Preparing for storage—grain stores and machinery

Correct grain hygiene is the basis for successful on-farm storage. Infestation generally occurs during or following harvest. The saying, *Prevention is better than cure*, certainly applies to grain hygiene. It is easier and better to prevent an infestation than to treat an established one. Maintaining a clean and tidy workplace also provides a safer environment.

Danger areas. From season to season, stored grain pests will multiply in grain left lying around storage structures and grain handling equipment. A bag of infested grain may produce over a million insects in one year. These insects will move to other sources of feed and start new infestations. Hygiene methods which eliminate insect breeding areas form the basis of successful grain storage.

The main sources of infestation are:

- grain stored for feed or seed
- residues of grain in harvesting or handling equipment
- residues of infested grain in storages.

Routine measures

Grain insects will hide in dark crevices, under grass and leaves surrounding storage areas, between steel sheeting joints in silos and sheds, around inlets and outlets, inside conveyors and headers or wherever grain is stored. Sheds and bulk stores usually have areas which retain significant amounts of grain and dust and require careful cleaning. Older silos too often have poor 'grain shedding' joins and ledges.

Bags should also be kept clean of grain residues or else thrown out. Grain spilt during loading and unloading should be cleaned up and destroyed straight away. Areas around storage structures and equipment should be kept clean and weed free, to assist in removing grain spills.

It is essential to plan a cleaning program and to have specific cleaning equipment. Equipment, which need not be expensive, would include an air compressor and fittings, air guns, vacuum cleaner, firefighting pump and hose and brooms.

Routine measures include:

- cleaning machinery

- cleaning storages
- surface treatment.

Cleaning machinery

Cleaning machinery before and after harvest prevents the breeding of insects. Headers are specially important in maintaining the hygiene of grain stored on-farm, as they are known to be the most common source of infestation in on-farm storage.

The time and effort involved in cleaning a header is well spent, because it will minimise insect reinfestation. Some growers clean the header by flushing it out with the first batch of grain. This is inadequate as there are always some insects which remain and the flushing grain may contaminate other grain. After cleaning out and disinfesting the header, treat it with Dryacide powder as per label rate and directions.

After cleaning out augers treat with Dryacide powder or Alfacron as per label rate and directions.

Cleaning storage structures

Clean out silos and storage structures using compressed air, vacuuming, brushing or washing as appropriate. Clean up around storages, removing weeds and rubbish. Mow around the storage facility and ensure easy access to it. Ensure any grain residues and old bags are removed and destroyed.

When inspecting empty storages, look for ways to make the structures easier to keep clean. Cracks and crevices should be sealed or filled to prevent grain lodging and insect infestation. Treat silos and storage structures with Dryacide (powder or slurry where directed) or approved insecticide as directed.

Surface treatment

Cleaning and surface treatment should be carried out six weeks before the expected start of harvest if possible—these treatments will be described below.

What preparation is required?

Surfaces should first be cleaned up with water or compressed air.

What materials can be sprayed?

There are several materials to choose from:

- an inert dust
- insecticide sprays containing fenitrothion or chlorpyrifos methyl (Reldan) alone or mixed with carbaryl
- the more effective but more expensive alfacron wettable powder
- the rapidly acting but short lived dichlorvos.

In Western Australia, only fenitrothion may be used.

When should the insecticide treatments be used?

Just before the silo is filled, any of the following can be applied:

- Alfacron wp
- or carbaryl plus Reldan
- or carbaryl plus fenitrothion.

This is not suitable, however, for residue free grain, due to the chance of contamination from the surface treatment.

When should inert dust be used?

Spraying surfaces with an inert dust such as dryacide is a long lasting non-polluting way of reducing infestation on surfaces. Dryacide inert dust should be applied as a slurry treatment at 600g/100m² at least 6 weeks (some say 4 weeks) before grain goes into the store. Dryacide is not good in persistently damp areas. It is suitable for storage of residue-free grain. Only dryacide is used in WA.

What about header treatment?

Dryacide as a powder application should also be used to protect the header against insects after cleaning with a non-chemical treatment.

When should dichlorvos be used?

Dichlorvos is a very quick acting insecticide of short persistence and should not used for residual treatments except in circumstances where an infestation must be cleared up in a very short time. It is also being used in central storage to control psocid infestations. Great care must be taken to avoid exposure to the spray—always follow the safety instructions on the label.

The following table shows the application rate of surface treatments:

Insecticide concentration*	**Application rate**
Alfacron 0.5 %	**5 litre per 100m²**
Reldan 1% plus carbaryl 1 %	**5 litre per 100m²**
fenitrothion 1% plus carbaryl 1 %	**5 litre per 100m²**
Actellic 1% plus carbaryl 1 %	**5 litre per 100m²**
dichlorvos 0.5 %	**5 litre per 100m²**

activated silica (Dryacide)	**600g powder per 100m² in a slurry with water**

*In Western Australia, only fenitrothion at 1% may be used.

Information about products, suppliers and formulations is given in the Updates section—see the bottom menu bar.

What is dryacide?

Dryacide is a type of inert dust. Inert dusts are generally an amorphous (i.e. non-structured) form of silica which acts by adsorbing the insect's cuticle (protective exterior), causing death by desiccation (drying out). The silica may be natural, as in diatomite, or synthetic. Dryacide was formerly produced in Western Australia but is now produced in the USA.

Can silica be used on pesticide residue free grain?

The use of silica as a surface treatment is suitable for handling pesticide residue free grain. The AWB Ltd and Flour Millers Council have approved the use of dryacide as a capping treatment to prevent insects reinfesting fumigated or aerated grain. However, dryacide cannot be used as an admixture treatment with wheat or barley because it alters physical properties such as bulk density and grain flow.

What are space treatments?

The term 'space treatments' refers to mist or fog treatments used to prevent infestation in mills, food processing plants and warehouses containing bagged goods. BOC (Australia) has developed Pestigas and Insectigas-D. These two products give the cleanest and most effective mists. Mist treatments are prepared as follows:

- insecticides are dissolved in liquid carbon dioxide
- 0.4% pyrethrins in carbon dioxide is called Pestigas
- 5% dichlorvos in carbon dioxide is called Insectigas-D.

Most Pestigas systems operate on a timer which releases the gas in the evening in closed premises. This avoids human exposure and maximises exposure of flying insects.

Should farmers be using Insectigas?

Insectigas will not be needed in on-farm storage unless there is a lot of bagged commodity in fairly well closed warehouses which needs protection from moths or other flying insects.

Pre-harvest checklist

The following is a pre-harvest checklist you could use:

ONE—Clean out and disinfest the header. Treat the header with Dryacide powder as per label rate and directions.

TWO—Clean out and surface treat silos and storage structures. Treat silos and storage structures with Dryacide (powder or slurry where directed) or Alfacron as per label rate and directions. In WA, only fenitrothion may be used.

THREE—Clean out and treat augers. Treat augers with Dryacide powder or Alfacron.

FOUR—Clean up around storages, removing weeds and rubbish. Mow around the storage facility and ensure easy access to the storage facility.

FIVE—Ensure any grain residues and old bags are removed and destroyed.

Monitoring

Good grain hygiene requires regular inspection of all stored grain. Grain must be checked for insects on a regular basis—every 2 to 4 weeks, but preferably every 2 weeks during warm weather. Regular checks are important because small insect populations can build up rapidly to very high levels that may destroy your grain. Most customers have a nil tolerance for live insects, and loads tendered with live insects will be rejected.

Detecting insects in grain bulks

There are two methods:

- **probe sampling:** samples of grain are taken from the grain bulk with a probe sampler and sieved using a standard wheat screen. Insects present in the sample should be visible in the screenings.
- **traps:**insect traps are inserted into grain bulks and periodically inspected to see whether any insects are present.

Trapping is much more efficient than probing and sieving for detecting insect populations. The traps are designed to reside in the grain and trap insects as they move through the bulk.

Figure: Detecting insects with pitfall traps

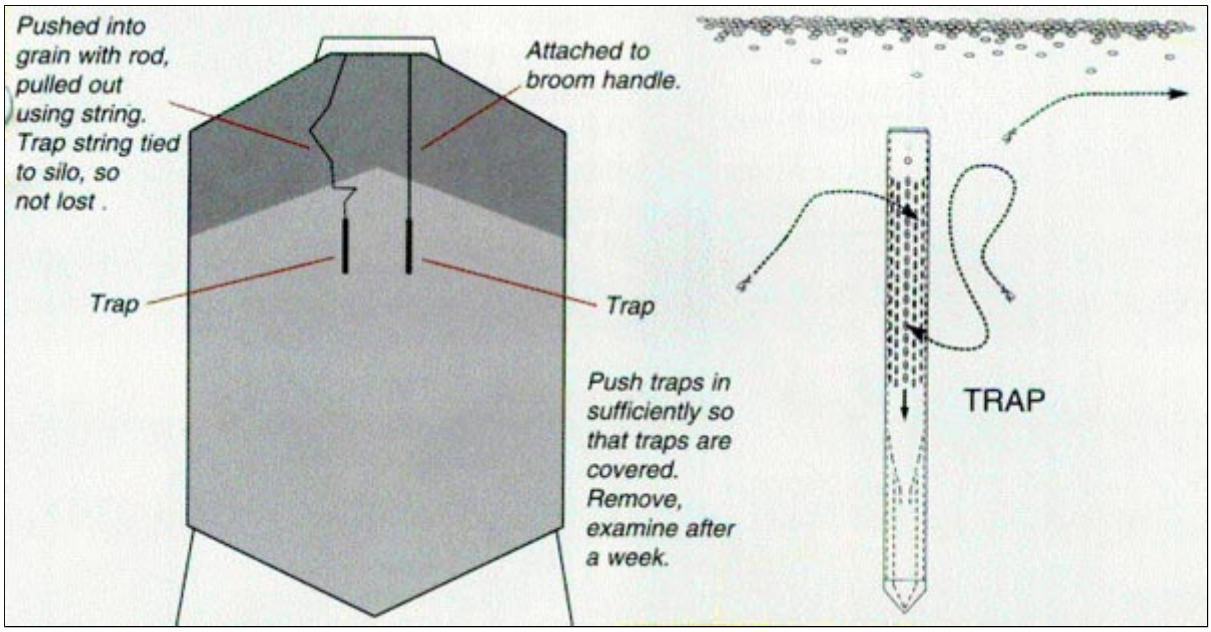


Diagram courtesy of GRDC and Dr David Rees, CSIRO Australia, Division of Entomology, Stored Grain Research Laboratory.

More details are provided in an article by Dr David Rees (❑).

For large bulks of grain, infestation may be detected by feeling hotspots on the top of the grain. Insect smell or frass may also indicate infestation. This inspection should also look for fungal damage on the grain surface. If insect infestation is found, control measures may be necessary to prevent excessive damage and cross-contamination. Remember, if the grain is to be treated prior to sale, always adhere to the withholding period on the chemical label.

Sources of probes and traps are given in the Updates section on the bottom menu bar.

Detecting insects in empty stores

Insect populations can quickly establish themselves from small resident populations living in the storage when the store is empty. These insects live mainly on grain spills, grain dust and other residues left behind from the previous harvest and pose a significant threat to new season's grain.

The presence of insects is best detected by using crevice or bait traps. These are described in the article by David Rees (❑).

Pheromones (sex attractants) are available for the open space traps and pitfall traps, but these would not be usual in on-farm storage. The main uses of pheromone traps (see Updates) are to measure moth densities in large warehouses and to disrupt mating.

To locate suppliers of insect traps, click Updates on the bottom menu bar, then choose Suppliers and services from the side menu.

Do-it-yourself traps

The following extracts and illustrations are from *Do-it-yourself Traps to Monitor Storage Pests* by David Rees, Stored Grain Research Laboratory, CSIRO Entomology, Canberra. The article was published in *Australian Grain*, February-March 1999, pp. 3-4.

Do-it-yourself traps

One way to monitor for the presence of insects is to use traps. The alternative—visual inspection—can be time-consuming to do properly. Many growers, too busy with other things, tend to neglect this activity with the risk of a nasty surprise later on.

Use of traps can cut down significantly the amount of time needed to search for insects. For most storage pest species, traps can detect the presence of insects at much lower population levels than is usually possible with visual inspection.

A number of traps are available commercially to detect grain storage insects. These have been carefully designed and are provided with various baits and lures. While many are highly effective, commercial traps can be expensive. But all is not lost. Effective traps for many pest species can be made easily and very cheaply from items found in any home.

Photo: Effective insect traps can be easily made out of common household materials

Traps can catch insects in several ways:

• Pitfall traps: insects fall into a container from which they cannot escape;

• Crevice traps: these provide a physical environment into which insects crawl and remain; and,

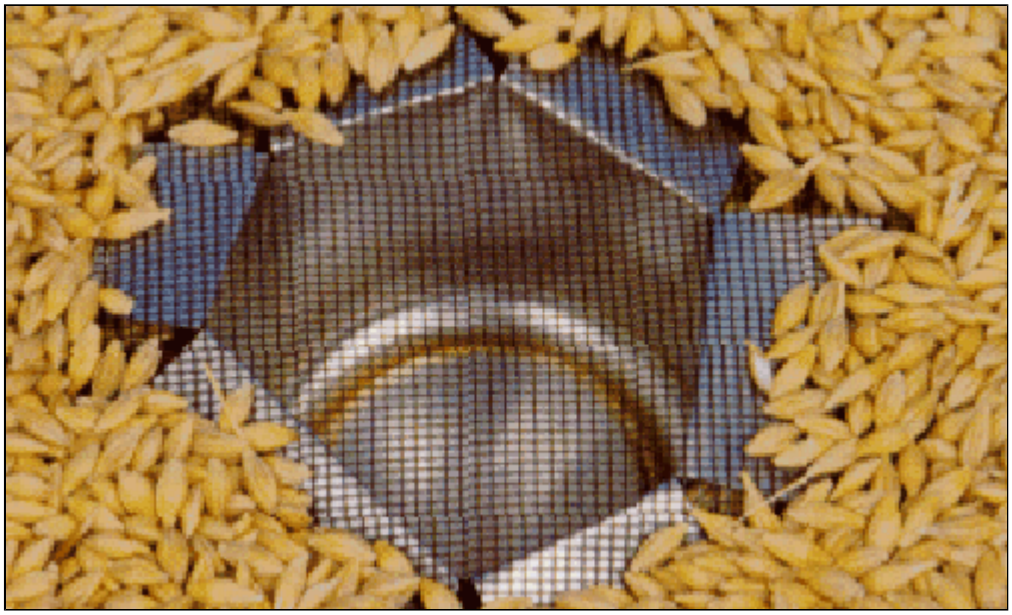
• Bait traps: these contain a food or some other form of bait attractive to the insect.

Pitfall traps

A simple pitfall trap is very easy to make. A vertical or near vertical sided container can be

used for this purpose. *Do not use glass containers or containers which have contained toxic or otherwise nasty materials.* Clean plastic takeaway food containers or clear plastic disposable cups (not the styrofoam ones) are ideal for this purpose. The chosen container is inserted into the surface of grain so that the rim is level with the grain surface. See the next photo.

Photo: A pitfall trap in use. Inserted into grain so that the top of the trap is level with the grain surface; this one is made from an empty beer can



If forgotten, pitfall traps tend to end up on a screen somewhere. Mark the position of the traps and try to remember to remove them before outloading.

A good spot to set pitfall traps is at or along the grain peak. Many insects tend to congregate at this point. Traps can be easily attached to a cane or broom handle to allow them to be inserted into grain from, say, the top of a silo without having to enter the bin.

Pitfall traps can be improved in a couple of ways. A piece of screen door netting held in place with an elastic band will stop the tray filling up with grain. See the next photo.

Photo: A simple pitfall trap made from a disposable plastic beaker

Do not use netting with too fine a mesh or you will keep insects out as well. A mesh with holes of 1.5–2.0 mm across will keep grain out but allow insects to pass through.

Some species, notably grain weevils (*Sitophilus spp.*) and saw-tooth grain beetles (*Oryzaephilus surinamensis*) are able to climb up most vertical surfaces and could escape from pitfall traps. One way to help prevent this is to put a small quantity of a vegetable cooking oil in the bottom of the trap. Trapped insects can become bogged down in this. *Do not use mineral oil.* Some edible oils are attractive to insects in their own right and act as baits. An example is wheat germ oil, which can often be obtained from health food shops.

Tests have shown that pitfall traps are very effective at detecting many beetle pests of stored grain, especially the more active species such as saw-toothed grain beetles, flour beetles (*Trilobium spp.*) and flat grain beetles (*Cryptolestes spp.*).

Crevice traps

Insects that attack stored grain don't like being out in the open, instead they usually prefer to hide in or under something. Crevice traps take advantage of this behaviour. A very simple, cheap, effective trap of this type is a piece of corrugated cardboard, cut from a clean cardboard box. See the photo below.

Photo: A crevice trap made from a piece of corrugated cardboard cut from a box. This trap has been lowered onto a grain surface on a piece of string.

This type of trap is especially useful to detect insects in empty storages or in grain handling equipment. After a period of time, traps can be collected up, and captured insects can be knocked out onto a tray or other clean flat light-coloured surface.

Trap efficacy may be improved by adding a bait. A small quantity of wholemeal flour or wheat germ can be dribbled into the corrugations of each trap. To help prevent this bait from falling out, a piece of sticky tape can be stuck over the open corrugations along one side of the trap. Corrugations on the other side are left open for insects to crawl into. Alternatively, a few drops of wheat germ oil can be soaked into the trap.

Traps can be made any size. In our research we use rectangles of 4 mm thick corrugated cardboard 100 x 150 mm with open corrugations on the long side. This type of trap can be easily dropped into and recovered from silos and bins of any size when attached to a piece of string or lightweight fishing line.

Bait traps

Certain foods are highly attractive to insects and some have already been mentioned. Brown (not white) rice fresh out of the packet and good quality natural muesli make good bait.

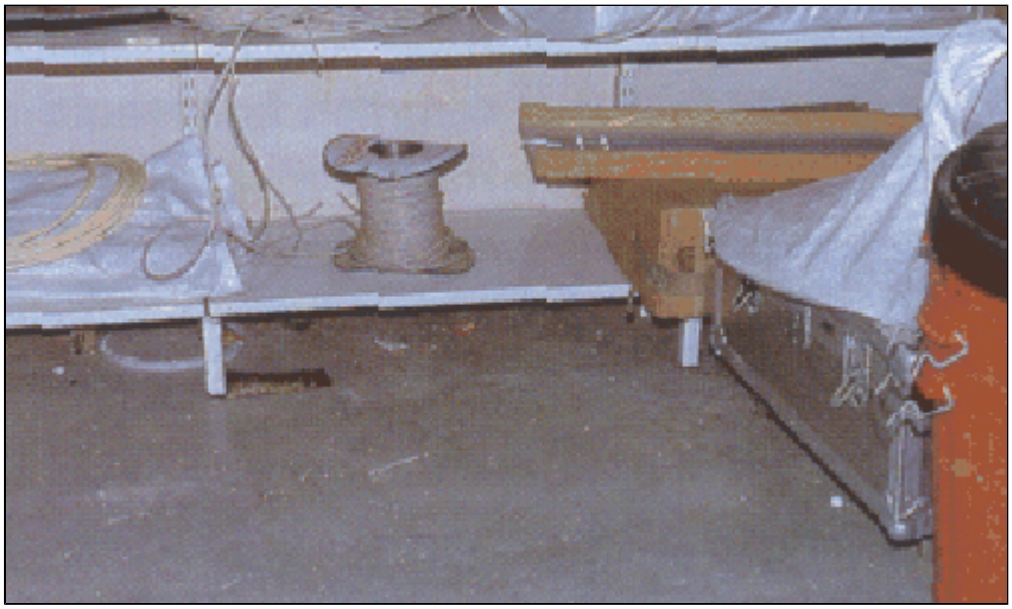
A simple bait trap is a mesh bag made from a square of flyscreen mesh 200 x 200 mm. This can be half filled with bait as shown in the following photo.

Photo: A bait trap made from fly screen and filled with muesli

After being set for a time in a place of interest, insects caught in bait traps can be simply shaken out of the trap over a tray. The mesh bag acts as a sort of sieve.

Bait traps are especially good at detecting beetles and moths in empty stores and in machinery where food could be scarce.

Photo: A bait trap being used to catch insects in an equipment store



How to use traps

You will get the most out of any trapping program if you are systematic, keep records and act on the results obtained.

First, draw up a simple sketch plan of your storage area. Identify locations where you would like to trap. The first priority should be your grain pathway—harvesting and handling machinery and storages. Other areas where food residues can lurk to maintain insect populations include storage sheds, disused equipment and other collections of 'stuff'.

If putting out traps in sheds, place them close to walls or pillars or in 'low traffic' areas. Insects will more likely be found in such places than in the middle of the floor. Also, avoid putting traps in areas that get very hot or are exposed to bright sunlight. Record and number these locations on your plan.

Examine traps at regular intervals—say every one to four weeks. If traps are reused, clean out pitfall traps and disinfest (by freezing) crevice and bait traps before re-use. Trapping before and after pest control procedures will help to determine how effective treatments have been. It is also important to start trapping well before harvest.

Some trap tips

It is important to understand that traps can only detect the presence of insects and not their absence. Not catching insects does not mean that none are present, it only means that none were caught.

Accurate identification of insects caught is useful, as species vary in their pest status. Different species respond to traps in different ways. Some important storage pests, notably grain weevils and the lesser grain borer (*Rhyzopertha dominica*) are hard to detect at low population densities. If either of these insects are captured, and the grain is to be stored for any length of time, then consider immediate fumigation or treatment urgently.

In contrast, other species, such as moth larvae, psocids, flour beetles, saw-tooth grain beetles and flat grain beetles are much easier to catch. Insects are also more active and are more likely to be caught when it is warm.

Sometimes, non-pest species are caught. While these insects may not be a direct threat to your grain it is important to be able to separate them from those that are.

CSIRO sells a pocket ID guide to storage insect pests that allows you to identify the important species.
Phone 02 6246 4191 or visit the CSIRO Stored Grain Research Laboratory website (❑).

Click to return to the Preparing for storage submenu.

Managing pests

❑	**Using the right strategy**
❑	**Grain protectants**
❑	**Aeration**
❑	**Technical Note 02, *Aeration helps maintain processing quality during storage***
❑	**Phosphine fumigation**
❑	**Technical Note 04, *Measuring phosphine concentrations***

Using the right strategy

Possible methods of insect pest control include thermal disinfestation, irradiation, mechanical shock and some form of biological control, but the main methods

are:

Spraying the grain with a residual insecticide protectant
Fumigating with phosphine in sealed storage
Aeration alone or backed up by chemical control
Fumigating the grain with phosphine using the SIROFLO continuous flow method

The farmer needs a robust solution to pest control problems, a solution that will be appropriate for any markets, for any storage period and for any commodity. Residual insecticides can only be used if the buyer is willing to accept the residues. Aeration alone is not an adequate means of eliminating pests, although it may prevent any pest increases. This leaves the two phosphine options as the most useful for on-farm storage. Correct use is essential to avoid increasing phosphine resistance (❑). Storage under carbon dioxide or nitrogen in sealed storage provides possible alternatives to phosphine, but are more expensive.

Good hygiene must be an essential component of all these strategies.

Click to return to the Managing pests submenu.

Grain protectants

Spraying grain with grain protectant is a method of controlling grain pests. This treatment may be carried out in any size of storage and requires very little capital investment. Grain spraying must be done responsibly to protect consumers and to avoid overuse, which can lead to insect resistance. Correct dose is absolutely essential. Proper training in grain spraying is necessary. The Farm Chemical Users Course from Farmcare Australia is the recognised training program in agricultural industries. Click ❑ for contact details.

Choosing a grain protectant

In choosing a grain protectant you need to be able to answer the following questions:

- Is it approved for the commodity?
- Will residues be accepted by the anticipated market?
- Will it be effective against species attacking this commodity?
- How long will the protection last?

Approved treatments

The following table lists nine compounds that are used as grain protectants. Note that only dichlorvos (see the last row in the table) can be used alone. The

compounds in rows 4 to 8 must be used in combination with one of those shown in rows 1 to 3.

None of these chemicals is approved for on-farm grain treatment in Western Australia. Malathion is approved for grain treatment and may have limited effectiveness.

Use the illustrations and lifecycle information in Grain pests to check the identity of insects.

Table: Compounds used as grain protectants

Common brand names of the protectants are shown in brackets in the table; this does not imply that Quality Wheat CRC endorses any particular product.

Updates on the following information about grain protectants may be found in our 'Updates' section - click on the toolbar at the bottom of the screen. You should check our latest updates and supplier information before deciding on, or using, any of these chemicals.

	Application rate (g/tonne)	Storage period (months)	Withholding period	Efficacy	Status
1. Chlorpyrifos methyl (Reldan)	**10**	**3-9**	**Until residue is less than 5 ppm**	**Most beetle species except *R.dominica***	**Preferred compound with methoprene except on malting barley**
2. Fenitrothion (Fenitrothion, Fenitrogard)	**For up to 12 months storage: 12 g/tonne For up to 3 months storage: 6 g/tonne**	**3-9**	**Until residue is less than 5 ppm**	**Most beetle species except *R.dominica***	**Not effective in Qld, NSW, Northern Vic unless resistance in *O.surinamens* is controlled by methoprene**
3. Pirimiphos methyl (Actellic)	**4**	**3-9**	**1 day**	**Most beetle species except *R.dominica***	**Similar to Reldan (see chlorpyrifos methyl above) but not preferred due to greater persistence**
4. Bioresmethrin + piperonyl butoxide (BRM)	**1 + 8**	**3-9**		***R.dominica* in combination with compounds shown in rows 1-3**	**Not used alone. Lesser grain borer (*R.dominica*) resistance in some areas, controlled by methoprene**
5. Methoprene (Diacon IGR, NEVWEB IGR)	**1**	**3-9**		**Resistant *O.surinamensis* and *R.dominica* in combination with**	**Use in Qld to control resistant *R.dominica***

				compounds shown in rows 1-3	
6. Deltamethrin + piperonyl butoxide (K-Obiol, not yet registered for use in on-farm storage)	**1 + 8**			**Most beetle species**	**Effective alone or with compounds shown in rows 1-3, but very persistent**
7. Pyrethrum + piperonyl butoxide (Pyrethrum)	**3 + 24**			***R.dominica* in combination with compounds shown in rows 1-3**	**Suitable only for special uses such as gluten wheat**
8. Carbaryl (Carbaryl)	**8**		**Until residue is less than 7 ppm**	***R.dominica* in combination with compounds shown in rows 1-3**	**Only accepted on sorghum**
9. Dichlorvos (Dichlorvos)	**6 or 12**	**7 days or 28 days**		**Most beetle species**	**Good disinfestant Withholding period must be kept Some resistance in the lesser grain borer**

Details of protectants

Reldan (chlorpyrifos methyl)

Widely effective moderately persistent organophosphate. First choice for most pests admixed with methoprene. Accepted by the USA for gluten etc. Not accepted on malting barley.

Fenitrothion

Effective moderately persistent organophosphate with bioresmethrin, but no longer effective in many areas against resistant *Oryzaephilus surinamensis*. Replaced with fenitrothion/methoprene or Reldan (chlorpyrifos methyl)/methoprene.

Actellic (pirimiphos methyl)

Persistent organophosphate similar to Reldan (chlorpyrifos methyl). Not accepted on malting barley.

Dichlorvos

Dichlorvos evaporates easily and has low persistence. It therefore has a useful role as an emergency grain treatment for cereals. It is good for psocid control and is used in the automatic insectigas-D formulation. It is registered for use only on cereal grains. The US has withdrawn registration for dichlorvos on the grounds that it may cause cancer. This prevents its use on any products which might end up in the USA.

Bioresmethrin

An extremely effective insecticide for controlling *Rhyzopertha dominica*. Bioresmethrin can be used locally on all cereals, but internationally there are agreed residue limits for wheat and wheat products only.

Deltamethrin

Registered in Australia for limited use on cereals, but not yet for on-farm storage in Australia. It is registered for post harvest use on cereals in many countries. It is also registered for use on legumes in some countries. There are no post-harvest Maximum Residue Limits (MRLs) for deltamethrin on oilseeds.

Methoprene

A safe and effective insect growth regulator which controls the pre-adult stages of several pests, including *Oryzaephilus surinamensis, Rhyzopertha dominica* and *Tribolium castaneum*, but not *Sitophilus spp*. Unfortunately *Rhyzopertha dominica* is already developing resistance to methoprene.

Carbaryl

An alternative to the pyrethroids, mostly restricted to sorghum and not accepted as an admixture treatment on milling wheat or malting barley. Carbaryl has been used extensively as a cheap alternative to bioresmethrin for spraying storage structures, but this use has mostly been replaced by dryacide.

Piperonyl butoxide

Used as synergist (i.e. to increase effectiveness) and is required in the application of all the pyrethroids.

Table of specifications of grain protectants

	½ life 30°C 50%RH weeks	ADI mg/kg-bw	Rat acute oral LD50 mg/kg-bw	Cereal MRL mg/kg
Dichlorvos	**1**	**0.004**	**80**	**5**
Fenitrothion*	**14**	**0.005**	**500**	**10**
Reldan (chlorpyrifos methyl)*	**19**	**0.01**	**1000**	**10**
Bioresmethrin	**38**	**0.03**	**7000**	**1**
Methoprene	**50**	**0.1**	**>10000**	**5**
Pyrethrins		**0.04**	**600**	**3**
Actellic (pirimiphos methyl)	**70**	**0.03**	**2000**	**10**
Deltamethrin	**100**	**0.01**	**130**	**1**

½ life 30°C, 50% RH, weeks: half life, in weeks, at 30°C and 50% relative humidity—a measure of the persistence of the insecticide residue

ADI: acceptable daily intake, expressed as mg per kg of bodyweight. Defines the residue hazard for consumers. For a compound to be internationally accepted as a grain protectant, the International Codex Committee on Pesticide Residues reviews data packages on toxicity, effectiveness and residues resulting from use of the compound according to good agricultural practice. The Committee sets an ADI for the compound and maximum residue limits for treated commodities.

LD50: the dose in mg per kg of bodyweight which would kill 50% of the population—in this case rats, not humans. Defines the toxic hazard for handlers of the chemical

MRL: internationally permitted maximum residue level (but this is not applicable for residue-free grain). Individual countries may adopt all or some of these Codex MRLs, or set lower MRLs or require residue-free product. The likelihood of finding residues depends on the persistence of the compound. This varies from a few days for dichlorvos, to over a year for deltamethrin.

*By agreement with the Flour Millers Council, grain treated with fenitrothion or Reldan is not moved into processing or export until the residue is below 5 ppm.

Problems of resistance and control

Pest control measures which are successful in eliminating a pest often tend to assist the increase of other species. There has been an alarming increase in the small insects called psocids, or booklice, which have become a major pest in South and Western Australian terminals. The West no longer uses residual insecticides and the absence of insecticide dust has been put forward as one possible reason for the psocid problem. Psocids are the first insects to appear after fumigation and may occur where control measures have eliminated other competing pests. As an added complication, they migrate in and out of the grain during the day. Some psocids do not respond to insecticides so far tested, so it is particularly important to prevent their breeding. Sealed storages, allowing aeration to keep the temperature below 20° C and the relative humidity below 60%, can prevent the numbers building up (Rees).

As a natural part of their survival, insect species adapt to the use of insecticides and become resistant. In Australia this process has led to widespread resistance to organophosphate and pyrethroid insecticides which were formerly very effective. Australia has been able to control these resistant species by introducing methoprene. This new type of protectant mimics the role of the juvenile hormone which controls the change from larva to adult; however, resistance to methoprene has already become apparent. Insecticide-resistant insects can be controlled by fumigation with phosphine, but resistance to phosphine is an even greater threat as the storage industry becomes alarmingly dependent on phosphine.

Resistance cannot develop when a treatment achieves 100% control of the infestation. The key to delaying the onset of resistance is therefore improved, even application of effective treatments.

Resistance in grain storage pest species

Species	
Sawtoothed grain beetle—*Oryzaephilus surinamensis*	**• widespread resistance to BRM/fenitrothion • slight resistance to Reldan • in Queensland there is frequent resistance to Reldan and Actellic • Reldan plus methoprene is still effective**
Lesser grain borer—*Rhyzopertha dominica*	**• increasing resistance to methoprene at half rate (0.5 ppm); must use full rate • Reldan plus methoprene preferred to fenitrothion plus BRM • increasing phosphine resistance • some resistance to dichlorvos • some resistance to bioresmethrin**
Red rust flour beetle—*Tribolium castaneum*	**• increasing phosphine resistance • fenitrothion and BRM may still be effective • Reldan is generally more effective than fenitrothion, but is not used in SA**
Rice weevil—*Sitophilus oryzae*	**• low level phosphine resistance • fenitrothion and BRM may still be effective**
Flat grain beetle—*Cryptolestes spp.*	**• low level phosphine resistance • fenitrothion and BRM may still be effective**

Psocids	**• difficult to control with insecticides and dryacide but dichlorvos is effective • needs efficient phosphine fumigation in sealed storage.**

For CD users with Internet access: For information on a resistance monitoring program, see the Australian Grain Insect Resistance Database.

Market acceptance of insecticide treated grain

Grain-protectant-treated grain cannot be delivered to any market that specifies residue-free grain. This includes prime hard and noodle wheat to Korea and Japan, and ASW to India.

Grain protectants must not be used for control of insect pests in legumes. Available insecticides are less effective on pulses than on cereals, and the market requires legumes to be residue free. Pests must be controlled by phosphine fumigation.

Grain protectants must not be used to protect oilseeds. Treatment of oilseeds can lead to very high residue levels in oil, and processors are generally opposed to the use of protectants. The preferred treatments are aeration and Siroflo fumigation.

Grain protectants must be applied strictly according to the label. This is to ensure:

- the safety of handlers
- effective treatment
- market acceptance.

The requirements for labelling are covered in the Farm Chemical Users Course ❑.

The application of grain protectants

The application of grain protectants is covered in the Farm Chemicals Users Course, but there are some essential points which are unique to the application of insecticides to grain for protection in storage.

Special precautions when applying grain protectants

Apply the insecticide to moving grain, not on the top of a stack of grain.

Apply insecticide at a rate that matches grain flow. Stop the application when there is no grain flow. The rate of insecticide flow must be matched to the grain flow to achieve a correct, even concentration.

Only dilute chemical as you need it; it must be used within 24 hours. Old mix must be discarded before a new batch is made up.

Keep agitating the apparatus to ensure the chemical stays properly mixed and evenly concentrated.

Disinfestation with grain protectants

All grain must be out-turned with no live insects present. Grain other than residue-free grain can be disinfested with dichlorvos but it cannot be sent to the customer immediately:

- if treated at 6 g/tonne, the grain must be held for 7 days before dispatch
- if treated at 12g/tonne the grain must be held for 28 days.

Dichlorvos disappears quickly when the temperature is about 30°C, but is much more persistent at lower temperatures. Dichlorvos is volatile: the vapour is toxic and should not be inhaled (see respirators in the Safety section). Dichlorvos cannot be used on residue-free grain.

Application rate	Withholding period
dichlorvos 6 g/tonne dichlorvos 12 g/tonne	7 days 28 days

Click to return to the Managing pests submenu.

We now turn to the technique of **grain aeration**. Click to continue, or choose another selection from the sidebar.