Grains Research UPDATE ADVICE

Grains Research & Development Corporation

Aeration in on-farm storage – what's possible

Low flow rate aeration fans either fitted to a new, or retro fitted to an existing storage are a relatively low cost way to maintain grain quality in storage for longer. Low flow rates around 2 litres per second per tonne (L/s/t) will cool grain, and suppress moulds and insects.

Used correctly, flow rates of 2-6 L/s/t can, in addition to cooling grain, enable the safe storage of grain for weeks to months at moisture levels at 2% above normal receival standards.

High flow rate aeration drying with flow rates greater than 10 L/s/t in a purpose designed drying silo provides the capability to dry grain from quite high moisture contents using ambient air, provided that:

- air of appropriate quality is readily available during the drying period
- a properly designed aeration drying silo is used, and
- the drying process is well managed.

There is significant risk in storing over moist grain in a system not designed for that purpose for which it is used, or where the system is not properly managed.

Aeration can be a highly profitable addition to on-farm storage - but requires good management, a supply of air of the appropriate quality and must be well designed for the purpose it is used for.

Low flow rate aeration with air of the appropriate quality cools grain and slows most quality deterioration processes affecting:

- barley malting grade
- germination and seed vigour
- insect and mould development
- wheat bread-making quality and
- oil quality of oilseeds – free fatty acid, rancidity, colour and odour.

Figure 1: Seed survival trend curves - barley stored at 35°C at various moisture levels

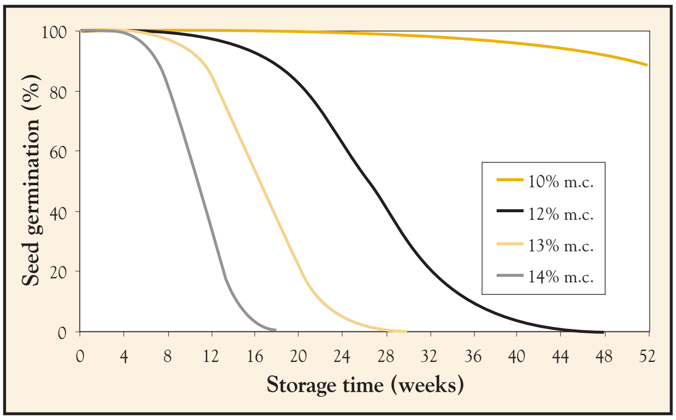
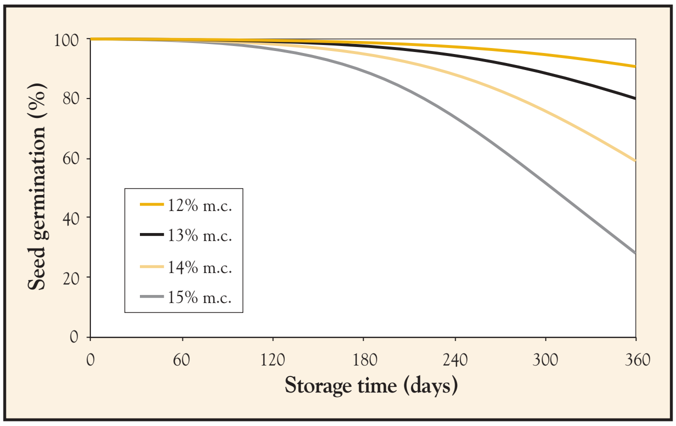


Figure 2: Potential influence of moisture levels on germination of wheat stored at 20°C



Note: The above graphs indicate trends only. Absolute values for seed germination after storage are highly dependent on the initial germination of the seed.

With proper management and correct flow rates, aeration cooling can be used to cool and store grain at moisture levels a little above receival standards. This could allow time to dry the grain in a dedicated drier, back blend with drier grain or sell it into a market that accepts higher moisture grain. Aeration cooling will not reliably dry grain and if used for this purpose, places the grain at significant risk.

The ability to store or dry over moisture grain enables the option of an earlier harvest, with potential benefits in yield and quality and reduced risk of weather damage. Benefits can include:

- More harvest hours as the harvest can start earlier and finish later each day, and resume earlier after rain - reducing pressure on both the farmer and equipment at a critical time.
- If a grain dryer is available, harvest can potentially start at even higher grain moisture contents.
- Harvesting high moisture grain closer to physiological maturity lowers the risk of downgrading or quality losses due to rain. Also, as moist grain is less prone to pre and post harvest shatter losses and splitting, yield and sample quality are usually better than if left to dry in the field.

However moist grain must be managed correctly or mould can rapidly set in. Upper limits of harvest moisture can be set by the amount of immature grain and the ability of some crop types and varieties to be threshed under higher moisture conditions. Excessive admixture is also an issue, as it may impede airflow through the grain stack, leading to uneven drying and the potential for grain spoilage. Chaff blowers on the auger can reduce this problem.

How significant are in field and harvest losses?

Trials have shown large yield losses due to shattering from the head or pod prior to and at harvest, deterioration in seed size, weight and colour, and increases in splitting. While each crop and year are different, trials from Esperance in Western Australia showed yield losses of typically between 0.25 – 0.75% and averaging at ~0.5% per day for barley and 0.18-0.53% per day for wheat. In Queensland, losses of 0.3-2.5% per day for wheat were reported (average of ~1% / day). Significant rain at harvest can greatly increase these losses with the economic loss increased if grain is downgraded.

Trials in pulse crops show even higher losses than for cereals, but with the added issue of increased splitting when crops are harvested dry.

The following tables look at the value and potential impact of different levels of grain loss. The bottom line is that even small yield losses per day, can lead to a

Table 1: Calculation of the value of harvest loss in cereals ($/ha) at yields of 2.5, and 4 t/ha at $200/t at loss rates of 0.5, 1.0 and 2% per day

	Loss in a 2.5t/ha crop by % loss per day $/ha			Loss in a 4t/ha crop by % loss per day $/ha		
% loss/day	0.50%	1.00%	2.00%	0.50%	1.00%	2.00%
1 day	$3	$5	$10	$4	$8	$16
5 days	$13	$25	$50	$20	$40	$80
10 days	$25	$50	$100	$40	$80	$160
15 days	$38	$75	$150	$60	$120	$240

Table 2: The impact of a $30, $50- and $70/t downgrade coupled with combined loss of weight of grain in the bin (yield and grain weight) of 10% (losses were accrued in the downgraded area of crop only) on grain sales from a 1,000 ha property yielding 4t/ha and a base wheat price of $200/t.

Price and yield received in unaffected crop	$200/t 4t/ha	$200/t 4t/ha	$200/t 4t/ha
Price and yield in downgraded area of crop	$170/t 3.6t/ha	$150/t 3.6t/ha	$130/t 3.6t/ha
% of crop downgraded	Lost farm income before handling costs		
0%	-$0	-$0	-$0
5%	-$9,400	-$13,000	-$16,600
10%	-$18,800	-$26,000	-$32,200
20%	-$37,600	-$52,000	-$66,400
50%	-$94,000	-$130,000	-$166,000

significant loss of profit if there is the option to harvest even 5 days earlier. If a part of the crop is downgraded – not only is grain weight and yield lost but the return per tonne is less. Options to harvest early can significantly reduce the risk of these potentially huge losses.

Insects

In the hot Australian climate, insects multiply rapidly and are a major threat to grain quality. Chemical control options for grain protection on most farms are limited to phosphine and an ever-decreasing number of protectants. Insect resistance to low doses of phosphine is becoming widespread. To control resistant populations, phosphine must be used in a sealed silo.

Cooling grain with aeration **may not eliminate the need for insect control,** but will slow insect development dramatically. At temperatures below 15°C, most insect reproduction stops.

What do you want to do?

Before deciding on a system, it is essential to discuss plans with a storage specialist and the manufacturer of the system you intend installing.

System costs (2004 estimates)

In a 70-100 tonne silo, it typically costs ~$750 (DIY +GST) to install ducting and a fan to deliver 2 L/s/t for aeration cooling. Two to three fans and ducts may be needed for reliable storage of higher moisture grain.

While possible to retrofit high flow rate aeration drying fans and ducts to existing silos, considerable design issues are involved and should only be undertaken with the input of an aeration storage designer.

The cost for new purpose built high flow rate aeration drying silos varies. One NSW based manufacturer indicated that sealable drying silos up to 200t capacity fitted with high flow rate fans cost 25% to 35% more than standard, sealed, upright storage.

To fit a supplemental heater to raise air temperature 4-10 degrees costs around $1,000 for a gas-powered unit that can potentially service two-200 tonne silos. However with supplemental heating fitted, some silo designs may have to be run at half capacity (ie 100t each) to maximise air-flow rates and minimise the extra condensation that can occur. A diesel unit would cost closer to $1,500 (2004 price approximations).

Table 3: Tasks and key aeration system features

Task	Type of system	Key system features
Cool dry grain for extended storage	Aeration cooling	Flow rates of ~1-2 L/s/t. Good ventilation. Easy and inexpensive to retro-fit to existing elevated and flat-floor storage. Low cost to install on new sealable storages.
Store moist grain (ie 13-15% for cereals) for weeks-several months	Aeration cooling	Flow rates of ~2-6 L/s/t. Flow rates at the higher end of the range and suitable ducts are needed if grain moistures are near the high end of the moisture range. Good ventilation is needed. Shallow bed depths may be needed if moistures are near the higher end of the range. Easy and inexpensive to retro-fit to existing elevated and flat-floor storage. Low cost to install on new sealable storages.
Dry wet grain (ie 13-20% for cereals)	Purpose built high flow rate aeration drying system	Flow rates of ~10-30+ L/s/t. Shallow bed depth with even flow fields of air in the whole grain stack are needed. Air of low relative humidity or supplementary heating is needed to dry grain. Heating raises the temperature of inlet air by 4-10 degrees and greatly improves the drying potential of air. Good ventilation is needed. More complex to retro-fit than for cooling. Wet grain is always at risk and good management is essential.
Dry wet grain in coastal or humid regions (Not tropics)	Purpose built high flow rate aeration drying system with a supplemental heater	As above, but flow rate should not be less than 20 L/s/t and system should be fitted with a supplementary heater to raise air temperature. This increases the ability to gently dry grain when the relative humidity of ambient air is too high for natural air-drying. More complex to retro-fit than for cooling. Seek advice to ensure that the system is in balance with the expected air quality in your region.

Running costs of a gas powered supplementary heater (if needed) are estimated at around \$2/t. Diesel heaters are likely to be closer to \$3/t for fuel.

In inland environments, supplementary heaters may not be needed, where air of suitable quality is readily available. In hot and/or dry environments, supplementary heating can lead to over-drying grain.

An automatic aeration - cooling controller with a 4 - storage control panel, costs around \$2,600 + GST (not installed). Labour to install, plus the cost of additional hardware eg. cabinet, overloads, contactors and time delays, must also be budgeted.

Aeration drying controllers are also available, but vary in their function and cost.

A new type of controller capable of controlling both drying and cooling processes is under development but costs are unknown. It is based on the Adaptive Discount Control method (ADC) developed by CSIRO.

Typical electricity costs to run cooling fans of 2L/s/t using a time proportioning cooling controller set to run $1/7^{th}$ of the time, are around \$0.05 /tonne/month.

Example of estimated electricity costs (per tonne per month) for aeration cooling in a 100t silo

a. Motor kW = 0.37 kW

b. Fan run hours for cooling in maintenance mode are $1/7^{th}$ of hours per month = 103 hrs / month

c. Kilowatt hours / month = 103 x 0.37kW = 38 kWh

d. Cost per kWh ~\$0.14*

e. Electricity costs per month per tonne is (c x d)/100t = \$0.05 /tonne/month

**Costs will vary*

The electricity costs to dry grain vary widely – due in part to variance in air quality, in system efficiency and the amount of moisture to be removed from grain. Commercial feedback is that many drying jobs use between \$2 and \$5 per tonne, however this can be substantially increased if fan run time becomes excessive due to poor quality air.

Example of estimated electricity costs (per tonne) for aeration drying in a 100t silo (Assumes a drying time of 336 hours of fan run time – note that this could greatly under-or over-estimate the time needed and is included only as an example of how costs can be calculated)

a. Motor kW = 7.5 kW

b. Fan run hours 336 hrs

c. Kilowatt hours = 336 x 7.5 = 2,520 kWh

d. Cost per kWh ~\$0.14

e. Electricity costs per tonne is (c x d)/100t = \$3.52 /tonne

All costs vary and these are indicative estimates only. More accurate estimates of cost can only be made when the starting moisture content, average quality of air used, and design parameters of the dryer are known.

Power and transformer costs

It may be necessary to upgrade your supply transformer and install soft starts or time-delays to keep start-up amps within allowable limits. Costs to upgrade a transformer will vary – speak to your electricity supplier and electrician.

Further Information

QDPI website: http://www.dpi.qld.gov.au/home/ many articles if search for ‘grain storage’

SGRL website: http://sgrl.csiro.au

Kotzur Silos: http://www.kotzur.com.au

Customvac: http://www.customvac.com.au

AgriDry Rimik website: http://www.agridry.com.au/

Agriculture WA website: http://www.agric.wa.gov.au

USA websites: http://bru.gmprc.ksu.edu/sci/flinn/
http://pasture.ecn.purdue.edu/~grainlab/

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