

FARM-STORED GRAIN and WAREHOUSES

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Additional information on stored product insects can be found at the Agriculture and Agri-Food Canada internet site; www.agr.gc.ca/science/winnipeg/cgs_e.htm. **Before applying any insecticide, read the instructions on the pesticide label and follow the instructions.**

FARM-STORED GRAIN

Common pests: rusty grain beetle, red flour beetle, foreign grain beetle, fungus beetles, granary weevil, hairy spider beetle, lesser mealworm, Indianmeal (Indianmeal) moth, psocid, dermestid beetles, sawtoothed grain beetle and storage mites.

Detection of Infestations

Monitoring insects is the first step to any IPM (Integrated Pest Management) control program. Sample grain bulks every two weeks for insects or heating of grain. Sieve grain samples over a No. 10 sieve (2.0 mm aperture). Warm siftings for a few minutes, and then examine for insect movement. While looking for insect activity, examine the grain for the presence of damage such as holes in the germ end.

Probe traps are more sensitive than sampling and sieving grain. Traps are inserted into grain and left for one to two weeks (5, 22, 23). Traps can be purchased from Trécé Inc., 7569 Highway 28 West, P.O. Box 129, Adair OK 74330, www.trece.com.

Non Chemical Control

Cold

Low temperature is an effective method of reducing the growth of insect populations, and from November to March in much of the Prairies ambient temperature is an effective tool for controlling infestations (3).

Moving grain from one bin to another during the winter will break up hot spots and cool the grain. Several transfers may be needed to lower grain temperature to below freezing (12). One transfer is capable of lowering average temperature of grain by 10°C.

Aeration is the most effective method for cooling grain in farm bins. Cool grain as quickly as possible after harvest as insects do not multiply below 20°C. Air flow and hence fan power needed to cool grain is much lower than is needed to dry grain.

Conditions needed to control all stages of the rusty grain beetle, the most cold-hardy of the insects found in Canadian grain:

- Twelve weeks at grain temperatures of -5°C
- Eight weeks at grain temperatures of -10°C
- Four weeks at grain temperatures of -15°C
- One week at grain temperatures of -20°C

Physical Control

Moving of grain by pneumatic vacuum rather than by an auger will kill most of the insects present. Only a few rusty grain beetle larvae in the seed germ survive one pass through the machine (18).

Fungus beetles are controlled by the same treatments recommended for rusty grain beetles and other species associated with stored grain. However, these beetles do not feed on grain but rather on fungi associated with grain. Thus, their presence indicates that the grain is deteriorating. Although insecticide

treatment will control the fungus beetles, it will not correct the underlying problem of deterioration. As soon as grain producers detect these beetles, they should immediately turn their grain to break up lumps of heating grain and if the moisture content exceeds 14.5% the grain should be dried or aerated before placing it back into storage.

Treatment of Grain with Residual Insecticides

Contact insecticides registered for use on or near stored whole and processed cereals in Canada (2, 8, 21)

Location	Chemical		Use	Formulation Spray (S)/Dust (D)	Long- term control	Toxicity (LD ₅₀ rats- oral)
	Type	Name				
Farm	Organophosphate	Malathion	Bin, protectant	S, D	Yes	1000-2800
	Organophosphate	Dichlorvos	Space	S	Limited	50
	Botanical	Pyrethrins (synergized)	Bin, Space	S	No	1500
	Inorganic	Silicon dioxide	Cracks	D	Yes	Low toxicity
Poultry barns	Organophosphate	Tetrachlorvinphos	Bin	S	Yes	4000-5000
	Carbamate	Carbaryl	Cracks, local	D	Yes	246
	Pyrethroid	Cyfluthrin	Cracks, local	S	Yes	900
	Inorganic	Boric Acid	Cracks	D	Yes	500-5000
Seed grain	Organophosphate	Diazinon	Bin, protectant	S	Yes	300-400
	Organophosphate	Malathion	Bin, protectant	D	Yes	1000-2800
	Inorganic	Silicon dioxide	Protectant	D	Yes	Low toxicity
Food processing plant	Inorganic	Boric Acid	Cracks	D	Yes	500-5000
	Organophosphate	Chlorpyrifos	Cracks, local	S	Yes	96-270
	Organophosphate	Diazinon	Cracks, local	S	Yes	300-400
	Organophosphate	Dichlorvos	Space	S	No	50
	Organophosphate	Malathion	Cracks, local	S, D	Yes	1000-2800
	Botanical	Pyrethrins (synergized)	Cracks, local, space	S	No	1500
	Pyrethroid	Allethrin	Cracks, local, space	S	Limited	685-1100
	Pyrethroid	Cyfluthrin	Warehouse, cracks, local	S	Yes	900
	Pyrethroid	d-trans allethrin	Cracks, local, space	S	Limited	860
	Carbamate	Propoxur	Cracks, local	S	Yes	50-104
	Inorganic	Silicon dioxide	Cracks	D	Yes	Low toxicity
	Growth regulators	Methoprene (tobacco)	Cracks, local	S	Yes	34 600

Malathion

Rates for malathion in grain.

Active Ingredient	Rate	References
malathion grain protectant		
0.5% dust		
1.0% dust	1.6 kg/tonne	10
2.0% dust	0.5 kg/tonne 0.4 kg/tonne	
malathion - premium grade, 83.6% EC	10 mL in 0.5 - 0.8 L water/tonne	13

Note: Malathion is more effective in dry grain than in tough or damp grain where rapid breakdown

occurs (10). The Canadian Grain Commission does not recommend the use of grain protectants. Cooling grain through aeration is the preferred management practice (23). Malathion resistance in stored-product insects is increasing in Canada (17).

Restrictions

Do not apply to grain within 7 days of selling for premium grade, deodorized grain protectant or 60 days for standard malathion grades (check label). Grain treated with malathion should not be used as livestock feed for at least 60 days

Preparation and Application of Malathion

Prepare a 1% malathion spray from premium grade, deodorized emulsifiable concentrate (83.6%) by using the following formula: $(83.6-1)/L = 82.6$. Therefore, use 1 part of concentrate for every 82.6 parts of water (23). If a 50% malathion product is used add 1 part malathion to 49 parts water.

Determine the flow rate of grain through the auger.

Use a pressurized sprayer or any other suitable applicator, such as a homemade drip device (8), to apply the 1% spray continuously to the grain stream as it is discharged from the spout or as it enters the auger tube.

Determine the rate at which the pressurized sprayer or other type of applicator discharges insecticide. A needle valve may have to be fitted to regulate the flow of spray from the nozzle of the sprayer or gravity flow applicator. For example, to treat 13.5 metric tons of wheat (500 bu.), 10.8 litres of 1% spray is needed. If it takes an hour to auger the grain, the sprayer must discharge the insecticide at $10.8/60 = 0.18$ litres (6.3 fl oz) per minute.

Rates of application of malathion.

Flow Rate (wheat)				Application Rate (spray)			
Per hour		Per minute		Per hour		Per minute	
tonnes	bushels	tonnes	bushels	litres	gallons	litres	gallons
3	110.4	0.050	1.84	2.4	0.54	0.04	0.009
6	220.2	0.100	3.67	4.8	1.08	0.08	0.018
9	330.6	0.150	5.51	7.2	1.56	0.12	0.026
12	441.0	0.200	7.35	9.6	2.10	0.16	0.035
15	551.2	0.250	9.19	12.0	2.88	0.20	0.048

Diatomaceous Earth

Diatomaceous earth is more effective in dry grain than in tough or damp grain where greater concentrations are required for efficacy. Rates vary from 100 to 1000 g/t. The Canadian Grain Commission does not recommend the use of grain protectants and requires those marketing diatomaceous earth products to place a notice on the label that the use of higher dosage rates effects test weight of the grain.

Rate of application of diatomaceous earth as a residual treatment on seed (4) varies with commodity treated and target insect. Use of any diatomaceous earth will lower grain test weight, so potential grade loss must be considered but will not be a problem most years. Weeks to months are needed for complete control and a dust mask should be worn during application.

Restrictions

Diatomaceous earth-treated grain should not enter the commercial handling system where rates exceed 100 ppm (100 g per tonne) as grain will be at risk of losing grade due to adhered material. Dilution of treated with untreated grain would be advisable to avoid discrepancies in grade allocation.

Preparation and Application of Diatomaceous Earth

Diatomaceous earth may be applied only as a dust directly to grain. The most effective method of dust application is to apply this product to the grain at harvest prior to augering into the bin. This will assist in distributing the product evenly to the grain. Dust may be applied to the grain in the truck prior to augering or directly to the grain as it is flowing to the auger. Care must be taken to ensure as even an application as possible as high rates (over-treated areas or high rates of application) can cause strain to augering equipment.

Application can be performed simply by hand using a small container or equipment such as seed-treating or additive feeders may also be used.

Treatment of Grain with Fumigants

Safety Measures

Fumigants are poisons! Take extreme precautions when they are used. Do not enter a structure that is under fumigation. After the required fumigation period, aerate for 48 hours. Do not re-enter the structure until the phosphine concentration is less than 0.3 ppm. Stay up-wind from the fumigant while it is added to grain going into the auger as a bin is being filled.

Read the labels on the containers! Follow the manufacturer's recommendations. Wear protective clothing and gloves. A gas mask with a fresh canister should be used. In structures that are not airtight, do not fumigate when the temperature of the commodity is below 10°C.

Fumigation of Cereals

To fumigate cereals with aluminum phosphide, seal the grain bin as well as possible with caulking and masking tape before putting the infested grain in the bin, leaks of fumigant gas reduce the effectiveness of the fumigation and present a hazard to people and animals immediately down-wind from the fumigated bin. Preferably, mix the fumigant with the infested grain as well as possible under the circumstances. To do this, add the fumigant to the grain as it is being augered into a bin. It may be necessary to transfer grain from one bin to another. Auger holes are a problem. Add some fumigant to the auger hole at the end of the fumigation, and seal the door.

Solid Fumigants*

Rates of application for aluminum phosphide

Active Ingredient	Rate (g AI/ha)	References
Phosphine gas (Aluminum phosphide)	4 tablets or 8 pellets/m ³ grain (1 m ³ = 28 bushels)	1, 2

*For all grains and oilseeds apply the tablets or pellets while augering the grain into a clean and well-caulked bin. Use the entire volume of the bin, including the headspace, in dosage calculations. As of November 1997 the use and sale of aluminum phosphide is restricted to licensed pesticide applicators possessing a valid fumigation license (Saskatchewan) or stored agricultural products license (Manitoba).

Rates of application of aluminum phosphide at different temperatures.

Grain Temperature (°C)	Minimum Exposure Period (Dosage per m ³)	Days
above 20	4 tablets or 8 pellets	3-4
16-20	4 tablets or 8 pellets	4-5
13-15	5 tablets or 10 pellets	5-7
5-12*	5 tablets or 10 pellets	10+
below 5	Do not fumigate	-

*Below 10°C, fumigation is not advisable in structures that are not air-tight.

Fumigants in Cylinders

Phosphine

A new formulation of the fumigant phosphine, gaseous phosphine in a cylinder, was registered in Canada in 2004. As with solid aluminum phosphide, the use is restricted to licensed pesticide applicators possessing a valid fumigation license. The only manufacturer is Cytec Canada Inc., and the product name is ECO₂FUME Fumigant Gas. The product is delivered in a cylinder, with 2% phosphine, and 98% carbon dioxide, with 0.61 kg of phosphine per cylinder. ECO₂FUME can be used at slightly lower temperatures than aluminum phosphide.

Rates of application of phosphine (ECO₂FUME) at different temperatures.

Grain Temperature (°C)	Dosage (ppm)	Days
above 16	200-500	2-3
12-15	200-500	3-5
5-12	200-500	4-10
0-4	200-500	6-14
0	Do not fumigate	-

Carbon Dioxide Fumigation

As with any type of fumigation, a very well sealed or relatively air-tight grain bin is needed for the product to be effective (16, 19, 20).

To fumigate cereals with carbon dioxide, seal the grain bin as well as possible with caulking, adhesives and tape prior to putting grain in the bin. As with other fumigants, leaks of fumigant gas reduce the effectiveness of the fumigation and present a hazard to people and animals immediately within the vicinity of the fumigation. As carbon dioxide is heavier than air, care must be taken in low lying areas where accumulation may occur. Carbon dioxide may be added to the bin from the bottom or the top, however, ensure purging is complete prior to sealing. This may be accomplished by measuring oxygen concentrations near the surface or bin bottom.

Fumigation of Grain with Carbon Dioxide

Exposure times to carbon dioxide at different temperatures.

Grain Temperature (°C)	Dosage	Exposure Time (Days)
≥ 25°C	≥ 60%	2-3
20°C - 25°C	≥ 60%	4-5
15°C - 20°C	≥ 60%	6+

* below 15°C a much longer exposure time is required.

Empty Bin Sprays and Dusts

Insecticides used in empty bins (2).

Active Ingredient	Rate	References
malathion - premium grade*	1% or 2.5-3%	1, 11
pyrethrins + piperonyl butoxide	0.1% + 1.0%	14
dichlorvos (DDVP-350)**	8 g/L oil at 2 mL/m ³	
diatomaceous earth	5g/m ²	4
cyfluthrin	0.05 to 0.1%	

* Apply 5 L/100 m² to floors and walls of empty, cleaned granaries. Malathion should be used 2-4 weeks before introducing grain. However, it may be used 1 day prior to storing grain. In granaries to be used for canola storage, apply malathion only to infested locations usually at floor and wall junctions (15, 16). Caution should be used when using malathion for crack and crevice insect control in bins to be utilized for canola storage. These oilseeds absorb malathion and various importing countries have very low tolerances to residues.

** Dichlorvos is applied by thermal or mechanical fogger at ultra low volumes.

WAREHOUSES

Common insect pests: confused flour beetle, dermestid beetles, hairy spider beetle, merchant grain beetle, red flour beetle, rusty grain beetle, sawtoothed grain beetle, merchant grain beetle and Indian meal moth.

Non-Chemical Control

Cold

As stated above low temperature will slow the rate of growth of insect populations and if temperatures are low enough for an extended time they will control insects. Different insects have different sensitivities to cold (3).

Chemical Control in Warehouses

Rates of application for different contact insecticides for warehouses.

Active Ingredient	Rate	References
malathion*	2% spray	9
pyrethrins + piperonyl butoxide	0.1% + 1.0%	
cyfluthrin	0.05 to 0.1%	

*Apply at 5 L/100 m² to floor and lower half of walls of warehouses every 7 to 28 days during March-August.

Note: Malathion and pyrethrins are much less effective on concrete than on wood surfaces (12). Pyrethrins generally breakdown quickly, but are more efficacious in cooler temperatures.

To control lesser meal worm in poultry barns there are a few products registered. Carbaryl (1a), tetrachlorvinphos, or boric acid 98%, are registered for use against this species in poultry barns. Carbaryl may be applied to floors at a rate of 1.25 kg. WP in 100 L of water. Note: These products are not to be applied to animal feed or grain for human consumption.

Fumigation of Food Processing Facilities, Processed Food and Warehouses

Magnesium phosphide generates phosphine faster than aluminum phosphide. It is available in four formulations. It can be used as a spot fumigant in food- and feed-processing machinery and equipment. It can be used to treat warehouses that contain processed foods, feeds and non-food commodities. See the discussion above regarding precautions needed when applying a fumigant.

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