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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

VETCH

SECTION 13

STORAGE

HOW TO STORE VETCH ON-FARM | AERATION DURING STORAGE | STORED GRAIN PESTS

Storage

Key messages

- Pulses stored above 12% moisture content require aeration cooling to maintain quality.
- Meticulous hygiene and aeration cooling are the first lines of defense against pest incursion.
- Fumigation is the only option available to control pests in stored pulses, which requires a gas-tight, sealable storage.
- Avoiding mechanical damage to pulse seeds will maintain market quality, seed viability and be less attractive to insect pests.
- Pea and Cowpea weevils are the most common insect pests affecting stored pulses.

Storing pulses successfully requires a balance between ideal harvest and storage conditions. Harvesting at 13–14% moisture content captures grain quality and reduces mechanical damage to the seed but requires careful management to avoid deterioration during storage.

MORE INFORMATION

Stored Grain website

Grain Storage GrowNotes

VIDEOS

WATCH: GCTV: Stored Grain: Oilseeds and Pulse storage.

13.1 How to store vetch on-farm

A recent trend has been increased use of on-farm storage. Much of Australia's grain production is now stored on-farm before delivery to bulk handling sites. The ABS estimates on-farm storage is growing by 4.8% p.a. In 2011, it was estimated that growers on the east coast had an average 11 million tonnes of on-farm storage. This allows farmers to maximise marketing opportunities and minimise storage and handling costs. [1]

To discourage mould growth and insect infestation, the moisture content of vetch seed stored on-farm for the next season should not be over 13%. If the moisture content of harvested grain is too high, aerated storage will prevent spoilage. Seed stored with high moisture content can deteriorate, particularly if stored at high temperatures.

13.1.1 Optimum moisture and temperature

Research has shown that harvesting pulses at higher moisture content (up to 14%) reduces field mould, mechanical damage to the seed, splitting and preserves seed viability. The challenge is to maintain this quality during storage as there is an increased risk of deterioration at these moisture levels (Figure 1). As a result, pulses stored above 12% moisture content require aeration cooling to maintain quality.

1 PricewaterhouseCoopers. (2011). The Australian Grains Industry: The Basics.

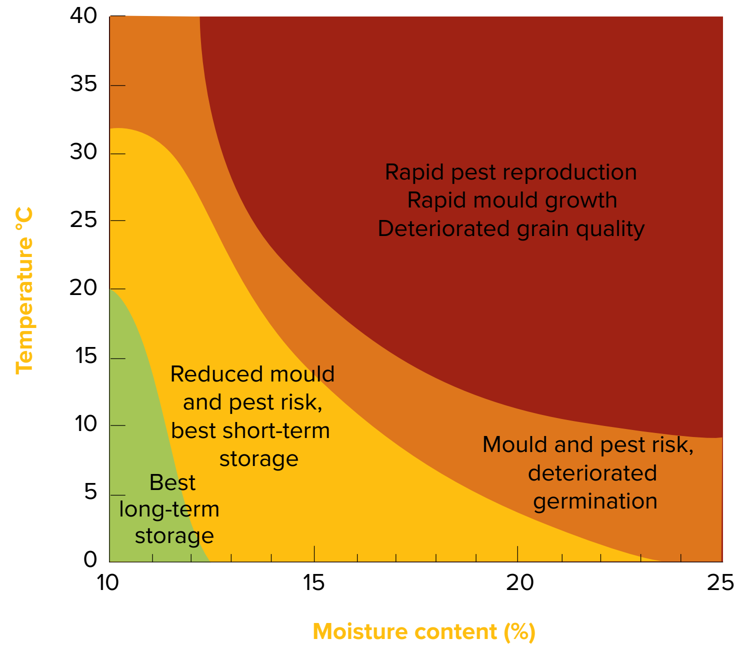


Figure 1: *Effects of temperature and moisture on stored grain.*

Source: CSIRO Ecosystems Sciences

Grain Trade Australia (GTA) sets a maximum moisture limit of 14% for most pulses but bulk handlers may have receival requirements as low as 12%. As a general rule of thumb, the higher the moisture content, the lower the temperature required to maintain seed quality (Table 1).

Without aeration, grain is an effective insulator and will maintain its warm harvest temperature for a long time.

Green pods and grains increase the risk of mould developing during storage — even at lower moisture content. Aeration cooling will help prevent mould and hot spots by creating uniform conditions throughout the grain bulk. [2]

Table 1: *Maximum recommended storage period.*

		Grain Temperature (°C)	
		20	**30**
Moisture Content (%)	14	3 months	N/A
	13	9 months	3 months
	12	> 9 months	9 months

Source: CSIRO

13.1.2 On-farm storage options

Grain storage systems come in a range of shapes and sizes to meet farm requirements and careful planning is needed to optimise an on-farm grain storage facility investment. According to the option selected, on-farm grain storage systems can provide a short-term or long-term storage facility. Depending on the goal of on-farm storage, whether it be access to improved markets or simply to maximise harvest efficiency, there are a number of options available.

2 GRDC. (2012). Grain storage factsheet: Storing Pulses.

Costs and storage flexibility can vary between grain storage options as can longevity of the investment. Table 2 identifies the major on-farm grain storage options, their advantages and disadvantages.

Table 2: *Advantages and disadvantages of grain-storage options.*

Storage type	Advantages	Disadvantages
Gas-tight, sealable silo	Gas-tight, sealable status allows phosphine and controlled atmospheres to control insects Easily aerated with fans Fabricated on-site, or off-site and transported Capacity from 15 t to 3,000 t 25 years or more of service life Simple in-loading and out-loading Easily administered hygiene (cone-based silos particularly) Can be used multiple times in a season	Requires foundation to be constructed Relatively high initial investment required Seals must be maintained regularly Access requires safety equipment and infrastructure Requires and annual test to check gas-tight sealing
Unsealed silo	Easily aerated with fans 7–10% cheaper than sealed silos Capacity from 15 t to 3,000 t Up to 25 year service life Can be used multiple times in a season	Requires foundation to be constructed Silo cannot be used for fumigation Insect control limited to protectants in eastern states and Dryacide® in WA Access requires safety equipment and infrastructure
Grain-storage bags	Low initial cost Can be laid on a prepared pad in the paddock Provide harvest logistics support Can provide segregation options Are ground operated	Requires purchase or lease of loader and unloader Increased risk of damage to grain beyond short-term storage (typically three months) Limited insect control options, with fumigation possible only under specific protocols Requires regular inspection and maintenance, which need to be budgeted for Aeration of grain bags currently limited to research trials only Must be fenced off Prone to attack by mice, birds, foxes, etc. Limited wet-weather access if stored in paddock Need to dispose of bag after use Single-use only

VIDEOS

WATCH: Over the Fence: On-farm storage delivers harvest flexibility and profit.

WATCH: Stay safe around grain storage.

MORE INFORMATION

Grain storage facilities

Grain storage cost–benefit analysis template

Saving weather-damaged grain for seed

Prepare on-farm storage early to protect your harvest

Storage checklist

Grain storage – invest today for the system of tomorrow

Economics of on-farm grain storage: cost–benefit analysis

Economics of on-farm grain storage: a grains industry guide

Storage type	Advantages	Disadvantages
Grain-storage sheds	Can be used for dual purposes 30 years or more of service life Low cost per stored tonne	Aeration systems require specific design Risk of contamination from dual purpose use Difficult to seal for fumigation Vermin control is difficult Limited insect control options without sealing Difficult to unload

Source: Kondinin Group

13.1.3 Silos

Silos are the most common method of storing grain in Australia, constituting 79% of all on-farm grain storage facilities nationally (Figure 2). Silos are the ideal storage option for pulses, especially if they are cone based for easy out-loading with minimal seed damage. For anything more than short-term storage (3 months) aeration cooling and gas-tight sealable storage suitable for fumigation are essential features for best management quality control.

Always fill and empty silos from the centre holes. This is especially important with pulses because most have a high bulk density. Loading or out-loading off-centre will put uneven weight on the structure and cause it to collapse.

Photo 1: *Storage silo with concrete slab underneath for easy cleaning.*

Source: GRDC

MORE INFORMATION

GRDC Silo buyer's guide

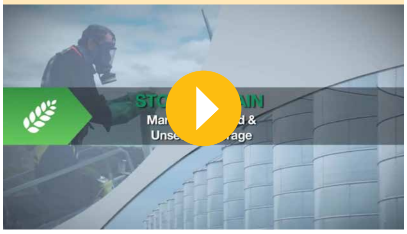
Gas-tight sealable silos

A gas-tight sealable silo will ensure phosphine, or other fumigants and controlled atmospheres, are maintained at a sufficient concentration to kill insects through their complete life cycle of eggs, larvae, pupae and adult. Be aware of cunning marketing terminology such as 'fumigatable silos'. Although such a silo might be capable of sealing with modifications, a gas-tight sealable silo needs to be tested onsite to meet Australian Standard (AS 2628–2010) after installation. Gas-tight sealable silos also can be used for alternative methods of insect control including controlled atmospheres of inert gasses, such as carbon dioxide or nitrogen. Current costs of using these gases (between $5 and $12/tonne to treat stored grain compared with $0.30 per tonne using phosphine) carbon dioxide and nitrogen atmospheres will arguably be used solely by niche growers, such as organic growers, until gas is less expensive.

There is significant work being carried out in lower-cost nitrogen gas generation and if buying a silo, ensure it is gas-tight for future proofing of the investment. [3]

VIDEOS

WATCH: GCTV. Stored grain: Managing sealed and unsealed storage



Pressure testing sealable silos

Key points:

- A silo sold as a 'sealed silo' needs to be pressure tested to be sure it's gas-tight.
- It is strongly recommended that growers ask the manufacturer or reseller to quote the AS2628 on the invoice as a means of legal reference to the quality of the silo being paid for.
- Pressure test sealed silos upon erection, annually and before fumigating with a five-minute half-life pressure test.
- Maintenance is the key to ensuring a silo purchased as sealable can be sealed and gas-tight.

Why do I need to do a pressure test?

In order to kill grain pests at all stages of their life cycle (egg, larvae, pupae, adult), phosphine gas concentration levels need to reach and remain at 300 parts per million (ppm) for seven days or 200ppm for 10 days.

Trials show that these levels of gas concentration are impossible to achieve in silos that are not pressure tested and gas-tight, so insects will not be killed at all life stages. The fumigation may appear successful when the adults die but the surviving eggs and pupae will continue to develop and re-infest the grain.

A pressure test is a measure of how well a silo will seal to contain fumigation gas.

When to perform a pressure test

If silos are properly maintained pressure testing does not take long and should be done at three distinct times.

1. When a new silo is erected on farm carry out a pressure test at a suitable time of day to make sure it's gas-tight before paying the invoice or filling with grain.
2. Importantly, a silo also needs to be pressure tested when full, before fumigating grain. If the silo has a slide plate outlet that has been tested empty, retest when full to make sure the pressure of the grain doesn't compromise the seal. The weight of grain can break the seal on the slide-plate outlet where it is not well supported by cams or bolts etc. For older, poorly-designed cone-bottom silos, gentle pressure from a jack may assist the seal. If the weight of grain on the slide plate stops it from sealing, some added pressure from a jack under the silo will assist the sealability.
3. Pressure testing silos needs to be part of the annual maintenance. It is much easier to replace seals and carry out repairs when silos are empty.

3 GRDC. (2016). Grain storage facilities: Planning for efficiency and quality. Stored grain hub. http://storedgrain.com.au/grain-storage-facilities/

VIDEOS

WATCH: GCTV2 - Carrying out a pressure test

MORE INFORMATION

Pressure testing sealable silos

Sealed silos – take the pressure test

Aerating stored grain: cooling or drying for quality grain

Carrying out a pressure test

1. Choose the right time to pressure test
2. Check seals
3. If there is no aeration fan, install an air valve
4. Check oil levels
5. Pressurise the silo
6. Time the half life
7. Look for leaks [4]

13.2 Aeration during storage

Grain that is over the standard safe storage moisture level of 12.5% moisture content can be dealt with in a number of ways.

- Blending — over-moist grain is mixed with low-moisture grain then aerated.
- Aeration cooling — grain of moderate moisture, up to 15% moisture content, can be held for a short term under aeration cooling until drying equipment is available.
- Aeration drying — large volumes of air force a drying front through the grain in storage and slowly remove moisture. Supplementary heating can be added.
- Continuous flow drying — grain is transferred through a dryer, which uses a high volume of heated air to pass through the continual flow of grain.
- Batch drying — usually a transportable trailer drying 10–20 tonnes of grain at a time with a high volume of heated air to pass through the grain and out through perforated walls. [5]

Without aeration, grain is an effective insulator and will maintain its warm harvest temperature for a long time. Like housing insulation, grain holds many tiny pockets of air within a stack. [6]

Why aerate grain?

Aeration cools grain and slows most quality deterioration processes:

- Germination and seed vigour is maintained for longer when cool and dry.
- When grain temperatures are below 15–20°C grain storage pests' life cycle slows or stops. Aeration can deliver these temperatures in winter and summer.
- Pulse grains maintain grain colour, reduce moulds risk.
- Mould development slows when grain moisture is uniform and below 13%.

Aeration capacity provides multiple benefits around harvest time:

- Ability to harvest early to reduce risk of weather damage causing quality and yield losses.
- Safely store grain at moisture levels a little above receival standards until blended with dryer grain.
- Hold high moisture grain safely for short periods prior to drying or blending.
- Return to harvesting earlier after rain delay.
- Gain extra harvesting hours each day. [7]

4 GRDC. (2014). Pressure testing sealable silos – Factsheet. http://storedgrain.com.au/pressure-testing/

5 GRDC. (2012). Grain storage factsheet: Storing Pulses.

6 GRDC Aeration cooling for pest control. http://storedgrain.com.au/aeration-cooling/

7 DAFF Qld. (2010). Aeration for cooling and drying. https://www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/broadacre-field-crops/grain-storage/aeration

13.2.1 Aeration cooling

Key points:

- Grain temperatures below 20°C significantly reduce mould and insect development.
- Reducing grain temperature with aeration cooling protects seed viability.
- Controlling aeration cooling is a three-stage process — continual, rapid and then maintenance.
- Stop aeration if ambient, relative humidity exceeds 85%.
- Automatic grain aeration controllers that select optimum fan run times provide the most reliable results.

Aeration cooling:

- Creates uniform conditions throughout the grain bulk.
- Prevents moisture migration.
- Maintains seed viability (germination and vigour).
- Reduces mould growth.
- Lengthens (and in some instances stops) insect reproduction cycles.
- Slows seed coat darkening and quality loss.

Aeration cooling allows for longer-term storage of low-moisture grain by creating desirable conditions for the grain and undesirable conditions for mould and pests. Unlike aeration drying, aeration cooling can be achieved with air-flow rates of as little as 2–3 litres per second per tonne of grain. At this rate, aeration cooling can be delivered from fans driven by a 0.37 kilowatt (0.5 horsepower) electric motor for silos around 100 t.

High-moisture grain can also be safely held for a short time with aeration cooling before blending or drying. Run fans continuously to prevent self-heating and quality damage.

Be aware that small seeds will reduce the aeration fan capacity as there is less space for air to flow between the grains. [8]

Research carried out by the Department of Agriculture, Fisheries and Forestry (DAFF), Queensland shows that with the support of an aeration controller, aeration can rapidly reduce stored grain temperatures to a level that helps maintain grain quality and inhibits insect development.

During trials where grain was harvested at 30°C and 15.5% moisture, grain temperatures rose to 40°C within hours of being put into storage.

An aeration controller was used to rapidly cool grain to 20°C and then hold the grain between 17–24°C during November through to March.

Before replicating similar results on farm, growers need to:

- Know the capacity of their existing aeration system.
- Determine whether grain requires drying before cooling can be carried out.
- Understand the effects of relative humidity and temperature when aerating stored grain.
- Determine the target conditions for the stored grain. [9]

Air used for cooling grain

Varying ambient conditions affect stored grain differently depending on the combination of temperature and relative humidity outside the silo and the temperature and moisture content of the stored grain (Table 3).

VIDEOS

WATCH: Grain Storage cooling aeration.

8 GRDC Storing Pulses. http://storedgrain.com.au/storing-pulses/

9 GRDC Aeration cooling for pest control. http://storedgrain.com.au/aeration-cooling/

Table 3: *The relationship between air temperature and relative humidity and grain moisture content.*

Inlet Air			Resulting temperatures in wheat at varying moisture contents (°C)	
Temperature (°C)	RH (%)	10%MC	12%MC	14%MC
10°C	30	10.2	8.5	7.7
	60	14	11.6	10
20°C	30	18.7	16.1	14.2
	60	24.1	21	18.8
30°C	30	27.4	24.3	22
	60	34	30.4	27.9

Source: GRDC

Grain with a higher moisture content can be cooled quickly with low-humidity air due to the evaporative cooling effect that occurs inside the storage.

The relative humidity of the ambient air affects the efficiency of grain cooling.

In an ideal world, growers would select air for cooling that is low in temperature and relative humidity, but these conditions rarely occur.

Air movement within the stack

Grain at the top of the stack is the hottest, as heat rises through the grain and it is exposed to the head space in the silo (Figure 2).

As the air in the head space heats and cools each day, it creates ideal conditions for condensation to form and wet the grain on the top of the stack.

Be aware aeration drying requires specifically-designed equipment and the process is much slower than aeration cooling or hot-air drying.

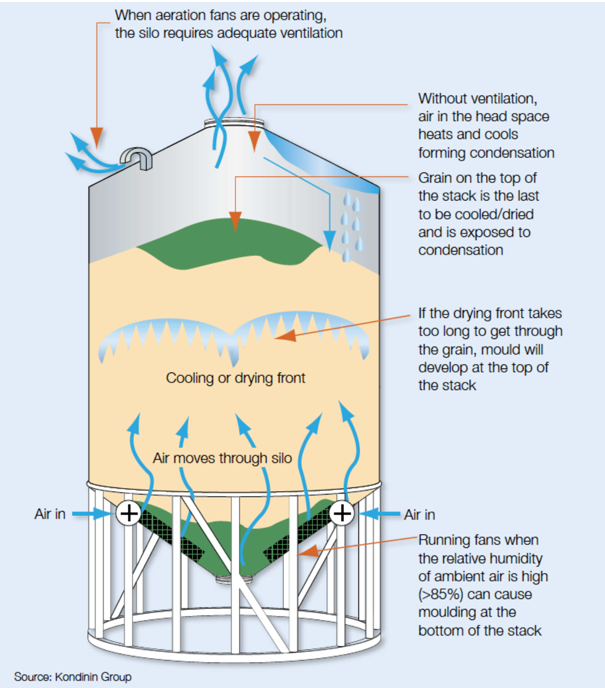


Figure 2: *Air movement within an aerated silo.*

Source: Kondinin Group

Operating an aeration fan for cooling requires a planned control program, which is best done with an automatic aeration controller. But even without an aeration controller growers need to aim for the same run time, following the same process.

For more information on automatic aeration controllers, see Section 13.3.4 Aeration controllers.

Without aeration, grain typically increases in temperature immediately after it enters the storage. The initial aim is to get maximum air-flow through the grain bulk as soon as it enters storage, to stop it from sweating and heating.

When first loading grain into storage, run the aeration fans continuously from the time the grain covers the aeration ducts for the next 1–3 days, until the cooling front reaches the top of the storage. However, do not operate the aeration fans on continuous mode if the ambient relative humidity is higher than 85% for extended periods of time as this will wet the grain.

After the aeration fans have been running continuously for 2–3 days to flush out any warm, humid air, reduce run time to 9–12 hours per day during the coolest period, for the next seven days. The goal is to quickly reduce the grain temperature from the mid 30s°C down to the low 20s°C.

An initial reduction in grain temperature of 10°C ensures grain is less prone to damage and insect attack, while further cooling becomes a more precise task. During this final stage, automated aeration controllers generally run fans during the coolest periods of the day, averaging 100 hours per month.

Grain temperature is gradually reduced as low as possible and then maintained throughout the storage period. [10]

The risks of getting it wrong

Running aeration fans on timers that are pre-set for the same time each day will not ensure the selection of the most appropriate air for grain quality maintenance.

The biggest risk with running aeration fans without a controller is forgetting or not being available to turn fans off if the relative humidity exceeds 85%.

Operating fans for extended periods of a few hours or days in humid conditions can increase grain moisture and cause moulding.

Aeration controllers are designed to automatically select the best time to run aeration fans. Fans on these systems only run when the conditions will benefit the stored grain.

13.2.2 Aeration drying

Grain growers are using silo aeration on their stored grain to gain harvest flexibility and more marketing options. Silo aeration can be used to cool grain and keep insect populations low. But it can also be used to dry the grain – allowing greater tolerance of moisture at harvest. Ambient air can also be used to dry grain. Here, high flow rates of air of at a temperature and humidity that will remove water from the grain (see grain equilibrium moistures) is pumped through the grain bulk.

Pulses stored for longer than three months at high moisture content (over 14%) will require drying or blending to maintain seed quality. Aeration drying has a lower risk of cracking and damaging pulses, which can occur with hot-air dryers.

Providing the air is of a quality that will dry and not re-wet the grain, the grain will dry from the bottom of the silo, with a drying front moving upwards through the grain stack. Aeration drying is a much slower process than aeration cooling or hot-air drying. The time it takes and the moisture content of grain after a drying front has reached the top of the grain stack is highly dependent on the quality of the air available and used for drying. Several drying fronts may be needed to dry grain to receival standards. If aeration is to be used for drying, check with your aeration

10 GRDC Aeration cooling for pest control. http://storedgrain.com.au/aeration-cooling/

VIDEOS

WATCH: GCTV5: Aeration drying – getting it right

MORE INFORMATION

How aeration works

Aerating stored grain – Cooling or drying for quality control.

Aeration cooling for pest control

supplier that the fan and ducting have sufficient flow rate and pressure to force a moisture change front through the grain in your silo quickly enough to prevent mould development. It is also critical to ensure that flow fields are even and grain depth is not too deep. Air with greatest capacity to dry, occurs most during the day when temperatures are high and relative humidity low, but this is not always the case. Very hot dry air can overdry and crack grain. The average quality of the inlet air (note fan heat effects) determines the final grain moisture content. [11]

Unlike aeration cooling, drying requires high airflow rates of at least 15–25 l/s/t and careful management. [12]

Well designed - purpose built high flow rate aeration drying silos with air flow rates of 15–20 l/s/t and higher, can dry grain from higher moisture contents, provided air of suitable relative humidity (RH) and temperature is available. Aeration drying requires careful management over several days and sometimes weeks depending on starting grain moisture and ambient conditions.

Note: It is vital to understand that aeration cooling equipment with low airflow rates of 2–4 l/s/t will not reliably dry grain and if used for this purpose, places the grain at significant risk.

For all aeration systems, provide adequate venting to ensure fan performance and air flow rates are not unnecessarily restricted. [13]

13.2.3 Cooling or drying — making a choice

Knowing whether grain needs to be dried or cooled can be confusing but there are some simple rules of thumb. For longer-term storage grain must be lowered to the correct moisture content.

Grain that is dry enough to meet specifications for sale can be cooled, without drying, to slow insect development and maintain quality.

Grain of moderate moisture can be either cooled for short periods to slow mould and insect development or, dried providing the right equipment and conditions are available.

After drying to the required moisture content, grain can be cooled to maintain quality. High-moisture grain will require immediate moisture reduction before cooling for maintenance. [14]

13.2.4 Aeration controllers

Running aeration fans on timers that are pre-set for the same time each day will not ensure the selection of the most appropriate air for grain quality maintenance. The biggest risk with running aeration fans without a controller is forgetting or not being available to turn fans off if the relative humidity exceeds 85%.

Operating fans for extended periods of a few hours or days in humid conditions can increase grain moisture and cause moulding. Aeration controllers are designed to automatically select the best time to run aeration fans (Photo 2). Fans on these systems only run when the conditions will benefit the stored grain. [15]

11 GRDC. (2004). How aeration works. http://www.customvac.com.au/downloads/GRDC_How_Aeration_Works.pdf

12 GRDC Storing Pulses. http://storedgrain.com.au/storing-pulses/

13 C Warrick. (2013). GRDC Factsheet: Aerating stored grain – Cooling or drying for quality control.

14 GRDC. (2016). Aeration cooling for pest control. Stored grain hub. http://storedgrain.com.au/aeration-cooling/

15 GRDC Aeration cooling for pest control. http://storedgrain.com.au/aeration-cooling/

Photo 2: *Automatic aeration controllers are the most effective way to cool grain and are designed to manage many storages from one central control unit.*

Source: GRDC

Controllers for cooling

For the purposes of aeration cooling, automatic controllers are by far the most effective and most efficient method of control. Not only will they cool grain quickly and efficiently, they all have trigger points to turn fans off if ambient conditions exceed 85% relative humidity, which can wet grain. Automatic aeration controllers for cooling are available in four main variations:

- Set-point controllers
- Time Proportioning Controllers (TPCs)
- Adaptive Discounting Controllers (ADCs)
- Internal sensing controllers.

Controllers for drying

Most aeration controllers are now available with a drying function, which is generally performed using the manual, set-point method, the adaptive discounting method, or the internal sensing method of control. However, drying depends completely on the airflow through the grain and even with the addition of a drying function does not mean it will dry grain without appropriate quantity and quality of airflow. An aeration controller will greatly assist the drying process, but they are not a set-and-forget tool, as the grain requires regular monitoring and in most cases the controller requires regular adjustments.

Operating in drying mode, aeration controllers select for air with low relative humidity. They also provide the added benefit of ensuring fans are not left running when the ambient conditions exceed 85% relative humidity and grain could be re-wet. [16]

13.2.5 Installation and maintenance tips

When retrofitting an aeration system, avoid splitting air-flow from one fan to more than one storage. Each storage will provide a different amount of back-pressure on the fan resulting in uneven air-flow and inefficient or even ineffective cooling.

If buying an aeration controller be aware that most controllers need to be installed by an electrician.

The preferred mounting location for aeration controllers is outside where the sensors can get ambient condition readings but are sheltered from the direct elements of the

VIDEOS

WATCH: Using aeration controllers – Philip Burrill.

16 C Warrick. (2013). GRDC Factsheet: Aerating stored grain – Cooling or drying for quality control.

weather. To avoid the chance of a dust explosion, avoid installing aeration controllers in a confined space.

Ensure your electrician installs wiring properly insulated and protected from potentially-damaging equipment, such as augers. [17]

13.2.6 Monitoring

Regular monitoring of stored grain is essential. Grain should be checked for, temperature, moisture content, quality, germination and for insect pests.

Aeration controllers reduce the amount of time operators need to physically monitor grain storages and turn fans on and off, but units and storage facilities still need to be checked regularly (Photo 3).

Most controllers have hour meters fitted so run times can be checked to ensure they are within range of the expected total average hours per month. Check fans to ensure they are connected and operating correctly. The smell of the air leaving the storage is one of the most reliable indicators if the system is working or not.

The exhausted air should change from a humid, warm smell to a fresh smell after the initial cooling front has passed through the grain. Animals can damage power leads and automatic controller sensors and fan blades or bearings can fail, so check these components regularly. Check for suction in and feel for air-flow out of the storage vents when the fans are running.

Keeping grain at the right moisture and temperature levels will reduce the likelihood of insect infestations, but stored grain still needs to be sampled regularly and monitored for any changes. If possible, safely check the moisture and temperature of the grain at the bottom and top of the stack regularly. [18]

Photo 3: *Monitor the effectiveness of the aeration cooling process by checking grain temperature with a temperature probe or a thermometer taped to a rod.*

Photo: Chris Warrick, Kondinin Group

13.2.7 Sampling grain for pests

Damage by grain insect pests often goes unnoticed until the grain is removed from the storage. Regular monitoring will help to ensure that grain quality is maintained.

17 GRDC Aeration cooling for pest control. http://storedgrain.com.au/aeration-cooling/

18 GRDC Aeration cooling for pest control. http://storedgrain.com.au/aeration-cooling/

Sample each grain storage at least monthly. During warmer periods of the year fortnightly sampling is recommended.

Take samples from the top and bottom of grain stores and sieve (using 2 mm mesh) onto a white tray to separate any insects (Photo 4).

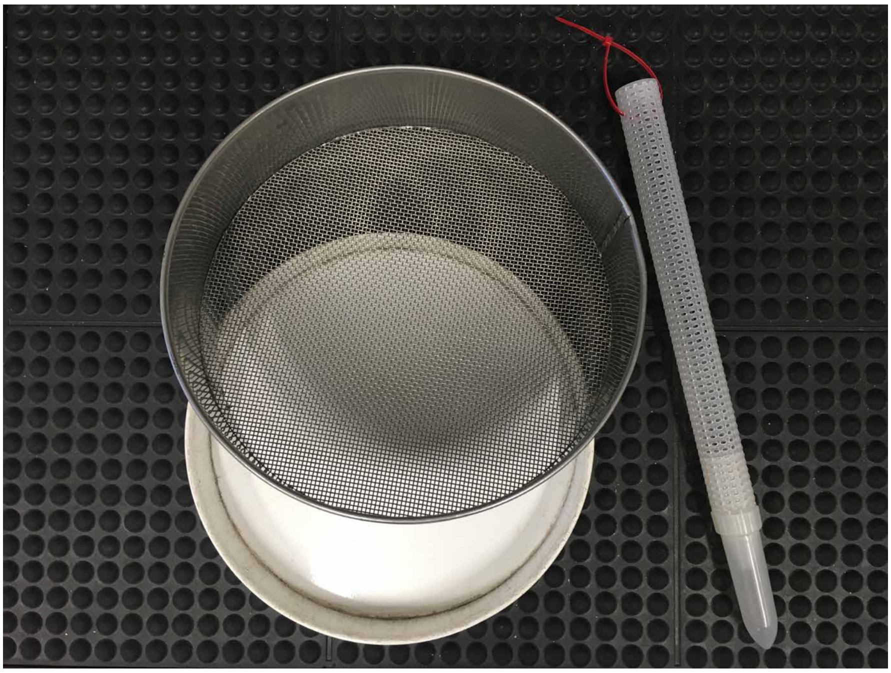


Photo 4: *Use a 2 mm mesh sieve to separate insects from grain.*

Source: GRDC

Hold tray in the sunlight for 10–20 seconds to trigger movement of any insects, making them easier to see. Use a magnifying glass to identify pests.

Grain probes or pitfall traps should also be used to check for insects. These traps are left in the grain during storage and are often able to detect the start of an infestation.

Push probe/trap into the grain surface and pull up for inspection fortnightly/monthly. Place 1–2 traps in the top of a silo or several traps in a grain shed (Photo 5).

Photo 5: *Probe traps pushed at the top of silos or bulk grain storages help detect the first signs of an insect infestation.*

Source: ProAdvice

MORE INFORMATION

Monitoring stored grain on-farm

Vigilant monitoring protects grain assets

Be sure to check grain three weeks prior to sale to allow time for treatment if required. [19]

Monitoring grain temperature and moisture content

Pests and grain moulds thrive in warm, moist conditions. Monitor grain moisture content and temperature to prevent storage problems. Use a grain temperature probe to check storage conditions and aeration performance. When checking grain, smell air at the top of storages for signs of high grain moisture or mould problems. Check germination and vigour of planting seed in storage. Aeration fans can be used to cool and dry grain to reduce storage environment problems. It is vital to monitor grain moisture content and temperature to prevent pests and grain moulds from thriving. [20]

13.3 Stored grain pests

Key points:

- The most common pulse pests are the cowpea weevil (*Callosobruchus* spp.) and pea weevil (*Bruchids pisorum*).
- Only treat grain when insects are found. Grain markets have limitations on levels of chemical residues that must be adhered to. The demand for freedom from insecticide residues is increasing.
- The only control options are phosphine, an alternative fumigant or controlled atmosphere, all of which require a gas-tight, sealable storage to control the insects at all life stages.
- Chemical sprays are not registered for pulses in any State.
- Weevil development ceases at temperatures below 20°C. This is a strong incentive for aeration cooling, especially if gas-tight storage is not available. [21]

The most common pulse pests are the cowpea weevil (*Callosobruchus* spp.) and pea weevil (*Bruchids pisorum*). The cowpea weevil has a short life span of 10–12 days while the pea weevil only breeds one generation per year. Though weevils are not usually a problem during short-term storage, they can damage grain that is cracked, has split seeds or has been damaged by seed borers.

Weevil development ceases at temperatures below 20°C. This is a strong incentive for aeration cooling, especially if gas-tight storage is not available. [22]

Insect control options are limited for stored pulses and oilseeds. Grain protectants are not registered for use on these grains. Chemical sprays are not registered for pulses in any State. The only control options are phosphine, an alternative fumigant or controlled atmosphere, all of which require a gas-tight, sealable storage to control the insects at all life stages.

The effectiveness of phosphine fumigation on oilseeds can be reduced due to phosphine sorption during treatment. Use sound grain hygiene in combination with aeration cooling to reduce insect activity. Small-seed grains, may need larger capacity aeration fans on stores. Always store pulses at their recommended grain moisture content level. [23]

Grain markets demand that delivered grain is free of live insects. If insects are detected as grain is out-loaded for sale, treatment is likely to delay the delivery by 2–4 weeks. To maintain pest-free stored grain of good quality and value, growers need to:

19 Plant health Australia. (2015). Monitoring stored grain on-farm. http://www.planthealthaustralia.com.au/wp-content/uploads/2018/03/Monitoring-stored-grain-on-farm-2018.pdf

20 Plant health Australia. (2015). Monitoring stored grain on-farm. http://www.planthealthaustralia.com.au/wp-content/uploads/2018/03/Monitoring-stored-grain-on-farm-2018.pdf

21 GRDC. (2016). Stored grain information hub: Storing pulses. http://storedgrain.com.au/storing-pulses/

22 GRDC Storing Pulses. http://storedgrain.com.au/storing-pulses/

23 GRDC. (2016). Northern and Southern regions grains storage pest control guide. http://storedgrain.com.au/pest-control-guide-ns/

- Make full use of good hygiene and aeration cooling – this can overcome 70% of pest problems.
- Identify pest incursions early through monthly monitoring (Figure 3). Early detection of pests gives the best chance of effectively treating the grain, preventing loss of grain quality and market access.
- Select the right storage treatments and apply them correctly.

The first grain harvested is often at the greatest risk of pest infestation due to contamination with grain left over from the previous season. It is good practice to separate the first few tonnes of grain that pass through headers and grain handling equipment at the start of harvest. Use it quickly for stock feed, or plan to aeration cool, then fumigate this grain within four weeks.

When it comes to controlling pests in stored grain — prevention is better than cure. Grain residues in storages or older grain stocks held over from last season provide ideal breeding sites.

Figure 3: *Common stored grain pests.*

Source: Kondindin Group

MORE INFORMATION

Grain storage pest control options and storage systems.

Finding storage pests early

13.3.1 Stored grain pest identification

The tolerance for live storage pests in grain either for domestic animal feed, human consumption or export markets is nil. Furthermore, an increasing number of grain markets are requesting low chemical residues on grain. It is important to accurately identify any pests to ensure use of the most appropriate control options. Correct identification and treatment choice helps prevent pest treatment failures due to chemical resistance. Follow the pest identification chart to work out which pest you have (Figure 4).

Keep a good magnifying glass handy to see the key features of these small insects. A piece of sticky tape may be helpful to hold insects still. To assist identification, place live insects into a glass container and check if they can climb up the glass. If it is cold, warm the jar in the sun briefly to encourage the insects to move.

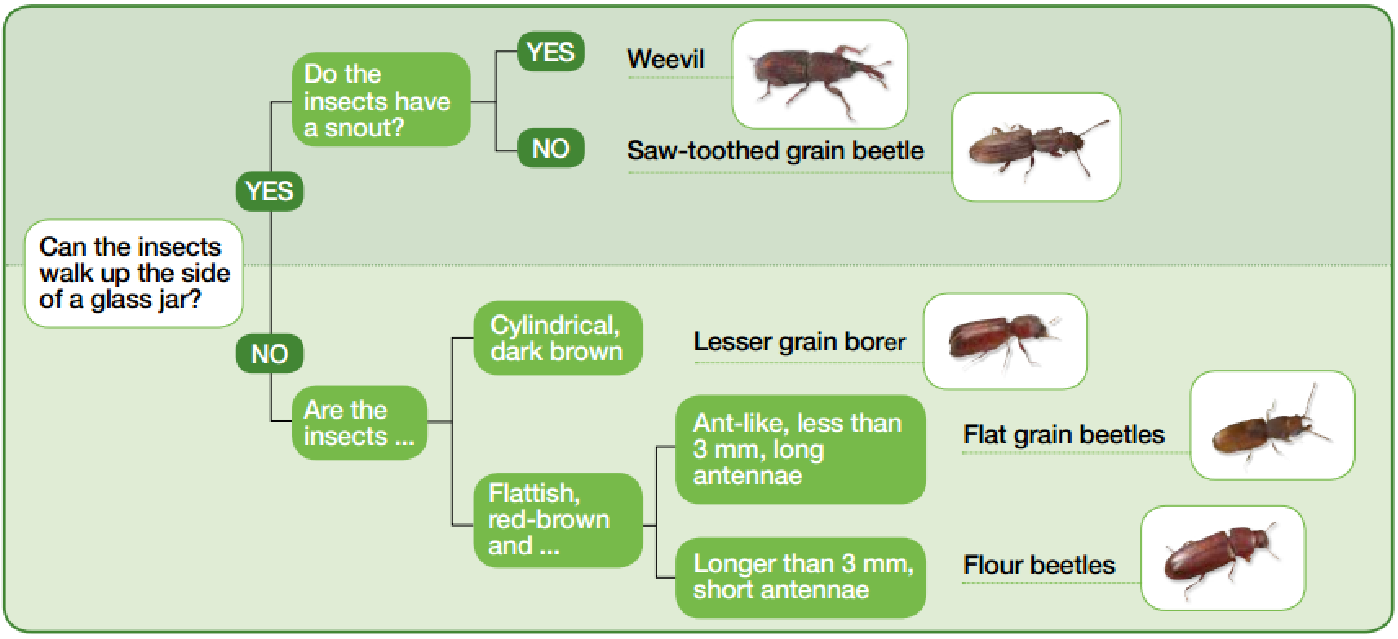


Figure 4: *Stored grain pest identification chart.*

Source: DAFF, Qld

The most common pulse pests are the cowpea weevil (Bruchids) and pea weevil.

Pea weevil

- Adults have globular shaped body (4–5 mm long) with long legs and antennae (Figure 11).
- Does not have a long snout like true weevils.
- Wings are patterned with white/cream spots.
- One generation per year and only breed in standing pea crops before harvest. Eggs laid and glued onto pods.
- Adult is long-lived and overwinters, but does not feed on field peas.
- Cream coloured and C-shaped larvae bore into the seed.
- Adults are strong fliers and reappear in spring to visit flowers to feed on the nectar, then seek out new field pea crops to lay eggs.
- Sieve and check seed for neat round holes (evidence adults have emerged).

Figure 5: *Adult Pea weevil and an example of damaged grain.*

Source: CSIRO

Cowpea weevil or Bruchids

- Adults (up to 4 mm long) have long antennae, climb vertical surfaces (e.g. glass jar) and are strong flyers.
- Globular, tear-shaped body is reddish brown with black and grey markings (Photo 6).
- Does not have a long snout like true weevils.
- Adults have a short lifespan (10–12 days).
- Adults do not feed, but lay about 100 white eggs on the outside of seed.
- Larvae feed and develop within individual seeds and emerge as adults leaving a neat round hole.
- Common problem in warmer months.
- Fortnightly sampling and sieving is important to prevent serious losses. [24]

24 Plant health Australia. (2015). Monitoring stored grain on-farm. http://www.planthealthaustralia.com.au/wp-content/uploads/2018/03/Monitoring-stored-grain-on-farm-2018.pdf

Photo 6: *Adult Cowpea weevil and an example of infestation in seed.*

Source: DAFF Qld

VIDEOS

WATCH: GCTV2: Grain storage insect ID

MORE INFORMATION

Identification of insect pests in stored grain

Stored grain pests identification: the back-pocket guide

Monitoring stored grain on-farm

Why identify stored insect grain pests?

Most insect-control methods for stored grain work against all species, so you don't need to identify the storage pests to make decisions about most control methods. But if you intend to spray grain with insecticides you may need to know which species are present if:

- A previous application has failed, and you want to know whether resistance was the reason—if more than one species survived, resistance is unlikely to be the cause.
- You intend to use a residual protectant to treat infested grain—pyrimiphos-methyl, fenitrothion and chlorpyrifos-methyl are ineffective against lesser grain borer, and pyrimiphos-methyl and fenitrothion are generally ineffective against saw-toothed grain beetles.
- You intend using dichlorvos to treat infested grain—if lesser grain borers are present you need to apply the higher dose rate, which increases the withholding period before grain can be marketed from seven days to 28 days. [25]

13.3.2 Hygiene

The first line of defence against grain pests is before the pulses enter storage — meticulous grain hygiene. Because pest control options are limited, it's critical to remove pests from the storage site before harvest.

Cleaning silos and storages thoroughly and removing spilt and leftover grain removes the feed source and harbour for insect pests.

25 DAFF. Identification of insects in stored grain. https://www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/broadacre-field-crops/grain-storage

Clean the following areas thoroughly:

- Empty silos and grain storages
- Augers and conveyers
- Harvesters
- Field and chaser bins
- Spilt grain around grain storages
- Leftover bags of grain [26]

When to clean

Straight after harvest is the best time to clean grain handling equipment and storages, before they become infested with pests. A trial carried out in Queensland revealed more than 1000 lesser grain borers in the first 40 litres of grain through a harvester at the start of harvest, which was considered reasonably clean at the end of the previous season. Discarding the first few bags of grain at the start of the next harvest is also a good idea. Further studies in Queensland revealed insects are least mobile during the colder months of the year. Cleaning around silos in July – August can reduce insect numbers before they become mobile.

How to clean

The better the cleaning job, the less chance of pests harbouring. The best ways to get rid of all grain residues use a combination of:

- Sweeping
- Vacuuming
- Compressed air
- Blow/vacuum guns
- Pressure washers
- Fire-fighting hoses

Using a broom or compressed air gets rid of most grain residues, a follow-up wash-down removes grain and dust left in crevices and hard-to-reach spots (Photo 7). Choose a warm, dry day to wash storages and equipment so it dries out quickly to prevent rusting. When inspecting empty storages, look for ways to make the structures easier to keep clean. Seal or fill any cracks and crevices to prevent grain lodging and insects harbouring. Bags of left-over grain lying around storages and in sheds create a perfect harbour and breeding ground for storage pests. After collecting spilt grain and residues, dispose of them well away from any grain storage areas. [27]

Photo 7: *TIPS: An extended broom handle makes sweeping out silos easier (left). A concrete slab underneath silos makes cleaning easier. (right).*

Source: Kondinin Group

VIDEOS

WATCH: GCTV2: Grain Silo Hygiene.

26 GRDC Storing Pulses. http://storedgrain.com.au/storing-pulses/

27 GRDC. (2013). Hygiene and structural treatments for grain storage – GRDC Factsheet. http://storedgrain.com.au/hygiene-structural-treatments/

13.3.3 Aeration cooling for pest control

While adult insects can still survive at low temperatures, most young storage pests stop developing at temperatures below 18–20°C (Table 4).

At temperatures below 15°C the common rice weevil stops developing.

At low temperatures insect pest life cycles (egg, larvae, pupae and adult) are lengthened from the typical four weeks at warm temperatures (30–35°C) to 12–17 weeks at cooler temperatures (20–23°C). [28]

Table 4: *The effect of grain temperature on insects and mould.*

Grain Temperature (°C)	Insect and Mould Development
40–55	Seed damage occurs, reducing viability
30–40	Mould and insects are prolific
25–30	Mould and insects are active
20–25	Mould development is limited
18–20	Young insects stop developing
<15	Most insects stop reproducing, mould stops developing

Source: Kondinin Group)

For more information on Aeration cooling, see Section 13.4.1 Aeration cooling below.

13.3.4 Structural treatments

While most grain buyers accept small amounts of residue on cereal grains from chemical structural treatments, avoid using them or wash the storage out before storing oilseeds and pulses. After cleaning grain storages and handling equipment treat them with a structural treatment.

It is always safer to check with the grain buyer's delivery standards for maximum residue level (MRL) allowances before using grain protectants. Diatomaceous earth (DE) (amorphous silica), commonly known as Dryacide®, can be applied either as a dust or a slurry to treat storages and handling equipment for residual control. DE acts by absorbing the insect's cuticle (protective exterior), causing death by desiccation (drying out). If applied correctly with complete coverage in a dry environment, DE can provide up to 12 months protection — killing most species of grain insects and with no risk of building resistance. [29]

13.3.5 Chemical treatment

Key points:

- Chemicals used for structural treatments do not list the specific use before storing pulses on their labels and MRLs in pulses for those products are either extremely low or nil.
- Using chemicals even as structural treatments risks exceeding the MRL so is not recommended.
- Using diatomaceous earth (DE) as a structural treatment is possible but wash and dry the storage and equipment before using for pulses. This will ensure the DE doesn't discolour the grain surface.
- If unsure, check with the grain buyer before using any product that will come in contact with the stored grain. [30]

VIDEOS

WATCH: GCTV7: Applying Diatomaceous Earth demonstration

MORE INFORMATION

Hygiene and structural treatments for grain storage

28 GRDC Aeration cooling for pest control. http://storedgrain.com.au/aeration-cooling/

29 GRDC. (2013). Hygiene and structural treatments for grain storage – GRDC Factsheet. http://storedgrain.com.au/hygiene-structural-treatments/

30 GRDC. (2016). Stored grain information hub: Storing pulses. http://storedgrain.com.au/storing-pulses/

VIDEOS

WATCH: GCTV Stored Grain: Phosphine Dose Rates.

Phosphine

In order to kill grain pests at all stages of their life cycle (egg, larva, pupa, adult), including pests with strong resistance, phosphine gas concentration levels need to reach and be maintained at 300 parts per million (ppm) for seven days (when grain is above 25°C) or 200ppm for 10 days (between 15–25°C).

Phosphine is available in two different forms for on-farm use (bag chains and tablets) and there are various ways to apply each option effectively in a gas-tight, sealed silo.

Bag chains are the safest form and the best way to guarantee no residue is spilt on the grain or will harm the operator. The other form is the traditional and most recognised — tablets — which can be bought in tins of 100. A third form — phosphine blankets — is available, but is designed for bulk storages larger than 600 tonnes.

Phosphine application rates are based on the internal volume of the gas-tight, sealable silo to be fumigated. Regardless of how much grain is in the silo whether it is full or empty, the rate is the same — based on the volume of the silo (Photo 8). [31]

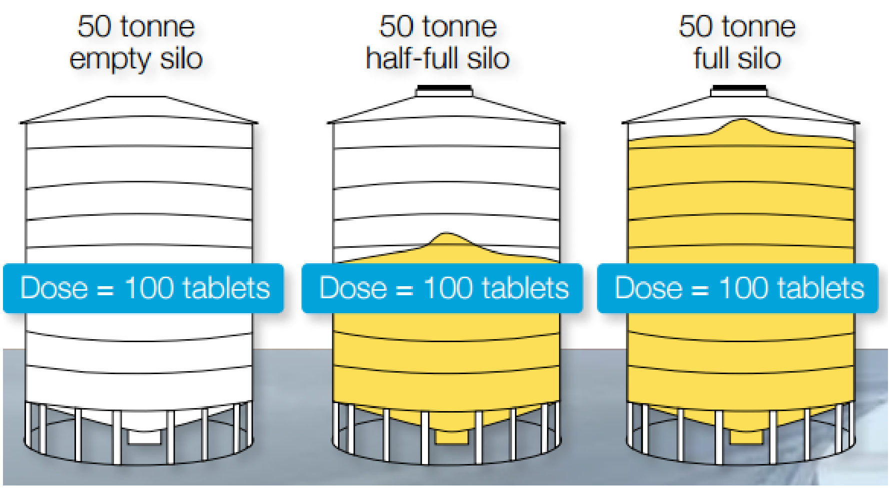


Photo 8: *Treat the silo volume, not the grain.*

Source: CBH

Using bag chains

The application rate for fumigating with a standard bag chain is one bag chain per 75m3 or 60 t of storage capacity. Always refer to the label. Do not cut a bag chain to save extra phosphine for use at a later date. The phosphine will start evolving as soon as it is exposed to air, so will be less effective if it's stored for use at a later date. Storing phosphine after it has already been opened also poses a danger when re-opened, as the gas has been dissipating in a confined space, potentially reaching explosive levels. For larger bulk storage silos, phosphine can be obtained in blanket form. Like bag chains, blankets must not be cut or separated so the minimum size storage for fumigation using a single blanket is 750m3 or 600 t of storage capacity.

Using tablets

The application rate for phosphine is 1.5 grams per cubic metre, which in tablet form equates to three tablets per 2m3. Always read the product label to confirm recommended application rates.

Application from the top

Hang bag chains in the head space or roll out flat in the top of a gas-tight, sealed silo so air can freely pass around them as the gas dissipates. Always spread out phosphine tablets evenly on trays, before hanging them in the head space or placing

31 GRDC. (2016). Fumigating with phosphine, other fumigants and controlled atmospheres. http://storedgrain.com.au/wp-content/uploads/2016/10/GRDC-PHOSP-Booklet_2016_R2_Reduced.pdf

them level on the grain surface inside a gas-tight, sealed silo. The aim is to place the tablets where as much surface area as possible is exposed to air so the gas can disperse freely. Prevent trays from sitting on an angle to avoid tablets piling up to one side and creating more than one layer in the tray.

Application from the bottom

Some silos are fitted with purpose-built facilities for applying phosphine from the bottom. This method of application carries a safety advantage as the operator doesn't have to leave the ground to apply the phosphine. However, ensuring top lids or vent openings on silos are in sound condition and correctly sealed before fumigation, will usually require a climb to the top. Bottom-application facilities must have a passive or active air circulation system to carry the phosphine gas out of the confined space as it evolves. Without air movement, phosphine can reach explosive levels if it's left to evolve in a confined space.

Fumigation period

A gas-tight, sealed silo (one that satisfies a half-life pressure test) must remain sealed for the full 7–10 days to achieve a successful fumigation using phosphine tablets or bag-chains. In a gas-tight, sealed silo the required fumigation period is seven days if the grain temperature is above 25°C or 10 days if the grain temperature is between 15–25°C. If the temperature inside the silo is below 15°C, insect pests will not be active and phosphine is not reliably effective — avoid its use.

Opening the silo during fumigation is potentially harmful to the operator if they are not wearing the appropriate PPE, but also compromises the fumigation as gas concentration levels will quickly fall below the lethal level required to kill insect pests. Phosphine label recommendations have been developed as a result of thorough industry testing so using phosphine as the label specifies will achieve the best result.

Phosphine resistance

Poor fumigations may appear successful when some dead adults are found but many of the eggs, pupae and larvae are likely to survive and will continue to develop and re-infest the grain. These partial kills are often worse than no kill at all because the surviving insects, (adults, pupae, larvae and eggs) are likely to be those that carry increased phosphine resistance genes as a consequence. Underdosing risks increasing the number of insect populations carrying the genes for phosphine resistance and this has serious consequences for the industry.

Phosphine remains the single-most relied upon fumigant to control stored grain pests in Australian grain production systems, but continued misuse is resulting in poor insect control and developing resistance in key pest species. In the same way that repeated herbicide use of the same mode of action leads to resistant weeds, repeated phosphine use leads to resistant grain pests (Figure 6). Unlike herbicides, where resistance can be avoided by rotating chemical group from year to year, there are few alternative stored grain fumigation options other than phosphine. Alternative fumigants and controlled atmospheres that are available for stored grain pests are in most cases more expensive. The best way to prevent resistance is to use phosphine correctly — in a gas-tight, sealed silo.

VIDEOS

WATCH: GCTV: Stored grain: Fumigation recirculation

MORE INFORMATION

Fumigating with phosphine, other fumigants and controlled atmospheres

Grain fumigation – a guide.

Fumigation to control insects in stored grain

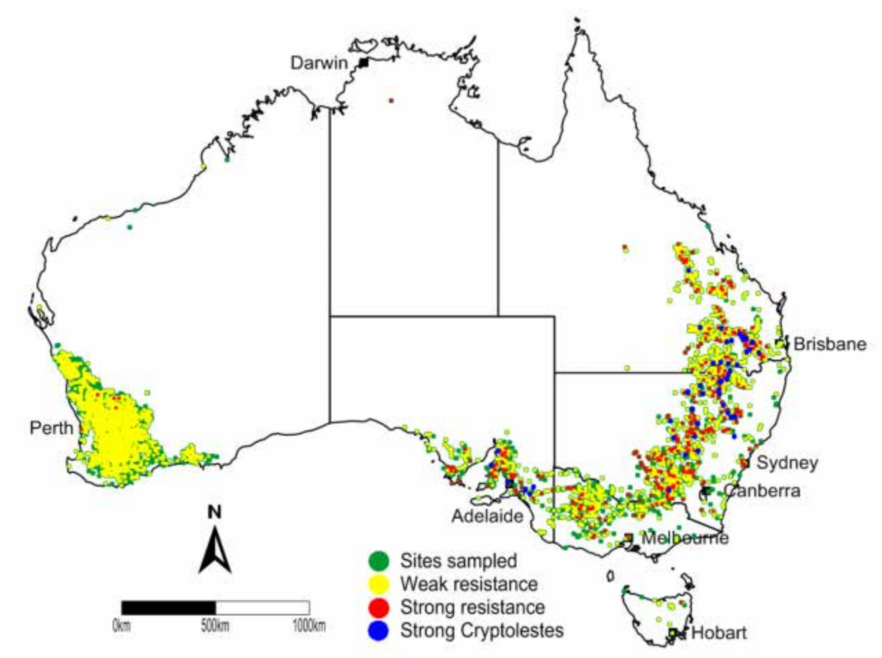


Figure 6: *Instances of phosphine resistance 1986 – 2014.*

Source: DAFWA

Phosphine safety

Caution should always be used when dealing with phosphine gas, it is not only toxic but also highly explosive. Observe all withholding periods for handling and grain use. Phosphine released from aluminium phosphide tablets, pellets or sachets has a characteristic smell which can usually be detected at concentrations within the safe level. Unless fumigating in a well-ventilated situation gas respirators suitable for protection against phosphine should be worn. Masks should fit properly for protection – this may be difficult for those with bearded faces – but is essential to avoid poisoning. Proper mask maintenance is also essential. For safety reasons, it is best not to work alone when applying phosphine tablets or in a structures that have been fumigated. Warning signs should be clearly displayed during fumigation. Always open containers of phosphine preparations in the open air or near open windows. If possible use the contents of a tin in one operation. If any is left over the tin lid should be replaced and sealed with PVC tape. [32]

Withholding period

After fumigating with phosphine, hold grain for a further two days after ventilation before delivering or using for human consumption or animal feed. This is a legal requirement as instructed by the label. The total time required for fumigation ranges from 10–17 days accounting for the minimum exposure period, ventilation and withholding period. It is important to monitor grain regularly and at least 17 days before out-loading to allow sufficient time for the fumigation process when required. [33]

Controlled atmospheres

Although phosphine is still the most commonly-used gas fumigant for controlling pests in stored grain, there are other options. Each of the alternatives still requires a gas-tight, sealable silo and are currently more expensive than using phosphine, but they offer an alternative for resistant pest species. Nitrogen and CO_2 carry the

32 Day, T., Day, H., Hawthorne, W., Mayfield, A., McMurray, L., Rethus, G., & Turner, C. (2006). Grain legume handbook. *GRDC: Canberra, ACT.* https://grdc.com.au/__data/assets/pdf_file/0032/208886/chapter-3-seeding.pdf.pdf

33 GRDC. (2016). Fumigating with phosphine, other fumigants and controlled atmospheres. http://storedgrain.com.au/wp-content/uploads/2016/10/GRDC-PHOSP-Booklet_2016_R2_Reduced.pdf

advantage of being nonchemical control alternatives. Both nitrogen and CO_2 methods of control are sometimes referred to as controlled atmosphere (CA) because they change the balance of natural atmospheric gases to produce a toxic atmosphere.

Carbon dioxide

Treatment with CO_2 involves displacing the air inside a gas-tight silo with a concentration level of CO_2 high enough to be toxic to grain pests. This requires a gas-tight seal, measured by a half-life pressure-test of no less than five minutes. To achieve a complete kill of all the main grain pests at all life stages CO_2 must be retained at a minimum concentration of 35% for 15 days. The amount of CO_2 required to reach 35% concentration for 15 days is one 30 kg (size G) cylinder per 15 t of storage capacity, plus one extra cylinder. CO_2 is a non-flammable, colourless, odourless gas that is approximately 1.5 times heavier than air. Food grade CO_2 comes as a liquid in pressurized cylinders and changes to a gas when released from the cylinder.

The basic process is to open the storage's top lid to let oxygen out as CO_2 is introduced. Regulate the CO_2 gas into the bottom of the silo via a high pressure tube ideally 1 metre long (no longer than 2m). One kilogram of liquid CO_2 will produce approximately half a cubic metre of gas. Each cylinder could take three hours to dispense. In cooler conditions this process will take longer as the gas will tend to freeze if released from the bottle too quickly. This method of fumigation is not recommended when temperatures are below 15°C. Once the concentration at the top of the storage reaches 80%, stop adding CO_2 and seal the top lid.

Even in a silo that meets the five-minute, half-life pressure test, an initial CO_2 concentration of 80% or more is required to retain an atmosphere of 35% for the full 15 days, because the CO_2 is absorbed by the grain, reducing the atmospheric concentration over time. If the storage does leak, CO_2 can be added periodically over the 15 days if required. The key is to maintain the CO_2 concentration above 35% for 15 consecutive days, which will require suitable electronic instruments or a gas tube detector kit for monitoring. At temperatures below 20°C carbon dioxide is less effective because insects are less active so the concentration must be maintained for an extended period.

Nitrogen

Grain stored under nitrogen provides insect control and quality preservation without chemicals. It is safe to use, environmentally acceptable and the main operating cost is electricity. It also produces no residues so grains can be traded at any time, unlike chemical fumigants that have withholding periods. Insect control with nitrogen involves a process using Pressure Swinging Adsorption (PSA) technology, modifying the atmosphere within the grain storage to remove everything except nitrogen, starving the pests of oxygen.

The application technique is to purge the silo by blowing nitrogen-rich air into the base of the silo, forcing the existing, oxygen-rich atmosphere out the top. PSA takes several hours of operation to generate 99.5% pure nitrogen and before the exhaust air has a reduced concentration of 2% oxygen. At 2% oxygen adult insects cannot survive, providing this concentration is maintained for 21 days with a grain temperature above 25°C. Anything less will not control all life stages — eggs, larvae and pupae. For grain below 25°C this period is extended to 28 days. The silo must be checked the day after fumigation and may need further purging to remove oxygen that has diffused from the grain. Nitrogen storage will also maintain the quality of canola and pulses by inhibiting the respiration process that causes oxidation, which leads to seed deterioration, increased free fatty acids and loss of colour. [34]

For further information on controlled atmosphere fumigation with CO_2 or nitrogen, contact the commercial suppliers of appropriate gas and equipment; BOC Gases Australia Ltd, on 13 12 62 or visit www.boc.com.au

34 GRDC. (2016). Fumigating with phosphine, other fumigants and controlled atmospheres. http://storedgrain.com.au/wp-content/uploads/2016/10/GRDC-PHOSP-Booklet_2016_R2_Reduced.pdf

13.3.6 Maximum Residue Limits

Key points:

- Grain samples are tested for pesticide residues in Australia and when export shipments leave the port to ensure they are within maximum residue limits (MRLs).
- A single violation of an importing country's MRL can lead to punitive measures on all Australian grain exported to that country and undermine Australian grains' reputation internationally.
- Consequences may include costs awarded against the exporter and/or grower. If repeated violations are detected with the same chemical, that chemical may be banned.
- It is essential that growers ensure both pre-harvest and post-harvest chemical applications adhere to the Australian Grain Industry Code of Practice.
- Use only registered products and observe all label recommendations including label rates and withholding periods.
- Trucks or augers that have been used to transport treated seed or fertiliser can be a source of contamination. Pay particular attention to storage and transport hygiene.
- Silos that have held treated fertiliser or pickled grain will have dust remnants that require particular attention. These silos either need to be cleaned or designated as non-food-grade storage.
- Compliance with Australian MRLs does not guarantee the grain will meet an importing country's MRL (which may be nil).
- Know the destination of your grain. When signing contracts, check the importing countries' MRLs to determine what pesticides are permitted on that crop.

By observing several precautions, growers can ensure that grain coming off their farm is compliant with the maximum pesticide residue limits that apply to Australian exports. Violations of maximum residue limits (MRLs) affect the marketability of Australian grain exports, and consequences may include costs being imposed on exporters and/or growers.

It is essential that both pre-harvest and post-harvest chemical applications adhere to the Australian Grain Industry Code of Practice, only registered products are used and all label recommendations, including rates and withholding periods, must be observed. Other key points include:

- Trucks or augers that have been used to transport treated seed or fertiliser can be a source of contamination – pay particular attention to storage and transport hygiene;
- Silos that have held treated fertiliser or pickled grain will have dust remnants – these silos either need to be cleaned or designated as non-food grade storage;
- Know the destination of your grain. When signing contracts, check the importing countries' MRLs to determine what pesticides are permitted on a particular crop. [35]

MORE INFORMATION

Managing MRLs factsheet

35 GRDC. (2014). Managing maximum residue limits in export grain - Factsheet. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2014/07/grain-marketing-and-pesticide-residues