# SOLAR-POWERED AERATION COOLING SHOWS PROMISE

By Nicole Baxter

INDEPENDENT ENGINEERS AND grain storage specialists have demonstrated that the sun's energy can be harnessed to keep silos that are located away from a mains power supply cool and insect-free.

Tests in a 75-tonne silo at Wyalkatchem, Western Australia, 200 kilometres north-east of Perth, by independent engineers Ben White and Josh Giumelli and grain storage specialists Chris Warrick and Peter Botta showed it is possible to build an energy-efficient, solar-powered. aeration-cooling system.

The GRDC-supported project, led by Ben White, found aeration-cooling systems in 75t silos typically use 0.37-kilowatt, 240-volt motor-driven radial fans, which deliver about 200 litres of air per second at 200 pascal static head backpressure. This equates to a fan efficiency of about 1850 watt-seconds/$m^3$.

For maximum efficiency, Mr White and his team selected a backward-inclined, curved blade centrifugal motorised impeller fan with an electronically commutated (EC) brushless direct-current motor. With this combination, specific fan power at comparable flow rates and backpressure was reduced to 560 watt-seconds/$m^3$, a 330 per cent efficiency improvement on standard fan motors usually suggested for grain aeration cooling.

The use of an EC motor prevented the application of an off-the-shelf aeration control system, so the research team customised a solution to meet its requirements.

"The controller uses two internal thermocouple temperature sensors embedded in the grain and selects the hotter of the two. This temperature is then compared with the external ambient temperature," Mr White says.

"If the external ambient temperature is lower than the grain temperature, and the ambient relative humidity is below 80 per cent, the controller engages the fan at the nominated operation speed. Alternatively, the fan can be set to run continuously, except when ambient relative humidity exceeds 80 per cent."

To accommodate the fan, a manhole access door was modified to extend into the silo, allowing the fan to be mounted inside with a large open-area free-flowing plenum attached. To collect sunlight energy, four 260W multi-crystalline solar panels were chosen to provide a total array size of $6m^2$.

For superior longevity at higher depth of discharge ratios, the team selected Absorbent Glass Mat (AGM) batteries.

Mr White says these batteries offer charging rates five times higher than flooded deep-cycle cells and are more resilient to deep-cycle depth of discharging.

To manage panel energy and prevent overcharging the batteries, a 48V power management system including a 3000W pure sine-wave inverter was chosen. This was wired through a 240V power distribution board to provide a 240V outlet to run the aeration fan and controllers.

For testing, the components were mounted into and on top of a trailer with custom-built battery and solar-panel storage for transport, internal electrical inverter and panel mounting.

On site, the panels were mounted at 30 degrees to the horizontal. In the silo, airflow was distributed via the customised scroll surrounding the fan impeller and a plenum designed to minimise backpressure and maximise open area to about $0.3m^2$.

The silo was filled with Scope® barley and airflow rates across a range of fan speeds and power draws were measured when the silo was half-full and full.

Airflow performance was found to be acceptable, with results showing the system could effectively cool barley to 15ºC.

While the results for the prototype are encouraging, Mr White says further refinement of the components would be needed to suit specific silo applications. He also encouraged the use of a licensed electrician to ensure correct fitting of electrical components. □

**GRDC Research Code BMW00001**

**More information:** Ben White, 0407 941 923, ben@storedgrain.com.au

PHOTO: BEN WHITE

A power source trailer was custom-designed and positioned to maximise solar capture.

# REDUCED PEST BURDEN SLOWS RESISTANCE

## Growers in Western Australia are driving research to improve biosecurity and grain quality

By Catherine Norwood

PHOSPHINE RESISTANCE IS a very real challenge for Western Australian growers, with eight populations of stored-grain insects (predominantly red grain beetles) with strong resistance confirmed in the state.

A resistant population in the Mingenew region, identified in 2014, has sharpened the focus of local research into aeration strategies to improve grain-protection practices.

The Mingenew–Irwin region, 380 kilometres north of Perth, has had its own grower-funded group committed to research for the past 20 years.

In 2013, the Mingenew–Irwin Group (MIG) partnered with the University of Western Australia and the Kondinin Group, with support from the GRDC and the Plant Biosecurity Cooperative Research Centre (CRC), in a three-year project to assess the effectiveness of aeration in improving the quality of stored grain in the region.

MIG takes in 320,000 hectares and has more than 200 members who represent 95 per cent of growers in the region. The town of Mingenew is home to the largest inland receival point in the Southern Hemisphere, handling 500,000 tonnes of grain a year worth $150 million, mostly for export.

The emergence of phosphine resistance is a major concern for MIG. Executive officer Sheila Charlesworth suggests it could cost the state bulk handler, CBH, as much as $40 million a year in alternative treatments if phosphine was to fail as an effective fumigant.

While aeration will not kill insects, the MIG trial has already demonstrated that it can considerably slow insect life cycles and reduce insect burdens – by an average of 60 per cent in seed grain stored in aerated silos, compared with adjacent control silos. Reducing the insect burden is part of the national strategy to prevent the spread of phosphine resistance.

A financial cost–benefit analysis that included the cost of the aeration equipment and controllers, which depreciated over the three years of the project, also demonstrated that growers were $2/t better off with aerated silos when storing seed wheat at current prices.

At each of four MIG farms taking part in the trial, aeration fans with GrainSafe aeration controllers and monitoring equipment were installed in one silo. Monitoring equipment was also installed in a nearby non-aerated silo at each site. Aeration was operated from silo fill in 2013 until sowing in the 2014 season and again in the 2014-15 season.

Data loggers were installed to measure temperature and relative humidity while insect probe traps were set at three depths in the grain bulk (0 to 30 centimetres, 30 to 60cm and 60 to 90cm from the top of the grain). Grain samples were taken monthly to test for seed viability.

A structural treatment for insect control using diatomaceous earth was also added to both aerated and non-aerated control silos in the 2014-15 season, although these results are not yet available.

The aeration system reduced temperatures in the grain bulk down to an average of 19ºC. The temperature in aerated silos was as much as 12ºC lower than in the non-aerated silos, which helped to reduce the rate of insect reproduction and growth.

Five insect species were found at the trial sites and identified by University of WA entomologists. These were predominantly the red flour beetle (*Tribolium castaneum*) and lesser grain borer (*Rhyzopertha dominica*), but also the longheaded flour beetle (*Latheticus oryzae*), the hairy fungus beetle (*Typhaea stercorea*) and the rusty grain beetle (*Cryptolestes ferrugineus*).

Aeration reduced insect densities by an average of 60 per cent compared with the non-aerated silos, and in one case by 72 per cent. There was also an improvement in the seed viability, with only 2.3 per cent of unviable seed in the aerated silos, compared with 4.6 per cent in non-aerated silos.

Mrs Charlesworth says that before the trial growers did not realise the extent of insect infestations in their grain or the impact it was likely to have on their grain.

## COST ANALYSIS

Project engineer and stored-grain extension officer Ben White says the aeration fans operated for an average of 400 hours between harvest and seeding. While growers expected power would be a significant cost, it equated to $0.56/t for aeration in the cost–benefit analysis (based on $0.24/kilowatt hour).

In the non-aerated silos the cost of storage and fumigations to control insects was estimated at $13.50/t, also accounting for seed losses, based on a seed cost of $300/t.

In the aerated silos, costs included the capital cost of equipment, depreciated over three years, and electricity, with savings made on fewer fumigations and increased seed viability. The total calculated cost of storing grain in an aerated silo was $11.56/t.

Mrs Charlesworth says cost savings of about $2/t could make a significant impact to the bottom line for growers when grain margins are very tight.

"Every one per cent or half a per cent we can save on production costs makes a difference to our profitability."

She says other growers in the Mingenew–Irwin region have already begun to adopt aeration and installed power to their silos, with some opting to install larger silos to further improve efficiencies.

MIG has also hosted visits from seven other grower groups from across Australia, at least two of which have also begun to install aeration in their silos. □

**GRDC Research Code NPB00013**
**Plant Biosecurity CRC Code 3076**

**Aerating silos can drop temperature by 12°C, reduce insect reproduction and save nearly $2/t.**

PHOTO: MIG

Mingenew-Irwin Group staff collecting grain samples and checking insect traps in a silo as part of the aeration research.

## BREAKDOWN OF COSTS

### AERATED SILO COSTS

**Power cost (total fan run time over 4.5 months):**

- 0.37kW x 438 hours @ 0.24/h = $38.89/70t = $0.56/t

**Capital cost (assumes one 0.37kW fan and a controller for four fans):**

- equipment cost: fan (@ $830) + ¼ controller ($5500/4=$1375). Total = $2205
- cost amortised over 20 years = $110.25/70t = $1.58/t

**Opportunity cost:**

- $2205 x 8% = $176.40/70t = $2.52/t
- subtotal cost of aeration treatment = $4.66/t

**Viable seed losses:** 2.3% germination reduction @ $300/t = $6.90/t

**Total:** $11.56/tonne

### NON-AERATED SILO COSTS

**Viable seed losses:** germination reduction: 4.5% @ $300/t = $13.50

**Total:** $13.50/tonne

- **Using MIG trial figures at $300/t for seed.**
- **Average cost of control including reduced germination: $13.50/t.**
- **Average cost of aeration including power, capital costs, opportunity cost and reduced germination: $11.56/t.**
- **$1.94/tonne better off with aerated seed silos.**