PHOTOS: NEIL MCALPINE

The field studies found that appropriate levels of gas-tightness were not being achieved in harvest bags on-farm, thus not achieving the hermetic conditions that can kill insect pests.

permitted according to the phosphine label and will result in phosphine-tablet residue being left on the grain.

A mechanism for introducing phosphine into harvest bags is needed. Pressure testing is well known and should be used to prove the seal of harvest bags. Reliable distribution of phosphine is needed to ensure disinfestation of the large proportion of the grain held in the surface layer where grain experiences large changes in temperature and moisture accumulation. This large fluctuation of conditions also makes harvest bags unsuitable for the longer-term storage of malting barley (longer than four months).

Growers considering the use of harvest bags as a cost-effective storage option should consider how they might address the following limitations and grain-hygiene-related issues identified by this study:

- a reliable insect disinfestation capability with harvest bags is not available;
- insects detected at out-turn pose considerable logistical problems;
- mixing of solid phosphine preparations with grain breaches label requirements;
- use of residual chemicals to control insect infestation is limited to where sufficient permanent storage capacity is available to turn and treat grain; and
- bags are difficult to sample for insect infestation. □

GRDC Research Code CSE00035
More information: download a copy of the full study from http://cms.csiro.au/resources/HarvestBagReport.html

Improved storage technology to slow resistance

Poor application techniques, even in sealed silos, are resulting in ineffective fumigation and increasing phosphine resistance. Integrated fumigation and aeration systems offer a solution By James Darby

PHOSPHINE, THE MOST widely used fumigant on-farm and in bulk storage, kills insects slowly. Insects require a minimum time to acquire a sufficient quantity of fumigant to die. Higher phosphine concentrations can reduce this time, but only if well distributed throughout the grain stack. This time period is affected by temperature – cool bugs take up phosphine more slowly as they are less active. Higher concentrations have been shown to kill all insects, irrespective of their resistance status.

It has been established that a wide variety of fumigant concentrations and exposure periods occur throughout grain stores and between different types of fumigation systems. Therefore, for phosphine to remain effective, better application techniques are required. Consistent increased concentrations will be very effective.

Research has shown that the time taken for fumigants to move by passive distribution into grain masses in well-sealed stores ranges from two to 15 days. The size and shape of the store, pressure relief details, weather incurred, filling extent, grain conditions and amount of fumigant applied all influence this distribution period. Generally, distribution times are longer the greater the distance that the fumigant has to penetrate into the grain mass.

Other work has established that a wide range of grain temperatures can occur at harvest across Australia, depending on weather, although 25°C to 35°C is common for winter crops harvested in summer. Once stored, grain will slowly change temperature over weeks in response to external weather, warming in summer and cooling in winter. Substantial temperature gradients occur between the perimeter and centre of a store. Insects thrive at 25°C to 30°C, which is the ideal temperature for fumigation, while temperatures of 15°C or less effectively stop insect populations growing.

Another factor that could contribute to variation in insect kill is sorption. This is the process whereby grains slowly remove phosphine from the air. In most cases sorption is negligible, but with certain grains, such as sorghum, paddy rice and canola, sorption may affect doses required for successful fumigation.

The use of a combined fumigation and aeration system is proposed as a method to overcome these problems and improve insect control, particularly for large grain stores, of 200 to 2000 tonnes.

Such a system would actively move the fumigant through the grain, ensuring good distribution and removing the reliance on passive distribution, which can be inadequate in stores greater than 200t, even if fully sealed. Aeration provides the ability to control grain temperature so fumigation is applied to warm grain, which is then cooled. Reducing grain temperature after fumigation suppresses insect development, provided temperatures of less than 20°C, and finally less than 15°C, are achieved. As with fumigant distribution, all the grain within the store needs to be cooled to such temperatures for insect suppression to be effective.

It is expected that an integrated aeration and fumigation system will significantly reduce the variation in fumigant concentrations and temperatures, helping to ensure that all grain within the store receives the correct exposure time to the fumigant.

A feasibility study on developing an integrated aeration-fumigation system was completed in 2005. The benefits of such a system are detailed below. This study compared the cost of an integrated fumigation and aeration system against existing systems, mainly sealed or unsealed silos with aeration or systems with separate aeration and fumigation systems. The study established that an integrated system would cost between $0.50 and $1.50 per tonne of grain, if the total cost is amortised over the 10-year life of the system.

In 2006 the GRDC commissioned a project to develop an integrated aeration-fumigation system. This project now is being undertaken by the Cooperative Research Centre for National Plant Biosecurity (CRCNPB). The initial two years of the project focused on modelling the four 'rate' components of the fumigation process using phosphine and three other gaseous fumigation products. The four rate components are insect population mortality, fumigant distribution, grain temperature and fumigant sorption.

A key component was to define the mortality response of grain-storage insects exposed to phosphine under varying and non-continuous doses. This was partly done from the literature, but additional data was required and further experiments were conducted.

Based on the modelled data, an industrial-scale prototype integrated aeration-fumigation system is being developed and constructed in collaboration with an equipment manufacturer. It is planned to trial this prototype with 2008 winter crop wheat.

The developed system will enable phosphine to be applied according to label rates, allowing for differing grain temperatures and the required periods for purging grain of intergranular and desorbed phosphine. The phosphine label recommends treatment exposures of seven days for grain temperature "above 25°C", "10 days for 15°C to 25°C", and not fumigating when the temperature is less than 15°C. Following the exposure period ventilation is required to purge air and remove desorbed phosphine. Aeration systems reduce the ventilation period to one day, as described on the label. □

GRDC Research Code CRC50059
More information: James Darby, senior research engineer scientist, CSIRO Entomology, james.darby@csiro.au

FOR PHOSPHINE TO REMAIN EFFECTIVE, BETTER APPLICATION TECHNIQUES ARE REQUIRED

BENEFITS OF THE INTEGRATED SYSTEM OVER THE STANDARD PASSIVE DISTRIBUTION OF PHOSPHINE IN SEALED STORES, OR STORES SOLELY FITTED WITH AERATION

- Fumigate effectively in the range of sealed silos typical of industry
- Faster complete fumigation (not partially fumigated leaving eggs etc)
- Can accommodate any initial grain temperatures
- Improves predictability and reliability
- Provides cooling after fumigation to prevent routine repeat fumigations
- Actual disinfestation of grain, not solely suppressing infestations

Robots could keep resistance at bay

New tools are being developed to reduce reliance on prophylactic pesticide treatments, which provide short-term risk mitigation but increase resistance

BY DARRYL HARDIE

THE AUSTRALIAN GRAINS industry is highly reliant on the prophylactic use of phosphine and other grain protectants in bulk and farm grain stores to control insects. Inevitably this type of use results in more applications than may be required and multiple applications of the same product to the same parcel of grain. Such practices generate resistant populations of storage pest species.

The main reason for the prophylactic use of these products has been the inability, at numerous levels within the industry, to accurately determine the presence and population size of the target species within stored grains.

The current systems of manual sampling and