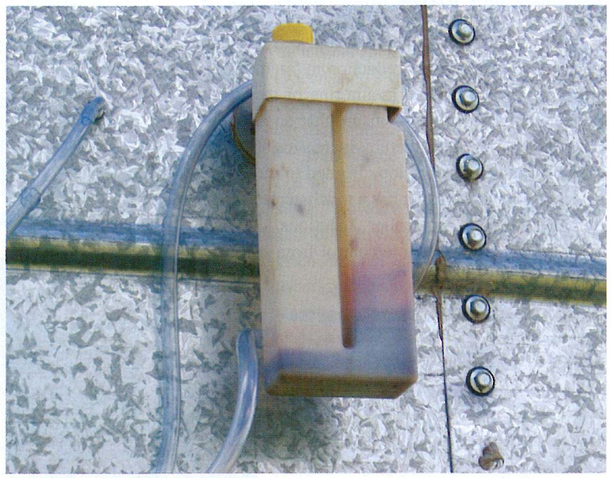
Time and temperature are the keys to successful fumigation

THE SUCCESSFUL USE OF PHOSPHINE, EVEN WHEN RESISTANT INSECTS ARE PRESENT, IS ALL A MATTER OF TIME, EXPLAINS PAT COLLINS*



The pressure relief valve for sealed silos also doubles as a manometer for testing silo gas-tightness.

Figure 1 Lesser grain borer

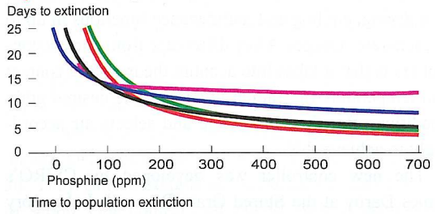
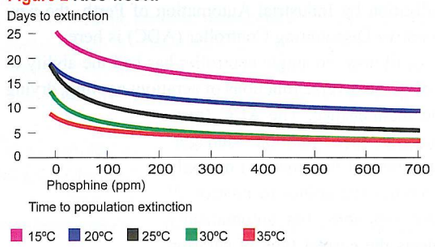


Figure 2 Rice weevil



UNLIKE MOST OTHER insecticides, resistance to phosphine in insect pests does not make the fumigant useless. This is because phosphine efficacy is multi-dimensional. Not only is the gas concentration important in achieving success but so is the fumigation period – that is, time under gas. In addition, we have found that a third factor, the temperature of the grain being fumigated, also affects phosphine toxicity.

Another important property of phosphine is that it is a slow acting poison. Most insecticides are neuro-toxins that act rapidly to immobilise and kill insects. Phosphine works in a different way – it causes the initiation of a rapid aging process that leads to the death of the insect but at a much slower rate.

Ten years ago we knew very little about the factors that influenced phosphine toxicity and successful fumigation. It was the detection of strong resistance to phosphine in several grain insect pests in 1997, and subsequently, that motivated our research. Because of the importance of phosphine for insect control and grain marketing, we needed to find out if resistant insects could be controlled and under what circumstances.

Both the GRDC and the Australian Centre for International Agricultural Research (ACIAR) recognised the significance of this issue and provided financial support for our research.

In the lab, we built mini-silos so we could precisely control phosphine concentrations, fumigation times and grain temperature. The mini-silos were filled with wheat and infested with phosphine-resistant insect populations containing all life stages. It was important to expose all life stages to the fumigant because different stages have different tolerances to phosphine – usually eggs and pupae are the most tolerant, but not always.

Data from the lab were then verified by undertaking full-scale trials in grain silos.

We investigated resistance in the five major beetle pests and in several psocid (booklouse) species. Two species stand out as the most troublesome for growers. Enemy number one is the lesser grain borer – it has the strongest resistance of any species yet detected. This insect is common on farms throughout Australia. Number two is the rice weevil, which is also cosmopolitan but most common in the northern region, and tougher to control at lower grain temperatures.

The graphs above show the time in days (vertical axis) to obtain complete control of resistant populations of lesser grain borer and rice weevil at fixed concentrations of phosphine (horizontal axis) at a range of temperatures (coloured lines). Note that at very low concentrations, less than 100 parts per million (ppm), it takes around 20 to 30 days to get full control! In fact, resistant lesser grain borer will happily live and reproduce at concentrations below 70ppm. Very high concentrations do not reduce the time needed for complete control. Finally, note that in general and especially at medium concentrations, time to complete control increases as temperature decreases. The cooler the grain the longer the fumigation time required.

These graphs do not include time taken for phosphine to evolve from the tablets added to the bin and for the gas to reach all parts. It takes two to four days or longer for the tablets to fully react and for the gas to diffuse through the silo.

From trials of fumigations in sealed farm bins, we have a good idea of concentrations of phosphine that can be obtained. This information, coupled with the graph data is the basis for recommendations for fumigations at different grain temperatures.

At grain temperatures above 25ºC, the standard seven days is required. At 20 to 24ºC, fumigate for at least 10 days before opening up the silo for ventilation and at 19 to 15ºC fumigate for at least 14 days.

Note that successful control of insects can only be achieved in well-maintained, sealed, pressure-tested silos.

The reason we are interested in the efficacy of phosphine at low temperatures such as 15 to 20ºC is the growing importance of cooling with aeration as a grain quality management tool. Cooling grain below 20ºC dramatically reduces grain insect population growth. Experience shows that to get the best results, the aeration fans should be turned on from when you first start loading the bin. This allows the aeration system to exploit the evaporative cooling effect of any moisture that may be in the freshly harvested grain.

Where grain is already dry, it is still valuable to utilise cooling aeration as it removes the 'harvest heat' from grain that is often 30 to 35°C going into the silo, due to the daytime temperatures during wheat and barley harvest.

With all harvested crops there is unevenness in grain moisture as it comes from different parts of a paddock. Also, with some crops, moist husk and stem trash comes in with the harvested grain. Aeration of a silo quickly evens out this variation and prevents hot, mouldy spots developing within the silo.

Cooling grain does not kill insects, it slows them down so that their lifecycle takes a lot longer and they produce fewer eggs. This slows population growth, but don't be fooled, you will not see any insects in the grain but they will be there. At harvest time they are on the wing looking for fresh grain to colonise. In addition, some will be loaded into the bin from your header where they have been camping since the last time you used it, and others will have already infested some seeds in the paddock.

Cooling grain provides flexibility. It means that you can concentrate on getting the harvest in and doing a good job with that. The insects can wait.

So when should you fumigate? If your grain is at less than 20ºC, and you make an effort with silo and equipment hygiene, then you should not need to fumigate for at least eight weeks after harvest. It is, however, important to check regularly. Sample and sieve a few litres of grain from the silo base and peak. If you see insects, then you will need to fumigate. If not, then you can delay fumigating a little longer.

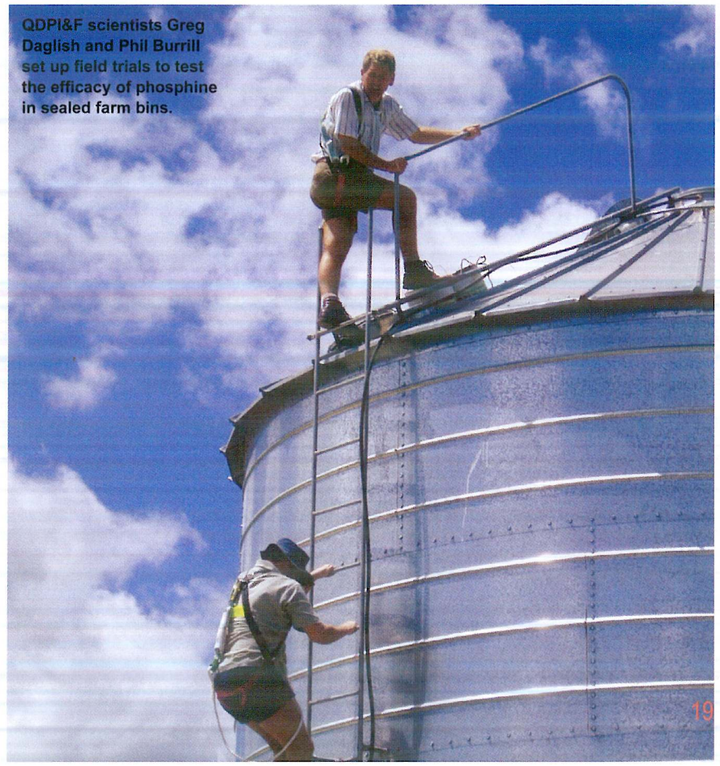
Don't get caught out by leaving your grain inspection until the day before the truck arrives – fumigation takes time.

If you do decide to fumigate this cool grain, make sure your silo rubber seals are OK, then pressure-test the silo. If the result is poor, use the aeration fan again to pressurise the silo and find the leaky spot with a hand sprayer containing soapy water. When it is well sealed, spread the tablets out on a tray, hang it in the silo headspace, shut the lid and leave it for at least two weeks. Application rate is one and a half tablets per cubic metre of storage capacity or two tablets per tonne (wheat) silo capacity. A 100-tonne wheat capacity silo will always need 200 tablets.

Grain not stored in a sealable silo? Then you will have to move it to a sealed bin to fumigate. Fumigating in an unsealed silo will not result in a successful fumigation that kills all the insect population.

Attention to hygiene and using aeration to cool stored grain are valuable first steps in protecting it from damage and deterioration. Remember, however, that cool grain temperatures of around 20ºC only slow the insect breeding cycle, and at some stage down the track you may need to fumigate. If you do, effective fumigation time on cool grain is longer, more like 10 to 14 days.

*Pat Collins, Senior Principal Entomologist, Department of Primary Industries and Fisheries, Queensland.



QDPI&F scientists Greg Daglish and Phil Burrill set up field trials to test the efficacy of phosphine in sealed farm bins.