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## EC78-1534 Insect Prevention and Control in Farm Stored Grain

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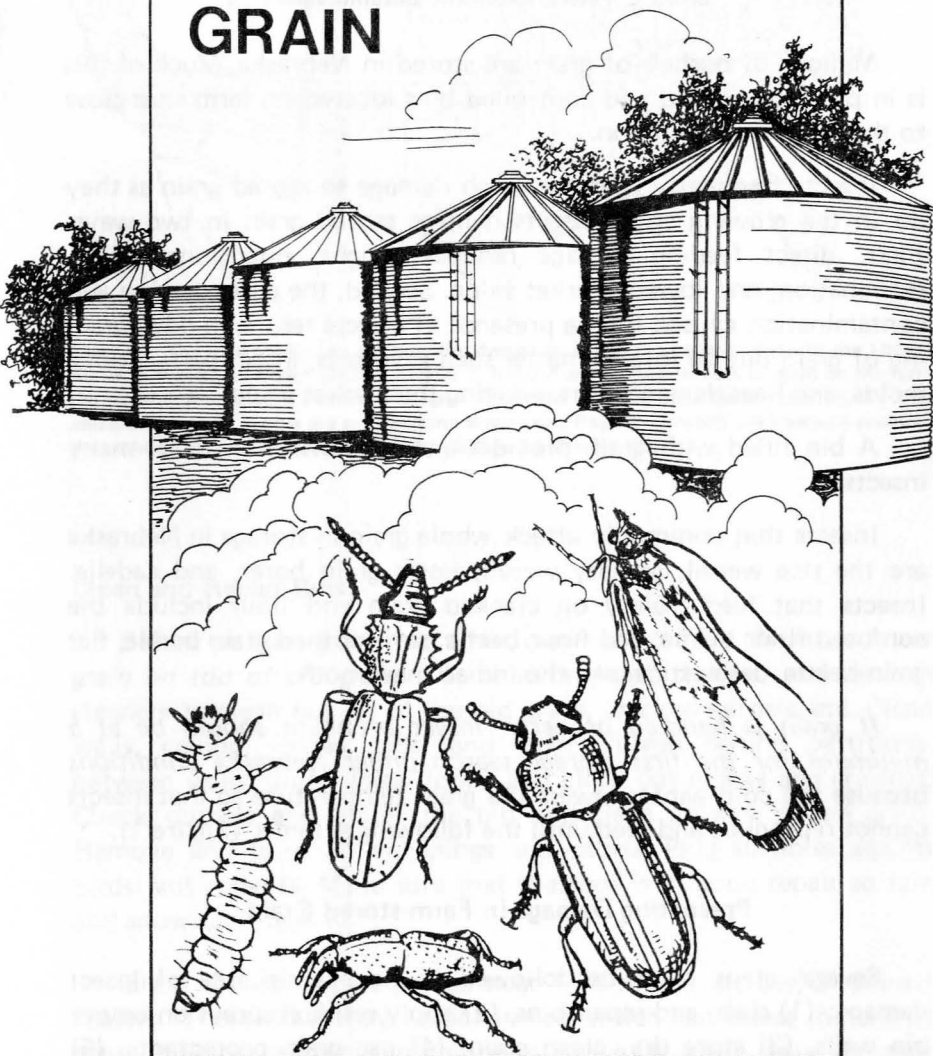
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EC 78-1534

# INSECT PREVENTION & CONTROL

## in FARM STORED GRAIN



# Insect Prevention & Control in Farm Stored Grain

Leroy L. Peters, Extension Entomologist

Millions of bushels of grain are stored in Nebraska. Much of this is in producer-owned and controlled bins located on farm sites close to the point of production.

Insects frequently cause as much damage to stored grain as they do to the growing crop. Insects damage stored grain in two ways. First, direct feeding damage reduces weight, nutritional value, germination, and lowers market value. Second, the deterioration and contamination caused by the presence of insects results in downgrading of grain due to foreign matter such as insects, insect parts, odors, molds, and heat damage, thus reducing the market value.

A bin filled with grain provides a stable environment for many insects.

Insects that commonly attack whole grain in storage in Nebraska are the rice weevil, granary weevil, lesser grain borer, and cadelle. Insects that feed mainly on cracked grain and flour include the confused flour beetle, red flour beetle, saw-toothed grain beetle, flat grain beetle, dermestids, and the Indian meal moth.

*If grain is handled properly, insect problems should be at a minimum for the first storage season under Nebraska conditions because the cold winter lowers the grain temperature so that insects cannot reproduce and feed until the following summer (Figure 1).*

## Preventing Damage in Farm-stored Grain

Several steps must be followed to keep grain free of insect damage: (1) clean and repair bins, (2) apply residual sprays on empty bin walls, (3) store dry, clean grain, (4) use grain protectants, (5) cool grain, and (6) where Indian meal moths are a problem, use Vapona® resin strips.

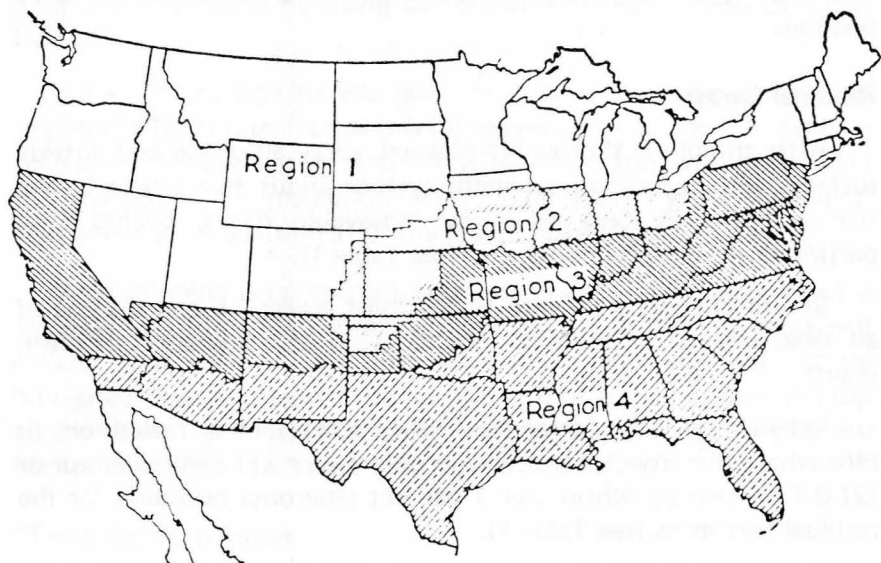


Figure 1. The map shows, by regions, the degree to which farm-stored grain in the United States is subject to insect attack. Region 1, little if any damage occurs to grain on the farm during the first season's storage. Region 2, insects may be troublesome during the first season. Region 3, insects are troublesome every year. Region 4, insects are a serious problem throughout the storage period. (From U.S.D.A. Leaflet No. 553)

## Clean and Repair Bins

Before putting grain into a bin, *clean out the bin. Never put new grain on top of old grain.* Use brooms, hoes, shovels, and vacuum cleaners to clean out all of the old grain, cracked kernels, etc. Clean walls, ceiling, ledges, sills, and floors. Clean behind partitions, between walls, under false floors, and clean out cracks and crevices. Check outside and under the bin and clean up any spilled grain. Remove and burn all sweepings and debris. Plug all holes against birds and rodents. Make sure that the roof is in good repair so rain and snow can't leak in.

Grain should not be stored near feed rooms, stables, or animal feeders. These areas may harbor insects which can infest the stored grain. Wagons, trucks, and combines in which waste grain accumulates can also serve as sources of insects to infest the bin and should be cleaned periodically.

Get rid of rats and mice and make bins as rodent proof as possible.

## Residual Sprays

After the bin is thoroughly cleaned, spray all inside and outside surfaces with malathion or methoxychlor about two weeks before storing grain. Be sure to spray removable doors, behind false partitions, under false floors, etc. (see Table 1).

Before putting grain into treated bins, sweep up and dispose of all dead insects on the bin floor to avoid contamination of clean grain.

Indian meal moth larvae have become resistant to malathion. In bins where this insect has been a problem, use: (1) methoxychlor or (2) 0.1 percent pyrethrin plus 1 percent piperonyl butoxide for the residual treatment (see Table 1).

Use a compressed air garden sprayer and spray surfaces to the point of runoff. One gallon (3.79 l) of spray will cover 750 to 1,000 square feet (70 - 93 m<sup>2</sup>) of surface, depending upon whether it is a wood, metal, or concrete wall. The porous surface of wood will require more spray than will a metal wall.

*Caution*—Premium grade malathion, methoxychlor, and pyrethrin plus piperonyl butoxide are registered for use in storage bins for barley, corn, oats, rye, sorghum, and wheat, *but not soybeans*.

## Store Dry, Clean Grain

Don't store grain with high moisture content. Take a sample to your elevator and have the moisture content checked. Moisture content of corn should be less than 15 percent, and the moisture content of other grains should be less than 12 percent for safe storage.

Grain containing weed seeds, cracked kernels, and other dockage will tend to become infested with insects sooner than will sound, clean grain.

## Grain Protectants

Dry, insect-free small grain or shelled corn can be protected from

most insect damage by using malathion as a grain protectant (see Table 1).

Apply insecticide to the grain stream as it comes out of the combine if grain is dry, or as it is being elevated into the bin. Forcing heated air through grain treated with malathion will reduce the effectiveness of the malathion. When using heat, dry the grain first, then apply the malathion after the grain has cooled.

After binning is completed, level the grain. If the grain surface is not level and the grain has to be fumigated later, the low spots will collect most of the fumigant, while the high spots will not be fumigated. Leave at least 6 inches (15 cm) of space between the top of the leveled grain surface and the top of the bin wall so that the fumigant will not "spill over" the sides.

### **"Topdress" Treatment**

Topdress the bin by treating all the surface grain with malathion or pyrethrin grain protectant. Use pyrethrin where Indian meal moths have been a problem (Table 1).

The "topdressing" acts as a barrier, preventing insects from entering the grain mass and from feeding on the surface grain. Each time the surface grain is disturbed, such as when probing for moisture or insect samples, the barrier is broken. Retreat disturbed areas with grain protectant.

### **Indian Meal Moths**

The adult is a moth about one-third to one-half inch (.8 - 1.3 cm) long. The tips of the wings are dark red or brown, with the basal one-third light gray. Full-grown larvae are about half an inch (1.3 cm) long, dirty white, sometimes with a pinkish or greenish tinge, and a dark brown head.

The larvae feed only in the upper portion of the grain mass unlike the other stored grain insects that feed throughout the bin. The top 1-2 inches (2.5-5 cm) of the grain is often webbed together by Indian meal moth larvae. Where the infestation is severe, a crust of webbing and trash will be very obvious. This crust hinders fumigant penetration and protects the larvae from contacting the

**Table 1. Stored grain bin insecticides and protectants.**

Use	Insecticide and Dosage		
	<i>malathion</i> <i>Use premium grade malathion labeled specifically for use in grain bins and on stored grain.</i>	<i>methoxychlor</i>	<i>pyrethrin plus piperonyl butoxide</i>
Residual bin spray	1/3 pt (156 ml) of 57% malathion per 1 gal (3.79 l) water	3/4 pt (355 ml) of 25% methoxychlor E.C. per 1 gal (3.79 l) water	0.1% pyrethrin plus 1% piperonyl butoxide
Grain protectant	1 pt (473 ml) of 57% malathion E.C. per 2-5 gal (7.6- 18.9 l) of water		
	or		
	50 lbs (22.7 kg) of 1% malathion dust		
	or	—	—
	10 lbs (4.5 kg) of 6% malathion dust		
Top-dress	per		
	1,000 bushels of grain		
	1/2 pt (237 ml) of 57% malathion E.C. in 1-2 gal (3.8 - 7.6 l) of water		0.3% pyrethrin plus 3% piperonyl butoxide in 1-2 gal (3.8 - 7.6 l) of water per 1,000 sq ft (93 m <sup>2</sup> ) of grain surface
	or		
	30 lbs (13.6 kg) of 1% malathion dust	—	
	or		
	5 lbs (2.3 kg) of 6% malathion dust		

Table 1. (Continued)

Top-dress

per

1,000 sq ft of  
(93 m<sup>2</sup>) of grain  
surface

grain protectant "topdressing." Remove the crust and damaged grain before treatment or before the grain bin is emptied.

Larvae prefer to feed on cracked or broken seeds, or weed seeds, but will feed on the germ of whole kernels.

If Indian meal moths have been a problem in the bin in the past, it is strongly suggested that a "topdress" of pyrethrin plus piperonyl butoxide be used, since these insects are resistant to malathion. However, malathion is still recommended as a protectant for the bulk of the grain since it is the most economical material, has a longer residual period, and still controls the other insects found in the grain mass. The use of another insecticide for the "topdressing" is desirable only where Indian meal moths are a problem. Use pyrethrin plus piperonyl butoxide in these situations as the "topdressing" insecticide.

*Caution*—Premium grade malathion and pyrethrin plus piperonyl butoxide are registered for use on stored barley, corn, oats, rye, sorghum, and wheat, *but not on stored soybeans*. Grain treated with malathion or pyrethrin plus piperonyl butoxide as recommended can safely be fed or sold at any time after treating.

### Cool Grain

If the temperature of the grain and the insects in the grain is reduced to 60°F (15.6°C) or lower, the insects stop feeding and reproducing. Cool winter temperatures can be effectively used to cool the grain mass in a bin, making the grain unfavorable for insect development and thus reducing damage to the grain. Use aeration fans to reduce the temperature of the grain to 40°F (4.4°C). Grain cooled to 40°F (4.4°C) should not become warm enough for insect damage until the following summer.



## Vapona<sup>®</sup> Resin Strips

Vapona resin strips are thin, plastic strips impregnated with dichlorvos. When these strips are hung in a closed area, they give off vapor that kills insects. To be successful with these strips, the area to be protected must be a closed area without ventilation because air exchange reduces the concentration of the vapor to the point that it will no longer kill insects.

The strips will control Indian meal moths in tight storage areas if they are hung above the grain with one strip for each 1,000 cubic feet (28.3 m<sup>3</sup>) of air space over the grain. The strips must be hung before moths begin to emerge in the spring. Strips will last up to four months. If strips are used, check grain once each month for a buildup of insects. Replace strips if pests are seen.

### Check for Insects

Examine grain regularly to detect early infestations of insects. If an infestation is detected early, insects can be controlled before they have caused extensive damage. There are minimum acceptable levels of damage and contamination.

Follow a systematic procedure for making probes. Empty each sample into a grain sampling tray or section of eaves trough long enough to accommodate the grain probe. Sift the samples through a 10 to 12 mesh per inch (2.5 cm) screen and examine for insects.

During cold weather, insects will congregate near the center of the grain mass where it is warmest, so sample the center of the grain mass thoroughly during the winter. During warm weather, infestations usually begin near the surface, so pay special attention to that area during the summer.

In the winter, when the grain is cooler, sample the grain every 4 to 6 weeks. During warmer months, sample grain every 2 to 4 weeks. Use a grain probe which may be purchased or borrowed from your local grain buyer.

When first entering the bin, insert the probe horizontally a couple of inches under the grain surface in the center of the bin before the grain surface is disturbed. Collect the sample and examine for insects. Take additional surface samples around the sides of the

bin. Then probe from the top to the bottom of the grain mass. Extensions may have to be attached to the probe so that it can penetrate to the bin floor.

In *round* bins, start the deep probes at the center, then probe around the wall. Insert the probe about one foot (30 cm) from the outer wall. Make surface and deep probes at the north, west, south, and east sides of the bin. Examine each sample for insects. In extremely large bins samples may have to be taken at more locations, no farther apart than every 20 feet (6 m) around the wall. Bins with diameter of more than 40 feet (12 m) should also be sampled more than once near the center of the bin.

In *flat storage* bins, grain should be sampled in the center and around the walls. Take samples no farther than 20 feet (6 m) apart. Take surface probes first, then probe from the top to the bottom, examining each sample for insects.

Always retreat surface with topdressing of grain protectant after disturbing the grain.

If you find considerable damage and/or insects in the probe samples and cannot identify the insects, you could show them to the county agent or elevator manager for positive identification. If one granary weevil, one rice weevil, or one lesser grain borer, or as many as five insects of other species such as flour beetles and saw-toothed grain beetles are found per quart (0.9 l) sample of grain, fumigation of the grain is necessary to prevent further insect damage. Grain temperature should be above 65° F (18.3° C) for the fumigant to be effective.

### **If Insects Are Found—Fumigate**

It is usually less expensive and more effective to have the fumigation done by a commercial fumigation company than to attempt to do it yourself. This is particularly true if large quantities of grain (over 10,000 bushels [3,500 hl]) need to be fumigated. Consider the cost of application on a per bushel basis. The cost should include the necessary safety and application equipment, as well as the cost of the fumigant. The time and labor expense should also be considered.

Flat storage structures and large round bins present special problems in maintaining the fumigant in place long enough to cause an effective kill.

Recirculating the fumigant is a technique often used by commercial applicators in these structures to make the distribution of the fumigant more uniform throughout the grain. This is accomplished by attaching a return duct between the overhead space above the grain surface and the fan on the aeration duct. Depending on the direction of the air movement, the fumigant can be drawn or pushed through the grain and then directed back to the grain by return duct. The fumigant is generally recirculated for a time estimated to produce two or more air changes within the stored commodity. Grain may be fumigated effectively at greater depths when bins are equipped with recirculating equipment.

Applicators must be EPA certified to apply fumigants, since fumigants are restricted-use pesticides.

## **Bin Preparation**

Seal all cracks. If the bin has many openings that cannot be sealed to prevent fumigant leakage, it's doubtful that the fumigation will be effective.

Circular storage structures constructed from corrugated metal strips and quonsets and other rectangular buildings constructed of corrugated and flat metal bolted together are usually the most gastight. Caulking the seams at the time of construction improves the tightness of these bins.

Wood structures are the most difficult to fumigate because such structures are porous and allow an excessive amount of fumigant to escape. For this reason, fumigant dosage recommendations for wooden bins are usually twice the amount recommended for metal bins. It may be necessary in some cases to cover the wooden structure with a gastight tarpaulin to retain the fumigant for a sufficient length of time.

Before applying the fumigant, spray the outside of the bin with a residual spray of premium grade malathion or methoxychlor (Table 1) to kill those insects forced out of the bin by the fumigant. These

insects could quickly reinfest the grain after the fumigant disappears. Also, clean up and dispose of any waste grain outside the bin for the same reason.

## Fumigant Selection

All fumigants are poisons and are toxic to humans and other warm-blooded animals, as well as to insects and other pests. Certain fumigants are highly flammable and corrosive. Some will leave undesirable residues if not used correctly. Some will injure seed germination and affect milling quality if improperly used (Table 2).

Aeration of the grain after fumigation is a necessity.

Fumigants are most effective when the air is calm and grain temperature is 65° F (18.3° C) or above. Remember that changes in average temperatures in grain lag 6 to 8 weeks behind changes in average air temperature.

Fumigants are available in *liquid*, *gas*, and *solid* formulations. However, they all must become a gas to be effective as a fumigant.

**Liquid Fumigants**—Formulations of liquids usually contain a mixture of two or more compounds. *Liquids* commonly used in farm fumigant mixtures are combinations of carbon tetrachloride with carbon disulfide, ethylene dibromide, or ethylene dichloride. Carbon disulfide should not be used alone because it is extremely explosive and flammable.

Liquid fumigants are usually applied to the grain surface. Because they are heavier than air, they settle to the bottom of the grain mass. Chloropicrin (tear gas) or sulfur dioxide are sometimes added to these mixtures as warning agents.

**Gaseous Fumigants**—Two *gaseous* fumigants, methyl bromide and hydrogen cyanide, may be used to fumigate grain. They are usually released from pressurized containers into the storage area and commodity.

Hydrogen cyanide (HCN) is lighter than air and will not effectively penetrate downward through the grain mass. Because of this, HCN is normally used only in facilities that have air recirculation systems which can be used to recirculate the fumigant through

**Table 2. Characteristics of several grain fumigants.**

<i>Fumigant</i>	<i>Heavier than air</i>	<i>Grain Penetration</i>	<i>Flammability</i>	<i>Warning odor</i>	<i>Germination effect</i>
carbon disulfide	Yes	Good	High	Rotten egg	Depresses
carbon tetrachloride	Yes	Poor	None	Pungent odor	Depresses
ethylene dibromide	Yes	Poor	None	Sweet odor	Depresses
ethylene dichloride	Yes	Good	High	Ether odor	Little
chloropicrin	Yes	Good	None	Tear gas	Depresses
sulfur dioxide	Yes	—	None	Irritating, sulfur	Destroys
hydrogen cyanide	No	Fair	High Concentration	Bitter almond	None
methyl bromide	Yes	Good	Little	None	Depresses
aluminum phosphide	Slightly	Good	In Presence Of Moisture	Carbide-like	None

the grain several times. Control with methyl bromide is also improved by using recirculation systems. Gaseous fumigants are extremely hazardous and require special equipment and precautions for handling. Application should be done only by experienced persons equipped to use these materials.

**Solid Fumigants**—*Solid* pellets or tablets containing aluminum phosphide (Phostoxin<sup>®</sup>) can be used to fumigate farm-stored grain. Tablets properly placed in the grain mass are activated by moisture in the air to release highly toxic phosphine gas. This material is extremely dangerous if improperly used, so should be applied only by experienced applicators who are thoroughly familiar with proper use of the material. Do not pour or spill water on those pellets.

## Volume Calculation

To determine the amount of fumigant required, you must know how many bushels of grain are in the bin. There are several ways of determining volume of a grain mass. The method used doesn't matter as long as it is accurate. The following formulas are simple to use.

*Bushels of grain in a square or rectangular bin:*  $\text{Bushels} = 0.8 \times \text{length (ft)} \times \text{width (ft)} \times \text{average depth of grain (ft)}$

*Bushels of grain in a round bin:*  $\text{Bushels} = 0.6283 \times \text{diameter (ft)} \times \text{diameter (ft)} \times \text{average depth (ft)}$

## Fumigant Dosage

Fumigants are sold under various trade names. Ingredients are listed on the container label. Table 3 shows ingredients and recommended dosages of some readily available liquid fumigants. The list should help in determining how much fumigant will be required. Other effective fumigants may also be available. In all cases, follow the label instructions and recommendations.

The approximate dosage rates for Phostoxin<sup>®</sup> are given in Table 4. Since it is stored as a solid and releases its vapor after exposure to air, it is applied in a different manner than are the liquid fumigants. It should be applied only by personnel who have been instructed in its use.

## How to Use Fumigants

Always use the recommended dosage of an approved fumigant for the type grain and bin you are treating.

Make a special effort to make the grain bin as air tight as possible. Level the grain surface to insure even penetration of the fumigant throughout the grain mass.

Apply liquid fumigants evenly to the entire surface as a coarse spray. Use a hand-type compressed air sprayer or bucket pump. The pump should have brass fittings and a plastic or plastic-lined hose, because some of the fumigants are corrosive.

Stay on the outside of the bin.

**Table 3.** Gallons of fumigant to apply per 1,000<sup>a/</sup> bushels of grain. Dosages listed are average amounts, refer to container label for specific recommendations.

<i>Fumigant mixture</i>	<i>Metal bin</i>			<i>Wood bin</i>		
	<i>Wheat rye</i>	<i>Shelled corn, oats, barley</i>	<i>Grain sorghum</i>	<i>Wheat, rye</i>	<i>Shelled corn, oats, barley</i>	<i>Grain sorghum</i>
80% carbon tetrachloride + 20% carbon disulfide <sup>b/</sup>	2.5	4.0	6.0	4.5	6.0	8.0
75% ethylene dichloride <sup>c/</sup> + 25% carbon tetrachloride	4.0	5.5	7.0	6.0	8.0	10.0
5% ethylene dibromide <sup>c/</sup> + 35% ethylene dichloride + 60% carbon tetrachloride	2.25	4.4	6.0	4.25	6.0	8.0

1 to 2% chloropicrin (tear gas) or sulfur dioxide may be added to the above mixtures to act as warning agents.

*a/ On less than 1,000 bushel lots, use the same dosage as recommended for 1,000 bushels.*

*b/ Carbon disulfide is explosive when used without a fire suppressant such as carbon tetrachloride. Apply when grain temperature is above 60°F (15.5°C).*

*c/ Apply when grain temperature is above 70°F (21.1°C).*

**Table 4.** Phostoxin<sup>®</sup> dosage rates per 1,000 bushels of grain.

<i>Type of storage</i>	<i>Amount per 1,000 bushels</i>
Round metal bins up to 9,000 bushel capacity	90-180 tablets, or 200-400 pellets
Wood bins	Cover with polyethylene tarpaulin then use above dosage

When fumigating large volumes of grain, power equipment may be used. Diaphragm or brass gear pumps may be used and driven by a small motor or tractor power take-off. Use a nozzle that disperses the liquid in an even pattern as a coarse spray.

Farm bins with the grain mass deeper than 10-12 feet (3-3.7 m) may require the use of both liquid and Phostoxin® for best results.

Because liquid fumigants settle to the bottom quickly, the grain in the top 2 to 3 feet (0.6 - 0.9 m) may not be exposed to the fumigant long enough to obtain good control.

The proper dose of Phostoxin® could be probed into the top 2 to 3 feet (0.6 - 0.9 m) of grain, and then the required dosage of liquid fumigant applied.

In all cases, close the bin immediately after applying the fumigant. Keep closed for at least 72 hours.

Place signs at all entrances warning that the bin is being fumigated and listing the fumigant used and the name, address, and telephone number of a responsible person to contact in case of emergency.

The bin may be opened and aired out after 72 hours and grain may be fed or placed in market channels after the grain is completely aired.

## Cautions

*All fumigants are dangerous if improperly used. Carefully follow the cautions listed on the container label and use only in strict accordance with label directions.*

Wear a gas mask with full face piece and proper canister approved by the U.S. Bureau of Mines and the National Institute of Occupational Safety and Health for use with the particular fumigant you will be using. Gas masks of this type will not protect the user against heavy fumigant concentrations in bins where oxygen has been replaced by the fumigant. The effective life of a gas mask canister is limited. Keep an accurate account of the time that a canister is used and replace it after 30 minutes of continuous or intermittent exposure to fumigants.

Avoid spilling fumigant on the skin, clothing, or shoes. Remove fumigant-wetted clothing or shoes at once and wash the skin thoroughly with soap and water.



*Never fumigate a bin by yourself.* Have someone else around to help if you get into trouble. The helper must also be properly fitted with a gas mask. Have a code so that you can communicate with each other. Make sure gas and electrical connections are turned off. Have available the telephone numbers of the police and fire departments, hospital, physician, and rescue squad.

### Summary

Grain is food—protect it from insect damage and contamination. Insect damage can be reduced in stored grain by:

1. Cleaning bins and harvesting and hauling equipment.
2. Cleaning outside of bins.
3. Spraying bin walls and floors and outside of bin.
4. Storing dry, clean grain.
5. Using grain protectants.
6. Top-dressing grain surface.
7. Cooling grain.
8. Inspecting grain regularly.
9. Fumigating if needed.

### Additional References

See EC 68-1517 for colored illustrations of stored grain insects. See NebGuide G73-5 "Pest Control in Stored Grain" for specific recommendations on rat and mouse control. These are available at your County Extension Office.