

Farmer Pesticide Certificate Home study Course

Pest Control in Stored Grain



Vermilion
Lloydminster
Strathcona County



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Environmental Sciences & Pesticides **(780) 853-8646**
Lakeland College
5707 - 47 Avenue West
Vermilion, Alberta
T9X 1K5

Production Team

Technical Coordinator:

Janet McLean (First edition)
Vivianne Servant (Second and 2006 edition)
Allan Schaaf and Vivianne Servant (2007 edition)

Facilitator/Processing Coordinator:

Robert Brad (First edition)
Melanie Mutter (Second edition)
Linden Lundback and Vivianne Servant (2006 and 2007 edition)

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Patrick Scholefield
Allan Schaaf

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Stored Agricultural Product Pests

Introduction

Protecting stored grain from spoilage is an essential part of grain production. Insects and mites eat stored grain, cause it to heat and spoil its appearance. Infested grain is hard to sell, and inspectors downgrade heated grain. These losses can usually be prevented by storing grain as dry as possible in clean, weatherproof, uninfested granaries and applying proper chemical controls when necessary.

Stored Grain Pests and their Biology

In Alberta there are 2 major species of grain beetles that are common, the rusty grain beetle and the red flour beetle. Many other beetles including saw-toothed grain beetles, weevils, foreign grain beetles and fungus beetles are occasionally a problem.

The rusty grain beetle is the most serious pest of stored grain in Western Canada because it can survive our cold winter conditions. The beetle is 2 mm long, reddish brown, and has a flattened appearance. This pest infests all types of grain and feeds on grain, dust and fungi.

The red flour beetle is also reddish brown but is about twice the size of the rusty grain beetle, 4 mm in length. When viewed from the side, the beetle has a rounded top as compared to the flat appearance of the rusty grain beetle.

Both species and many other grain beetles can fly under warm summer conditions, and can spread from one granary to another. None of the stored grain pests can multiply in grain growing in the field; therefore, infestations are always initiated from infested granaries or grain. In the natural environment, these pests can survive summer conditions living in trees, bird nests and other protected locations. Therefore, it is wise to clean-up infestations during the winter and spring before the insects can disperse during the summer months.

The beetles' reproductive cycle varies with temperature and grain moisture conditions. When the grain is dry (11-12% moisture content) the beetles cannot multiply very successfully. However, grain is rarely that dry throughout and isolated moist spots occur in most bulk grain providing sites for reproduction.

Grain Condition and Damage Symptoms

The beetles feed on the kernels, eat the germ portion of grain and sometimes cause heating. The actual damage due to feeding is usually minor, however, the presence of beetles usually indicates out-of-condition grain and eventual spoilage.

When grain is harvested, it is usually warm. Once placed in a bin the grain begins to cool very slowly. As winter temperatures speed up cooling, convection currents rise through the centre of the bulk. As these warm moist currents reach the cool surface, the moisture condenses and is deposited near the surface creating a suitable habitat for the beetle. This occurs even in very dry grain. Therefore, many infestations in steel bins are at the surface near the peak of the pile.

If grain is stored at moisture levels significantly above 12 %, moulds that produce heat and moisture may develop, and greatly enhance the chances of an infestation of grain beetles to develop. Constant monitoring of the grain temperature, moisture, and presence of pests are necessary to avoid damage.

Preventing Infestations

Infestations normally start because the granary is infested before the grain is stored. Surveys of empty granaries on the prairies showed that 50% of bins contained residual populations of storage pests. Consequently, the addition of grain to a bin just provides the conditions for a problem to develop. Many such problems can be prevented by routinely cleaning empty granaries before harvest and applying a residual malathion spray treatment to the bins and surrounding areas. The procedure is easy, cheap and a good management practice. The one exception to this would be when storing canola seed. In this case, malathion must not be used. Feed mill and seed cleaning facility managers should regularly use a similar precautionary treatment since they could be acting as a source of insects for their customers. They should check undisturbed sites that accumulate grain and dust, as they may harbour insects. Sanitation makes good sense!

Sampling for Insects

Stored grain should be sampled every 2 weeks to detect spoilage or insects before the occurrence of severe damage. Probes are available from most grain elevator agents and possibly at some seed cleaning plants. Samples removed with probes or by hand should be shaken over screens that will allow insects to pass through. The material passing through should be warmed to room temperature and examined for moving insects and mites (these pests are difficult to see unless they are moving).

Semi-permanent sampling traps made of perforated pipes will exclude grain but allow insects to pass into the trap. Cups filled with water may also be inserted into the grain surface as a trap during the summer.

Temperature probes will help indicate hot or heating grain. Grain should be sampled at least 1 metre in to the top of the bin. Use of electronic temperature probes can provide a quick temperature profile of the entire

grain handling facility.

Control of Mites

Most mite infestations occur at the surface of bulk grain. Breaking up the surface, drying, and cooling the grain are the best control procedures. Control with chemicals is not usually recommended and is marginal at best.

Controlling Infestations

The owner of infested grain has several options when dealing with the problem. Grain temperature, moisture content, the season of the year and the type of insect or mite infestation will influence the control decision.

Cold Weather Treatment

Turning the grain during cold (-30°C) weather will cool any heating spots, and kill some beetles. Effective control depends on how quickly the beetles are cooled. A drop from +5° C to -20° C overnight will effectively kill the beetles. Slow cooling will not kill the insects, but will slow down insect activity until the grain can be milled and fed to livestock, or held until spring when the grain can be fumigated. If the grain is heating, turning is the only procedure that will reduce damage, since most heating is caused by fungi that cannot be controlled effectively by chemical fumigants.

Grain Fumigation

Fumigants can only be applied by the following individuals:

- a commercial applicator holding a valid Fumigation or a Fumigation Restricted to Stored Ag. Products Certificate, or
- a farmer holding a valid Farmer Pesticide Certificate with the Grain Fumigation endorsement if issued after 2008.

Fumigants should be used with extreme care, as they are toxic to all forms of life including humans and animals. Label directions must be followed exactly and proper safety equipment used during application.

Aluminum and magnesium phosphide are the only fumigants approved for grain fumigation. They are manufactured as tablets or pellets, which release phosphine gas (also known as phosphane or hydrogen phosphide) when exposed to moisture in the atmosphere. The tablets or pellets are probed into grain via pipes, or are added to the grain as it is augered into a bin. These fumigants must not be used when the grain temperature is 5° C or lower. Fumigated grain must have been ventilated for at least 48 hours and the phosphine concentration must be below 0.3 ppm, before it can be transported off the farm.

Grain Treatments

Several alternatives to fumigation grain treatment exist including:

- application of malathion grain protectant dust either while augering grain into the bin at harvest or while turning the grain after an infestation has been discovered. Before using malathion dust, ensure that the treated product can be used for its final use. For example, malathion must not be used when storing canola seed.
- application of diatomaceous earth (silicone dioxide) while augering grain into the bin at harvest or while turning the grain after an infestation has been discovered. Before using this product, ensure that the treated product can be used for its final use. For example, malting barley may be rejected for malt production when treated with diatomaceous earth.

These products can be applied to the grain as it is augered back into the bin. The augering helps in distributing the material uniformly throughout the grain.

Phosphine Fumigants

Phosphine fumigants are the only grain fumigants used in Alberta. These products are sold as solid aluminum or magnesium¹ phosphide, both of which give off the highly toxic phosphine gas. Phosphine fumigants provide control of all stages of stored grain insect pests. The fumigants are available as tablets or pellets.

Tablets begin release phosphine gas in 2-4 hours after being exposed to the atmosphere, whereas pellets begin evolving phosphine gas in only 1-2 hours. In addition to phosphine, which has no odour or colour, the fumigant also releases ammonia, various diphosphines, and methanethiol. The latter two gases are responsible for the characteristic garlic (or rotten fish) odour associated with grain fumigation. The ammonia has the added benefit of reducing the potential for spontaneous ignition.

The rate of decomposition of the tablets or pellets varies depending on the grain moisture and temperature. The higher the temperature and moisture of the grain, the faster the fumigant will be evolved. Conversely, the lower the temperature and moisture, the slower the fumigation. However, when the temperature of the grain is below 5°C, fumigation is not permitted because the reaction is too slow for effective fumigation. However, aluminum phosphide will react and release phosphine gas even at -40°C. After complete decomposition, a fine grey-white non-poisonous powder remains.

Aluminum phosphide pellets and tablets are prepared in two spherical

¹ Magnesium phosphide is only available to certified commercial applicators.

shapes. The rounded tablets weigh approximately 3 grams and release 1 gram of phosphine gas. They are about 16 mm in diameter and are bulk packaged in resealable aluminum flasks containing 30, 100 or 500 tablets each. The pellets weigh approximately 0.6 grams and release 0.2 gram of phosphine gas. They are about 9 mm in diameter and are packaged in resealable flasks containing about 166, 500 or 1666 pellets.

NOTE: Phosphine gas is highly corrosive to metals used in electronic equipment, therefore such equipment should be removed from the area to be treated.

Guidelines for Safe Use of Fumigants

All fumigants are highly toxic and strict attention must be paid to safety and safe handling procedures. In addition, all fumigations of stored grain must be performed as indicated in the regulatory document called the "Procedures for Grain Bin Fumigation in Alberta" available from your retailer or from Alberta Environment. (<http://environment.gov.ab.ca/info/library/6312.pdf>).

General Precautions When Fumigating

The following precautions apply to all types of fumigations:

- always read and follow the label;
- do not ventilate during a temperature inversion (indicators of a temperature inversion are low-lying fog and smoke that does not rise, but flattens out parallel to the ground);
- do not involve anyone under 18 years in a fumigation;
- if a fumigant is lost or stolen, it is advisable to report the incident to Alberta Environment and the police;
- use proper warning sign and make sure warning signs are visible day and night;
- keep all entrances locked during the fumigation;
- keep one person outside the structure being fumigated, when the fumigant is being set out or probed. This person is there to get help if a problem arises;
- open aluminum phosphide flasks and pouches in a well ventilated area. Because of the risk of spontaneous ignition, never open flasks in a dusty and/or flammable environment, such as inside a grain storage.
- To dispose of leftover aluminum phosphide it must be allowed to react in a controlled manner, so as to render it harmless. To this effect submerge leftover aluminum phosphide in a 2% detergent solution for at least 36 hours to make sure the gas is completely released. This must be done in a safe location under the supervision of a certified individual, with warning signs posted, downwind phosphine levels monitored and out of reach of children, pets and livestock. The person carrying out this

A commercial agriculturalist is a person who is engaged in agricultural production. Farmers are commercial agriculturalists.

task should wear all required personal protective equipment, including a properly fitted cartridge respirator.

- all commercial agriculturalists performing grain fumigations are advised to keep a record of the application. Although not compulsory, it is good business practice to do so. See page 8 for an example of a record sheet.

Necessary Equipment

The following equipment is necessary to perform a safe fumigation:

- Aluminum phosphide tablets (or pellets),
- measuring tape,
- duct or masking tape,
- sponge rubber for sealing holes,
- if probing tablets into grain, a 1.75--2.5 cm pipe, 2 - 4 m in length,
- thermometer to check grain temperature,
- cotton gloves to safely handle the tablets,
- warning signs,
- locks to prevent unauthorized entry into the fumigated bin or boxcar,
- plastic and tape to seal the bin, boxcar or container,
- flashlight,
- appropriate ladders,
- fall restraint equipment
- an appropriate canister type respirator or a self contained breathing apparatus (SCBA) for each person participating in the application
- phosphine detection tubes or a gas meter capable of detecting phosphine levels at least as low as 0.3 ppm.

Dosage and Exposure Time

To determine the dosage and exposure time, ALWAYS read the label.

Dosage and exposure time varies with temperature and the tightness of your bin, or other grain storage facility. Increasing dosage cannot compensate for a shortened exposure.

Dosage

When fumigating grain, the dosage is usually 180-500 tablets or 880-2500 pellets tablets per 100 cubic metres (for grain bins or 100-300 tablets or 500-1500 pellets per 100 cubic metres for other storage facilities.

The higher end of the dosage range may be required under sub-optimal conditions, where diffusion may be slow and a larger amount is needed to achieve effective phosphine levels.

Exposure Time

When fumigating grain, exposure time is related to the temperature of the grain as indicated in Table 1.

All stored grain which is to be fumigated must have an accurate temperature

reading before fumigation is initiated. The use of a probe thermometer placed approximately 1 metre into the top of the grain is recommended. Hot grain may have to be turned shortly after the fumigation is complete to prevent spoilage.

Table 1 - Fumigant Exposure Time based on the Temperature of the Commodity

Temperature of the Grain	Fumigant Exposure Time for Aluminum Phosphide
above 20 ⁰ C	3 days
16 ⁰ C to 20 ⁰ C	4 days
13 ⁰ C to 15 ⁰ C	5 days
5 ⁰ C to 12 ⁰ C	10 days
below 5 ⁰ C	DO NOT FUMIGATE

Example of a record sheet
GRAIN BIN FUMIGATION RECORD USING ALUMINUM PHOSPHIDE

Name of Commercial Agriculturalist _____

Telephone No. _____

Legal Land Description of fumigation _____

Amount of aluminum phosphide used _____

Where purchased _____

Date of fumigation _____

Amount of grain fumigated _____ (Bushels)

Temperature of grain _____ °C

Pest being controlled _____

Personnel involved in the fumigation:

Name	Address	Phone No.

Signed _____ Date _____

Fumigation Procedure Using the Probe system

Use the following procedures if you are using a probe system:

- the bin or other type of grain storage facility must be tightly sealed for a successful fumigation since phosphine expands to fill all available space (tape and plastic will hold in phosphine gas);
- make sure that there are no people or animals in adjoining structures; phosphine gas can slowly penetrate through concrete block walls, and other materials;
- open all doors and vents before the fumigation;
- check the time; fumigation must be completed within 2 hours of exposing the first tablets;
- for fumigating grain, insert the probe at 1.3 m intervals over the entire grain surface. For best results, insert the probe to within 3 m of the floor. The number of tablets or pellets per probe is determined by dividing the total number of tablets or pellets by the total number of probings carried out. The tablets or pellets should be dropped into the probe one at a time at intervals from 2.5 to 10 cm as the probe is withdrawn. Place the last tablet or pellet of each probing, at least 15 cm below the surface;
- check the end of the probe regularly to ensure it isn't plugged;
- pull a tarp over the grain for an effective fumigation, especially in partially filled bins and Quonsets - close and seal all openings;
- post warning signs on all doors of the bins, boxcar or container and lock all entrances to the fumigated structure;
- after fumigation, open all doors and vents and aerate for at least 4 hours and until phosphine levels are below 0.3 ppm.
- remove the tarps or plastic barriers when fumigation is complete to avoid sweating of the grain
- remove warning signs only after the grain has been fully ventilated and phosphine levels are below 0.3 ppm;
- allow aeration of the fumigated grain for at least 48 hours before offering the product for sale;
- a vacuum probe may be used, especially in large volumes of grain or in deep hard to penetrate grain when use of safety equipment is difficult or impractical for long periods of use.

Non-Probing Fumigation Application

Several options are available if you are not using a probe to insert the aluminum phosphide tablets or pellets into the grain:

- follow all safety procedures as in the above probing example;
- if grain is being moved from one bin to another, apply the tablets or pellets to the intake of the auger at the appropriate dosage based on the auger capacity;
- if the bin is full, remove a few truck loads, probe in the required number of tablets or pellets for the grain volume in the bin, then add the tablets or pellets to the remaining grain stream as the bin is refilled;

Safety

Safety must be the most important factor when fumigating any commodity. A comprehensive safety program is needed to prevent accidents and must be understood by everyone involved in carrying out the fumigation. This includes having read the label and the guidelines for Fumigation of Grain Bins (www.environment.gov.ab.ca/info/library/6312.pdf), and to follow safe working procedures relevant to grain storage facilities, which include:

- work in pairs, and have a person capable of responding to an emergency stationed outside the confined space;
- never enter a bin where 'bridging' or a high wall of grain exists. A cave in will result in almost certain smothering. Fall restraint equipment is essential.
- do not enter a grain bin during loading or unloading.
- check the time when you open the fumigants; the application should be completed within 2 hours;
- For all types of fumigations, if application of fumigant is to be performed from within the structure to be fumigated, then approved respiratory protection must be worn by all personnel. Approved respiratory protection must also be worn if re-entry of the treated area is necessary before complete aeration;
- wear a cartridge type respirator in good working order or a Self Contained Breathing Apparatus (required if phosphine is above 15 ppm); insure that you know how to correctly use this equipment (no beard or long sideburns that may interfere with forming a tight seal);
- monitor phosphine levels using phosphine tubes or an appropriate gas meter;
- open the cans pointing away from you outside the bin because spontaneous ignition may occasionally occur from flasks when first opened;
- If a flask ignites, either recap immediately or pour into a large secondary container. This will bring the phosphine level below the Lower Explosive Limit (LEL). The pellets or tablets can then be applied safely.
- never confine the product in a small, gas-tight enclosure (such as a plastic bag) or spontaneous combustion may occur;
- wear cotton gloves and wash your hands after using the fumigant;
- don't eat, drink, or smoke during the fumigation;
- lock all entry points to the grain storage under fumigation and ensure the key is retained by a responsible person until the aeration process is complete;
- post warning signs to all entry points;
- don't enter the structure without a full face respirator with a phosphine filter (yellow in colour), or a self contained breathing apparatus when phosphine levels are above 0.3 ppm or unknown;
- remove warning signs after the treatment;
- All clothing used during the fumigation must be kept away from living quarters and aired out in a well ventilated area for several days. Contaminated clothing should never be transported in the cab of a vehicle;
- Never allow farm animals and pets to be in the area while applying the aluminum phosphide to prevent possible ingestion;

- Locate and remove any dead birds and rodents present to prevent contamination of the grain;
- Note all equipment (e.g., flasks and probes) at the beginning of the job and make sure that all items are present after the application is complete. A lost piece of equipment or a full flask could have serious consequences.

Transportation of Fumigated Product

It is illegal to transport grain by truck on Alberta highways while under fumigation (phosphine levels > 0.3 ppm).

Storage and Transportation of Fumigant

Because fumigants are very toxic, try to purchase only as much as you will need to do the immediate fumigation.

- never let the product contact a liquid as this causes immediate release of phosphine gas;
- Ensure all opened flasks are properly closed and moisture proof
- store aluminum phosphide flasks under lock and key in a dedicated pesticide storage that is not located in a building or adjacent to a building occupied by people or livestock
- follow the Transportation of Dangerous Goods Regulations when transporting phosphine products as they are designated as a hazardous good (Class 4.3 "Flammable solids; substances liable to spontaneous combustion; substances that on contact with water emit flammable gases" and Packing Group I);
- Use appropriate placards on transportation vehicles.
- It is advisable to promptly report lost or stolen fumigants to the authorities

First Aid for Phosphine Poisoning

Symptoms

Improper use or a careless attitude towards phosphine fumigants can lead to serious poisoning. The symptoms of phosphine poisoning are as follows:

Light poisoning-	sensation of cold, pulling pains in the region of the diaphragm, numbness, diarrhea, and vomiting
Moderate Poisoning -	dizziness, giddiness, ringing in the ears; anxiety, sense of pressure in the chest, dry cough, furred tongue, loss of appetite, intense thirst
Severe Poisoning-	gastric pains, reeling accompanied by vomiting, pains in limbs, enlarged pupils, choking attacks, rapid onset of stupor

Treatment

Get the patient out of the gas atmosphere and into fresh air. Make the patient sit or lie down in a comfortable position and keep the patient warm while transporting to the nearest medical facility. Apply artificial respiration if breathing stops.

Calculations

Because the pesticide label indicates metric units, you will require some initial calculations to convert your grain bin, boxcar or container volume to a cubic metre volume. The following will illustrate the calculations required for grain fumigation using phosphine tablets or pellets. NOTE: The size of a grain storage facility might be quoted in bushels, cubic metres (m³), area/100 m³ or cubic feet (ft³). It is not uncommon for the size to be wrong or sometimes unknown. All bin size must be recalculated for size if any doubt exists.

Metric Conversion Factors

Some useful formulas and conversions

1 bushel = 36.37 L or 1 litre = 0.027 bushels
metres = feet X 0.305 or 1 metre = 3.28 feet
Bushels = 1.3 ft³
ft³ = 0.76 bushels
1 m³ = 1000 Litres

Symbols

↑ denotes the evolution of a gas;
h = height;
l = length;
r = radius;
d = diameter

Volume Calculations

Volume of a Box

Volume = height x width x depth.

As well as a basic knowledge of dosage and concentration, knowledge of volume calculation to obtain the correct concentration of gas is required.

Example

The volume of a box = 8m x 12m x 13m
= 1248m³

In calculating the volume of a complex structure, it is easier to break it down into its various parts, calculating the volume of each, and then adding them together to give the total volume. For example, a typical steel grain bin is the total of a cylinder and cone. A variety of shapes and sizes will be encountered when breaking a structure down into parts. It is useful, therefore, to be familiar with calculating the volume of cylinders, cones, oval tanks etc. Here are some volume calculation examples followed by a problem.

Volume of a Cone

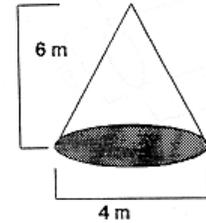
$$= \frac{\pi(r^2)h}{3}$$

[π = pi which has a value of = 3.141]

[r = diameter of 4m / 2]

$$= \frac{[3.141 \times (4 / 2m)^2] \times 6m}{3}$$

$$= \frac{75.4}{3} = 25.13m^3$$

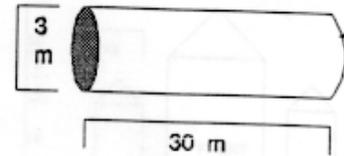


Volume of a Cylinder

$$= \pi(r^2)(h)$$

$$= (3.141)(3 / 2m)^2 \times 30m$$

$$= (3.141)(2.25m^2) \times 30m$$



Determining the Volume of the Fumigating Structure

Step 1

of bushels the bin* holds X 36.37 = bin*volume in litres

Step 2

bin* volume in litres / 1,000 = bin* volume in cubic metres

Example

Your grain bin has a 1,000-bushel capacity. What is the volume in cubic metres?

$$\begin{aligned} \text{Volume } m^3 &= 1,000 \text{ bu.} \times (36.37 \text{ litres/bushel}) \times (1 m^3 / 1000 \text{ litres}) \\ &= 36,370 \text{ litres} \times 1 m^3 / 1,000 \text{ litres} \\ &= 36.37 m^3 \end{aligned}$$

Determining the Amount of Fumigant to Use

Find the label rate (tablets or pellets per cubic metres) then use the volume of the bin (in cubic metres) to calculate how many tablets you need to do the fumigation.

$$\# \text{ of tablets to use} = \text{label rate (tablets/m}^3\text{)} \times \text{volume of bin* (m}^3\text{)}$$

(*can also be a boxcar or container)

Example

If your grain bin has a 36.37 m³ capacity and your label reads: "Use 5 tablets to treat one cubic metre of grain." How many tablets will you require to fumigate the grain bin?

$$\begin{aligned} \# \text{ of tablets to use} &= 5 \text{ tablets/m}^3 \times 36.37 \text{ m}^3 \\ &= 181.85 \text{ tablets} \end{aligned}$$

You require 182 tablets to treat your grain bin (roundup the number to the next whole number).

Step 1

To figure out how many tablets or pellets to put in a container, you first need to determine the volume of the container. The following formulas allow you to determine the volume of the some standard containers:

volume of a rectangle or square container = length X width X height (note all measurements must be in metres to determine cubic metres)

volume of a cylinder = 3.14 X radius²* X length
(*radius equal to 1/2 of the diameter of the cylinder)

Step 2

The next step involves determining how many pellets or tablets to put into the container. One tablet weighs 3 grams and one pellet weighs 0.6 grams. To determine how many tablets are required, use this formula:

$$\# \text{ of tablets required} = \frac{\text{label rate (grams/m}^3\text{)} \times \text{container volume (m}^3\text{)}}{3 \text{ grams}}$$

To determine how many pellets are required, use this formula:

$$\# \text{ of pellets required} = \frac{\text{label rate (grams/m}^3\text{)} \times \text{container volume (m}^3\text{)}}{0.6 \text{ grams}}$$

Example

You have to fumigate a full container that is 40 feet long by 10 feet wide by 10 feet high. The fumigant label reads: "Use 4 grams per cubic metre"

The container size in metric units is:

$$40 \text{ ft.} \times 0.305 = 12.2 \text{ metres}$$

$$10 \text{ ft.} \times 0.305 = 3.05 \text{ metres}$$

$$\begin{aligned} \text{Container volume} &= 12.2 \text{ m} \times 3.05 \text{ m} \times 3.05 \text{ m} \\ &= 113.49 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \# \text{ of tablets required} &= \frac{4 \text{ grams/m}^3 \times 113.49 \text{ m}^3}{3 \text{ grams}} \\ &= 152.32 \text{ tablets} \end{aligned}$$

You need 153 tablets (round up to the next whole number).

NOTES

1. When fumigating large, flat storage grain bins or Quonsets, volume calculations are very difficult. Many operators have very accurate records of the amount of grain stored in the structure. Also, crop insurance records will provide much valuable information as to the potential volume.
2. Whenever possible, keep notes of the size of the bins treated. The circumference, number of rings and the cone height will be useful when treating similar bins.