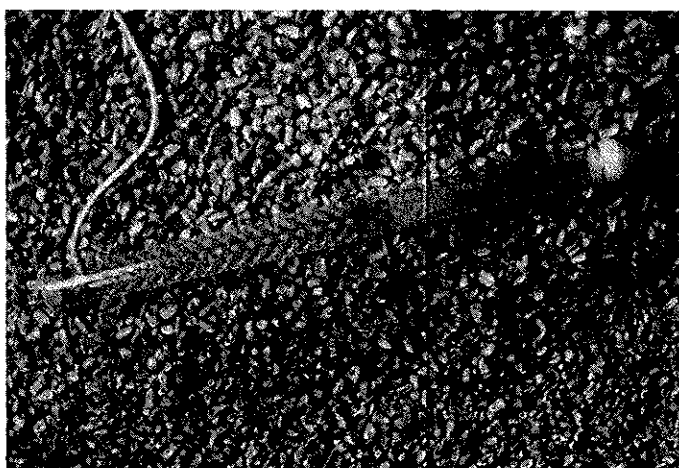


Fig. 7. A plastic grain probe trap for stored-grain insects.

Grain probe traps are more effective than grain probe triers commonly used for sampling grain. If no insects are collected with a trap, it is unlikely that an economic infestation will be detected by sampling methods used at the point of sale.

Storage Facility Access and Safety

Periodic inspection of stored grain involves a significant physical effort with a degree of risk, especially if the physical facility does not allow easy access. Installation of bin stairs or adequate guard rails is a necessity, not an option. Note the following general safety precautions:

1. Never inspect a grain-storage facility alone. Always be accompanied by a second party.
2. Never enter a grain-storage facility without prior knowledge of its history. If grain has been removed, surface layers may have formed, leaving a bridge that could collapse.
3. Never enter a grain-storage facility when grain-removal equipment is in operation or could be accidentally triggered into operation. Post a sign at the control panel indicating personnel are working in the bin.
4. Always use adequate safety gear to prevent accidental falling or being trapped in a grain mass. In general, inspection of a grain-storage facility requires equipment similar to any climbing situation. A harness and safety ropes are recommended.
5. Always use of a dust/spore filtered respirator when working in a bin.

Serious, sometimes fatal, accidents occur in Ohio each year due to the disregard for standard safety procedures required when working around stored grain. Therefore, it is essential to follow the recommendation cited.

Corrective Pest Control Procedures

Corrective action is required if a serious pest infestation is detected in stored grain. In general, a serious infestation warrants a fumigation treatment. A light infestation of bran bugs or moths may be brought under control with a surface treatment or application of a protectant if the grain can be readily moved and treated in the process. However, if the infestation is due to a primary pest such as weevils or grain borers that internally infest the grain or to an abundance of other insect pests, fumigation is the only method that will ensure control.

If an alternative treatment — such as a protectant — is used to eliminate an infestation, growers must exercise caution if the grain has received a protective treatment previously. Chemical residues accumulate from the use of protectants. If the accepted residue is exceeded, the residue may be detected later at a point of sale and provide a basis for rejection of the grain.

If properly implemented, fumigation will eliminate insect infestations. However, a number of factors influence the effectiveness of a fumigant. The key factor affecting efficiency is leakage of a gas fumigant from the storage facility. Proper sealing of the area or grain mass to be fumigated is essential to eliminating an infestation. Excessive dockage or grain moisture may adversely affect fumigant efficacy. A fumigant may not

reach a problem area when a pocket of grain has spoiled and blocks gas penetration. A failure to eliminate an infestation by fumigation is never due to a failure of the chemical, but rather to such factors as applicator error or the condition of the facility or product being fumigated.

Two fumigants remain for use in farm-stored grain, namely the solid formulations of aluminum phosphide, marketed in solid form, and the gas fumigant methyl bromide.

Phosphine Gas-Generating Fumigants

Formulations of solid phosphine gas generating fumigants used for fumigation of farm-stored grain include PhosTek, Gastoxin, Fumitoxin, Detia, and Degesch Phostoxin in pellet or tablet formulations.

Aluminum phosphide pellets are about 3/8 inch in diameter and release 0.2 grams of hydrogen phosphide. The tablets are about 5/8 inch in diameter and release 1 gram of hydrogen phosphide.

Upon exposure to air, these solid formulations react slowly with atmospheric moisture to produce hydrogen phosphide (phosphine gas). This reaction gradually accelerates and then tapers off again as the aluminum phosphide decomposes.

The aluminum phosphide solid formulation also contains ammonium carbamate, which releases a pungent-smelling ammonia gas that serves as a warning agent.

After conclusion of the reaction, a grey-white powder composed of aluminum hydroxide and a small amount of unreacted aluminum phosphide remain. This residue is not considered a hazardous waste, and the remaining aluminum phosphide decomposes when raw commodities are moved.

The rate of decomposition of tablets and pellets varies depending on prevalent temperature and moisture. The time required for fumigation and the time required to evolve a deadly dose may both vary. As a result, gases given off must be monitored to determine the safety level of the environment and the effective time period required for successful fumigation.

Solid formulations of aluminum phosphide fumigant are marketed in relatively gas-tight, resealable aluminum flasks. The fumigant's shelf life is virtually unlimited as long as the containers are kept tightly sealed. Given the potential danger of formulations of aluminum phosphide being handled by irresponsible people or children, formulations must be stored in a locked, safe, dry area that is well-ventilated and away from heat.

Materials and Equipment Required

The following materials and equipment are required to perform a farm-storage fumigation with aluminum phosphide:

1. The aluminum phosphide fumigant, which requires certification for purchase.
2. PVC rigid 1.25-inch-diameter probes that are 5 to 7 feet long, or equivalent application device. Attachment of a PVC funnel at one end and a hinged flap at the other end facilitates application.
3. Dry gloves, such as washable cloth, for handling the solid fumigant.
4. Aluminum phosphide warning signs.

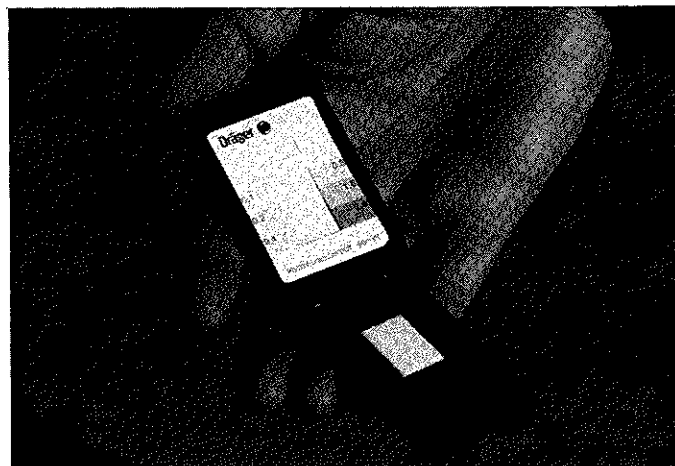


Fig. 8. The Draeger badge for monitoring exposure to phosphine gas.

5. Polyethylene sheeting (4 mil advised) for sealing openings, fan ducts, and possibly grain surface if overhead space is extensive or cannot be adequately sealed.

6. Detection equipment to monitor gas levels throughout the fumigation process. Equipment available for monitoring phosphine gas includes Draeger gas detector pumps and Matheson Kitagawa detection pumps, MSA Universal sampling pumps, Bendix/Gastec pumps, or Aver Pumps. In addition, a supply of tubes is needed for measuring phosphine gas.

7. Draeger phosphine badges for measurement of applicator exposure to phosphine gas during fumigation operations (Fig. 8). This personal dosimeter has an indicator that discolors gradually with exposure to various levels of phosphine and provides an economical and passive method of monitoring Permissible Exposure levels (PELs; 0.3 for phosphine).

8. Approved respiratory equipment. A full-face gas mask with a canister labeled for phosphine gas is minimum equipment. A self-contained breathing apparatus is required in some situations.

Dosage for Aluminum Phosphide

Recommended dosages for aluminum phosphide tablets vary depending on the tightness of the storage facility, the commodity temperature, and the condition of the commodity. As a result, recommended dosages are cited in ranges, and the range cited by different manufacturers varies although the amount of actual material per tablet or pellet has been standardized. Dosages are always cited per 1,000 cubic feet or per 1,000-bushel units. However, the cubic-foot unit is the dominant factor unless the commodity is tightly sealed under a tarpaulin.

The following table provides dosage ranges for application of aluminum phosphide pellets or tablets on raw commodities.

**Aluminum Phosphide Dosage Ranges
for Raw Commodities**

Product	Per 1,000 cu ft	Per 1,000 bu
Pellets	100 – 725	120 – 900
Tablets	20 – 145	25 – 180

Most manufacturers package 1,660 pellets per resealable flask. Tablets are packaged in 100 and 500 tablets per flask, depending on flask size. Assuming a mid-range of dosages recommended by various manufacturers, one flask of 1,660 pellets is needed to fumigate 2,500 to 5,000 bushels of grain.

The following table provides representative dosage recommendations by various aluminum phosphide manufacturers or distributors for farm-bin and flat storage:

Representative Dosage Recommendations

	Pellets	Tablets	Unit of Vol.
PhosTek or Gastoxin			
Raw Ag. Comm. Comm.	120 – 300	60 – 180	1,000 bu
Fumitoxin			
Farm bins	200 – 600	90 – 180	1,000 bu
Flat stores	270 – 540	90 – 180	1,000 bu
Degesch Phostoxin			
Farm bins	450 – 900	90 – 180	1,000 bu
	350 – 725	70 – 145	1,000 cu ft
Flat storage	300 – 900	60 – 180	1,000 bu
	250 – 725	50 – 145	1,000 cu ft
Detia			
Farm bins	450 – 900	90 – 180	1,000 bu
	350 – 725	70 – 145	1,000 cu ft
Flat storage	325 – 900	65 – 180	1,000 bu
	250 – 725	50 – 145	1,000 cu ft

Time Period Required for Fumigation with Aluminum Phosphide

The time required for successful fumigation with aluminum phosphide depends primarily on temperature and the distance the gas must penetrate. The following table provides suggested exposure time periods.

Suggested Exposure Times

Temperature	Minimum Exposure Periods	
Degrees F	Pellets	Tablets
Below 40	Do not fumigate	Do not fumigate
40 – 53	8 days	10 days
54 – 59	4 days	5 days
60 – 68	3 days	4 days
Above 68	2 days	3 days

When pellets or tablets are not added uniformly to the grain mass being fumigated (i.e., surface application or shallow penetration), the exposure time should be lengthened to allow penetration of gas throughout the grain mass. The general “rule of thumb” is to add a minimum of 1 to 2 days to the exposure periods cited in the above table for each 10 feet the gas must penetrate downward.

Given the requirements for airtight sealing and the time period necessary for aluminum phosphide fumigation, such fumigation procedures cannot be executed rapidly nor on a grain-transport vehicle. Too often, growers detect infestations after the grain has been unloaded from a bin or after it has been transported to the elevator. Therefore, if an infestation is to be fumigated before sale, insect infestations must be detected while the grain is in the storage facility and adequate time allowed to perform a fumigation, if needed.

Application Procedures Using Aluminum Phosphide

Assuming that (1) grain or space volume to be fumigated has been calculated and adequate fumigant materials are on hand; (2) required respiratory and gas-monitoring equipment have been acquired; and (3) storage facility has been sealed and ready for application of fumigant, the following procedures should be executed.

1. Implement fumigation procedures working in pairs. Both individuals should be certified and trained in fumigation procedures. Never work alone while handling fumigants.

2. Prepare the plan of action so that less than 15 minutes will be spent inside the structure being fumigated, and initiate fumigation procedures during the cool part of the day.

3. If polyethylene sheeting is to be used over the surface, pre-cut the sheeting with 2 feet extra to tuck into the perimeter where grain meets a solid surface.

4. Before entering the enclosed area to be fumigated, open the aluminum phosphide container outdoors to allow the initial concentration of phosphine gas to escape. Otherwise, a dosage of accumulated gas will be released into the work area causing unnecessary exposure.

5. One person should probe grain at 4- or 5-foot intervals using PVC tubing and dropping 25 to 50 pellets or 10 to 20 tablets per probe. Wear dry cotton gloves during this procedure (Fig. 9). The second person should assist with equipment, tarping, and other physical tasks.

6. Take gas readings with detection equipment periodically during the application procedure if gas concentration is suspected to be above 0.1 ppm. Exposure to phosphine gas should not exceed 0.3 ppm measured as an 8-hour time-weighted average (TWA) for applicators during application. Use of the Draeger phosphine badges will facilitate monitoring of applicator exposure.

7. A NIOSH/MSH-approved full-face gas mask/hydrogen phosphide canister combination may be used for gas concentrations up to 15 ppm. A self-contained breathing apparatus is required for concentrations above 15 ppm. A full-face gas mask is strongly recommended for routine handling of aluminum phosphide pellets or tablets in an enclosed environment.

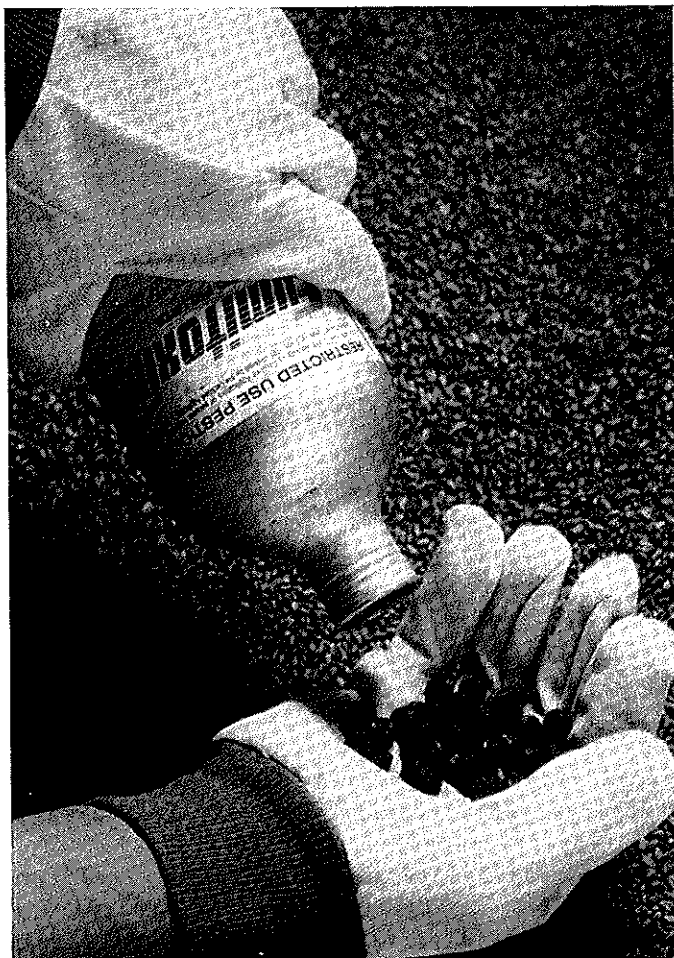


Fig. 9. Wear dry, cotton gloves when handling aluminum phosphide fumigants.

8. When applying the fumigant, begin at the farthest point away from the exit site and work toward the exit to minimize exit time following application.

9. If tarp or plastic sheeting is used to cover the surface, tie rope to the tarp to allow its removal for aeration without having to re-enter the area under fumigation.

10. If fumigating the farm bin with aeration fans, place fumigants into fan ducts as far as possible using PVC tubing to fumigate debris in the lower portion of bin. Cover and seal the fan with 4-mil polyethylene sheeting.

Note: Make sure the duct area is dry. A fire or explosion may result if the solid fumigant contacts standing water.

11. Place warning signs on all doors, ladders, and other points of entry to prevent unauthorized entry into the fumigated area.

12. After the commodity has been exposed to the fumigant for the prescribed time period, unseal the storage facility, remove any tarps covering the grain surface, and allow aeration.

13. Following aeration, measure the phosphine gas level remaining in the fumigated area with a gas-detection device to determine whether it is safe to re-enter.

14. When the storage facility is safe to re-enter (based on gas readings), apply surface treatment of grain protectant to prevent reinfestation of the commodity, especially if anticipating an additional prolonged period of storage.

15. If tarp or plastic sheeting was used in fumigation, treat the area above the tarp with an approved above-grain space treatment.

16. A residual spray should be applied to the outside of the storage facility either before or after the fumigation.

Fumigation with Methyl Bromide

In addition to the solid fumigants that generate phosphine gas, a second fumigant available for use on stored grain is methyl bromide. It is available as a pressurized gas (liquid) in steel cylinders and cans. The liquid becomes a gas immediately on release.

Use of methyl bromide requires training and experience equivalent to or exceeding that required for aluminum phosphide. Equipment for applying methyl bromide is more extensive than that required for aluminum phosphide. However, some professional fumigators prefer to use methyl bromide, partly due to the shorter period of time required to fumigate. Grain mills and other grain-processing facilities requiring periodic fumigation often prefer methyl bromide when permanent arrangement of delivery equipment can be installed. Cool temperatures, size and type of grain storage, electronic equipment available, and other factors also may cause a professional to prefer methyl bromide for a given fumigation task.

Concluding Remarks on Fumigation

The above procedures recommended for use of aluminum phosphide and methyl bromide fumigants make it clear that this process should be executed by a trained professional with the necessary equipment to perform the task safely and effectively.

Professional fumigators sometimes use probes with colonies of test insects to determine whether a kill of insects in various areas of a commodity has been achieved. In the case of metal farm bins, this procedure requires drilling holes in the bin wall and probing cages with live insects. Such efforts monitor the efficacy of a fumigation and ensure completion of the task.

Given the value of a commodity requiring fumigation, the services of a professional fumigator warrant consideration. However, if attention is paid to all the points listed and instructions on the label are closely followed, a grower may perform the process safely and effectively. The label provided with a fumigant product lists required procedures and precautions. Fumigation may be performed safely and effectively if the user complies with these requirements.

Exceptional Situations

The information provided in the previous text applies to grain-storage conditions applicable to most farms. However, exceptional situations occur for which the standard recommendations do not apply. This section provides questions and answers for various situations that may occur.

Question: A small grower has a unique whole-grain product that preferably should not have any chemical residue. What should he or she do if an infestation is found?

Answer: Formulations of pyrethrin plus piperonyl butoxide

labeled for use as a protectant on stored grain are available. Synergized pyrethrin works as a contact insecticide and provides a quick kill, but does not leave a lasting residue. Application of these materials as a grain-protectant treatment at labeled dosage should control most external feeding insects without leaving a residue.

If the amount in question is small (less than 1 ton), consider obtaining a small storage process bin at minimal expense that can be tightly sealed and fumigated easily.

Question: For organic grain producers who cannot use any chemical treatment, are organic alternatives available for grain protection?

Answer: Strict sanitation and maintenance of grain in optimal condition will minimize insect infestations. Use of INSECTO, a refined formulation of diatomaceous earth labeled for use on stored grain, applied both as an empty-bin treatment and grain protectant, may provide additional protection against insect infestation. INSECTO is applied at the rate of 2 pounds per ton or 1 ounce per bushel of grain.

Question: A grain-storage manager has been approached by a commercial firm promoting the release of beneficial insects (parasites and predators) for management of insect pests in stored grain. Will this program be effective?

Answer: Considerable research has been conducted on the use of beneficial insects to manage pest insects of stored grain. Effective and economic implementation of biological control practices on farm storage or other commercial storage facilities has not yet been demonstrated. If nonchemical procedures are required, a combination of basic sanitation and effective management of the grain environment (temperature and moisture) should achieve effective results.

Question: A grower has heard that pumping anhydrous ammonia into a grain bin will control insects. Is this a valid option?

Answer: No! Anhydrous ammonia is not labeled for use as an insecticide or fumigant. Furthermore, any grain treated as such cannot be marketed legally.

Question: A grower in a remote area has a partially filled bin that has a serious insect infestation and is neither trained nor certified to perform a fumigation. Given the cost of bringing in a professional fumigator and the limited amount of grain infested, what are some cost-effective options?

Answer: If the grain is infested by an internal feeder (weevil), any treatment other than fumigation will not eliminate the infestation completely. However, if the grain can be moved and treated with an approved protectant, it is possible that an infestation other than weevil may be eliminated, especially if climatic conditions are cool and the grain is in good condition.

Stored-Grain Pests

Accurate identification of grain pests facilitates use of appropriate pest-control actions. Although an objective of grain-storage management is to maintain a pest-free product, the presence of pests such as weevil or grain moths indicates a need for specific control measures that may not be necessary in the case of a pest incapable of causing injury to sound grain.

The following section illustrates key characteristics of stored-grain pests commonly found in Ohio.

Grain Weevils

Grain weevils are considered the most important insect pests of grain because the immature stages of the weevils' life cycles result in internal infestation of the grain kernels. Detection of weevils in grain indicates that immature development stages exist internally in grain kernels that cannot be removed by cleaning and can be eliminated only by fumigation treatment.

The adult weevils move freely among the kernels. Adult weevils can easily be separated from other grain insects by noting the elongated beak or snout. During egg-laying, the female bores a small hole in a kernel and deposits her egg, which hatches into a larvae that develops inside the kernel. When fully grown, the larvae transforms to a pupae and later to an adult, which emerges from the kernel. Due to the internal injury to the kernels, grain infested by grain weevils is generally referred to as "weevily."

Granary Weevil *Sitophilus granarius* (Linnaeus): The granary weevil is the most common grain weevil in Ohio. The adult is not more than 3/16 inch long. This beetle has no wings under the wing covers. Adults live ca. 7 to 8 months, and a female lays 50 to 250 eggs during this period. The development of the immatures stages within the grain kernel requires about a month in warm weather.

Rice weevil *Sitophilus oryzae* (Linnaeus): The rice weevil is less common in Ohio than the granary weevil. It is smaller than the granary weevil, averaging ca. 3/32 inch long. The rice weevil may be distinguished from the granary weevil by the presence of 4 large light areas on the wing covers and fully developed wings under the wing covers. The adult rice weevil lives 4 to 5 months, and each female lays from 300 to 400 eggs during this period.

A third species, the **Maize weevil** *S. zeamais* Motschulsky, exists in the south and is a larger version of the rice weevil.

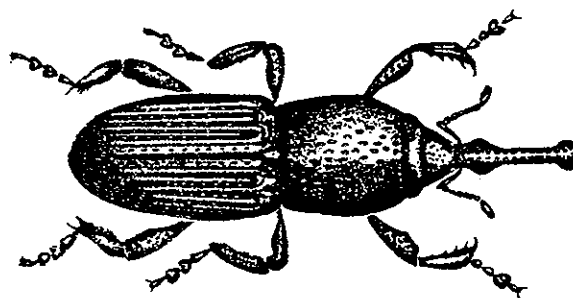


Fig. 10. Granary weevil.

Grain Borers

The **lesser grain borer** *Rhyzopertha dominaca* (Fabricius) is a major grain pest in the Midwest, but it is less common in Ohio. Like the weevils, grain borers attack sound kernels, causing weevil-type injury. Adults are ca. 1/8 inch long, and their heads are literally tucked down under their shoulders. Related to a group of beetles that normally attack trees, the grain borers have powerful jaws that enable them to bore into grain kernels. Each female lays from 300 to 500 eggs deposited loosely in the grain. The immature stages feed on the flour produced by the adult feeding activity. In summer, a complete life cycle from egg to adult requires about 1 month.

A second species, the **larger grain borer** *Prostephanus truncatus* (Horn), exists in warmer areas of North America.

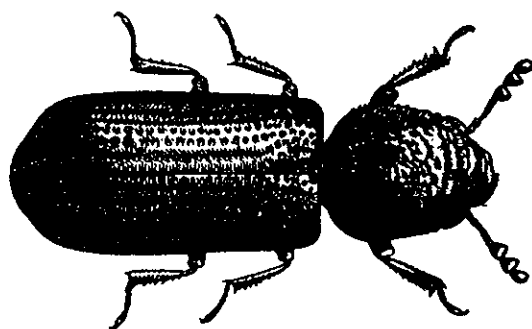


Fig. 11. Lesser grain borer.

Grain and Flour Moths

The term "grain moth" generally refers to moths that attack sound grain. An example is the **Anquomois grain moth** *Sitoroga cerealella* (Olivier), which is a serious pest of cereal grains in the southern states. This pest is relatively rare in Ohio because the adult stage is unable to survive the winter. Another moth attacking grain is the **European grain moth** *Nemapogon granella* (Linnaeus), which is found in the northern states, but is not very abundant.

The term "flour moth" generally applies to moths associated with milled products. This group includes the **Indian meal moth** *Plodia interpunctella* (Hubner), which is probably the most widespread and common stored-grain pest problem in Ohio.

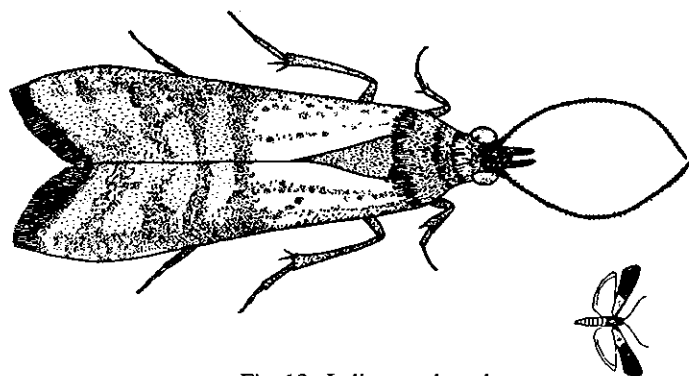


Fig. 12. Indian meal moth.

The Indian meal moth infests a wide range of grains, including corn, wheat, and soybeans. Furthermore, it is resistant (or tolerant) of malathion treatment, and cases of tolerance to newer chemicals are beginning to appear. As a result, infestations of Indian meal moth occur when other pest populations are controlled.

The Indian meal moth feeds on broken grains and milled products and is capable of feeding on the softer portions of grain kernels, such as the germ of wheat. Larvae spin a webbing over infested grain that is considered a contaminant and may clog grain-handling equipment such as automatic feeders in poultry and livestock operations.

The adult Indian meal moth has a wing spread ca. 3/4 inch, and the outer portion of the forewings is dark brown compared to the gray color of the inner portion. Adult females lay 100 to 300 eggs each, which hatch into larvae that cause the actual damage to the grain. Development from egg to adult requires 6 to 8 weeks. Full-grown larvae are about 1/2 inch long. Larvae of moths can be distinguished from larvae of beetles by the presence of a series of prolegs on the abdominal segments in contrast to beetle larvae that have only 3 pairs of legs. However, the most evident feature of a flour moth infestation is the presence of webbing, which may cover the entire walls of an infested storage facility.

A number of other flour moths occur in various grain-handling operations, including the **Mediterranean flour moth** *Anagasta kuehniella* (Zeller), the **tobacco moth** *Cadra cautella* (Walker), the **almond moth** *Ephesia elutella* (Hubner), and the **raisin moth** *Cadra figlilella* (Gregson). Under certain conditions such as in a feed mill, one of these moths may be more prevalent than the Indian meal moth. Another flour moth is the **meal moth** *Pyrallis farinalis* Linnaeus, which has a delta-shaped wing spread when at rest. Larvae of the meal moth form tubes from loose grain and are about 1 inch long when full grown.

Grain and Flour Beetles

A number of beetles found in grain are considered secondary pests compared to those that damage sound kernels. When in abundance, such beetles may cause dockage of grain price as readily as weevils or grain borers. These beetles generally feed on the fines in the grain, but some flour beetles may feed on the germ of grain kernels.

The **sawtooth grain beetle** *Oryzaephilus surinamenis* (Linnaeus) is among the most common found in farm storage. This beetle is very small (ca. 1/8 inch long) and can be recognized by the sawtooth serration along the thorax (shoulder) region. The adults live 6 to 10 months, but records show that some live for a few years. A female lays from 40 to 285 eggs. Development from egg to adult requires about 1 month.

The **flat grain beetle** *Cryptolestes pusillus* (Schoenherr) and the **rusty grain beetle** *Cryptolestes ferrugineus* (Stephens) are very small beetles (ca. 1/16 inch long) and are probably the most common grain beetles found in farm-stored grain. Identification of the flat grain beetle from the rusty grain beetle requires examination of the antennae. Detection of these beetles in most farm storage is possible with probe traps. At low levels, these beetles may be undetected in grain transactions.

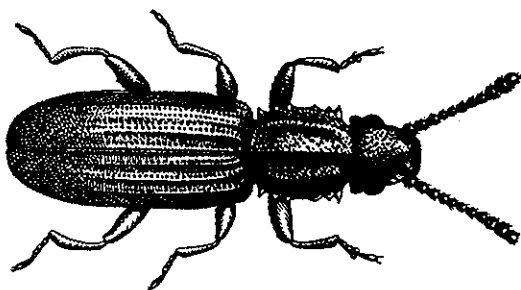


Fig. 13. Sawtooth Grain Beetle.

The **confused flour beetle** *Tribolium confusum* Jacquelin du Val and the **red flour beetle** *T. castaneum* (Herbst) are flattened, reddish-brown beetles about 1/7 inch long. The adults live as long as a few years, and each female lays about 450 eggs. The eggs hatch into larvae that reach a length of about 3/8 inch. The life cycle from egg to adult requires about 6 weeks. Given the size of these beetles, they may be more readily detected than the smaller flat grain or rusty grain beetles.

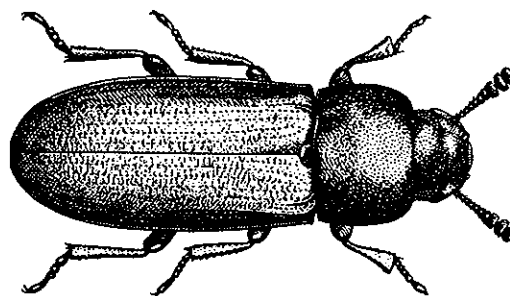


Fig. 15. Red Flour Beetle

Mealworm larvae may reach 1 inch in length when fully grown.

Another group of insects found in stored grain includes the dermestid beetles. Larvae of this group of beetles are very hairy. Dermestid beetles tend to be associated with animal matter. Within this group is the **khapra beetle** *Trogoderma granarium* Everts, which is a grain pest of major importance in the world that has been controlled in the United States by the enactment of quarantine and eradication procedures when detected in commercial shipments.

Collection of Specimens for Identification

Accurate identification of stored-grain insect pests will influence decisions regarding pest-control actions. If identification of a pest problem is in doubt, a sample should be collected and submitted for identification by an expert. Submit a sample for identification large enough to include many specimens along with sufficient host grain material to illustrate the damage present. Preservation of a number of specimens in an alcohol preservative in a tightly sealed vial is recommended. Providing smashed specimens in envelopes or on sticky tape is not recommended.

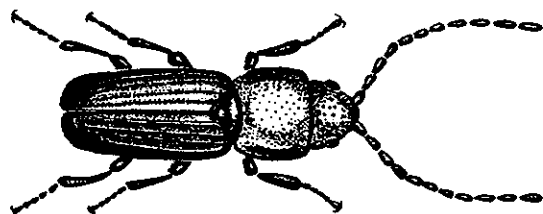


Fig. 14. Flat Grain Beetle.

Other Stored-Grain Pests

A number of other insect species may be found in stored grain. The presence of some species often depends on the presence of foreign materials or development of grain molds. Development of grain molds and fungi attracts a number of stored-grain insects, including the **hairy fungus beetle** *Typhaea stercorea* (Linnaeus) and other closely related species. In addition, damp grain often fosters development of grain mites and psocids, which are nearly microscopic in size. Itching from handling grain is sometimes associated with the presence of grain mites. When mold-related insect fauna is found in grain, attention must be given to the condition of the grain in storage.

Large ground beetles (ca. 3/4 inch long) may be found in grain. Such beetles are the adults of meal worms (*Tenebrio* sp.) that commonly infest damp, moldy accumulations of grain.

Additional Information on Grain Pests

For additional information on stored-grain pests, refer to USDA Agriculture Handbook No. 500, *Stored-Grain Insects*.

Grain Storage Math

Dry Measure

1 bushel = 1.2445 cubic ft

1 cubic ft = 0.8035 bushels

Liquid Measure

1 pint = 16 fl oz

1 gal = 12.8 fl oz

Calculating Surface Area

Surface area of a circular surface (e.g., metal bin)

Circular Bin Surface Area = 0.7854

x Bin Diameter Squared

For example, a bin having a diameter of 21 feet would have a circular surface area of $(0.7854 \times 21 \times 21)$ or 346.4 square feet.

Surface area of rectangular surface (e.g., flat storage)

Rectangular Surface Area = Length x Width

For example, flat storage 50 feet long and 30 feet wide would have a surface area of (50×30) or 1,500 square feet.

Because flat storage is generally peaked, assuming a 28 degree angle of repose, the rectangular surface area should be increased 10 percent to obtain a more accurate measure of surface area to be treated. Thus, a more accurate estimate of flat-storage surface area would be $(50 \times 30) \times 1.1$ or 1,650 square feet.

Calculating Grain Surface Treatments

Assuming treatment of 3 fluid ounces of protectant in 2 gallons of water per 1,000 square feet of surface area, the amount of protectant required for surface area of a bin 21 feet in diameter would be calculated as follows:

Surface area = $(0.7854 \times 21 \text{ ft} \times 21 \text{ ft})$ 346.4 sq ft

(Dosage / 1,000 sq ft) x (surface area / 1,000)

= 3 fl oz / 2 gal)

x $(346.4 / 1,000)$ = 1 fl oz / 0.7 gal

Thus, apply 1 fl oz of protectant in 0.7 gal of water to the grain surface area of a bin 21 ft in diameter.

Calculating Grain Volume

Volume of Circular Storage Facility

Circular Volume = 0.7854 x Diameter Squared

x Height

For example, a bin with a diameter of 21 feet and a fill height of 24 feet would have a volume of:

$(0.7854 \times 21 \times 21)$ or 8,312.7 cu ft,

or 6,679 bu $(8,312.7 \text{ cu ft} \times 0.8035 \text{ bu/cu ft} = 6,679 \text{ bu})$

Volume of Flat Storage

Assuming that flat-storage grain is peaked with an angle of repose of about 28 degrees, calculation of the volume of flat storage must include the volume of a rectangular shape plus the volume of the peaked grain. Estimate of such a shape would include:

Rectangular volume = Width x Length

x Grain height on wall

Peaked volume = Width squared x 0.125

x (Length - 1/2 Width)

For example, a grain store 40 feet wide and 60 feet long with a grain height along the wall of 8 feet and the grain peaked down the center would have a volume as follows:

Rectangular volume = $[(40 \text{ ft} \times 40 \text{ ft} \times 0.125)$

$\times (60 \text{ ft} - 20 \text{ ft})] = 8,000 \text{ cu ft}$

Total vol = (Rectangular vol + Peaked vol)

= 27,200 cu ft

or $(27,200 \text{ cu ft} \times 0.8035 \text{ bu/cu}) = 21,855 \text{ bu}$

Calculating Protectant Requirements

Assuming the above example of flat storage of 21,855 bu, how many fluid ounces of protectant and water carrier are required if Actellic is applied at a rate of 10 fluid oz in 5 gallons of water per 1,000 bushels (ca. 60,000 lbs)?

Protectant required = 10 fl oz x $(21,855 \text{ bu}/1,000 \text{ bu})$

= 219 fl oz or 1.71 gal

Water carrier required = 5 gal x $(21,855 \text{ bu}/1,000)$

= 109 gal water

Thus, 1.7 gal Actellic in 109 gal water / 21,855 bu corn

Calculating Protectant Flow Rate

Assuming application of 2 gallons of protectant mixture (protectant plus water carrier) to 1,000 bushels of grain, how many fluid ounces of mixture should flow per minute during a calibration test if grain flows through an auger or leg at the rate of 500 bushels per hour?

Mixture Rate = 2 gal mixture per 1,000 bu grain

Grain Flow = 500 bu/1 hour

Mixture/hour = 2 gal x $(500 \text{ bu/hr} / 1,000 \text{ bu})$

= 1 gal mixture/hour

Mixture/min test = 1 gal x $(1 \text{ min} / 60 \text{ min})$

= 1/60 gal = 0.0167 gal

or = $0.0167 \text{ gal} \times (128 \text{ fl oz/gal}) = 2.14 \text{ fl oz}$

Calculating Fumigant Requirement

Assuming a circular bin of 8,300 cubic feet had to be fumigated using aluminum phosphide pellets at the rate of 400 pellets per 1,000 cubic feet, how many flasks are required if 1,660 pellets are in a flask?

Pellets required = $8,300 \text{ cu ft} \times (400 \text{ pellets} / 1,000 \text{ cu ft})$

= 3,320 pellets

Flasks required = $3,320 \text{ pellets} / 1,660 \text{ pellets per flask}$

= 2.0 flasks

Poison Information Centers

Be sure your doctor has this list of poison information centers and the "note to physicians" printed on labels of dangerous pesticides. Your doctor should know in advance what dangerous pesticides you plan to use so he or she can relay the right chemical name to the poison information center in case of emergency. Treatment for pesticide poisoning is very exacting. In an emergency, you could call the poison information center, but it is preferable to let your doctor consult the center in order to avoid mistakes.

Ohio Poison Information Centers

Akron: 44308

Akron Regional Poison Control Center
Children's Hospital, 281 Locust St.
Phone: 1-800-3620-9922 (toll free) or 216-379-8562
216-379-8446 (TTD)*

Canton: 44308

Akron Regional Poison Center
Children's Hospital, 281 Locust St.
Phone: 1-800-3620-9922 (toll free) or 216-379-8562
216-379-8446 (TTD)*

Cincinnati: 45267

Drug & Poison Information Center
University of Cincinnati
Medical Center, Room 7701
231 Bethesda Ave. ML 144
Phone: 1-800-872-5111 (toll free) or 513-872-5111

Cleveland: 44106

Greater Cleveland Poison Control Center
2101 Adelbert Road
Phone: 216-231-4455

Columbus: 43205

Children's Hospital Poison Center
700 Children's Dr.
Phone: 1-800-682-7625 (toll free) or 614-228-1323

Dayton: 45404

Children's Medical Center, Poison Center
One Children's Plaza
Phone: 1-800-762-0727 (toll free) or 513-222-2227

Lorain: 44053

Lorain Community Hospital
Poison Center
3700 Kolbe Rd.
Phone: 1-800-821-8972 (toll free) or 216-282-2220

Mansfield: 44903

Mansfield General Hospital
Poison Center
335 Glessner Ave.
Phone: 419-526-8200

Springfield: 45501

The Community Hospital
Poison Center
2615 E. High St.
Phone: 513-325-1255
513-325-7752 (TTD)*

Toledo: 43614

Medical College Hospital
Poison Center
3000 Arlington Ave.
Phone: 1-800-589-3897 (toll free) or 419-381-3897

Youngstown: 44501

Mahoning Valley Poison Center
1044 Belmont Ave.
Phone: 1-800-426-2348 (toll free) or 216-746-2222
216-746-5510 (TTD)*

Zanesfield: 43701

Bethesda Poison Control Center
2951 N. Maple Ave.
Phone: 614-454-4221

Out-of-State Poison Information Centers

Charleston, W.VA.: 25304

West Virginia Poison Control Center
3110 McCorkle Ave.
Phone: 304-348-4211

Pittsburgh, PA: 15213

Pittsburgh Poison Center
Children's Hospital
One Children's Place
3705 5th Ave. at DeSoto
Phone: 412-681-6669

Indianapolis, IN: 46206

Indiana Poison Center
1701 N. Senate Blvd.
P.O. Box 1367
Phone: 317-929-2323
317-929-2336 (TTD)*

U.S. Environmental Protection Agency

345 Courtland Street NE
Atlanta, GA 30365
Phone: 404-347-4727

* Phone number for the deaf.

