



## MANAGEMENT OF INSECT PESTS OF STORED PRODUCTS IN WAREHOUSES

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Almost all stored food commodities, stock feeds and seeds, whether raw or processed, are subject to damage or contamination by insects. These pests typically enter warehouses in new stock or, less frequently, by flying in. The amount of contamination or damage inflicted depends primarily on the population levels the pests are able to attain. This, in turn, is determined by food quality (including its moisture content) and by environmental factors, such as temperature and humidity.

Under favourable conditions insect pests of stored products have the ability to very rapidly increase their numbers. For this reason, and because markets demand zero contamination, emphasis in the control of stored products pests must be placed on *prevention* of infestations.

Prevention of insect infestations requires a combination of the following strategies:

1. Inspection of and, if necessary, disinfestation of incoming produce.
2. Strict adherence to effectively hygiene procedures.
3. Keeping produce cool and dry.
4. Use of residue free or chemical protection.

If preventative measures break down or are not properly implemented, infestations will occur. These must be treated with either a fumigant or dichlorvos to prevent further losses.

Treatment of established infestations in warehouses is difficult and expensive, and disrupts normal operations. By introducing measures into routine warehouse operations that reduce the risks of heavy infestations developing, major disruption can be avoided.

### **Inspection and disinfestation of incoming produce**

All incoming produce should be sampled for insects before it is unloaded. Bulk produce can be sampled using a grain spear and bags with a bag probe. Sieve the sample using about a 2 micrometre (0.0787 in) mesh opening. Grain or stock feed found to contain insects should be either rejected or fumigated immediately. This will not be as effective as fumigation of all incoming produce as very low numbers of insect pests that can develop into serious infestations during storage may not be detected. However, routine follow-up

sampling of produce stored in the warehouse should detect any infestations that may escape the initial inspection.

Sampling for insects in silos and bagged produce should be carried out once every two weeks in summer and every four weeks in winter. In silos, samples should be taken from the surface of the grain, the auger boot and bag chute and then sieved to detect any insects present. Bag stacks should be inspected (with emphasis around ears and stitching of bags) for adults, larvae and pupae, and probe samples taken and sieved. In addition, commodities should be moved according to age so that infestations do not have time to develop.

### **Maintenance of hygiene procedures**

Maintaining good hygiene is the best way of minimising pest population build-up in a warehouse. Control of insect pests cannot be achieved where old stock, spillages and dust allow continual breeding of the pests to infest new stocks. All residue should be removed from the premises and surrounds on a weekly basis. Processing equipment should also be cleaned weekly, paying particular attention to parts where material lodges. Building and equipment should be designed or modified to allow the removal of all residues at minimal labour cost.

After cleaning, Dryacide® dust maybe used as a residual surface treatment. This treatment may complement but **not substitute for** cleaning. All surfaces of walls, floors, ledges and machinery should be treated yearly, or twice yearly in heavy traffic areas. Dryacide® is a protective dust that collects on insects and dries them out. It can be applied to surfaces in two ways:

1. As a slurry – this is a very efficient method and is applied at the rate of 6 g/m<sup>2</sup>.
2. As a dust - Dryacide® requires an air stream to move it into surfaces and into crevices at the rate of 2 g/m<sup>2</sup>. When applying the dust to large areas, use a power duster such as a Stihl SR400. Operators of such equipment should wear disposable dust masks.

### **Keeping produce cool and dry**

While infestations develop rapidly when the temperature and moisture levels of the commodity are favourable, development ceases when conditions are unfavourable. Grain insects are more active, grow faster and produce more progeny at higher temperatures. They generally do best at about 30 to 35 °C. In cooler conditions however, insect activity and reproduction are slower. At temperatures below 20 °C most insects reproduce so slowly that little damage occurs. Below 15 °C population growth stops for most species, although this temperature does not kill them. Similarly development is not possible in dry produce; for example, insects are not a problem in wheat with a moisture content of 8% or less but are able to breed rapidly in wheat of 14% moisture. This critical moisture level varies from commodity to commodity.

As warehouse design influences the temperature and moisture levels of the produce, it also influences the severity of the pest problem. It may be economical to use cooling or drying equipment to condition the air inside the shed thereby reducing pest problems.

## **Aeration**

Aeration is a relatively cheap means of reducing temperature and useful way to store stock feed without the use of chemicals. A well managed aeration system alone will keep grain substantially free of insects. Although insects will be present, their numbers will be low and damage will be insignificant. However, the grain may need to be fumigated with phosphine or treated with dichlorvos if the stock feed is to be sold.

A carefully controlled aeration system can greatly reduce insect activity in stored grain. Aeration lowers the temperature of grain by blowing cool, dry air through it.

Heat is transferred from the grain to the air and carried out with the exhaust air. The air may also remove a small amount of moisture from the grain, causing an evaporative cooling effect.

It is best to use an efficient automatic controller, rather than thermostats or timers or manual switches, so that only the coldest air available (usually a few hours early in the morning) is blown through the grain. The extra cost of the automatic controller will be well worth it. Further information on drying and cooling with aeration can be obtained from your local DPI Information Centre or adviser.

For high value goods, refrigeration provides an ideal method of maintaining quality and controlling pests.

## **Residue-free or chemical protection**

### **Dryacide®**

When used properly Dryacide® is an excellent residue-free treatment for stored feed. It can be mixed with whole or milled grain to give one to two years' protection from insect attack. Dryacide® requires no withholding period, that is, Dryacide® treated feed can be given immediately to stock as it is non-toxic to humans and animals.

Dryacide® treated grain will not be accepted by GRAINCO and some other buyers because it changes the angle of repose of grain and slows its movements through augers.

To effectively protect grain, Dryacide® must be applied to dry grain – 12% moisture content or less – and it must be applied evenly. A pickle applicator or a special Dryacide® applicator, available from rural supply houses, are the best way to apply this material. The application rate is 1kg/tonne. Cost of treatment is about \$2.50/tonne.

Dryacide® will not control existing, obvious infestations. It is most successful on newly harvested grain.

## **Chemical Protection**

Grain protectants are insecticides that are mixed with grain to protect it from insect infestation during storage for up to nine months. The advantage of

these materials is that they are effective in all types and standards of storage – no modifications to storages or equipment are needed. However they must be applied evenly to grain to be fully effective. Simple, correctly calibrated application equipment is needed.

Grain protectants leave residues on the grain to protect it against insects and detectable residues may prevent sale of the grain to some markets. As with all insecticidal chemicals, insects can develop resistance to protectants and this is a major factor limiting their use.

#### *Recommended protectants*

Most protectants are registered for application only to cereal grains including wheat, barley, sorghum, maize, oats, triticale, rice and millets. Actellic and dichlorvos (Mafu, Vapona) are also registered for peanuts and dichlorvos for soybeans and navybeans. Only BRM 5/50 plus fenitrothion can be used on malting barley as other chemicals either taint the flavour of beer or interfere with fermentation.

Mixtures of grain protectants are recommended because there is no single chemical that will control all species. Currently, because of resistance problems, DPI recommends particular combinations: for stock feed or seed only: Reldan or Actellic plus Carbaryl (also called Bugmaster), for either stock feed and seed or human consumption: Reldan, fenitrothion (Folthion, Fenitrogard) or Actellic plus methoprene (trade names Nevweb IGR, Diacon). These are the most effective of the protectants available. Note that methoprene is an 'insect growth regulator' – it controls only immature stages and will not kill adults.

#### *Applying Protectants*

To ensure adequate grain protection, two application rates are given – **short term** storage of 6 weeks to 3 months and **long term** for 3 to 9 months. The short term rate minimises residue levels in grain stored up to 3 months.

Protectants must be applied while grain is being augured into or between storages. Liquid concentrates should be diluted with water at the rate specified on the protectant container label. The spray equipment must be calibrated to spray 1 litre of solution per tonne of grain. That is, the spray rate, measured in litres per hour, must equal the auger or elevator uptake in tonnes per hour.

Concentrated insecticide should be diluted with rainwater if possible. – alkaline water caused insecticides to break down very quickly. Dilute sufficient material for the job at hand. Diluted insecticide should be used within 48 hours.

#### *Protectant residues on feed*

Recommended application rates for all grain protectants are lower than residue set in Agricultural Standard Regulations for stock feed grain. However, a **withholding period of one day** should be observed before feeding protectant treated grain to stock.

### *Maximum residue limits*

Insecticide residues in grain sold for human consumption must not exceed defined Maximum Residue Limits (MRL). Where application rates exceed the MRL withholding periods must be observed to ensure that residues decay to acceptable levels before the grain is sold. The withholding period for the higher rates of fenitrothion or carbaryl is 90 days and for the lower rates of each chemical it is 1 day. The withholding periods for Actellic, Reldan, BRM and Diacon are 1 day for both rates.

**Important** – many buyers are now requiring that grain and grain producers have nil chemical residues. Check with potential buyers before you treat with protectants.

### **Treatment of infestations**

#### **Dichlorvos**

Application of dichlorvos (other names: DDVP, Mafu, Vapona) can be a convenient way to disinfest grain or stock feeds. This chemical rapidly decomposes leaving minimal residues. The concentrate is diluted in water at the rate specified on the label (either 5.3 mL or 12 mL per litre) and 1 litre of mixture is sprayed per tonne of grain while augering. A **withholding period of 7 days** applies following dichlorvos treatment.

Manufacturers advise that protectants will not reliably *disinfest* grain. If protectants are to be added to infested grain then the grain should be treated with phosphine before adding the protectants or, alternatively, dichlorvos can be applied at the same time as the protectants.

#### **Fumigants**

Fumigation is usually the most convenient treatment to control insects in stored commodities. With proper sealing, fumigants kill all insects by penetrating to all parts of the commodity.

Fumigation must be carried out in a gas-tight enclosure. If a room or building is used as the enclosure, the internal surfaces should be painted to prevent gas leaks through the floor, walls and ceiling. Ensure that cracks around doors and windows are taped over. Bag stacks should be covered with PVC sheeting (at least 0.25mm thick) or polythene sheeting (at least 0.13mm thick) to form an enclosure. All joins and edges of the sheeting should be rolled together and fastened.

#### *Which fumigant?*

Phosphine is easier and safer to apply than methyl bromide. Phosphine is usually applied as tablets, but phosphine in cylinders, similar to those for methyl bromide is now available. The recommended dose rate is 1.5g phosphine (from 1.5 tablets) per cubic metre of space within the fumigation enclosure. The fumigation enclosure should be left sealed for at least 7 days if the temperature is above 25° C, or 10 days for temperatures of 15° C - 25° C. Do not use phosphine if the temperature is less than 15° C or the relative humidity in the enclosure is less than 25%. Phosphine evolves very slowly under these conditions, and is ineffective at low temperatures.

Phosphine is effective against insects in most types of grain. Some commodities however, such as cottonseed and linseed, soak up phosphine very quickly, leaving little to kill insects. The gas does not control insects effectively in these materials.

Methyl bromide is more difficult to apply, and can only be used by a licensed fumigator for volumes greater than 15 m<sup>3</sup>. Recommended dosage rate is 32g per cubic metre for 24 hours. Methyl bromide may impair seed germination: this phytotoxicity varies with species and the condition of seed.

In areas where there is limited access and difficulty in sealing, such as machinery, a liquid fumigant, Milspot No. 2, can be used. This is applied as a liquid and vaporizes through most parts of the treated machinery. A complete kill cannot be guaranteed if there are leaks from the fumigated enclosure.

### *Safety Issues*

Fumigants are highly toxic to humans so treatments should not be carried out in enclosed spaces in which people are working. They should be conducted in a specially constructed fumigation enclosure outside the warehouse or while buildings are not occupied. The produce must be well aired after fumigation, and shipping containers must be purged of remaining gas to ensure that fumigant concentration has reached a safe level.

Fumigant levels considered to be safe in the workplace have been set by the National Health and Medical Research Council. Short Term Exposure Limits for workers apply for short exposures of 15 minutes, providing there are not more than 4 per day and there is 60 minutes or more between exposures. These limits are 15 ppm for methyl bromide and 1 ppm for phosphine. At no time should this limit be exceeded.

Threshold Limit Values are time weighted average concentrations for a normal 8 hour work day and a 40 hour work week, to which all workers may be repeatedly exposed, day after day, without adverse effect. These limits are 5 ppm for methyl bromide and 0.3 ppm for phosphine.

### *Monitoring fumigations*

Gas concentrations in the workspace and in the fumigation enclosure can be easily measured using indicator tubes and a small hand pump. These are available from several sources and vary in price: Air-Met Scientific (07 3881 1360), Drager (07 3274 2433), GRAINCO (07 46321088) and MSA (07 3891 1966). In the absence of measurement of fumigant concentrations, airing periods are recommended to ensure that fumigant levels are safe before handling. In the case of grain without forced ventilation, methyl bromide should be aired for 7 days while phosphine should be aired for 5 days.

### **Moths**

Moth infestations in warehouses can be controlled by the use of dichlorvos (other names: Mafu, Vapona) as a space spray. Moths fly at sunset to mate and lay eggs. By applying the spray each evening, all moths which fly into the building or emerge after developing in produce in the store will be killed.

Eventually the number of moths, and their progeny, will be reduced to undetectable levels.

Dichlorvos can be applied in several ways. A misting machine can be used to apply dichlorvos manually, but working hours may not coincide with peak moth flight. In large warehouses, dichlorvos is most efficiently applied through gas lines and nozzles placed through the warehouse, connected to a canister of propellant and dichlorvos, and controlled by a time switch. Solenoid triggered 'pressure pack' sprayers may be more applicable to small stores as they avoid some of the capital costs in the previous system. Dichlorvos has little residual effect, so a warehouse is safe for occupancy on the morning after an evening spraying. For moth control in small warehouses and in head spaces in silos, pest strips which continually release dichlorvos into the atmosphere can be hung at all times.

Dichlorvos does not penetrate commodities in bulk or bags, so it has little effect on moth larvae or beetles feeding in the commodity. The withholding period after dichlorvos treatment is 7 days.