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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

OATS

SECTION 13

STORAGE

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

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 cereal grains. 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 cooling, growers see warmer grain temperatures in storage, favouring rapid breeding of insect pests and negative impacts to grain quality.

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 aeration is important for maintaining grain quality and protecting Australia's markets. (Photo: QDAFF)

Grain Trade Australia (GTA) stipulates standards for heat-damaged, bin-burnt, storage-mould-affected or rotten grain, all of which can result in grain being discounted or rejected. GTA has nil tolerance to live, stored grain insects for all grades from milling grades to feed. [1] Effective management of stored grain can eliminate all of these risks to quality (Figure 1).

1 Grain Trade Australia (2013) Wheat Standards, 2013/2014 season. GTA, August 2013.

Growers should aim for stored oats grain temperatures of 20 to 23°C during summer and less than 15°C in winter. [2] On-farm storage trials in New South Wales and southern Queensland demonstrated how properly managed, aerated silos, will achieve average summer time grain storage temperature of 20°C. This reduces pest and grain quality problems.

13.1 How to store oats on-farm

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

Aerated silos that can be sealed during fumigation are widely acknowledged as the most effective ways to store oats on-farm (Table 1). There is now an Australian standard (AS2628) 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 t up to 3000 t • Up to 25 years plus service life • Simple in-loading and out-loading • Easily administered hygiene (cone base particularly) • Can be used multiple times in-season	• Higher initial investment required • Seals must be maintained • Requires an annual test to check gas-tight sealing
Non-sealable silo	• Easily aerated with fans • 7–10% cheaper than sealed silos • Capacity from 15 tonnes up to 3,000 tonnes • Up to 25–35 years of service life • Can be used multiple times in-season	• Grain in non-sealable silo cannot be fumigated for pest control — see phosphine label • Insect control options are limited, that is, protectants in eastern states and Dryacide in Western Australia.
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 grain damage beyond short-term storage (typically three 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 is not practical in most circumstances • Should be fenced off from domestic and native animals • Bags and grain 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 of bag

More information

DAFWA (2015) Oats: harvesting, swathing and grain storage

GRDC Stored grain information hub, Northern & Southern Regions Grain Storage Pest Control Guide

GRDC Stored grain information hub, Northern & Southern Regions Stored Grain Pests – Identification

[2] P Burrill (2013) Grain Storage Future pest control options and storage systems 2013–2014., GRDC Update, July 2013.

Storage type	Advantages	Disadvantages
Grain storage sheds	• Can be used for dual purposes • 30 year plus 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 may be difficult • Limited insect control options without sealing • Difficult to unload

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'.

When growers use aerated, sealable silos, they should be pressure-tested once a year to check for damaged seals on openings or other fittings. Storages must be able to be sealed properly for the short period (e.g. 7, 10 or 20 days – see label) while fumigation is in progress. This ensures high phosphine gas concentrations are held long enough to give an effective kill of all insect pests.

At an industry level, it is in growers' best interests to only fumigate 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. [3]

The Kondinin Group National Agricultural Survey 2009 revealed that 85% of respondents had used phosphine at least once during the previous five years, and of those users, 37% used phosphine every year for the past five 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 (Figure 2), a minimum gas concentration of 300 ppm for 7 days or 200 ppm for 10 days is required. Fumigation trials 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. [4]

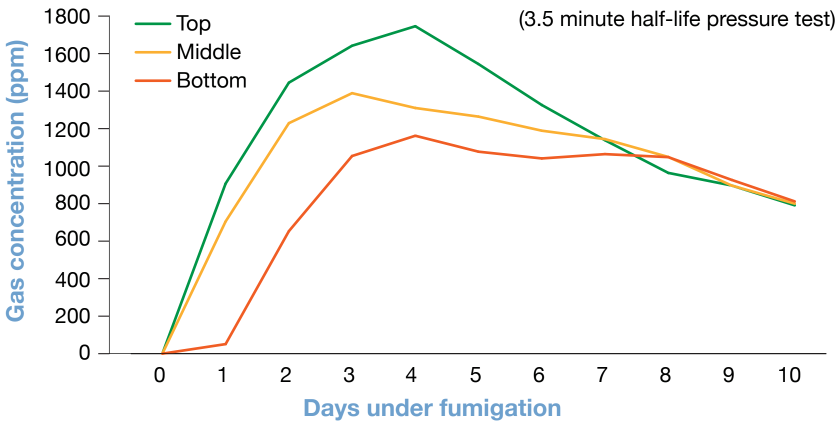

Figure 2: Good gas concentration maintained over time in gas-tight sealable silo. (Source: QDAFF)

3 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).

4 P Botta, P Burrill, C Newman (2010) Pressure testing sealable silos. GRDC Grain Storage Fact Sheet, September 2010.

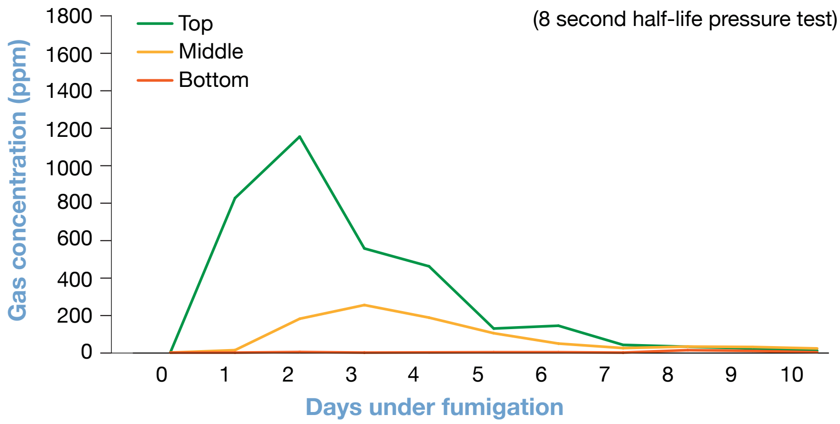

Figure 3: Gas concentration is poor over the 10 days in a non-gas-tight silo. (Source: QDAFF)

To find out more about how to pressure-test silos, visit 'Fumigating with phosphine, other fumigants and controlled atmospheres' at DAFWA (2015) Oats: harvesting, swathing and grain storage.

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

Aeration controllers that automatically monitor ambient 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 potentially cause grain damage. Most aeration 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, for example, approximately 100 hr fan run-time per month.

It is important to be aware of the differences between aeration systems used for 'aeration cooling' and aeration systems designed specifically to achieve reliable 'aeration drying'. Aeration drying systems require much higher airflow rates. 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 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 itself. [5]

Researchers in Australia have developed a device that measures working airflow rates of aeration fans fitted to grain storages. 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 the existing aeration system design. A GRDC Fact sheet, 'Performance testing aeration systems', details construction and use of the 'A-Flow' device.

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 airflow rate per tonne of grain.

5 P Burrill, A Ridley (2012) Performance testing aeration systems. GRDC Research Update Northern Region, Spring 2012, Issue 66.

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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 (Figure 4). 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 storages and breed best in warm conditions. Insects will also breed in outside dumps of unwanted grain. Try to bury grain or spread out unwanted grain to a shallow depth of less than 20 mm so insects are exposed to the daily temperature extremes and insect predators.

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

A trial in Queensland revealed more than 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 sorghum harvest. [6] Further studies in Queensland revealed that insects are least mobile during the colder winter months. Clean in and around silos, equipment and sheds on farm in

[6] P Burrill, P Botta, C Newman, B White, C Warrick (2013) Northern and southern regions—Grain storage pest control guide. GRDC Grain Storage Fact Sheet, June 2013.

the winter months before early spring. This will reduce insect pest numbers during the warmer months around harvest time.

Figure 5: Lesser grain borer - Ryzopertha dominica. (Photo: QDAFF)

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 can 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 of 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. DE is generally acceptable as a structural treatment for all storages used for cereals, pulses, oilseeds and organic grains. However, before using any treatment, including DE, always check with grain buyers first and use it according to the label.

Although shown on the DE label, the treatment of grain with DE dust (rate 1 kg/t) is generally not accepted by grain handlers or buyers.

Cereal grains buyers may accept other approved chemical insecticide structural treatments to storages, but growers should avoid using them, or wash the storage out, before storing oilseeds and pulses.

There are a number of export and domestic grain markets that require 'pesticide residue free' grain (PRF), so growers are advised to check with potential grain buyers before using grain protectants or structural treatments.

To find out more about what to use and when and how to clean equipment and storages to minimise the chance of insect infestation, visit www.grdc.com.au to download the GRDC's Grain Storage Fact Sheet 'Hygiene and structural treatment for grain storages' (June 2013).

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.

Markets that require PRF grain do 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. Before using a grain protectant or fumigant, growers need to check with prospective buyers, as the use of some chemical may exclude grain from certain markets.

Although phosphine has some pest resistance issues, it is widely accepted as having no chemical residue issues. The grain 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 fumigant or protectant. [7]

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

Recent 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 one resistance gene. Further testing with DNA markers that can detect phosphine resistance is expected to identify problem insects before resistance becomes entrenched, and thereby help to prolong phosphine's effective life, as well as increasing the usefulness of the break strategy. [8]

7 P Collins (2009) Strategy to manage resistance to phosphine in the Australian grain industry. Cooperative Research Centre for National Plant Biosecurity Technical Report.

8 D Schlipalius (2013) Genetic clue to thwart phosphine resistance. GRDC Ground Cover, Issue 102, Jan.–Feb. 2013.

Field trials have shown that sulfuryl fluoride (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 was analysed to assess the impact of using SF as an alternative fumigant to phosphine. This revealed that after SF was introduced 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. Complementary laboratory experiments have shown that phosphine resistance does not show cross-resistance to SF, which is an additional advantage of using SF. [9]

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 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 one day with aeration fans running, or five days if no fans are fitted. A minimum withholding period of two days is required after ventilation before grain can be used for human consumption or stockfeed. 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 'Fumigating with phosphine, other fumigants and controlled atmospheres: Do it right—do it once: A Grains Industry Guide': http://www.grdc.com.au/~/media/FC440FBD7AE14140A08DAA3F2962E501.pdf

Two new grain protectants have recently become available. These include:

- 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. The maximum residue limits have been established with key trading partners and there are no issues with meat residue bioaccumulation. A 'product stewardship' program from Dow AgroScience is in place to ensure correct use of the product.
- 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. [10]

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.), saw-toothed beetle, flat grain beetles, storage moths and psocids (booklice). However it does not fully control all stages of rice weevil. It can only be used by a licenced fumigator.

Controlled atmosphere/non-chemical treatment options include:

- Carbon dioxide (CO_2): Involves displacing the oxygen inside a gas-tight silo with a high concentration of CO_2 combined with a low oxygen atmosphere lethal to grain pests. To achieve a complete kill of all grain pests at all life stages, CO_2 must be maintained at a minimum concentration of 35% for 15 days.

9 M Nayak (2012) Sulfuryl fluoride—A solution to phosphine resistance? GRDC Research Update Northern Region, Spring 2012, Issue 66.

10 P Burrill (2013) Grain Storage Future pest control options and storage systems 2013–2014. GRDC Update, July 2013.

- Nitrogen (N_2): This also displaces the oxygen inside a gas-tight silo with a high concentration of N_2 to create a low oxygen atmosphere lethal to grain pests. It provides insect control and quality preservation without chemicals. It is safe to use and environmentally acceptable. The main operating cost is electricity used by the equipment to produce N gas. This process of flushing out oxygen from a silo can take many hours. There is also a high capital cost of purchasing this equipment. The process uses pressure swing adsorption or membrane technology to produce N_2. There are no residues, so grains can be traded at any time.

Silo bags as well as silos can be fumigated (Figure 7). Research conducted by Andrew Ridley and Philip Burrill from DAFF Queensland and Queensland farmer Chris Cook found that sufficient concentrations of phosphine can be maintained for the required time to successfully fumigate grain 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: QDAFF)

When using phosphine in silos or silo bags it is illegal to mix phosphine tablets directly with grain due to tablet residue issues. As trays in silo bags are not practical, 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. [11]

[11] P Burrill, A Ridley (2012) Silo bag fumigation. GRDC Research Update Northern Region, Spring 2012, Issue 66.

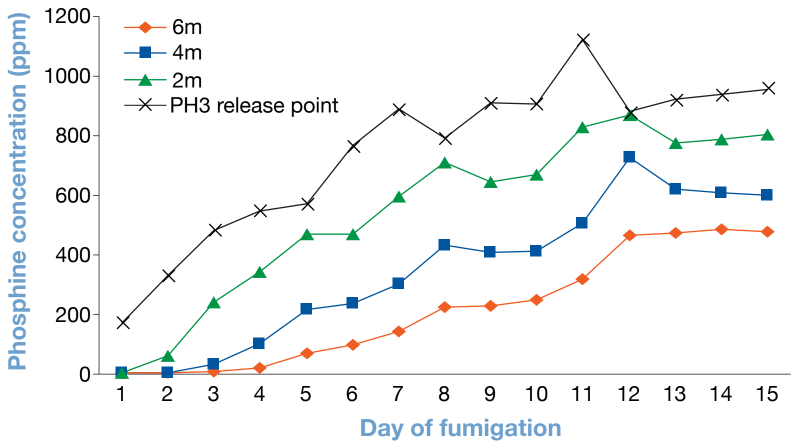

Figure 8: Spread of phosphine gas in a silo bag from a release point to gas monitoring lines at 2, 4 and 6 m along a silo bag.

13.4 Aeration during storage

Aeration has a vital role in both 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. As a general rule, silos should only be sealed up during a fumigation operation which typically lasts for one or two weeks.

Aeration cooling reduces stored grain temperatures by more than 10°C during summer which significantly reduces the threat of a serious insect infestation. Producers in the Darling Downs and northern New South Wales regions should achieve grain temperatures in storage of 20–23°C during summer storage and less than 15°C in winter. [12]

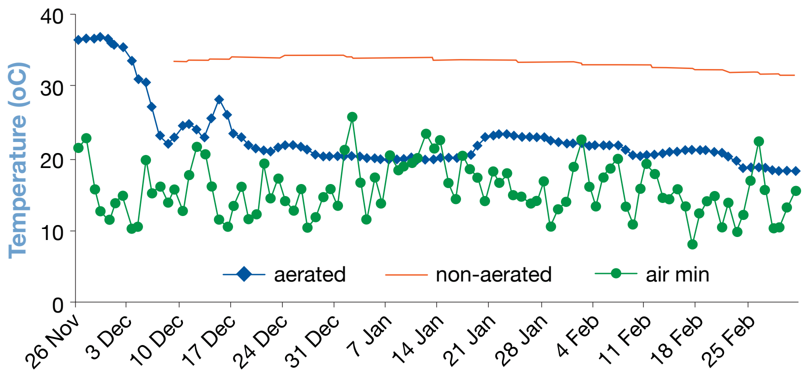

Figure 9: Comparison of wheat grain temperatures in aerated and non-aerated silos.

As soon as grain is harvested and put in storage, run the aeration system 24 hours per day for the first five days to reduce grain temperatures and produce uniform moisture conditions in the grain bulk. Without aeration, grain holds its heat as it is an effective insulator and will maintain its warm harvest temperature for a long time (Figure 9). Wheat at typical harvest temperatures of 28–35°C and moisture content greater than 13–14% provides ideal conditions for mould and insect growth (Table 2). [13]

[12] P Burrill (2013) Grain Storage Future pest control options and storage systems 2013–2014. GRDC Update, July 2013.

[13] P Burrill, P Botta, C Newman, B White, C Warrick (2013) Dealing with high-moisture grain. GRDC Grain Storage Fact Sheet, June 2013.

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Table 2: 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 still survive at low temperatures, the life-cycle stages of most storage pests are very slow or stopped at temperatures below 18–20°C. One of the more cold-tolerant pests, the common rice weevil, does not increase its population with grain temperatures below 15°C. 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).

Research also shows that wheat at 12% moisture content stored for six 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 oats at receival, but deliveries are usually in the range 10.5–11%. [14] Special measures must be taken to minimise the risk of insect infestations or heat damage if the grain is harvested in damp conditions.

Research by the NSW Department of Primary Industries has shown that if grain temperatures are kept below 15°C it can protect seed quality and stop all major insect infestations. Aeration slows the rate of deterioration of grain even if the moisture content is in the 12.5–14% range for a short period.

A trial by DAF Queensland revealed that high-moisture grain generates heat very quickly when put into a confined storage, such as a silo. Cereal grain 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 two days reached 46°C, providing ideal conditions for mould growth and grain damage (Figure 10). [15]

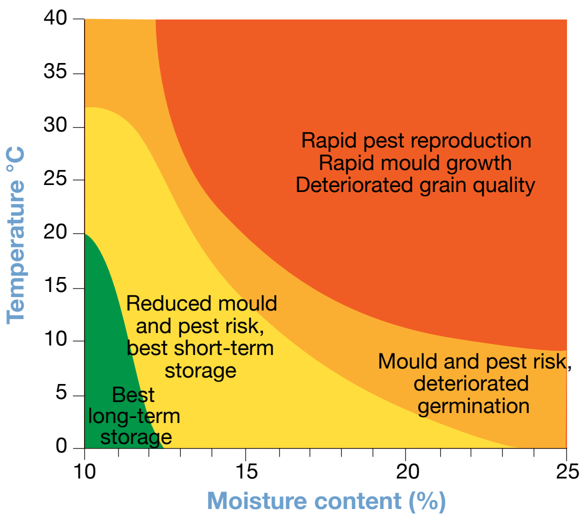

Figure 10: Effects of temperature and moisture on stored grain.

(Source: CSIRO Ecosystems sciences as published in http://www.grdc.com.au/~/media/36D51B725EF44EC892BCD3C0A9F4602C.pdf)

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

[15] P Burrill, P Botta, C Newman, B White, C Warrick (2013) Dealing with high-moisture grain. GRDC Grain Storage Fact Sheet, June 2013.

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

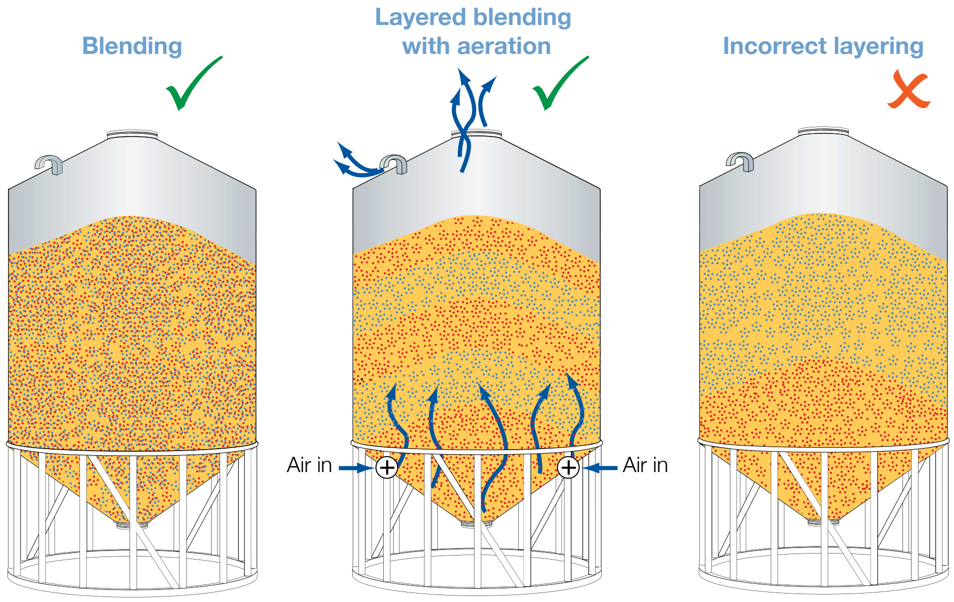

Figure 11: Correct blending. (Source: Kondinin Group)

Aeration drying when correctly set up forces large volumes of air through the grain in storage and slowly removes moisture. 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 oats in batches or with continuous flow, before it is put into silos, but excessive heat applied post-harvest can reduce the quality of milling oats.

A wet harvest or damp conditions can make drying prior to storage a necessity. These rules will help you to decide whether it is safe to store your oats without drying:

- Oats that do not exceed the maximum moisture level of 12.5% can be aeration cooled without drying to slow insect development and maintain quality during storage.
- Grain of up to 15% moisture can be safely held under continuous aeration for a number of weeks until a hot air drier or an aeration drying process can take place to reduce the moisture for safe longer term storage. Blending with dry grain and aerating may also be feasible.
- Grain of more than 15% moisture should be dried to a safe storage moisture immediately, then held under normal aeration cooling for maintenance.

13.5 Monitoring oats

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 two weeks is advisable. Insect pests present in the on-farm storage environment must be identified so growers can exploit the best use of both chemical and/or non-chemical control measures to control them.

Oats 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 oats crop.

When monitoring stored grain by sieving, trapping and quality inspections, growers should keep monthly records. If possible, grain temperature should also be checked regularly. Any grain treatments, such as fumigations, should also be recorded. [16]

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

The lesser grain borer and rust-red flour beetle are some of the most common insect pest found in stored cereals. Other common species to watch for include weevils (*Sitophilus* spp.), saw-toothed 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*).

Photographs and descriptions of these pests can be found in the GRDC Grain Storage Fact Sheet entitled 'Northern and southern regions stored grain pests—Identification' and GRDC 'Stored grain pest identification – The Back Pocket Guide'. Download it from: http://storedgrain.com.au/northern-southern-regions-grain-storage-pest-control-guide/ or http://www.grdc.com.au/GRDC-FS-StoredGrainPestID

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 month (four weeks) for early pest detection. Pitfall or probe traps installed in the top of the grain store will also help early detection of storage pests.
- Holding the insect sieve in the sunlight, this will encourage insect movement, making pests easier to see. Sieve samples on to a white tray, again to make small insects easier to see. Sieves for pest detection should have 2 mm mesh and need to hold at least 1 L of grain.
- To help identify live grain pests, place them into a clean glass container. Warm the jar in the sun for two minutes to encourage insect activity. Weevils and saw-toothed 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 saw-toothed grain beetles do not. [17]

[16] P Burrill, P Botta, C Newman (2010) Aeration cooling for pest control. GRDC Grain Storage Fact Sheet, September 2010.

[17] P Burrill, P Botta, C Newman, B White, C Warrick (2013) Northern and southern regions stored grain pests—Identification. Grain Storage Fact Sheet, June 2013.

Recent research in southern and central Queensland has shown that industry may need to consider an area-wide approach to pest and resistance management. The research indicates significant flight dispersal by the lesser grain borer and the rust-red flour beetle, both of which are major insect pests of stored grain. The research involved setting beetle traps along a 30-km transect in the Emerald district and showed that the lesser grain borer flies all year round in Central Queensland. By contrast, the flour beetle appeared to be located mainly around storages during the winter months, spreading into the surrounding district in summer. This study highlights the importance of good grain storage and equipment hygiene to limit the number of pests that can infest clean grain. In another study, beetles were found to be flying between farms over a number of kilometres. [18]

More information

NSW DPI (2015) Winter crop variety sowing guide 2005

NOTE: Exotic pests including Karnal bunt (*Tilletia indica*) and Khapra beetle (*Trogoderma granarium*) are a threat to the Australian grains industry. Learn to identify common pests and report unusual pest sightings immediately.

18 G Daglish, A Ridley (2012) Stored grain insects: How they spread and implications for resistance. GRDC Research Update Northern Region, Spring 2012, Issue 66.