

WAREHOUSES AND FARM STORED GRAIN

Noel D.G. White and Paul G. Fields

Additional info 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.

Warehouses

Confused flour beetle, dermestid beetles, hairy spider beetle, merchant grain beetle, red flour beetle, rusty grain beetle, sawtoothed grain beetle, merchant grain beetle, Indian meal moth.

Chemical Control in warehouses

Active Ingredient	Rate	References
malathion*	2% spray	4
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 (8). Pyrethrins generally breakdown quickly.

Grain/Bins

Dermestid beetles, foreign grain beetle, fungus beetles, granary weevil, hairy spider beetle, lesser mealworm, meal moth, psocid, red flour beetle, rusty grain beetle, sawtoothed grain beetle, storage mites.

Residual Treatments

Empty Bin Sprays and Dusts

Active Ingredient	Rate	References
malathion - premium grade †*	1% or 2.5-3%	1,1A,4
pyrethrins + piperonyl butoxide	0.1% + 1.0%	10
dichlorvos (DDVP-350)	16 g/2 L oil at 2 mL/m ³	1
diatomaceous earth	5g/m ²	20
cyfluthrin	0.05 to 0.1%	

* Apply 5 L/100 m² to floors and walls of empty, cleaned granaries.

† In granaries to be used for rapeseed storage, apply malathion only to infested locations usually at floor and wall junctions (11,12).

Notes: Malathion should be used 2-4 weeks before introducing grain. However, it may be used 1 day prior to storing grain. Dichlorvos is applied by thermal or mechanical fogger at ultra low volumes.

Prevention Or Control in Stored Wheat, Oats Or Barley

Active Ingredient	Rate	References
malathion grain protectant		
0.5% dust	1.6 kg/tonne	5
1.0% dust	0.5 kg/tonne	-
2.0% dust	0.4 kg/tonne	-
malathion - premium grade 83.6% EC	10 mL in 0.5 - 0.8 L water/tonne	9

Note: Malathion is more effective in dry grain than in tough or damp grain where rapid breakdown occurs (5). The Canadian Grain Commission does not recommend the use of grain protectants (1). Cooling grain through aeration is the preferred management practice (7).

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).

* Rate of application of diatomaceous earth as a residual treatment (20) varies with product 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. A dust mask should be worn during application.

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 (7). 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 (3), 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 are 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.

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

All contact insecticides registered for use on or near stored whole and processed cereals in Canada (19)

Location	Chemical		Formulation	Use	Spray (S)/ Dust (D)	Long-term control	Toxicity (LD ₅₀ rats-oral)
	Type	Name					
Farm	Organophosphate	Malathion	Bin, protectant	S, D	Yes	1000-2800	
		Dichlorvos	Space	S	Limited	50	
	Botanical	Pyrethrins (synergized)	Bin, Space	S	No	1500	
Poultry barns	Inorganic	Silicon dioxide	Cracks	D	Yes	Low toxicity	
	Organophosphate	Tetrachlorvinphos	Bin	S	Yes	4000-5000	
	Carbamate	Carbaryl	Bin	S	Yes	246	
	Inorganic	Boric Acid	Cracks	D	Yes	500-5000	
Seed grain	Organophosphate	Diazinon	Bin, protectant		Yes	300-400	
	Chlorinated hydrocarbon	Lindane	Bin, protectant	S	Yes	88-125	
Food processing plant	Inorganic	Methoxychlor	Bin, protectant	S, D	Yes	6000	
		Silicon dioxide	Protectant	D	Yes	Low toxicity	
	Organophosphate	Clorpyrifos	Cracks, local	S	Yes	96-270	
		Diazinon	Cracks, local	S	Yes	300-400	
	Pyrethroid	Dichlorvos	Space	S	No	50	
		Fenthion	Cracks, local	S, D	Yes	250	
		Malathion	Cracks, local	S, D	Yes	1000-2800	
		Naled	Space	S	Yes	250	
		Pyrethrins(synergized)	Cracks, local, space	S	No	1500	
	Carbamates	Allethrin	Cracks, local, space	S	Limited	685-1100	
		Cyfluthrin	Warehouse, cracks local	S	Yes	900	
		d-trans allethrin	Cracks, local, space	S	Limited	860	
		Bendiocarb	Cracks, local	S	Yes	40-156	
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		

Feeding Treated Grain to Livestock

According to the Abell-Waco label, grain treated with 50% EC malathion applied at recommended rates, should not be fed to livestock for at least 2 months after treatment. According to the American Cyanamid label for Cythion, grain treated with formulations made from 83.6% or 50% premium-grade malathion

should not be used as livestock feed for at least 60 days.

Note: Malathion resistance in stored-product insects is increasing in Canada (13). As of 1991, malathion will likely no longer be registered for use on grain in the U.S.A. because of residues and lack of interest by manufacturers to collect re-registration data.

Fumigation

Safety Measures

Fumigants are poisons; take extreme precautions when they are used. Do not enter a structure that is under fumigation. Wait for at least 13 days before opening a farm structure that has been under fumigation. Most fumigants will have escaped by 5 days but a further 7 day waiting period is advised. Stay up-wind from the fumigant while the fumigant is added to grain going into the auger as a bin is being filled with grain.

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. Do not fumigate when the temperature of the commodity is below 10°C.

Fumigation of Food Processing Facilities, Processed Food and Warehouses

Magnesium phosphide generates phosphine faster than aluminium 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.

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.

Chemical Control

Solid Fumigants*

Active Ingredient	Rate (g Al/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, wait 12 days before opening the storage structure. 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

WCCP 2004

restricted to licensed pesticide applicators possessing a valid fumigation license (Saskatchewan) or stored agricultural products license (Manitoba).

Grain Temperature (°C)	Minimum Exposure Period (Dosage per m³)	Days
above 20	4 tablets or 8 pellets	3
16-20	4 tablets or 8 pellets	4
13-15	5 tablets or 10 pellets	5
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.

After fumigation aerate all products at least 48 hours (i.e., open all doors and vents, and use aeration fans if available).

Fumigants in Cylinders

Phosphine

A new formulation of the fumigant phosphine, gaseous phosphine in a cylinder, was registered in Canada in 2004. As with the 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.

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

Carbon Dioxide Fumigation

Carbon dioxide gas is no longer registered for insect control in stored grain in Canada. This method was

effective (14,15) but relatively air-tight storage structures were needed (sealed steel hopper bins, see 21)

Turning Grain in Cold Weather

Auger 'cooling' grain to another bin during winter. Several transfers may be needed to lower grain temperature to below freezing (6). One transfer lowers average temperatures about 10°C.

Aeration: Cool grain as quickly as possible in the fall (insects do not multiply below 20°C).

To control all stages of the rusty grain beetle:

One week at grain temperatures of -20°C

Four weeks at grain temperatures of -15°C

Eight weeks at grain temperatures of -10°C

Twelve weeks at grain temperatures of -5°C

Pneumatic Movements of Grain: Movements of grain with pneumatic vacuum rather than an auger will kill most of the insects present. Only a few rusty grain beetle larvae in the seed germ will survive one grain pass through the machine (19).

Lesser mealworms are occasionally found in grain and animal feed. Because they are relatively large, they are readily visible and therefore appear to be more serious than they actually are.

Chemical Control - Malathion or pyrethrins may be used to control these insect in grain; however, carbaryl (1A), tetrachlorvinphos (Disp 50, Gardona), or Boric acid 98% (Darkling Beetle Dust; cracks and crevices), 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.

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.

Probe traps for insertion into stored grain to detect insects at low densities are extremely useful tools for grain managers (16,17) and can be purchased from Trécé Inc., 7569 Highway 28 West, P.O. Box 129, Adair OK 74330, www.trece.com.

References

1. Anon., Stored Grain Pests Supplement to the Official Grain Inspectors' Manual. Can. Grain Comm. Winnipeg. 1989.
- 1A. Anon., Manitoba Agriculture, Insect Control Guide. 1988.
2. Monro, FAO Agr. Studies No. 79,381 pp. 1969.
3. Quinlan, White, Wilson, Davidson and Hendricks, J. Econ. Entomol. 72:90-93. 1979.
4. Tauthong and Watters, J. Econ. Entomol. 71:115-121. 1978.
5. Watters, J. Econ. Entomol. 53:341-349. 1959.

WCCP 2004

6. Watters, J. *Econ. Entomol.* 56:215-219. 1963.
7. Mills *et al.*, *Agric. Can. Publ.* 1851. 1990.
8. Watters, J. *Econ. Entomol.* 69:353-356. 1976.
9. Watters and Bickis, J. *Econ. Entomol.* 71:667-669. 1978.
10. Watters and Sellen, J. *Econ. Entomol.* 49:280-281. 1956.
11. White and Abramson, J. *Econ. Entomol.* 77:289-293. 1984.
12. White, J. *Econ. Entomol.* 78:1315-1319. 1985.
13. White and Loschiavo, J. *Econ. Entomol.* 78:511-515. 1985.
14. White, Jayas and Sinha, *Phytoprotection* 69:31-39. 1989.
15. White, Jayas and Sinha, J. *Econ. Entomol.* 83:277-288. 1990.
16. White *et al.*, *J. Kansas Entomol. Soc.* 63:506-525. 1991.
17. Madrid, White and Loschiavo, *Can. Entomol.* 122:515-523. 1990.
18. White and Leesch., *Chemical Control*. In: *Integrated Management of Insects in Stored Products*. 1996.
19. White, Jayas, and Demianyk, *Phytoprotection*. 78: 25-84. 1997.
20. Fields and Muir. *Physical Control*. In: *Integrated Management of Insects in Stored Products*. 1996.
21. Mann, Jayas, White, and Muir. *Can. Agric. Engin.* 39:91-97.