

Planning the key to effective fumigation

by Peter Annis,
CSIRO

Using effective methods of disinfecting farm-stored grain could yield substantial benefits for growers searching for a way of delivering a pest-free product to customers.

One method which has attracted considerable attention recently has been quick last-minute disinfection with fumigation, particularly with phosphine, the one fumigant widely available for on-farm use throughout Australia.

But while the idea may sound promising, it has several serious consequences.

Phosphine is a gas that is highly toxic to insects and other animal life including humans. Most adult insects are highly susceptible to phosphine, while pupae and eggs are harder to kill than other stages.

Both the phosphine concentration and exposure time are important in killing insects but the time tends to be more important than concentration.

This means that unless the gas is contained for a specific minimum time it is unlikely that all insects will be killed despite the concentration.

Phosphine is normally supplied as a solid preparation under a number of trade names and in a variety of forms such as tablets, pellets, sachets, blankets or plates. These react with moisture in grain and surrounding air gradually releasing phosphine gas, a process which, under Australian conditions, typically takes up to five days.

The difficulties which arise are:

- Grain delivered or transported after being recently fumigated, or under fumigation, could contain gas and still active preparations releasing gas.
- These could poison or even kill unsuspecting people handling, transporting and using such grain, or animals being fed on it.
- High concentrations of phosphine may ignite under some conditions and in the worst case may explode.

Fumigation takes time

Phosphine fumigations take time. Typically this involves seven to 20 days under fumigation, followed by two to five days' ventilation and a further two days withholding period.

This means safe, effective phosphine fumigations require a total of 11-27 days, ensuring the preparation has finished releasing gas and any gas present has been allowed to escape.

Fumigated grain can only be legally transported after it has been vented for the required time and then only used for



While on-farm fumigation can help growers deliver a clean product to the buyer, properly timing the process and factoring in suitable withholding periods requires thorough planning.

human and animal feed after the withholding period has passed.

Problems can also occur with carbon disulphide, a fumigant currently registered only in New South Wales. Carbon disulphide is a highly flammable liquid that vapourises quickly and, if retained for long enough, will kill all stages of insects.

The grain takes up the fumigant quickly but only releases it gradually during airing. If the airing period is too short then dangerous amounts may still be present.

With either fumigant, there is a general perception that increasing the dose will lead to a faster fumigation.

But it is important to remember that application of any pesticide above the label rate is an unacceptable practice in the grain trade and is illegal. It increases the risk of unacceptable chemical residues getting into food.



inbrief

- Phosphine is a widely used method of fumigating stored grain but requires time if it is to be used effectively and safely.
- Carefully following the directions on the label and ensuring the necessary fumigation, ventilation and withholding periods are met are vital for safe phosphine use.
- Carbon dioxide fumigation is used by organic farmers and may be an option if customers have particular chemical-use requirements.

On-farm phosphine fumigation

There are some practices that will increase the chances of having a successful fumigation. There are also processes that may cause problems with some grain end-users. For the best chance of a successful fumigation, the storage must be sealed after filling and meet a three minute or better pressure test half time. When pressure tests are less than three minutes, the chance of the fumigation being fully effective are much reduced.

Fumigation in structures with a pressure test of less than 10 seconds can be no different to fumigating in an unsealed structure. Two issues make phosphine fumigation a more complex process than it first appears. A mixture of the preparations with grain may, in some circumstances, lead to excessive preparation residue in part or all of the grain when it leaves the storage. This is especially true where the grain has been treated more than once.

Additionally, putting the preparation safely into the storage structure in a way that the preparation residues are removable is not straight-forward. But using a few overall principles will help in performing a safe and effective fumigation with phosphine.

Preparation

- Ensure there is enough time for the fumigation before the grain has to be moved.
- Seal the silo to the pressure test standard.
- Read the preparation label.

Dosing

- Use the correct amount of preparation (see the label).
- Under no circumstance enter a silo bin when it has grain in it.

Phosphine...

- Do not contaminate grain with phosphine preparation residues.
- Do not heap phosphine producing preparations (when heaped they can heat up and cause a fire).
- Do not add water to phosphine preparations (there is a risk of fire during the reaction with free water).
- Reseal the structure after the preparation is added.
- Label the structure as under fumigation.

After exposure

- Under no circumstance enter any silo bin when it has grain in it.
- Allow the full exposure period plus an airing time before removing the preparation residue or the grain.
- Be very careful when handling preparation residues — they are likely to have some unreleased phosphine gas and there may, under some circumstances, still be significant amounts of unreleased phosphine.
- Correctly dispose of the residues according to label or local regulations (if not otherwise instructed, bury to about 0.5 metres on-site — do not transport residues in a closed vehicle).

It is also important to thoroughly record each fumigation. Fumigation records are useful in explaining fumigation failures and may also have value in documenting grain treatment for meticulous buyers, for example those who want to be sure that specific chemicals have or have not been used to treat the grain.

The type of information commonly recorded includes storage, commodity, dosing, exposure, and post-exposure details.

Carbon dioxide treatment

Treatment of grain with food-grade carbon dioxide (CO₂) in a sealed silo is one of the few acceptable ways of disinfesting and protecting commodities for the organic food market.

The treatment is relatively simple and reliable if carried out in a sealed structure that passes a pressure test. The carbon dioxide concentration needs to be more than 35 per cent for 15 or more days for a carbon dioxide treatment to kill all stages of all insects likely to be found in an Australian on-farm storage facility. This can be achieved by a single addition of gas in an adequately sealed white bin, that is, one which passes a pressure test (see Table 1).

While it is difficult to compare the costs of each treatment, the material costs for phosphine are much lower and in the range of 15-25 cents/treated tonne in a full storage. CO₂ is in the \$1.20-1.90/treated tonne range. These costs are based on prices quoted during September 1998.

For more information, contact Peter Annis, CSIRO Stored Grain Research Laboratory, phone (02) 6246 4184, fax (02) 6246 4202.



TABLE 1 Procedures for carbon dioxide treatment of bulk grain in small bins

Requirements

- A sealed silo or a silo that can be sealed to a high standard of gas-tightness and fitted with a gas inlet at the top and bottom.
- Several lengths of plastic tubing (at least enough to go from the ground to the top of the bin and back).
- A few rolls of self-adhesive plastic tapes. 18 millimetre electrical tape and 50mm duct tape are the most useful for making temporary seals and connections.
- Sealing mastic in a putty gun cartridge. Silicone sealants are best. Butylmastic can be satisfactory but is harder to apply.
- A mastic gun.
- An oil filled pressure relief valve or a 'U' tube manometer.
- A source of compressed air.
- At least one 30 kilogram (G size) cylinder of food grade carbon dioxide (CO₂) per 20 tonnes of storage capacity plus one extra cylinder.
- CO₂ pressure regulator with a fitting to connect to flexible plastic pipe.
- A method of estimating the approximate CO₂ concentration. There is a range of commercial devices available for this purpose.



Carbon dioxide can be connected to the base of a silo via a pressure regulator and a plastic tube. The amount of ice on the cylinder will show the gas level.

Treatment method

- Seal all openings to the silo using tapes and mastics as appropriate.
- Examine silo for obvious leaks, with special attention to hatches and joints, and fill any potential leaks.
- Carry out a pressure test.
- The bin leaks and should be further sealed if the pressure test halving time is less than three minutes in a full bin, five minutes in an empty bin..
- Ensure there is an opening at the top of the bin and that it is open.
- Turn on the CO₂ cylinder valve and the flow regulator. The flow should be such that the inlet tube just becomes covered in frost.
- Continue to add gas until the concentration at the top of the bin reaches 60-80% CO₂ or the cylinder freezes and the gas flow is reduced.



Pressure testing the silo will help determine how effective a fumigation treatment will be.

- If the cylinder freezes disconnect and add gas from another cylinder. The frozen cylinder will thaw with time and can be used later if needed.
- When the concentration at the top of the bin reaches 60-80% stop adding CO₂ and close the top of bin.
- If the bin passed the pressure test the concentration should stay higher than 35% CO₂ for 15 days.
- If the bin did not quite pass the pressure test it is possible to add gas daily as required so long as the concentration does not fall below 35%. But if the bin badly fails the pressure test, even concentration make up will not be possible.

Source: CSIRO Stored Grain Research Laboratory