

# Researchers raise the heat on pests

CSIRO Entomology researcher Rashid Qaisrani reveals a possible chemical alternative to control insect pests in stored grain. Heat disinfestation could be in widespread use in the Australian grains industry during the next 10 years.

Heat could provide Australian grain growers with a rapid, non-chemical alternative to fumigation for control of stored grain insects.

The concept of heating grain to control insect pests is not new. During World War I, stored wheat was heated to 58–60 degrees Celsius for at least three minutes as an insect control strategy.

A continuous-flow machine was used and wheat was circulated over steam-filled pipes. The average time grain was kept within the machine was 15 minutes at an average throughput of 28 tonnes per hour.

During the early 1900s, several food processing companies in the United States successfully used heat to control pests.

## Alternatives needed

The Australian grains industry needs to develop alternatives to chemical methods of grain preservation and pest control.

Fumigation and grain protectant applications are the most common and immediately available methods for insect control.

More than 80 per cent of the Australian cereal, oilseeds and pulse crops are treated with the fumigant phosphine to control infestations. A declining proportion is treated with residual chemical protectants.

But an increasing market preference for residue-free grain, the development of high-level insect resistance to phosphine, and the phasing-out of methyl bromide currently used for rapid disinfestation of grain, all support the need for research and development in heating technology.

When methyl bromide is phased out during 2005 heat disinfestation could be widely



Researcher Rashid Qaisrani checks an in-situ heat disinfestation system currently being evaluated by CSIRO for use in small-capacity grain storage units.

used in the grain industry, particularly where an integrated approach to grain protection is required.

## Fluidised-bed heat disinfestation

Hot-air convection heating in a fluidised bed was first studied in Australia during 1978.

The disinfestation process involved rapid heating followed by rapid cooling to safe handling and storage temperatures.

In a fluidised bed, the grain passes at a predetermined flow rate across a sloping metal plate perforated with holes of specified diameter and orientation.

During flow of grain across the fluidised bed, the grain is heated to a specific temperature that kills all developmental insect stages, including the larval and pupal stages of insect species which develop inside grain kernels.

Several factors influence the effectiveness of heat treatment regimes, including temperature, exposure time, insect species and their age-structure, initial grain temperature and moisture content.

The lesser grain borer and grain weevils are the most heat-tolerant species of stored grain pests.

CSIRO studies show grain flowing at 360–500 kilograms per hour at a depth of 100–250 millimetres across a fluidised bed (with an inlet air temperature of 80–90°C) is completely disinfested within three minutes.

The first commercial unit had a capacity of 50t/h, an air inlet temperature of 100°C and achieved a maximum grain temperature of 65°C using an average time in the unit of two minutes.

Complete kill of lesser grain borer was obtained at higher grain flow rates of up to 200t/h, when grain temperature was raised to 65–70°C with a grain flow rate of between 2.1–2.4 kilograms per second per square metre and average treatment time of 2–4.5 minutes.

## In-situ heat disinfestation

In-situ heating of grain is another method that shows promise for use in small capacity (up to 50t) farm silos. It is currently being investigated at CSIRO's Stored Grain Research Laboratory (SGRL) with funding from the Grains Research Development Corporation.

In-situ heat disinfestation involves slowly heating the infested grain bulk by moving a heating front through the grain.

Ambient air is heated to the required temperature and fan-forced into the grain. The concept is similar to that used for rapid cooling of grain using aeration.

There is a window between heat dosages that kill insect pests and those which cause significant damage to product quality.

SGRL is evaluating suitable heat disinfestation systems and heating and cooling regimes. Grain temperatures in the range of 48–50°C are being evaluated.

The system being evaluated comprises a high-capacity fan, a heating unit with variable output and four perforated ducts inside the silo.

The addition of a steam generator improves performance. Typically, hot air with higher

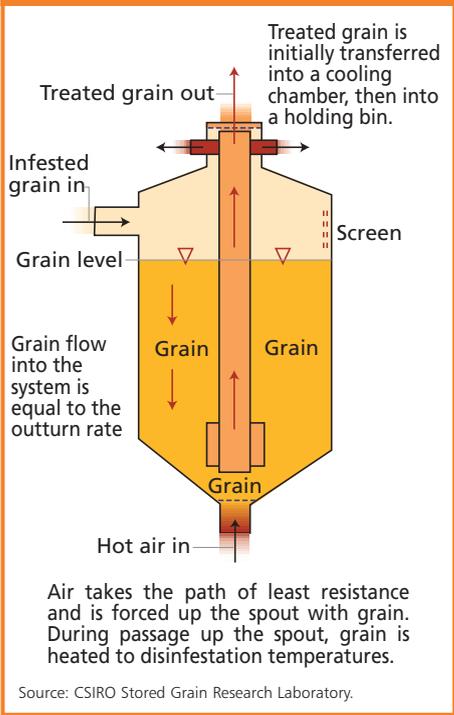


The continuous flow fluidised-bed disinfestation system was first developed by CSIRO during the 1980s. The system had a design capacity of 50 tonnes per hour.



- As more consumers demand residue-free food products, research into alternative non-chemical forms of insect control is being supported by the grain industry.
- Heat disinfestation has long been known to protect grain quality and researchers are developing suitable ways to incorporate it on-farm.
- By using heat effectively, grain storers can kill all developmental insect stages and species.

**FIGURE 1 Spouted-bed system**



relative humidity increases grain temperature without excessive drying and improves performance by reducing loss of energy through evaporative cooling.

A complementary cooling unit has been incorporated into the system to prevent prolonged heating of treated grain. The in-situ system also can be modified easily for ambient aeration.

## Spouted-bed heat disinfestation

Spouted-beds are a modified form of the fluidised-bed heat disinfestation system.

In a spouted-bed hot air enters at high velocity through a nozzle located at the conical bottom of the bed.

A high velocity air stream causes grain to spout above the air inlet (see Figure 1). As infested grain is percolated up the spout, it is heated to temperatures which disinfest the grain.

Following treatment, grain is moved from the spouted-bed into a cooling chamber where grain temperature is rapidly reduced to levels which minimise quality loss. After cooling, the grain is transferred to a holding bin.

A spouted-bed heat disinfestation system capable of heat treating grain at 10t/h is currently under investigation at SGRL with funding from GRDC. This system has

potential use on-farm, being more rapid than an in-store heat disinfestation unit.

The spouted-bed can also be used to disinfest or dry larger grain such as corn and has no moving parts. Its operation is easier and occupies less space, compared with a fluidised-bed.

Preliminary results show the spouted-bed is the most economical method of heat treating grain (see Table 1).

Further design modifications to the in-situ and spouted-bed disinfestation systems are likely to reduce the operational and capital costs.

The flexibility of being able to use either system as a grain dryer and the in-situ unit for ambient aeration make heat disinfestation a more cost-effective and attractive option for on-farm use.

## Heat damage

Susceptibility of grain to heat damage varies and is influenced by grain type and moisture content at the time of the heat treatment.

Both physical and biochemical damage can result from rapid heating. It is important to choose a disinfestation strategy that will achieve control of the insect pests without reducing grain quality.

Dry grain is more tolerant of the effects of rapid heating. Most grain harvested and delivered into central storage in Australia is received at moisture contents of less than 12.5%.

The dryness of grain at the time of harvest makes an in-line rapid disinfestation method such as fluidised-bed technology a feasible option for Australian growers.

It is possible to damage grain without careful management of the heat treatment process.

A drying process, where heated air is fan-forced through a treatment chamber to remove grain moisture can also reduce grain quality.

Damage from poorly controlled grain drying is a well recognised problem in the grain industry.

For example, loss of processing quality in malting barley through reduced seed viability and vigour can result from an inappropriate inlet air temperature or exposure time.

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**TABLE 1 Comparative operational costs of different heat disinfestation systems**

Heat disinfestation system	Energy cost of disinfestation (\$/t)	Comparative cost (\$/t)
In-situ (45t partially sealed steel silo)	2.10	1.6
Fluidised bed (30t/h)	1.43	1.1
Spouted-bed (10t/h)	1.30	1.0

Source: CSIRO Stored Grain Research Laboratory.