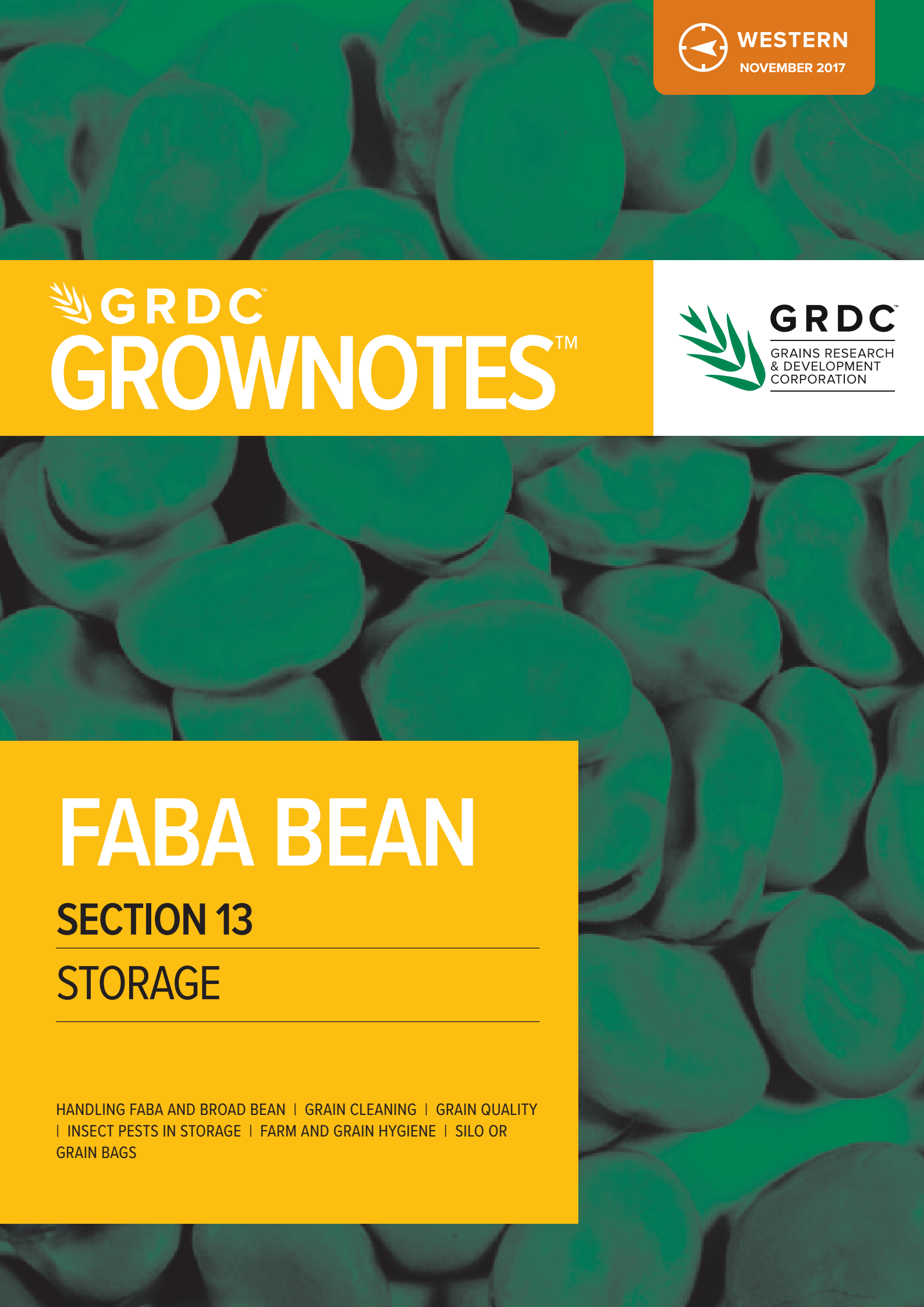

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FABA BEAN

SECTION 13

STORAGE

HANDLING FABA AND BROAD BEAN | GRAIN CLEANING | GRAIN QUALITY | INSECT PESTS IN STORAGE | FARM AND GRAIN HYGIENE | SILO OR GRAIN BAGS

Storage

Key messages

- Good farm hygiene, storage choice and aeration cooling are important for maintaining grain quality.
- Harvesting grain at a higher moisture content (up to 14%) reduces field mould and mechanical damage, but increases the risk of deterioration during storage.
- High-moisture grain can be stored for short periods with aeration cooling, prior to drying or blending.
- Aeration cooling can reduce grain temperature and insect breeding, and aid in maintaining grain quality.
- Monitor stored grain monthly for moisture, temperature and pests.

13.1 Handling faba and broad bean

Faba beans are a very large, plump grain and are prone to mechanical damage during handling. This applies to over-dry grain (<10% moisture content) and to crops that have been exposed to weather damage prior to harvest.

Grain may be handled up to six times before delivery to receival points, so it is important to:

- minimise the number of handling stages wherever possible; and
- use efficient handling techniques that minimise damage.

The use of belt conveyors can reduce damage compared with conventional spiral augers.

If using augers:

- Operate slowly and full.
- Use large-diameter augers.
- The flight pitch should be greater than the auger diameter.
- Keep the auger length as short as possible.
- Keep auger incline as low as practical.
- Check the flight casing clearance; optimal clearance is typically 50% of grain size to minimise the amount of grain that becomes wedged between the auger spiral and the casing.
- Auger drives should be at the discharge end, not on the intake.

13.2 Grain cleaning

Cereals can be cleaned from most pulses with a 3 or 4mm rotary screen. The 3.75mm slotted screen is popular and will help screen out split grain. The paddles or agitators in rotary screens should be new or sufficiently worn so that the grain being harvested cannot jam between the outside of the paddle and the rotary screen.

Screens or paddles can be damaged beyond repair if the grain jams. Fitting the screens with a spacer will provide additional clearance and so avoid the problem. [1]

1 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.

13.3 Grain quality

It is very important to monitor the quality of grain before and during harvest. Seed coat and kernel (cotyledon) can be discoloured by crop-topping or premature desiccation in parts of the paddock if ripening is uneven. Staining of seed caused by green plants in the crop or an admixture of splits, weeds, stones, etc., will only reduce the value of the grain and can lead to rejection or premium dockages.

Visual appearance is vital. Human food markets demand a quality sample without cracking, staining, de-hulled seeds or insect damage. Pulse samples showing no header damage will always be more acceptable to a buyer.

Grain quality is at its highest when first loaded into storage but can steadily deteriorate if the storage environment is not well managed. A combination of good farm hygiene, storage choice and aeration cooling are important for maintaining grain quality and overcoming many pest problems associated with storage.

13.3.1 Storage life

The storage life of pulses is determined by temperature, moisture content, insects and diseases. Careful management of these factors is essential to avoid deterioration during storage. Pulse grain with high germination potential and good vigour can remain viable in storage for at least three years, provided the moisture content of the grain does not exceed 11% and cool grain temperatures are maintained.

When grain enters storage, it needs regular monitoring, so that early action can be taken if insect or grain-quality problems arise. Monitoring grain at least monthly for insects, moulds, grain temperature and moisture should be standard practice.

Critical points to remember with regard to storing pulses:

- Store pulses dry and cool to maintain quality. Aeration cooling will assist with holding higher moisture content pulses for short periods before drying or blending.
- Meticulous hygiene and aeration cooling are the first lines of defence against storage-pest infestations.
- Fumigation is the only option available to control a pest infestation in stored pulses. Only fumigate in a gas-tight, sealable storage unit to achieve control of all life-cycle stages of the pest.
- Minimising mechanical damage to pulse seeds will maintain market quality and seed viability, and seed will be less attractive to storage pests.

Growers contemplating medium–long term storage (six to 12 months) need to be aware that faba beans continue to age after harvest, and quality will deteriorate in sunlight and over time. All faba beans will darken considerably in storage, and the rate of seed coat darkening (deterioration in grain colour) will be accelerated by:

- high seed moisture content
- high temperatures
- high relative humidity
- poorer condition of the seed at harvest
- sunlight [2]

To maintain lighter seed-coat colour and minimise darkening of seed, any pulses stored at >12% moisture content will require aeration cooling to maintain quality.

Mature seed that has suffered field weathering before harvest will deteriorate a lot quicker in storage, even if stored under acceptable levels of temperature and relative humidity. Growers should avoid even short to medium term storage of weather-damaged grain.

MORE INFORMATION

GRDC (2014) Storing pulses. Fact sheet.

GRDC (2015) GCTV Stored Grain: Storing Pulses. Video

Vigilant monitoring protects grain assets, Stored Grain Information Hub.

2 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.

13.3.2 Moisture

For storage, pulses harvested at ≥14% moisture require aeration and drying, or blending with dry grain, to preserve seed germination and viability. As a rule, every 1-percentage point rise in moisture content above 11% will reduce the storage life of pulse seed by one-third.

For most storage situations, grain is best stored using aeration cooling. Generally, a silo is only left sealed for a short period of 1 or 2 weeks for fumigating insects. If grain is sealed in a silo, it must be of sufficiently low moisture content to prevent moisture migration.

Moisture sources

Grains. Because grain and seed are living they release moisture as they respire. In silos with no aeration, this moisture moves upwards by convection currents created by the temperature difference between the grain in the centre of the silo and the walls, which can be either warmer or cooler.

Grain insects. Insects or mites in the grain respire and release moisture and heat into air spaces. If grain is stored at >14% moisture content, enough moisture may be carried into the upper grain layers to place that grain at risk of mould. Normally, there is no moisture migration in an aerated silo as the entire stack is cooled to one temperature (≤23°C).

Condensation impact. Moisture carried into the silo headspace can condense on a cold roof and fall back into the grain as free water. This can then cause a circle of mould or germinated grain against the silo wall.

Leaks in silo. Water entering through structural damage will increase grain moisture content allowing mould and insect growth. [3]

13.3.3 Temperature

High temperatures in storage will cause deterioration in grain viability. Temperatures of stored pulse grain should not exceed an average of 25°C, and preferably the average temperature should be <20°C. In general, each 4°C rise in average stored temperature will halve the storage life of the grain.

Grain is a good insulator against heat transfer, so the sun's heat on the north and west walls of the silo plus the roof does not penetrate much further than 30 cm beyond the silo wall. However, having light silo walls will help keep temperatures down. Painting a silo white is practical way of reducing the temperature of stored grain next to the silo walls and in the silo headspace. Dark grey walls on silos will absorb more of the sun's heat. Small silos (<30 t) and field bins will have a larger proportion of grain exposed to these surface-temperature fluctuations, and will promote more rapid deterioration in grain quality. Combine aeration cooling plus white paint or bright, reflective surfaces on small silos storing planting seed or other grains. [4]

13.3.4 Silo capacity

The approximate weight of grain stored in a cubic metre of silo is shown in Table 1. The actual figures can vary as much as 6–7% in wheat and barley and 15% in oats. In pulses, the variation is likely to be less (3–4%), and will vary with grain size, variety and season.

3 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.

4 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.

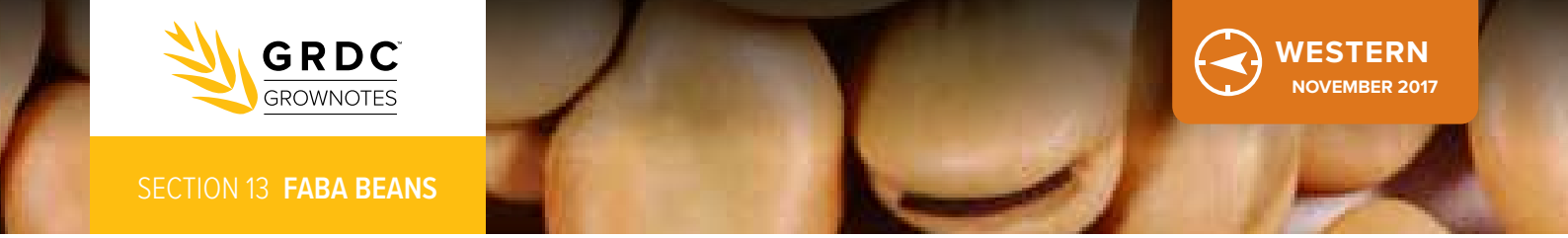

Table 1: *Calculating silo capacities.*

Grain	Volume (m^3)	Weight (kg)
Broad beans	1	645
Chickpeas	1	750
Faba beans	1	750
Field peas	1	750
Lentils	1	800
Lupins	1	750
Vetch	1	750
Wheat	1	750
Barley	1	625
Oats	1	500
Example silo of faba beans	67.4	50,550

Source: Grain Legume Handbook, 2008.

13.3.5 Cooling grain and aeration cooling

Cooler grain temperatures have several advantages:

- Seed viability (germination and vigour) is maintained longer.
- Moist grain can be safely held for a short time before blending or drying.
- Moisture migration and condensation inside the silo is reduced.
- Insect life cycles are slowed (or cease in some instances) and hot spots are prevented.
- Mould growth is reduced.
- Darkening of the seed coat is slowed.

Aeration cooling is a vital tool when storing pulses in a silo. It allows for longer-term storage of low-moisture grain by creating cool, uniform conditions that maintain seed quality, protect seed viability, and reduce mould and insect development. Its use also allows grain to be harvested earlier and at higher moisture levels, thereby capturing grain quality and reducing mechanical seed damage.

Aeration systems

Aerated silos are fitted with fans that push air through the grain to cool it and equalise the moisture and temperature throughout the silo. An aeration system requires a waterproofed vent on the top of the silo to allow air to escape freely. The vent needs to be sealable if fumigation is required.

The aeration system used should provide the appropriate airflow rates to protect the grain and maintain quality. Aeration cooling can be achieved with airflow rates of 2–4 litres per second per tonne (L/s/t). For example, a small, single-phase aeration fan driven by a 0.37 kW (0.5 horsepower) electric motor for silos ~70–100 t capacity should deliver this airflow rate.

Controlled aeration should reduce grain temperature to ≤23°C. Controlling aeration cooling is a three-stage process:

- continual aeration, to maximise airflow through the grain as it goes into storage;
- rapid cooling, which occurs after initial cooling to quickly bring the temperature of the grain down; and
- maintenance cooling, once the grain has been cooled.

MORE INFORMATION

C Warrick (2011) Aerating Stored Grain: Cooling or Drying for Quality Control. GRDC.

GRDC (2012) Performance testing aeration systems. Fact sheet.

GRDC (2013) Dealing with high-moisture grain. Fact sheet.

For general information on handling, drying and cooling, read the website of Agridry Rimik.

The degree of cooling achieved during storage depends on the moisture content of the grain and the humidity and temperature of the incoming air. Automatic aeration controllers are used to turn fans on and off, and to select the optimum ambient temperature and humidity conditions. This provides the most reliable results. [5]

13.3.6 Drying grain and aeration drying

Continuous-flow or batch dryers provide reliable drying, although they can reduce grain quality if run at too high a temperature. Do not exceed 45°C when using heat to dry faba beans. Check the specifications or talk to the manufacturer about safe conditions for drying pulses.

High-capacity aeration drying systems can also be used to dry grain, and are ideally suited for drying grain harvested at 15–16% moisture content. Aeration drying gives a lower risk of cracking and damaging pulses than hot-air dryers. Aeration drying requires much higher-performance fans to move high volumes of air through the grain at a faster rate than that required for cooling only.

Airflow rates of at least 15–25 L/s/t are required for reliable aeration drying. By comparison, airflow rates as small as 2–4 L/s/t can achieve aeration cooling.

Careful selection of ambient air temperature and dryness using an automated controller can remove moisture from the stored grain over a period of 1 or 2 weeks. [6]

13.4 Insect pests in storage

Insects are not considered a major problem in stored faba beans.

The only exception appears to be in cases where faba beans are loaded into storages containing residues of cereal grain already infested with cereal pest insects such as flour beetles (*Tribolium* spp.) and grain borers (*Rhyzopertha* spp.). These prior infestations can develop and spread in the faba beans.

The key to control is maintaining excellent hygiene in and around storage facilities. Combined with aeration cooling, this should prevent infestations developing.

Most insect development ceases at temperatures <20°C. Freshly harvested grain usually has a temperature of ~30°C, which is an ideal breeding temperature for many storage pests. Aeration fitted to stores will rapidly reduce grain temperatures, reducing insect breeding and aiding grain quality (Table 2).

5 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.

6 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.

Table 2: *Effect of grain temperature on storage pest insects and mould.*

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 active
20–25	Mould development is limited
18–20	Young insects stop developing
<15	Most insects stop reproducing, mould stops developing

Source: GRDC (2014) Aeration cooling for pest control. Fact sheet

If insects in stored faba beans need treatment, the only control options are phosphine fumigation, an alternative fumigant, or controlled atmospheres such as carbon dioxide (CO_2) or nitrogen (N_2).

To ensure effective fumigation and control of all insect life stages, and to reduce the risk of resistance development, fumigation must be carried out in a sealed, gas-tight silo.

No insecticide sprays are currently registered for use on faba beans. Markets are particularly sensitive to insecticide residues, so detection of any residues on faba beans could result in the loss of a market, not just rejection of a contaminated delivery.

Residual sprays should not be used on storages and handling equipment that is to be used for faba beans.

The use of diatomaceous earth (DE), for example Dryacide®, as a structural treatment may be possible. Always check with the grain buyer for delivery standards or allowances before using any product that will come into contact with stored grain.

Not all silos can be sealed adequately to enable fumigation. However, all silos can have aeration added to them. So if the silo is not sealable, fitting aeration cooling fans will assist with controlling pests and maintaining grain quality. Well-managed aeration cooling, coupled with excellent hygiene, can overcome insect pest infestation problems in seven out of 10 years. [7]

13.5 Farm and grain hygiene

Maintaining good farm and grain hygiene plays a crucial role in overcoming many problems associated with storage pests. Basic hygiene practices include:

- Remove all grain residues from empty storage facilities and all grain handling and carriage equipment before new grain is stored and equipment used.
- Clean up spillages around silos and remove or use all residues to prevent re-infestation.
- Always spread grain residues to a depth of <50 mm at a dump site to prevent it from becoming a breeding site for storage pests. Most of these insects are strong fliers, and move >1 to 2 km.
- Once storages and equipment have been cleaned, treat them with an inert dust (e.g. DE).
- Ensure that insect pests or weeds are not carried onto your property on farm equipment (e.g. harvesters); and thoroughly clean down equipment after use.

Storages should be cleaned before filling with new grain. However, if there is reason to believe there are stored-grain insect pests in a silo or in freshly harvested grain, fumigation can be carried out immediately to ensure that all stages are eliminated before any grain damage or weight loss occurs. If possible, as a valuable first step,

MORE INFORMATION

GRDC (2013) Hygiene and structural treatments for grain storages. Fact sheet.

GRDC (2014) Storing pulses. Fact sheet.

GRDC (2013) Grain storage pest control guide. Fact sheet.

7 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.

before fumigating, aerate freshly harvested grain to create uniform, cool conditions in the grain bulk. [8]

13.5.1 Controlling insects in storage with phosphine

While insect pests are not a major problem in stored faba beans, fumigation is the primary control measure if they are detected.

Currently, phosphine is the only fumigant registered for use in pulses, and it can only be used in sealed storage. It is illegal and dangerous to put phosphine into unsealed storage.

Provided fumigation is carried out correctly, it will destroy all stages of insects: adults, eggs, larvae, and pupae. This includes insects that may have developed some level of phosphine resistance. Effective fumigation with phosphine needs a concentration of 300 ppm (a chemical to air ratio) to be maintained for seven days (when grain is stored >25°C) or 200 ppm for 10 days (15–25°C). An unsealable silo will not hold these concentrations, even with a high dosage rate.

Poor fumigations may appear to have been successful when dead adults are observed, but many of the eggs, larvae and pupae will have survived and will continue to infest the grain. In addition, insects that survive are more likely to carry phosphine-resistance genes. This has serious consequences for future insect control across the entire industry.

Minimum fumigation exposure times for phosphine are:

- 7 days with grain temperatures >25°C
- 10 days at 15–25°C

Grain stored <15°C should not be fumigated with phosphine, because insects are hard to kill at low temperatures.

For large, sealable storages (e.g. >150 t capacity), a fumigation recirculation system should be fitted to ensure that gas is evenly distributed throughout the grain bulk in a timely manner during the fumigation exposure period.

Use phosphine carefully

Phosphine is a highly toxic substance. Always read safety advice on the label and comply with state legislative requirements. [9]

13.6 Silo or grain bags

Grain bags (known also as silo bags, sausage bags or harvest bags), are a form of sealed storage with no aeration, and are becoming increasingly popular. It is important to appreciate their role and how they function, particularly when used to store pulse grain. They should be used only as temporary storage because of the difficulty of maintaining grain quality (Photo 3).

Pulses are riskier grains than cereals to store in grain bags: pulse grain has been rejected by markets because of objectionable taints and odours derived during improper storage in a grain bag.

To maintain grain quality in storage, it is essential to bag the grain at the correct moisture content, and to ensure that the bag remains sealed throughout the entire storage period to prevent moisture ingress.

High-moisture grain, condensation, water aggregation under the film, or leaks can cause localised mould and widespread spoilage in pulses.

8 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.

9 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.

Even with adequate seals, hermetic conditions (low oxygen (O_2), high CO_2) to protect against insects and mould are difficult to achieve consistently because of either high grain temperatures or low grain moisture content at the time of storage.

Photo 1: *Silo bags should be considered as only temporary storage for pulse grains because of quality issues that can arise.*

Photo: W. Hawthorne, Pulse Australia

13.6.1 Pulse quality risks and grain bags

There are risks associated with storing pulses in grain bags:

- Pulse grain may not retain its quality and colour, especially if the seal is breached.
- Contamination and moisture can enter bags from vermin and other pests that create holes in the bag.
- Excessive grain moisture can result in condensation within the bag, causing pockets of mouldy grain along with an offensive, distinctive 'mouldy' odour throughout. There is a no tolerance of this in receival standards.
- Removing taints and odours in affected grain may not be possible, even with further aeration.
- Achieving and keeping hermetic conditions under Australian conditions is difficult, and bags should not be relied on as the only source of insect control during storage.
- Grain moisture content is critical. Pulses, particularly the larger-seeded ones such as faba beans, have bigger airspaces between grains than cereals, so moisture can move more freely in them. [10]

MORE INFORMATION

GRDC (2014) Successful storage in grain bags. Fact sheet.

10 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 8—Desiccation, Harvest & Storage.