

Avoid Surprises at Delivery: Good Grain Storage Practices.

Paul Fields (pfields@agr.gc.ca) and
Noel White (nwhite@agr.gc.ca)
Agriculture and Agri-Food Canada
Cereal Research Centre
195 Dafoe Rd., Winnipeg, MB

WHY DO WE CONTROL STORED-GRAIN INSECTS?

Canada has a reputation around the world for high quality grain. To maintain this high standard of quality, Canada sells its grain with an assurance that it is free of grain-feeding insects. Given the correct conditions, insect populations can increase rapidly, decreasing the quantity of grain, reducing the quality and in extreme cases causing "hot spots", moist pockets of heating grain (White, 2001).

THE GOOD, THE BAD AND THE RED HERRINGS

There are four types of insects that you can find in stored grain.

1. Grain-feeding: These insects feed directly on the grain and are considered primary insects by the Canadian Grain Commission. The most common insect of this type found in grain stored on the farm in Western Canada is the rusty grain beetle, (Figure 1A). This beetle usually develops on the germ. The larvae feed inside the kernel at the germ end, and the adult (0.2 cm long, flat, reddish-brown, antennae not clubbed shaped) moves throughout the grain bulk. They consume the entire seed germ. The second most common grain-feeding insect is the red flour beetle (Figure 1B). It is twice as long as the rusty grain beetle and has clubbed antennae. They consume the entire seed germ and chew parts of the endosperm. Other insects that are common in the USA are now being found sporadically in stored grain in the Canadian Prairies. The lesser grain borer has been detected a few times in grain and thousands have been found flying outside of grain-handling facilities in Alberta and Manitoba. The rice weevil has also been sporadically found in grain in Canada. Both these insects bore directly into the kernel and cause more damage than the rusty grain beetle and the red flour beetle. It is doubtful that these new insects can become widespread as they need high temperature grain to reproduce and survive. However, they may become a problem in badly managed grain stocks, such as large unaerated grain bulks.

2. Fungus Feeding: These insects can be found in large numbers in grain and oilseeds especially if the seed is tough or damp. These are considered secondary insects by the Canadian Grain Commission. Fungus beetles feed on moulds and dust, not directly on the grain and oilseed, and if these are the only insects found in the grain, control is not required. However, their presence indicates the grain is going out of condition and needs to be turned or dried. Often these insects are confused with the rusty grain beetle or even the red flour beetle for which control is required. The most common fungus beetles are the foreign grain beetle, the square-nosed fungus beetle

and the sigmoid fungus beetle. Fungus beetles can climb on glass walls, whereas the rusty grain beetle and the red flour beetle can not.

3. Predators: These insects feed on other insects and in some situations they can reduce the population of grain-feeding insects dramatically. Some examples are the bug *Xylocoris flavipes* and the wasp *Bracon hebitor*. In the USA, parasitoids released into grain bulks have controlled stored-grain pests. Little work has been done in Canada, partly because the zero tolerance for stored-grain pests would be difficult to obtain with just predators and parasitoids, and our grain is stored cooler than most grain in the USA.

4. Field Origin: These insects feed on the crops in the field, and they are present just after harvest. However they will not live for very long and do not feed on the stored grain. Some of examples of these insects are grasshoppers, flea beetles, lygus bugs or ground beetles. It is unnecessary to control these insects in stored grain.

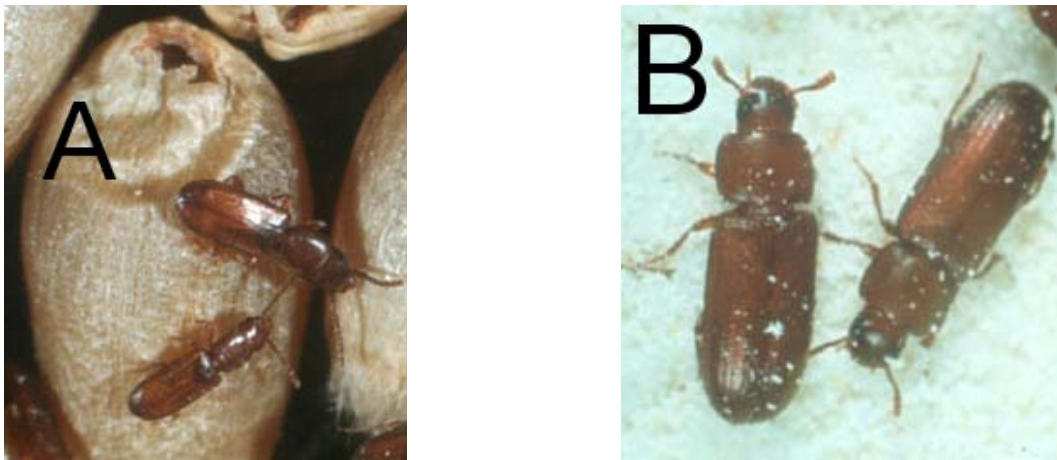


Figure 1 (A)The rusty grain beetle, the most common insect in stored grain in Western Canada, both on the farm and at the elevator, (B) the red flour beetle, the second most common insect in stored grain in grain stored on farms in Canada.

WHERE THERE'S SMOKE THERE'S FIRE

Detecting stored-grain insects can be like looking for the proverbial needle in the haystack. These insects are hidden, small, and can be deep within the grain bulk.

Carbon dioxide and temperature are the "smoke" from the "fire" of an insect infestation. Because insects respire they give off heat, and at high densities, "hot spots" can be created that are detected by measuring the temperature. Metal rods placed in the grain for an hour are one way to detect hot spots. Thermometers, either attached to the end of a probe or wired permanently into a bin with a remote electronic readout, give a quicker more accurate picture of grain temperature. However, hot spots can be very localized and heat will not move more than 1 metre, therefore they are difficult to detect. Also by the time hot spots are detected, significant damage is already done. Increases in the carbon dioxide concentrations in the grain indicate at an earlier stage of the infestation that there are insects or mouldy grain in the bin. Tubes are placed down into

the top centre of the grain mass, and the intergranular air is sampled every 2 weeks. Air is sampled with a hand pump and passed through a Drager tube for measuring carbon dioxide. Levels above 1% mean the grain must be moved or aerated. Both these methods will also detect the growth of moulds, which also produce heat and moisture and carbon dioxide.

Most grain managers don't call the fire department (take action) until they see the fire (insects in the grain). Insects are most often detected when grain is shaken down to estimate dockage (foreign material and broken seeds) at the grain elevator. This method has two major short comings; it will not detect insects that are inside the kernel, and often only one sample is taken per truck load or bin. This may be adequate to assess the grade of grain, but because grain insects have a clumped distribution, more samples are needed to insure that a grain bulk is not infested, using a grain probe. The advantage of this method is that it can be done rapidly and the type of insect can be identified. Insects typically become abundant around November or December, if the grain is warm after insects have been multiplying for 3 or 4 generations.

The Canadian Grain Commission and some larger grain-handling facilities use Berlese funnel extractions. Grain samples are placed on a funnel with a light bulb above it which heats and dries the grain, driving the insects into a collection jar with water or alcohol. The major disadvantage of this method is that it takes several hours, and once again only one sample is usually taken for several tonnes of grain. The main advantage of this method is that it will drive out some insects, especially larvae that are hidden inside the kernel.

Probe pitfall traps (Figure 2, www.trece.com) are one way to sample a larger area of grain than the kilogram placed on a sieve or Berlese funnel. It is placed into the bulk grain, and as insects move through the grain they fall into the trap. The traps are left in the grain and are checked periodically. The advantage of this method is that it is more sensitive than the previous two methods. The disadvantages are the length of time needed run the test (traps should be left in 2-7 days), it is ineffective below 10 °C (insects stop moving) and the trap must be placed in the grain (impractical in many elevators).

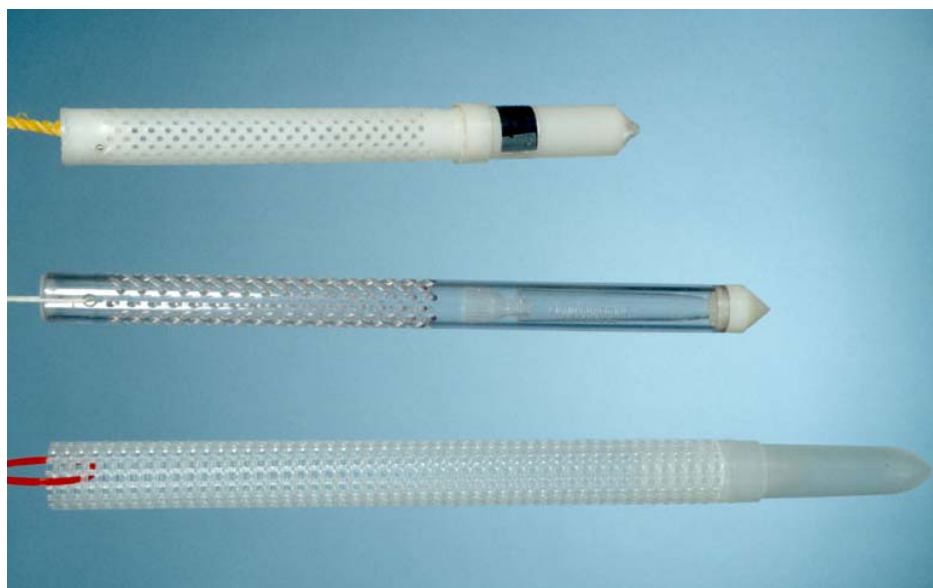


Figure 2. Probe pit fall trap used to detect insects in stored grain.

CONTROL OPTIONS

Aeration and Turning

Cool grain right away at harvest when it is first loaded into the bin, usually at night using. Aeration systems are designed either to cool or to cool and dry. To cool grain, airflows of 1-2 (L/s)/m³ will cool grain in 75-200 hours. To cool and dry grain, much higher airflows, 9-30 (L/s)/m³ and more powerful fans are required (Friesen and Humnicki 1986). The cooler the grain, the slower the insects will develop and there will be fewer insect problems down the road. Insects stop developing at 15°C. Later in the fall, grain can be aerated again to bring temperatures down low enough to kill insects. To kill all stored-product insects it takes grain temperatures of -20°C for 1 week, -15°C for 4 weeks, -10 for 8 weeks or -5°C for 12 weeks.

Turning grain during the winter is another way to cool grain. It is not as effective as aeration to cool grain, but it will break up hot spots or moist pockets in the grain bulk. Cool grain on the outside of the bin will be mixed with the warm grain in the centre of the bin.

Physical Control

Pneumatic grain conveyers (grain vac) with cyclones that have an airlock and a speed of 1000 rpm will kill insects and mites when grain is moved. Red flour beetles are common in farm stored grain, but are rare in terminal elevators, where the most common insect is the rusty grain beetle larva. Movement of the grain from farm to elevator to railcar to terminal elevator is probably responsible for the reduction of red flour beetle infestation as grain moves to the terminal elevator. Cleaning grain will remove most of the adults, but larvae and pupae will remain in the grain and continue to cause damage.

Contact Insecticides

Contact insecticides can be sprayed on to the surfaces of empty grain stores to insure that no insects are present when grain is loaded into the bin (Table 1). Some contact insecticides may be sprayed directly on to grain to give long term protection against infestation.

Malathion is more effective in dry grain than in tough or damp grain where rapid breakdown occurs. The Canadian Grain Commission does not recommend the use of grain protectants. Cooling grain through aeration is the preferred management practice. 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). Pyrethrins with piperonyl butoxide can be used as a space treatment for flying stored-product insects or exposed beetles. The building or empty bin should be kept closed for one hour after application. Dichlorvos can be used as a fog to control stored-product insects infesting packaged or bagged food commodities. Diatomaceous earth (DE) is made up of the skeletons of prehistoric diatoms, single-celled algae. DE used for pest control is a fine powder consisting of mainly silicon dioxide. The DE attaches to the skin of the insects, absorbs the waxy layer and insects die from desiccation, a mode of action very different than synthetic insecticides. DE can be used directly on the grain or in empty bins to control insects before filling with grain. Cyfluthrin (Tempo) is used as a spray in empty bins, warehouses feed mills and food processing facilities. It can be used as a crack and crevice application.

Table 1. Contact insecticides registered for use in empty grain stores and directly on grain.

Active Ingredient	Rate for empty bins	Rate for grain
malathion	1% or 2.5-3%*	1.6 kg/t grain**
pyrethrins + piperonyl butoxide	0.1% + 1.0%	Not Permitted
dichlorvos	16 g/2 L oil at 2 mL/m ³	Not Permitted
diatomaceous earth	5 g/m ²	100-1000 ppm
cyfluthrin	0.05 to 0.1%	Not Permitted

* do not use malathion for bins used to store canola or other oilseeds

** 0.5 % malation dust

Fumigants

Two fumigants are registered in Canada for grain, phosphine and carbon dioxide. 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.

Aluminium phosphide pellets are the most common method of fumigation. Aluminium phosphide reacts with water in the air to produce phosphine gas. To fumigate cereals with aluminium 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 aluminium phosphide pellets with the infested grain as it is being augered into a bin. Aluminium phosphide pellets can also be probed into the grain, but this requires workers to enter into the bin and gives a more uneven fumigant distribution, but the grain does not have to be moved. For bins over 20 metres high, recirculation of the fumigant enables the grain to be fumigated with out being moved.

Recently, a new formulation of phosphine, ECO₂FUME, has been registered in Canada. It is gaseous phosphine (compressed gas in a cylinder), which allows a more precise dosage of phosphine, faster fumigations and fumigation at a slightly lower minimum temperature (0°C) than aluminium phosphide (5°C).

Carbon dioxide is applied to grain as a gas from cylinders or as dry ice. To be effective carbon dioxide must be applied in well-sealed bins, such as hopper-bottomed bins with modified hatches. Grain should be at least 25°C, with 80% carbon dioxide for 9 days, 60% carbon dioxide for 11 days or 40% carbon dioxide for 17 days. When carbon dioxide is introduced pressure will increase in the container and a pressure release valve should be attached.

Additional information on stored product insects can be found at the Canadian Grain Commission web site
http://www.grainscanada.gc.ca/Entomology/insect_infestations-e.htm.

TAKE HOME MESSAGE

Not all insects found in stored-grain need to be controlled. Those that do need to be controlled often are only found when they have already caused considerable damage. For grain stored on the farm, probe pitfall traps are the best way to detect insects in grain bins. They provide a sensitive, continuous method to monitor for insects in the bin. In Western Canada, traps will become ineffective by December when grain temperatures in non-aerated grain drop below 10°C and the insects' movement is significantly reduced. However, most bins that will have a problem with insects will have them by late October. For grain received or stored at the elevator, sieving is a good quick way to detect insects. For stocks that are suspect, additional sampling and Berlese funnel extractions should be done. There are several ways to control storage insects, cold, contact insecticides and fumigants. Before applying any insecticide, read the instructions on the pesticide label and follow the instructions.

REFERENCES

Friesen O.H. and Huminicki D.N. 1986. Grain aeration and unheated air drying. Manitoba Agriculture, Agdex 732 – 1.

White, N.D.G. 2001. Protection of farm-stored grains, oilseeds and pulses from insects, mites and moulds. Agriculture and Agri-Food Canada Publication 1851/E (Revised).