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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

BARLEY

SECTION 13

STORAGE

HOW TO STORE BARLEY ON-FARM | HYGIENE | GRAIN PROTECTANTS AND FUMIGANTS | AERATION DURING STORAGE | MONITORING BARLEY

SECTION 13

Storage

An on-farm storage system designed for good hygiene that includes aeration and sealable silos for fumigation is essential for growers who wish to maximise their returns from barley (Figure 1). Without sealable silos, growers could be contributing to Australia's problem of insect resistance to phosphine, the most common fumigant used in the Australian grain industry. Without aeration, growers risk excluding themselves from markets that will not accept chemically treated grain.

In conjunction with sound management practices, which include checking grain temperatures and regular monitoring for insect infestations, an on-farm storage system that is well designed and maintained and properly operated provides the best insurance a grower can have on the quality of grain to be out-turned.

Figure 1: Storage with aeration is important for protecting Australia's markets. (Photo: DAF Qld)

Grain Trade Australia (GTA) stipulates standards for heat-damaged, bin-burnt, storage-mould-affected or rotten barley, all of which can result in the discounting or rejection of grain. GTA has nil tolerance to live, stored grain insects. [1] Effective management of stored grain can eliminate all of these risks to grain quality.

Target grain temperatures of stored wheat should be 20–23°C during summer and <15°C in winter. [2] Aerated silos, properly managed, should allow growers to target an average summertime grain-storage temperature of 20°C.

1 GTA (2013) Barley Trading Standards, 2015/16 season. Grain Trade Australia, August 2015, http://www.graintrade.org.au/sites/default/files/file/Commodity%20Standards/2015_2016/Section%2002%20-%20Barley%20Trading%20Standards%20201516%20Final.pdf

2 P Burrill (2013) Grain Storage Future pest control options and storage systems 2013–2014. GRDC Update, July 2013, https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Grain-Storage-Future-pest-control-options-and-storage-systems-2013-2014

13.1 How to store barley on-farm

13.1.1 Malt barley

Special consideration should be given to storing malt barley. Storage conditions largely determine the rate at which quality parameters of Australian barley varieties change after harvest. Initial kernel condition, temperature, moisture content and storage time are major factors influencing changes in malting quality.

Barley is typically harvested and initially stored at moderate temperatures (25–30°C). Depending on storage conditions, Australian malting barley can take several months to reach optimum malting quality while dormancy and water sensitivity are broken down.

Manipulating storage conditions can provide maltsters with homogeneous barley to malt. Research has identified several options for managing barley dormancy to provide opportunities to malt and export barley earlier, such as use of agricultural chemicals or application of dry heat.

GRDC-funded CSIRO research shows that by understanding and carefully manipulating the storage process, post-harvest dormancy can be removed without compromising barley quality. [3]

Delaying aeration cooling for a short period, or raising the grain temperature using aeration fans during the warmer part of the day followed by rapid cooling after dormancy has been removed, can effectively accelerate the maturation of barley. [4]

13.1.2 Storage options

According to the Kondinin Group National Agricultural Survey 2011, silos account for 79% of Australia's on-farm grain storage, compared with 12% bunkers and pits and 9% grain bags.

Aerated silos that can be sealed during fumigation are widely acknowledged as the most effective ways to store wheat on-farm (Table 1). An Australian standard (AS2628) is now available for sealable silos that manufacturers in Australia can choose to use as a construction standard to ensure reliable fumigation results.

Table 1: Advantages and disadvantages of grain storage options

Storage type	Advantages	Disadvantages
Gas-tight sealable silo	• Gas-tight sealable status allows phosphine and controlled atmosphere options to control insects • Easily aerated with fans • Fabricated on-site or off-site and transported • Capacity from 15 to 3000 t • Service life up to 25 years or more • Simple in-loading and out-loading • Easily administered hygiene (cone base particularly) • Can be used multiple times in-season	• Requires foundation to be constructed • Relatively high initial investment required • Seals must be regularly maintained • Access requires safety equipment and infrastructure • Requires an annual test to check gas-tight sealing

[3] CSIRO and Barrett Burston Malting Co. The effect of storage conditions on post-harvest maturation and maltability of barley. E-Malt, http://www.e-malt.com/statistics/ScientificDigest/BTSbarleyStorage.pdf

[4] CSIRO (2011) Stored barley manipulated to brew better beer. CSIRO Food and Agriculture June 2010, Updated October 2011.

Storage type	Advantages	Disadvantages
Non-sealed silo	• Easily aerated with fans • 7–10% cheaper than sealed silos • Capacity from 15 to 3000 t • Service life up to 25 years or more • Can be used multiple times in-season	• Requires foundation to be constructed • Silo cannot be used for fumigation—see phosphine label • Insect-control options limited to protectants in eastern states and Dryacide® in Western Australia • 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 all ground-operated • Can accommodate high-yielding seasons	• Requires purchase or lease of loader and unloader • Increased risk of damage beyond short-term storage (typically 3 months) • Limited insect-control options, fumigation only possible under specific protocols • Requires regular inspection and maintenance, which needs to be budgeted for • Aeration of grain in 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
Grain storage sheds	• Can be used for dual purposes • Service life 30 years or more • 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

Growers should pressure-test sealable silos once a year to check for damaged seals on openings. Storages must be able to be sealed properly to ensure that high concentrations of phosphine gas are held long enough to give an effective fumigation.

At an industry level, it is in growers' best interests to fumigate only in gas-tight sealable storages to help stem the rise of insect resistance to phosphine. This resistance has come about because of the prevalence of storages that are poorly sealed or unsealed during fumigation. [5]

The Kondinin Group National Agricultural Survey 2009 revealed that 85% of respondents had used phosphine at least once during the previous 5 years, and of those users, 37% used phosphine every year for the past 5 years. A GRDC survey during 2010 revealed that only 36% of growers using phosphine applied it correctly—in a gas-tight, sealable silo.

Research shows that fumigating in a storage that is not gas-tight does not achieve a sufficient concentration of fumigant for long enough to kill pests at all life-cycle stages. For effective phosphine fumigation, a minimum gas concentration of 300 parts per million (ppm) for 7 days or 200 ppm for 10 days is required (Figure 2). Fumigation trials

5 C Warrick (2011) Fumigating with phosphine, other fumigants and controlled atmospheres: Do it right—do it once: A Grains Industry Guide. (Reprinted 2013) GRDC, http://www.grdc.com.au/uploads/documents/GRDC-Fumigating-with-Phosphine-other-fumigants-and-controlled-atmospheres.pdf?shortcut=1

in silos with small leaks demonstrated that phosphine levels are as low as 3 ppm close to the leaks (Figure 3). The rest of the silo also suffers from reduced gas levels. [6]

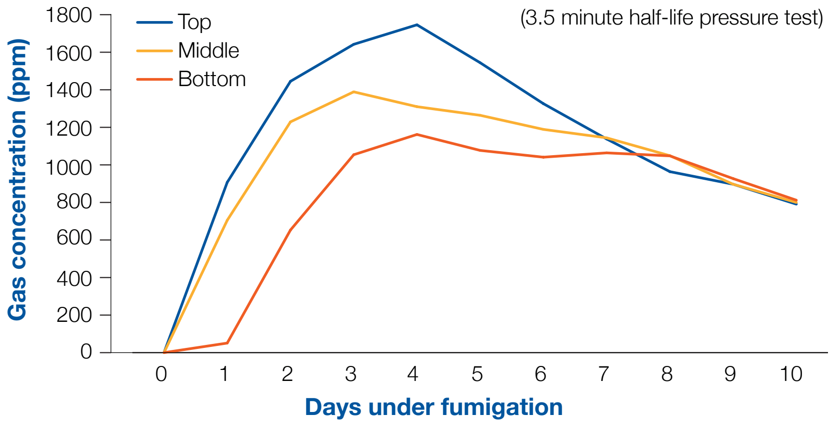

Figure 2: Gas concentration in gas-tight silo. (Source: DAF Qld)

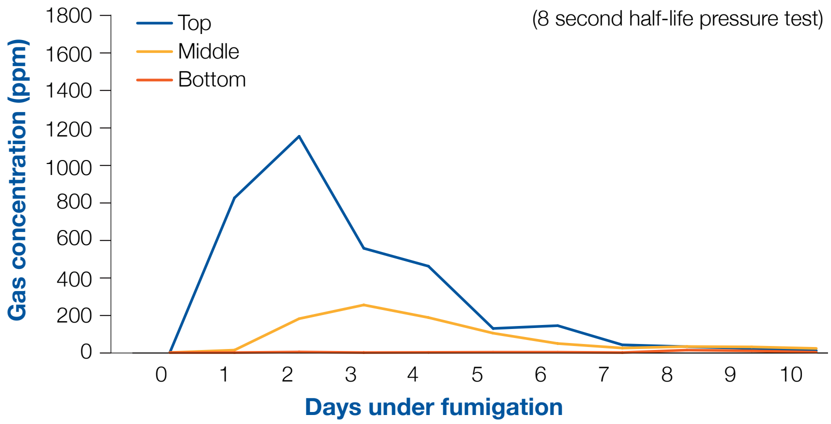

Figure 3: Gas concentration in a non-gas-tight silo. (Source: DAF Qld)

Aeration of stored barley is the key non-chemical tool used to minimise the risk of insect infestations and spoiling through heat and/or moisture damage.

Aeration controllers that automatically monitor air temperature and humidity are designed to turn fans on and off at the optimum times. The controller reduces the risk of having fans running on storages at times that may cause grain damage. Most aeration controllers have hour meters fitted, so run-times can be checked to ensure that they are within range of the expected total average hours per month (e.g. 100 h/month).

Aeration systems commonly used for 'aeration cooling' should be separated from those designed specifically to achieve reliable 'aeration drying'. Serious grain damage has occurred when fan performance has not met the required airflow rates as measured in litres per second per tonne (L/s.t). If aeration drying of grain is attempted with elevated moisture levels and using an inadequate airflow rate and/or a poor system design, sections of the storage can develop very high moisture and grain temperatures. With low airflow rates, moisture-drying fronts move too slowly to prevent grain spoilage. Grain-quality losses from moulds and heat occur rapidly. This type of damage often makes the grain difficult to sell and may cause physical damage to the silo. [7]

6 P Botta, P Burrill, C Newman (2010) Pressure testing sealable silos. Grain Storage Fact Sheet, GRDC, September 2010, http://www.grdc.com.au/~/media/FC440FBD7AE14140A08DAA3F2962E501.pdf

7 P Burrill, A Ridley (2012) Performance testing aeration systems. Grain storage Fact Sheet, GRDC, 22 August 2012, http://www.grdc.com.au/Resources/Factsheets/2012/08/Grain-Storage-Performance-testing-aeration-systems

Researchers in Australia have developed a device that measures working airflow rates of fans fitted to grain storage. Called the 'A-Flow', it has been validated under controlled conditions, using an Australian Standard fan-performance test rig, to be within 2.6% of the true fan output. The device was used on a typical grain storage that was in the process of aerating recently harvested grain. A fan advertised to provide 1000 L/s (equivalent to 6.7 L/s.t on a full 150-t silo) was tested and shown to be producing only 1.8 L/s.t. Because of this test, the farmer recognised a need to make changes to his current aeration system design.

More information

GRDC: Fumigating with phosphine, other fumigants and controlled atmospheres

A number of changes may be required if airflow rates are not suitable for efficient aeration cooling or drying. A new fan that is better suited to the task could be installed, or the amount of grain in the silo reduced to increase flow rate per tonne of grain.

Detailed information about selecting, siting and fitting-out silos, grain storage bags, sheds and bunkers is contained in the GRDC Grains Industry Guide 'Grain storage facilities: Planning for efficiency and quality'.

13.2 Hygiene

Effective grain hygiene and aeration cooling can overcome 75% of pest problems in stored grain. All grain residues should be cleaned out when silos and grain-handling equipment are not in use to help minimise the establishment and build-up of pest populations.

In one year, a bag of infested grain can produce more than one million insects, which can walk and fly to other grain storages where they will start new infestations. Meticulous grain hygiene involves removing any grain residues that can harbour pests and allow them to breed. Grain pests live in protected, sheltered areas in grain-handling equipment and storage and they breed best in warm conditions. Insects will also breed in outside dumps of unwanted grain (Figure 4). Try to bury grain or spread unwanted grain out to a shallow depth of <20 mm so that insects are exposed to the daily temperature extremes and other insect predators.

Figure 4: Poor grain hygiene undermines effective stored grain insect control. (Photo: DAF Qld)

A trial in Queensland revealed >1000 lesser grain borers (*Rhyzopertha dominica*) (Figure 5) in the first 40 L of grain through a harvester at the start of harvest; this harvester was considered reasonably clean at the end of the previous season. [8] Further studies in Queensland revealed that insects are least mobile during the colder winter months. Cleaning around silos in winter can reduce insect numbers before they become mobile.

Figure 5: Rhyzopertha dominica. (Photo: DAF Qld)

Successful grain hygiene involves cleaning all areas where grain residues become trapped in storages and equipment. Grain pests can survive in a tiny amount of grain, which can go on to infest freshly harvested clean grain. Harvesters and grain-handling equipment should be cleaned out thoroughly with compressed air after use.

After grain storages and handling equipment are cleaned, they should be treated with a structural treatment. Diatomaceous earth (DE) is an amorphous silica also commonly known as the commercial product Dryacide™ and is widely used for this purpose. It acts by absorbing the insect's cuticle or protective waxy exterior, causing death by desiccation. If applied correctly with good coverage in a dry environment, DE can provide up to 12 months' protection by killing most species of grain insects and with no known risk of resistance. It can be applied as a dry dust or slurry spray.

More information

GRDC Fact Sheets:
[Hygiene and structural treatment for grain storages]

Although many cereal grain buyers accept the use of approved chemical insecticide structural treatments to storages, growers should avoid using them, or wash the storage out, before storing oilseeds and pulses. Several export and domestic markets require 'pesticide residue free' grain (PRF), and growers are advised to check with potential grain buyers before using grain protectants or structural treatments.

13.3 Grain protectants and fumigants

Grain Trade Australia is aware of cases where various chemicals have been used to treat stored grain that are not approved for grain or that particular grain type. When they are detected, an entire shipload can be rejected, often with serious long-term consequences for important Australian grain markets.

Accessing markets that require PRF grain does not rule out the use of some fumigants, including phosphine (Figure 6). However, PRF grain should not have any chemical residues from treatments that are applied directly to the grain as grain protectants.

8 P Burrill, P Botta, C Newman, B White, C Warrick (2013) Grain storage pest control guide. Northern and southern regions. Grain Storage Fact Sheet, GRDC, 25 June 2013, http://www.grdc.com.au/Resources/Factsheets/2013/06/Grain-Storage-Fact-Sheet-Grain-Storage-Pest-Control-Guide

Before using a grain protectant or fumigant, growers need to check with prospective buyers, because the use of some chemicals may exclude grain from certain markets.

Although phosphine has resistance issues, it is widely accepted as having no residue issues. The grains industry has adopted a voluntary strategy to manage the build-up of phosphine resistance in pests. Its core recommendations are to limit the number of conventional phosphine fumigations on undisturbed grain to three per year, and to employ a break strategy. The break is provided by moving the grain to eliminate pockets where the fumigant may fail to penetrate, and by retreating it with an alternative disinfestant or protectant. [9]

Figure 6: Phosphine is widely accepted as having no residue issues. (Photo: DAF Qld)

Research has identified the genes responsible for insect resistance to phosphine. A genetic analysis of insect samples collected from south-eastern Queensland between 2006 and 2011 has allowed researchers to confirm the increasing incidence of phosphine resistance in the region. Whereas few resistance markers were found in insects collected in 2006, by 2011, most collections had insects that carried the resistance gene. Further testing with DNA markers that can detect phosphine resistance is expected to identify problem insects before resistance becomes entrenched, thereby helping to prolong phosphine's effective life, as well as increasing the usefulness of the break strategy. [10]

According to research at Department of Agriculture and Fisheries Queensland, sulfuryl fluoride (SF) has excellent potential as an alternative fumigant to control phosphine-resistant grain storage pests (Table 2). It is currently registered in Australia as a grain disinfestant. Supplied under the trade name 'ProFume', SF can be used only by a licenced fumigator.

9 P Collins (2009) Strategy to manage resistance to phosphine in the Australian grain industry. Cooperative Research Centre for National Plant Biosecurity Technical Report, http://www.graintrade.org.au/sites/default/files/file/Phosphine_Strategy.pdf

10 D Schlipalius (2013) Genetic clue to thwart phosphine resistance. GRDC Ground Cover, Issue 102, Jan.–Feb. 2013, http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-102/Genetic-clue-to-thwart-phosphine-resistance

Table 2: Resistance and efficacy guide for stored grain insects (northern and southern regions) in cereal grains

WHP, Withholding period (days). Note: Pirimiphos-methyl, combined products such as Reldan Plus PGR and chlorpyrifos-methyl are not registered for use on malt barley. For more information, see p. 121, Table 2, of the NSW DPI Winter crop variety sowing guide 2015, or visit APVMA

Treatment and example product	WHP	Lesser grain borer	Rust-red flour beetle	Rice weevil	Saw-toothed grain beetle	Flat grain beetle	Psocids (booklice)	Structural treatments
Grain disinfestants—used on infested grain to control full life cycle (adults, eggs, larvae, pupae)								
Phosphine (Fumitoxin®) [A,B] when used in gas-tight, sealable stores	2							
Sulfuryl fluoride (ProFume®)[C]	1							
Dichlorvos (e.g. Dichlorvos 1140®)[D]	7–28							K
Grain protectants—applied postharvest. Poor adult control if applied to infested grain								
Pirimiphos-methyl (Actellic 900®)	nil[H]							
Fenitrothion (Fenitrothion 1000®)[E]	1–90							
Chlorpyrifos-methyl (Reldan Grain Protector®)[F]	Nil[H]							
Methoprene (Grain Star 50®)	Nil[I]		J		J			
Combined product' (Reldan Plus IGR Grain Protector)	Nil[H]							
Deltamethrin (K-Obiol®)[C]	Nil[H]							
Diatomaceous earth, amorphous silica—effective internal structural treatment for storages and equipment. Specific-use grain treatments								
Diatomaceous earth, amorphous silica (Dryacide®)[G]	Nil[H]							

Not registered for this pest
High-level resistance in flat grain beetle has been identified, send insects for testing if fumigation failures occur
Resistant species likely to survive this structural treatment for storage and equipment
Resistance widespread (unlikely to be effective)
Effective control

[A] Unlikely to be effective in unsealed sites, causing resistance, see label for definitions.
[B] Total of (exposure + ventilation + withholding) = 10–27 days.
[C] Restricted to licenced fumigators or approved users.
[D] Restriced to use under permit 14075 only; unlikely to be practical for use on farm.
[E] Nufarm label only.
[F] Stored grains except malting barley and rice/ stored lupins registration for Victoria only/ not on stored maize destined for export.
[G] Do not use on stored maize destined for export, or on grain delivered to bulk-handling authorities.
[H] When used as directed on label.
[I] When applied as directed, do not move treated grain for 24 hours.
[J] Periods of 6–9 months storage including mixture in adulticide, e.g. fenitrothion at label rate.
[K] Dichlorvos 500 g/L registration only.

Source: Registration information courtesy of Pest Genie, APVMA and InfoPest (DEEDI).

Field trials have shown that SF can control strong phosphine-resistant populations of rusty grain beetle (*Cryptolestes ferrugineus*). Monthly sampling of fumigated grain has revealed no live insects for three consecutive months in large-scale bunker (pad) storages after the fumigation.

Annual resistance-monitoring data were analysed to assess the impact of SF as an alternative fumigant to phosphine. This revealed that after the introduction of SF in central storages across the northern and southern grain regions in 2010, there was a 50% reduction in the incidence of strongly phosphine-resistant populations of rusty grain beetle at the end of the first year, and the downward trend is continuing.

A 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Complimentary laboratory experiments have shown that phosphine resistance does not show cross-resistance to SF, which is an additional advantage of using SF. [11]

Effective phosphine fumigation can be achieved by placing the chemical at the rate directed on the label onto a tray and hanging it in the top of a pressure-tested, sealable silo. A ground-level application system is also an efficient application method, and these can be combined with a silo recirculation system on larger silos to improve the speed of gas distribution. After fumigation, grain should be ventilated for a minimum of 1 day with aeration fans running, or 5 days if no fans are fitted. A minimum withholding period of 2 days is required after ventilation before grain can be used for human consumption or stock-feed. The total time required for fumigating ranges from 7 to 20 days depending on grain temperature and the storage structure.

To find out more, visit the GRDC Grains Industry Guide: Fumigating with phosphine, other fumigants and controlled atmospheres. Do it right—do it once.

Two other grain protectants are now available:

- K-Obiol (active ingredients deltamethrin 50 g/L, piperonyl butoxide 400 g/L). Features acceptable efficacy against the common storage pest lesser grain borer, which has developed widespread resistance to current insecticides. Insect-resistance surveys in the past consistently detected low levels of deltamethrin-resistant insect strains in the industry. This is a warning that resistant populations could increase quickly with widespread excessive use of one product. A 'product stewardship' program has been developed to ensure correct use of the product. [12]
- Conserve On-Farm. Has three active ingredients (chlorpyrifos-methyl 550 g/L, S-methoprene 30 g/L, spinosad 120 g/L) to control most major insect pests of stored grain, including the resistant lesser grain borer. Maximum residue limits have been established with key trading partners and there are no issues with meat residue bioaccumulation.

A grain disinfestant combined with carbon dioxide gas currently has some limitations:

- VAPORMATE (active ingredient ethyl formate 166.7 g/kg). Approved for use in stored cereals and oilseeds. It is registered to control all life-stages of the major storage pest insects lesser grain borer, rust-red flour beetle (*Tribolium* spp.), sawtoothed beetle, flat grain beetles, storage moths and psocids (booklice). However, it does not fully control all stages of rice weevil. It must only be used by a licenced fumigator.

Controlled atmosphere/non-chemical treatment options include:

- Carbon dioxide (CO2). Involves displacing the oxygen inside a gas-tight silo with a high concentration of CO2 combined with a low oxygen atmosphere lethal to grain pests. To achieve a complete kill of all grain pests at all life-stages, CO2 must be maintained at a minimum concentration of 35% for 15 days.
- Nitrogen (N_2). Provides insect control and quality preservation without chemicals. It is safe to use and environmentally acceptable, and the main operating cost is electricity used by the equipment to produce N_2 gas. The process uses pressure swing adsorption (PSA) technology to produce N_2, thereby modifying the atmosphere within the grain storage to create a very high concentration of N_2, and starving insect pests of oxygen. [13] There are no residues, so grains can be traded at any time.

[11] M Nayak (2012) Sulfuryl fluoride—A solution to phosphine resistance? GRDC Research Update Northern Region, Spring 2012, Issue 66, https://www.grdc.com.au/~/media/DAF5F438D9644D90B9A4FA9716B2014E.pdf

[12] P Burrill (2013) Grain Storage Future pest control options and storage systems 2013–2014. GRDC Update Papers, 18 July 2013, https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Grain-Storage-Future-pest-control-options-and-storage-systems-2013-2014

[13] C Warrick (2011) Fumigating with phosphine, other fumigants and controlled atmospheres: Do it right—do it once: A Grains Industry Guide. GRDC Stored Grain Project, January 2011 (reprinted June 2013), http://www.grdc.com.au/uploads/documents/GRDC-Fumigating-with-Phosphine-other-fumigants-and-controlled-atmospheres.pdf?shortcut=1

Silo bags as well as silos can be fumigated (Figure 7). Research conducted by Andrew Ridley and Philip Burrill from DAF Qld and Queensland farmer Chris Cook found that sufficient concentrations of phosphine can be maintained for the required time to fumigate grain successfully in a silo bag. Trials on a typical, 75-m-long bag containing approximately 230 t of grain successfully controlled all life stages of the lesser grain borer.

Figure 7: Silo bags can also be fumigated. (Photo: DAF Qld)

When using phosphine in silos or silo bags, it is illegal to mix phosphine tablets directly with grain because of tablet residue issues. Trays in silo bags are not practical; therefore, tablets are placed in perforated conduit to contain tablets and spent dust. The 1-m tubes are speared horizontally into the silo bag and removed at the end of the fumigation. Trial results suggest that the spears should be no more than 7 m apart and fumigation should occur over 12–14 days (Figure 8). In previous trials when spears were spaced 12 m apart, the phosphine gas took too long to diffuse throughout the whole bag. [14]

[14] P Burrill, A Ridley (2012) Silo bag fumigation. GRDC Research Update Northern Region, Spring 2012, Issue 66, http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-96-January-February-2012/Researchers-devise-practical-silo-bag-fumigation-method

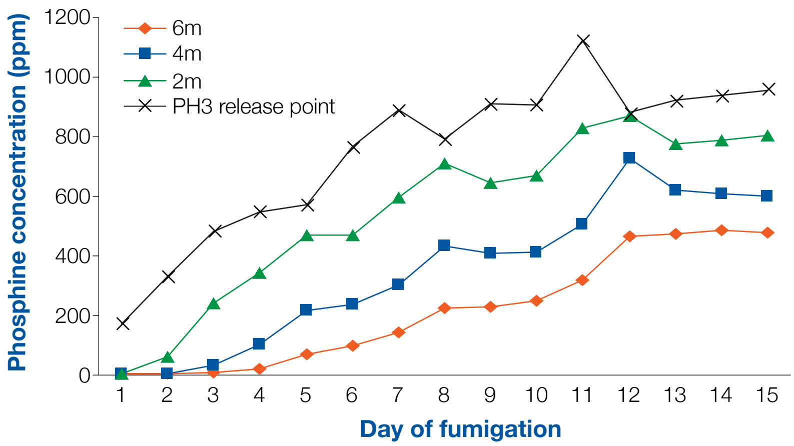

Figure 8: Spread of phosphine gas in a silo bag from a release point to gas-monitoring lines at 2, 4 and 6 m along a silo bag.

13.4 Aeration during storage

Aeration has a vital role in maintaining grain quality attributes and reducing insect pest problems in storage. Most grain in storage is best held under aeration-cooling management with the silo having appropriate roof venting. Generally, silos should be sealed up only during a fumigation operation, which typically lasts for 1–2 weeks.

Aeration typically reduces stored grain temperatures by more than 10°C during summer (Figure 9), which significantly reduces the threat of a serious insect infestation. [15]

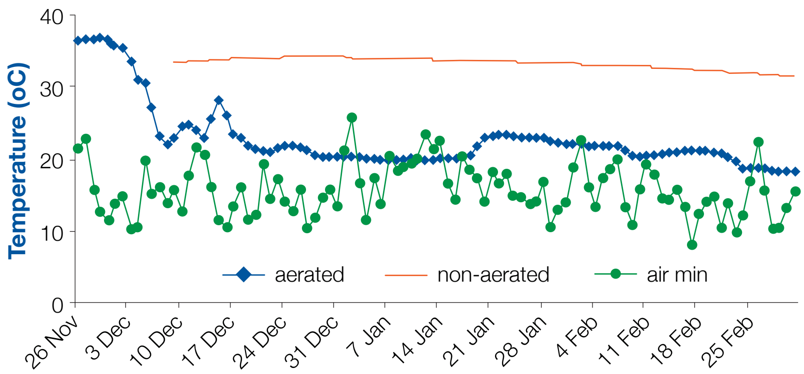

Figure 9: Comparison of wheat grain temperatures in aerated and non-aerated silos.

As soon as grain is harvested and put in storage, run the aeration system continuously for the first 5 days to reduce grain temperatures and produce uniform moisture conditions in the grain bulk. Without aeration, grain holds its heat because it is an effective insulator and will maintain its warm harvest temperature for a long time. Wheat at typical harvest temperatures of 28–35°C and moisture content >13–14% provides ideal conditions for mould and insect growth (Table 3). [16]

[15] P Burrill (2013) Grain Storage Future pest control options and storage systems 2013–2014. GRDC Update Papers, 18 July 2013, https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Grain-Storage-Future-pest-control-options-and-storage-systems-2013-2014

[16] :P Burrill, P Botta, C Newman, B White, C Warrick (2013) Dealing with high-moisture grain. Grain Storage Fact Sheet, GRDC, June 2013, https://www.grdc.com.au/~/media/Documents/Resources/Publications/Fact-sheets/GSFS-7_HighMoistureGrain_2013_LR_Final-pdf.pdf

Table 3: The effect of grain temperature on insects and mould (Source: Kondinin Group)

Grain temperature (°C)	Insect and mould development	Grain moisture content (%)
40–55	Seed damage occurs, reducing viability	
30–40	Mould and insects are prolific	>18
25–30	Mould and insects active	13-18
20–25	Mould development is limited	10-13
18–20	Young insects stop developing	9
<15	Most insects stop reproducing, mould stops developing	<8

Although adult insects can survive at low temperatures, most storage-pest life-cycle stages are very slow or stop at temperatures <18–20°C. One of the more cold-tolerant pests, the common rice weevil, does not increase its population at grain temperatures <15°C. Insect-pest life cycles (eggs, larvae, pupae and adults) are lengthened from the typical 4 weeks at warm temperatures (30–35°C) to 12–17 weeks at cooler temperatures (20–23°C).

Research also shows that cereals at 12% moisture content stored for 6 months at 30–35°C (unaerated grain temperature) will have reduced germination percentage and seedling vigour.

A national upper limit for moisture of 12.5% applies to barley at receival, but deliveries are usually in the range 10.5–11%. [17] Special measures must be taken to minimise the risk of insect infestations or heat damage if the crop is harvested in damp conditions.

A trial by DAF Qld revealed that high-moisture grain generates heat when put into a confined storage, such as a silo. Wheat with 16.5% moisture content at a temperature of 28°C was put into a silo with no aeration. Within hours, the grain temperature reached 39°C and within 2 days reached 46°C, providing ideal conditions for mould growth and grain damage (Figure 10). [18]

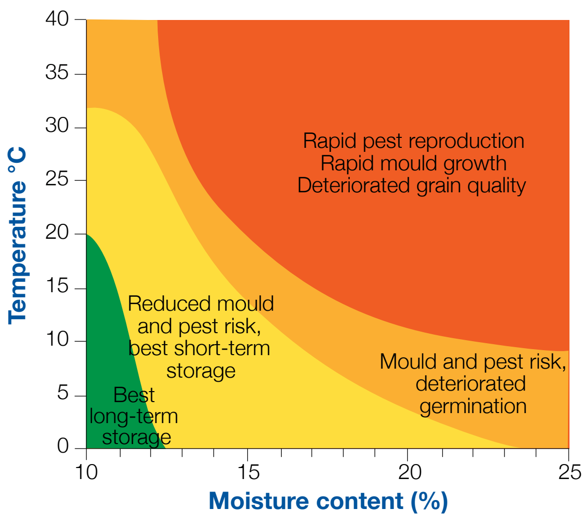

Figure 10: Effects of temperature and moisture on stored grain. (Source: CSIRO Ecosystems sciences as published in Grain Storage Fact Sheet—dealing with high-moisture grain)

If use of a grain dryer is not an option, grain that is over the standard safe storage moisture content of 12% and up to the moderate moisture level of 15% can be

[17] Wheat Quality Objectives Group (2009) Understanding Australian wheat quality. GRDC, http://www.grdc.com.au/~/media/6F94BAEDAAED4E66B02AC992C70EB776.pdf

[18] P Burrill, P Botta, C Newman, B White, C Warrick (2013) Dealing with high-moisture grain. GRDC Grain Storage Fact Sheet, June 2013, https://www.grdc.com.au/~/media/Documents/Resources/Publications/Fact-sheets/GSFS-7_HighMoistureGrain_2013_LR_Final-pdf.pdf

managed by aerating until drying equipment is available. Blending with low-moisture grain and aerating is also a commonly used strategy (Figure 11).

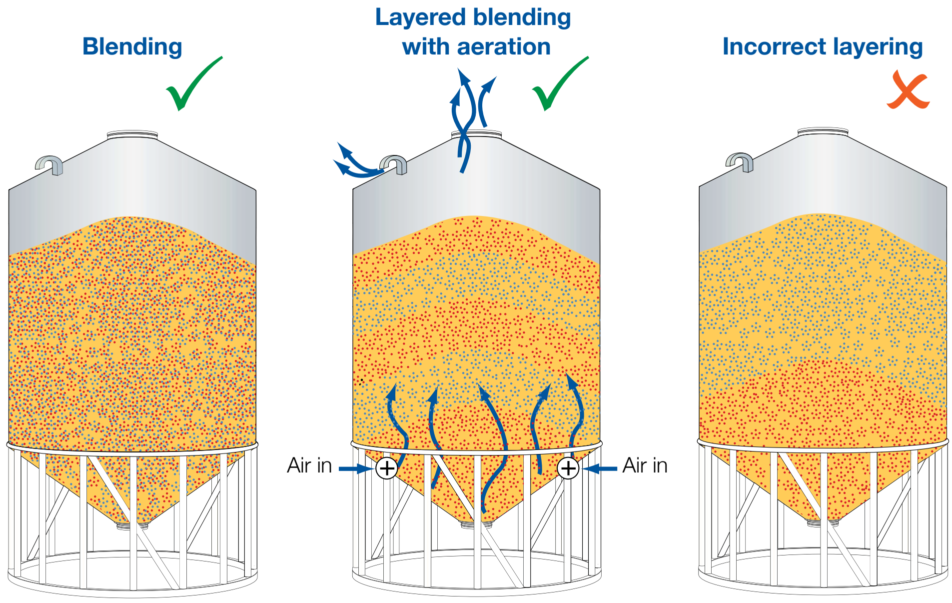

Figure 11: Correct blending. (Source: Kondinin Group)

Aeration drying forces large volumes of air through the grain in storage and slowly removes moisture. Supplementary heating can be added when ambient conditions typically have high humidity. Aeration drying can be done in a purpose-built drying silo or a partly filled silo with high-capacity aeration fans.

Dedicated driers can be used to dry grain in batches or with continuous-flow, before it is put into silos, but excessive heat applied postharvest can reduce quality.

13.5 Monitoring barley

Growers are advised to monitor all grain in storage at least monthly. During warm periods in summer, if grain moisture content is near the upper end of the safe storage moisture content, monitoring every 2 weeks is advisable. Insect pests present in the on-farm storage must be identified so that growers can exploit the best chemical and/or non-chemical control measures to control them.

Barley for domestic or export use must not contain live storage pests, and feed grades can lose nutritional value and palatability through infestations. Keeping storage pests out of planting seed grain is also important because they can reduce the germination and vigour quality of seed, with serious consequences for the next barley crop.

When monitoring stored grain through sieving, trapping and quality inspections, growers should keep records of findings. If possible, grain temperature should also be checked regularly. Any grain treatments applied should be recorded (Figure 12). [19]

[19] P Burrill, P Botta, C Newman (2010) Aeration cooling for pest control. Grain Storage Fact Sheet, GRDC, September 2010, https://www.grdc.com.au/~/media/ReFocus-media-library/Document/GRDC-Document-Store/Publications-Media-and-Communications/Factsheets/Grain-storage-FS-Aeration-cooling-for-pest-control.pdf

A 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Figure 12: Keep records of findings from stored grain insect monitoring. (Photo: DAF Qld)

The lesser grain borer and rust-red flour beetle are some of the most common insect pests found in stored cereals. Other common species to watch for include weevils (*Sitophilus* spp.), the sawtoothed grain beetle (*Oryzaephilus* spp.), flat grain beetles and rusty grain beetle (*Cryptolestes* spp.), psocids (booklice), Indian meal moth (*Plodia interpunctella*), and angoumois grain moth (*Sitotroga cerealella*). Another dozen or so beetles, and mites, are sometimes present as pests in stored cereal grain.

Photographs and descriptions of these pests can be found in the GRDC Grain Storage Fact Sheet Northern and southern regions stored grain pests—Identification, or the GRDC Stored grain pests identification. The Back Pocket Guide.

The Fact Sheet outlines how to monitor stored grain for infestations. Here are some basic points to follow when monitoring for insect pests in your grain:

- Sample and sieve grain from the top and bottom of grain storages every 4 weeks for early pest detection. Pitfall traps installed in the top of the grain store will also help with early detection of storage pests.
- Holding an insect sieve in the sunlight will encourage insect movement, making pests easier to see. Sieve samples onto a white tray to make small insects easier to see. Sieves should have 2-mm mesh and need to hold at least 1 L of grain.
- To identify live grain pests, place them in a clean glass container. Briefly warm the jar in the sun to encourage insect activity. Weevils and sawtoothed grain beetles can walk up the walls of the glass easily, but flour beetles and lesser grain borer cannot. Look closely at the insects walking up the glass—weevils have a curved snout at the front and sawtoothed grain beetles do not. [20]

NOTE: Exotic pests including Karnal bunt (*Tilletia indica*) and khapra beetle (*Trogoderma granarium*) are a threat to the Australian grains industry—report sightings immediately.

[20] P Burrill, P Botta, C Newman, B White, C Warrick (2013) Stored grain pests—identification. Northern and southern regions. Grain Storage Fact Sheet, GRDC, June 2013, https://www.grdc.com.au/~/media/Documents/Resources/Publications/Fact-sheets/GSFS-2_SGPestIdent_NS_2013_LR_Final-pdf.pdf