Cool Cows

Shade, sprinklers and fans on dairy farms
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DEALING WITH heat stress is an important part of caring for our animals. The good news is that it can be managed effectively.

Heat stress affects milk production and income, and its impact on cow fertility, health and welfare lasts well beyond the seasonal hot weather.

Dairy Australia’s Cool Cows program, launched in 2008, is involved in a number of important research and farm demonstration activities. It has delivered more than 60 on-farm workshops and other extension activities to date, all in close collaboration with farmers, advisers, researchers and industry partners. Cool Cows also provides dairy farmers and their advisers with practical information and innovative web-based tools via its website, www.coolcows.com.au.

Shade and evaporative cooling play important roles in managing heat stress in Australian dairy herds. However, many farmers have doubts about the capital cost, payback period or lack the detailed design and management information required to proceed with confidence.

In response to this, the Cool Cows program has developed this Shade, sprinklers and fans on dairy farms booklet and a new Cost Benefit Calculator web tool. These initiatives enhance the Cool Cows information and tools already available, and put the industry in a good position to deal with heat stress effectively into the future.

These new Cool Cows resources are supported by funding from Dairy Australia and the Australian Government Department of Agriculture, Fisheries and Forestry under FarmReady, part of the Australia’s Farming Future initiative.

I encourage you to use these terrific resources.

Ian Halliday
Managing Director
Dairy Australia
Introduction

There are three locations on a dairy farm where you can focus your cooling efforts:

- Paddocks and laneways
- Dairy yard
- Feedpad

Which of these locations works best for you will depend on a number of factors, including:

- Your herd’s susceptibility to heat stress – low / moderate / high – based on location, breed, milk production level and age profile of herd.
- Whether you need to deal with prolonged periods of hot weather or only need to manage infrequent heat wave events.
- How much tree shade you already have in your paddocks and laneways.
- Whether you are willing to wait long enough for shade trees to grow.
- What irrigation infrastructure and water you have available.
- Whether it is feasible to provide adequate tree shade in paddocks to all your cows each day, given the size of your herd.
- What feeding infrastructure and equipment you have? Do you have a feedpad and mixer wagon? Is the feedpad surface concrete?
- Which feeding system you use (see page 4 for systems 1 to 5 as classified by Dairy Australia’s Grains2Milk program). If you use a hybrid system (system 4) or a TMR system (system 5) and do not graze cows over summer, then how much tree shade you have in paddocks and laneways is irrelevant.
- Whether you have a shady loafing paddock available near the dairy.
- Walking distances for cows between paddocks and the dairy, and between the dairy and the feedpad (if you have one).
- How many hours your cows spend in the dairy yard before each milking.
- How many times a day you milk.
- Whether you own the farm or not, and how long you plan to be on the farm.

Wherever you choose to focus your cooling efforts, and whatever infrastructure option(s) you choose to set up, there are many things you need to consider before you invest.

Sections 1 to 3 of this booklet describe the main options for shade, sprinklers and fans you should consider for your farm. For each option, its strengths and limitations are listed and the keys to success are described. The most interesting information is likely to be found in the case studies from farms across Australia.

Section 4 discusses an issue that is often not given enough attention – stock water supply.

Be sure to read Section 5, which describes design considerations that could mean the difference between a shade structure or evaporative cooling system that works extremely well for you for a long time and one that disappoints.
For more information about keeping your cows cool, visit Dairy Australia's Cool Cows website at www.coolcows.com.au. You can also access it via www.dairyaustralia.com.au. The website gives you free access to these user-friendly tools:

- **ACTIONS GENERATOR** tool helps you identify actions you can make on your farm to improve your heat stress management.
- **COST BENEFIT CALCULATOR** tool estimates the likely return on investment and payback period for a new cooling infrastructure item on your farm.
- **WEATHER FORECASTER** tool enables you to monitor the daily heat stress risk level in your local area and adjust your cooling strategies to suit.

THE FIVE main feeding systems used by Australian dairy farmers are:

1. **LOW BAIL**
   - Grazed pasture + other forages + up to 1 tonne grain or concentrate in the bail.

2. **MODERATE-HIGH BAIL**
   - Grazed pasture + other forages + >1 tonne grain or concentrate in the bail.

3. **PMR**
   - Grazed pasture for most or all of year + Partial Mixed Ration on feedpad and/or grain or concentrate in the bail.

4. **HYBRID**
   - Grazed pasture for less than 9 months/year + Partial Mixed Ration on feedpad and/or grain or concentrate in the bail.

5. **TMR**
   - Zero grazing. Cows housed and fed Total Mixed Ration.
If you want to keep your cows cool, always start with shade. Shade is the most effective way of reducing heat load because it blocks solar radiation, so providing shade to the herd should be your first priority.

Natural paddock shade

Trees can be planted in paddocks or laneways and can reduce the radiant heat load by 50% or more.

The shade and shelter that trees in paddocks and along laneways provide can be used strategically to manage both heat gain in summer and heat loss in winter.

Strengths:

- Trees are the cheapest method of providing shade.
- Trees absorb CO₂ and don’t require electricity to establish or maintain.
- Trees enhance local biodiversity.

Priorities for cooling cows

1. Use shade first
   *Minimise heat gain – block solar radiation*

2. Use sprinklers and fans
   *Maximise heat loss – encourage evaporative cooling*

Limitations:

- It takes many years to establish plantings.
- It can be difficult to provide adequate shade every day during paddock rotation.
- Trees along laneways can be a risk in severe wind conditions.
- You may need supplemental irrigation to establish or speed up tree growth.
Trees for shade

Background

The existing farm (108 ha) has been planted out with about 28,000 trees over the past 20 years. The owners have acquired another 35 ha and eventually this will also be planted out.

Costs were subsidised initially by a local agroforestry project.

The primary aim was to provide shade and shelter for the dairy herd. The agroforestry potential was seen as a secondary benefit to the property, as their focus was milking cows – not growing timber.

In the early 1990s the property reconfigured the farm layout and planned the renewal of internal fencing. The project provided a great opportunity to renew fencing at a subsidised rate.

The property developed a whole farm plan that matched soil types and trees species, aligned paddocks and proposed tree plantings to maximise shade and shelter for the summer and winter months.

Farmer’s name: Mark

Facts about the farm layout:

- Designed by: Mark, with assistance through local agroforestry project
- Constructed by: Mark, with some contract labour
- Lifespan: Indefinite

Other cooling infrastructure on this farm:

- Sprinklers in dairy yard

As part of the whole farm plan, areas of the property were also re-lasered which allowed separate bays to be constructed specifically for tree plantings. This allowed the trees to be strategically watered – separate from the irrigation bays which the herd accessed for grazing.

The tree bays were ripped and trees planted in late December, and also in autumn using root stock and

Note the north-south orientation of plantings. Cattle can access shade all day simply by shifting from eastern to western side of the paddock in the afternoon.
bare-rooted trees. The property found it easier to manage weeds with the late December plantings.

Bays were planted out with 4-6 rows of trees, which incorporated different species to provide upper and lower storey cover (i.e. both shade and shelter in a single paddock).

Furrows adjacent the plantings were used to direct irrigation water to the trees, which also minimised the spread of water in the bays and subsequent weed growth.

Species planted included – red gums, flooded gums, spotted gums, iron bark, grey box, yellow box, black box, melaleuca, acacia wattle, West Australian swampy yate.

Swampy yate was planted along fence lines that bounded channels. The leaves from this tree fall on the ground and release a weed-repelling toxin. This is beneficial as the farm is certified biodynamic and is unable to use synthetic fertilisers or chemicals for weed control and reducing grass growth in and around the banks of the channels.

The majority of fences are still in place, segregating the tree planting bays and the irrigation (grazing) bays.

Mark’s management tip

Manage recently sown pasture bays (up two years old) carefully to prevent ‘pugging’ along the fence lines where the cows stand to access shade/shelter. High traffic areas down the lower end of the bays also need to be managed during pasture establishment. Some re-sowing may be required.
Trees for shade and shelter

The main laneways leading to and from the dairy have established plantings. Cows are therefore happy to travel to and from the dairy during hot weather.

The daily milking routine remains unchanged regardless of the weather conditions. The cows are provided with shade and shelter every day, therefore it has never been an issue walking the herd to the dairy.

Over the past 10 years the property has never seen a cow enter the dairy showing signs of heat stress (e.g. excessive panting).

The cows utilise the tree shade and shelter as required. The herd usually seeks shade when the temperature exceeds 25°C (in summer this is usually around 10 am).

The herd has access to tree bays to control grass and weeds, however they prefer to stand on the green grassed irrigation bays than directly under the trees. It appears the grassed bays provide a cooler environment than the tree bays where there is no green grass in the summer months. The dry areas under the trees re-radiate heat from the ground – grassed areas don’t re-radiate as much heat.

If strong cool winds are present in the winter the herd can be put in the ‘bush block’ with some hay. The thick tree density provides shelter from the winds. The dry areas under the trees re-radiate heat from the ground – grassed areas don’t re-radiate as much heat.

If strong cool winds are present in the winter the herd can be put in the ‘bush block’ with some hay. The thick tree density provides shelter from the winds.

Mark’s comment

We are very satisfied with all the work we’ve put in and believe the trees play an invaluable role in our dairying operation. Additional trees will be planted along the main laneway to complete the shade/shelter corridor.
What would you change?

Knowing what you know now...

Mark says that they'd reduce the number of rows planted per bay – 4-6 is too many. With low water allocations trees can out-compete perennial pastures in adjacent irrigation bays, especially if there is a dry spring and no water available for irrigation. However, if water is available then both trees and pasture can co-exist without affecting each other.

Tree belts running east – west should have no more than 2-3 rows to avoid pugging paddocks in winter and excess shade.

If a single row of trees is planted ensure multiple varieties are used to produce an upper and lower storey, otherwise the shelter component will be insufficient. Mark believes he planted too many tall eucalypts and not enough smaller ‘habitat’ trees.

Trees indigenous to their area are more likely to survive than trees adapted to other environments.

If planting out paddocks exclusively for young stock and dry cattle there is less need for shade, as compared to lactating cows. Young heifers are content to sit in the sun, while a lactating cow will seek shade in comparable temperatures.

Comments from the experts

This property adheres to all the key design principles. Aspects of the design worth noting include:

- The plantings were established in fenced off bays to protect the trees from cattle hooves, excessive deposition of manure and removal of bark or branches.
- North-south orientation of the paddocks means the herd can access shade all day simply by shifting from the eastern to the western side of the paddock in the afternoon.
- Shade and shelter is provided in the majority of paddocks, as well as the main laneways leading to/from the dairy.
- The property has a whole farm plan and trees were matched to soil characteristics.

Tree plantings in paddocks and laneways have been well thought out and planned to provide good levels of shade and shelter to the herd in every season.
**Keys to success**

- **WHEN REDESIGNING** farm layouts, consider orientating the long axis of paddocks north-south to help maximise shade/shelter.

- **AIM FOR** 4 m² of shade/cow at midday.

- **SEEK RECOMMENDATIONS** on suitable tree and shrub species from an adviser, e.g. Greening Australia, Regional NRM bodies like local CMA, DPI or Landcare.

- **STRATEGICALLY PLANT** species based on natural traits, e.g. West Australian swampy yate, can minimise grass growth beneath its canopy through the secretion of a toxin.

- **DECIDUOUS TREES** will allow solar radiation to penetrate through canopies and allow laneways to dry out quicker in the winter.

- **FENCE OUTSIDE** the perimeter of the tree root systems to protect trees from excessive compaction and manure that may kill some species.

- **LOCATE FEED** and drinking water 20-30 metres away from trees so that cows don’t defecate excessively in the shaded areas.

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It’s said that the best time to plant trees was 20 years ago. The next best time is now! These photos show what can be achieved in a short time.

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A web-based commercial tool called WebShade ShadeAudit can help you quantify the existing shade on your farm and plan to increase shade cover. For more information, visit www.webshade.com.au
The most effective way of reducing heat load is to block solar radiation by providing shade. When not enough natural paddock shade is available, artificial shade can be used to minimise cows’ exposure to solar radiation. Portable paddock shade structures may incorporate shade cloth or corrugated iron roofing. Wheels or skids enable the structures to be towed behind a tractor or four-wheel motorbike to where they are needed.

**Portable paddock shade**

These structures are very effective when no other cooling is available in paddocks, such as overhead sprinklers (e.g. lateral move and centre pivot irrigators).

These shade structures can be located in paddocks/laneways, in dry corners of centre pivot irrigated paddocks or near portable feeding troughs and hay rings.

**Priorities for cooling cows**

1. **Use shade first**  
   *Minimise heat gain – block solar radiation*

2. **Use sprinklers and fans**  
   *Maximise heat loss – encourage evaporative cooling*

**Strengths:**
- Enables you to bring the shade to the cows, as opposed to cows to the shade.
- Best suited to smaller herds.
- Can be readily moved with the animals, or moved to cleaner, drier locations close to feed and water when necessary.

**Limitations:**
- May need several structures to provide sufficient shade for all animals.
- May lead to localised pugging, nutrient build-up or compaction if not shifted regularly.
- A time cost needs to be allocated to shifting shade structures.
- Shorter useful life than a permanent shade structure.
- Vulnerable to high winds.
Portable shade structures

Background

With little tree cover on many parts of the farm and none in the centre pivot area, a number of paddock shade structures were built in 2001 at the cost of about $5,000/structure.

Shade structures are used between December and March and on average are used by the cows for about 3 hours/day – generally between 11 am and 3 pm.

Once built, the structures have practically no running costs and are moved around the farm by four-wheel motorbike as required.

Farmer’s name: Frank

Facts about the structures:

- Designed by: WA Department of Agriculture staff
- Built by: Vasse Research Centre staff and some made commercially
- Lifespan: Now 9 years old; expected to last another 10 years with some maintenance

Other cooling infrastructure on this farm:

- Sprinklers in dairy yard
- Fans over bails in dairy

The dimensions of the shades used on this farm are:

- Base frame: 150 mm x 50 mm
- Main supports: 50 mm x 50 mm
- Shade frames: 25 mm x 25 mm
- Pitch of shade cloth: about 30%
- Tension applied to shade cloth
- Length of shade: 8.0 m
- Width of shade: 4.0 m
- Vertical height: 3.2 m in the apex
- Total length including draw bar: 9.0 m

Shelters are high enough so that heat is not reflected from under the roof back down onto the cows, and cows do not interfere with the roof structure if riding on the back of another.

Frank’s comment

When we bring them out for the first time at the start of summer, the cows run over to the structures before they have even been set up!

They obviously enjoy the comfort they get from the shades.

Shade structures are located in the laneway adjacent to the centre pivot so cows can seek shade after their morning grazing.
What would you change?

Knowing what you know now...

Frank suggests that it is important to remember that lots of building materials deteriorate in the sun. The rope and plastic latches used to fix shade cloth were affected by UV radiation and had to be repaired or replaced every one or two seasons. Frank recommends using pre-tensioned cables to fix shade cloth to steel frames.

Also, use second-hand wheels and tyres where possible. Standard fit Holden rims are good – they are cheap and readily available.

Frank’s management tip

Use latches or chains to prevent shade structures from being blown off their support beams / trusses. These structures may not be suitable for farms that regularly experience high winds.

Comments from the experts

The portable shade structures suit the needs of this farm very well.

Shade cloth is porous, which enables heat that is evaporated from cows underneath to vent through the cloth. This reduces humidity underneath the shade cloth and creates air movement by circulating air from the sides of the shade structure up through the material. Cows can off-load heat by means of evaporation and convection.

The small amount of radiation that penetrates through the shade cloth assists in drying out the earthen surface beneath. This improves cow comfort and reduces the risk of mastitis outbreaks.
Other options

A simple, low-cost design, but one that might not be suitable in windy conditions. Note some shade cloth tears along the edges.

An iron-roofed structure will re-radiate heat on the cows underneath, so where possible create a larger gap between the cows and roof.

Keys to success

- **IF LOCATED** near property boundaries, shade structures should be positioned to take advantage of any natural tree shade from neighbouring vegetation on road reserves.

- **RE-LOCATE STRUCTURES** if manure builds up or the ground underneath is muddy. This reduces the risk of mastitis around calving time – the risk is particularly high if the condition of cows’ teat ends is poor.

- **BEFORE YOU** build your own structure, seek professional advice from a registered engineer or builder.

- **IF USING** shade cloth, install it properly under tension, so it is not damaged by winds. Make sure that it blocks at least 80% of sunlight.

- **SEEK PROFESSIONAL** advice from a registered builder or structural engineer, as the height of the portable shades will affect wind loads on the structure.

- **WIND LOAD** will increase with roof height, and therefore the base needs to be heavier and wider to prevent the wind from tipping the structure over.

- **ENSURE THERE** is a gap between the portable sections of the roof (when raised), so that heat can be vented through the top of the structure. This is especially important for iron roofed structures.

- **ENSURE THE** footings and the base of the structure is wide enough to support the roof spans – this needs to be worked out for the specific individual structure.
Providing shade minimises heat gain in cows in the first place, but if they have accumulated heat load, then you need to do all you can to maximise heat loss via evaporation.

Paddock sprays and sprinklers wet the cow’s hair and skin. As the water evaporates, heat is off-loaded from the cow to the surrounding environment. This increases with air movement.

Sprays and sprinklers work best in low humidity conditions.

**Paddock sprays & sprinklers**

Cows cool themselves by standing in the evaporative zone of paddock sprays rather than directly under the water.

**Strengths:**
- Cheap capital outlay.
- Effective method of cooling a large number of cows.

**Limitations:**
- Requires access to reliable water supply.
- Needs to be shifted daily.
- Effective in low humidity areas only.

"Cow Cooler" water jet sprinkler.
Paddock sprinkler

Background

Terry farms in an irrigation district. He bought a towable ‘Cow Cooler’ water jet sprinkler with a geared head after hearing about its success from a number of other farmers.

The unit is mounted on a frame that is equipped with a fire fighter pump and long suction hose that can draw water from on-farm channels, dams or tanks. The system was designed by an ex-dairy farmer from Kyabram in Victoria.

The system is suited to most dairying regions that have dry temperate climates with low humidity, as long as water is available for pumping. It requires a close, reliable water source.

On days where the temp is 30°C or more, the ‘cow cooler’ starts operating at 10-11 am. The cows can move in and out of the water jet while they are grazing or feeding from the hay rings if they are confined from fresh pasture.

Terry said the cows will come and cool down then move back to grazing away from the water jet. When they are cooling themselves they never stand directly under the jet of water but rather stand close to the mist that comes off the jet in the ‘evaporative zone’.

On very hot and humid days over 35°C the cows are shifted from the pasture paddocks to a loafing paddock with tree shade, water and hay rings located within 100 m of the dairy. During these days the cows move back and forth from the shade to the water jet, and some also feed from the hay rings.

The unit runs on petrol and the petrol tank holds about 10 litres of fuel, which can operate the pump for about 18 hours at 75-85% of maximum engine revs.

Farmer’s name: Terry

Facts about the sprinkler system:
- Designed by: Local ex-farmer
- Installed by: Terry
- Lifespan: Been operating for seven years without failure, minimal rusting

Other cooling infrastructure on this farm:
- Loafing paddock 100 m from dairy with tree shade, water and hay rings

Terry’s comment

The pump can be used for other applications by simply removing the water jet (the green unit shown in the photographs).

I use it for general washing and flushing jobs around the farm.
On average, petrol is added every second day at a cost of about $12.50 (e.g. 10 L of fuel at $1.25/L).

The unit was bought in 2002/03 for $3,300 ($4000 at today’s prices) and includes the following features:

- 5 HP motor with 5 cm Davey fire fighter pump
- 30 m; 5 cm suction hose
- 3.5 cm jet (orifice diameter)
- Geared head to control movement of the jet – it can be stationary or complete a full rotation
- Small splash plate creates a mist of water that cover the cows
- Application radius is 30 m
- Height of sprinkler orifice – about 2 m from the ground
- The head is angled at about 20° and shoots water to a height of about 5 m
- Water use efficiency is between 3,000 and 3,500 L/hr.

Comments from the experts

The cow cooler adheres to the key principles of a sprinkling system by providing large droplets of water that wet the cow’s hair coat to the skin. The water then evaporates.

Portable and quick to set up, it is a good way to help cool large numbers of cows in the paddock when shade is limited. It is a cheap investment that can also be used for other jobs around the farm.

It is an option suitable for those farmers who graze cows throughout the hot season. It should be considered as a supplement to paddock shade, not a substitute.

Terry’s management tip

Shift the cow cooler daily, otherwise cows will pug the wetted area then start sitting in the wet, muddy patches.

If this occurs then the cell count may increase dramatically so get onto it early.
Centre pivots and travelling irrigators can also provide cows with evaporative cooling on warm to hot days.

This photo was taken in south-east South Australia on a 40°C day with strong northerly winds.

The pivot was orientated east-west.

Note that the majority of the 700-cow herd is standing in the ‘evaporative zone’ south of the sprinklers rather than directly under the sprinklers.

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Keys to success

- **SHIFT PADDOCK** sprinkle daily to avoid pugging and cows sitting in wet/muddy patches and so reduce the risk of mastitis.

- **A CLOSE**, reliable water source.
Shade structures

Minimising heat gain through shade should be the first priority for farmers hoping to keep their cows cool.

There are two main options for providing shade in the dairy yard.

The cheapest is shade cloth and if well-constructed and maintained it can have a lifespan of at least 10 years. Solid-roofed shade structures last much longer, but are more expensive to build.

If complemented with sprinklers and air movement at milking time, shade provided at the dairy yard is particularly effective in cooling cows. If the cows’ skin is wet, air movement enhances cooling. It also allows for faster milk let down and more incentive for the herd to walk to the dairy.

Shade cloth structures

Shade cloth minimises solar radiation – the cows can voluntarily seek shade to off-load heat via evaporation.

Strengths:

- Shade cloth is porous, so heat evaporated from cows can vent through it.
- The small amount of radiation that penetrates through the shade cloth ensures the concrete surface regularly dries out, which prevents mould/bacteria from establishing on the concrete and reduces risk of the cows slipping.
- Can be manufactured off-site then installed in a day.
- Can be removed in cooler months.
- In most council areas no planning permit is required, as shade cloth is not considered a solid roof structure.

Limitations:

- Can be affected by hail damage and machinery exhausts.
- Shorter lifespan compared to a solid-roofed structure.
- If not well-designed and constructed, shade cloth can rip in high wind.

Solid-roofed structures

Strengths:

- Offers significant protection from both solar radiation and wet conditions.
- Improves the operating environment for milking staff.
- Much longer useful lifespan than a shade cloth structure.

Limitations:

- A building permit is required.
- There is a significant cost to build and it may take several weeks to build.

Priorities for cooling cows

1. Use shade first
   Minimise heat gain – block solar radiation

2. Use sprinklers and fans
   Maximise heat loss – encourage evaporative cooling
Case study

Dairy yard shade cloth structure

Background

Over the past 30 years extensive tree planting has been undertaken on this property, but a number of these plantings have died as a result of water stress due to on-going drought. With insufficient tree shade for the grazing rotation and the reduced availability of irrigation water, the property has had to rationalise its total irrigable area. In addition, the original Jersey herd was changed to Holstein-Friesians, which are more affected by heat stress.

These factors required a re-think about how to reduce the impact of heat stress on the herd, so alternate means of providing shade were considered.

The owners organised for their nutritionist to complete a cost-benefit analysis of the capital cost and payback of the shade structure and sprinkler system based on potential milk loss due to heat stress.

A 110 x 100 m feedpad was built in 1996 and the shade structure over the dairy yard was installed in 1997.

Farmers' names: James, Rose and Glenn

Facts about the shade structure:

- Designed by: Local contractor
- Built by: Contractor built steel frame on-site, farm staff assisted with the placement and securing of shade cloth over the frame; took 2-3 weeks
- Lifespan: Now 13 years old and not showing any signs of deterioration; expected to last at least another 10 years

Other cooling infrastructure on this farm:

- Low-pressure sprinklers along feed alleys of feedpad
- Sprinklers at top of yard to pre-cool concrete, plus both sides of dairy yard
- Extensive tree plantings in majority of milker paddocks

Do your figures before you start ...

A 20 m x 20 m yard area can be covered with shade cloth for about $17,000-$20,000 (incl. support posts, footings and concrete, shade cloth manufacture and installation with a 10-year warranty).

Comparatively, a gable-style steel roof designed and installed to meet local council building standards could cost up to about $50,000, but the useful lifespan will be around 20-30 years.
The dairy is centrally located. The top of the yard where the cows move on to the milking platform is not covered by shade cloth, however there are sprinklers located on both sides of the yard fence. These are used to pre-cool the yard before the afternoon milking.

When temperatures reach 28-30°C, cows usually walk back to the feedpad and shaded yard at around 10.30-11 am. In summer and early autumn the herd spends about seven hours a day on the feedpad and shaded area, not including the pre-milking feeding time.

The shade cloth area is equipped with oscillating garden sprinklers that are used to pre-cool the yard before the afternoon milking and this allows cows to off-load heat via conduction through their contact with the cooler concrete surface. The feedpad has low-pressure water jet sprinklers along each feed alley.

Support posts were installed in the top section of the dairy yard so that the shade structure could be extended over the whole yard, but this has not been done. At most, a cow will spend an hour in the uncovered section before milking. The farmers feel there is no justification for extending it as the cows never show signs of heat stress when entering the platform. The overhead sprinklers can be used in the uncovered section of the yard if required.

James’ comment

The cows are not stressed or spending time and energy trying to get cool. They are eating and producing milk instead!

The herd is calmer during milking, which makes the job for the milkers less frustrating and less stressful overall.

Also, we think that the cooling infrastructure has helped remove the fluctuations in our in-calf rate.
The steel trusses and support posts; 90% solar rating shade cloth cost $8,000 for materials, construction and installation in 1997 (about $20,000 in today’s dollars).

The shade cloth structure has the following dimensions:

- Area under shade in the holding yard – 37 m long x 12 m wide.
- Uncovered section of the holding yard – 13 m long x 12 m wide.
- 11 trusses were used with 3.4 m spacings.
- Height of apex was 4.2 m.
- Pitch of shade cloth was calculated once truss and apex height was confirmed.
- Circular steel support posts were used and spaced about every 3.4 m.

Water for the property is sourced from the irrigation channel as part of the property's allocated water.

Two pumps supply pressurised water to the property (one acts a back-up or, alternatively, they can be run in series if demand is high).

Comments from the experts

This property exemplifies all the key principles associated with providing shade and shelter for the herd.

In addition to the shade cloth structure over the southern end of the dairy yard, the property also has sprinklers along the feed alleys of the feedpad, under the shade cloth and on the fence of the uncovered portion of the dairy yard. Tree plantings mean that the farmers can also provide paddock shade and shelter for the herd in both hot and cold conditions.

The combination of the feedpad and cooling infrastructure ensures the herd is willing and able to eat on hot days. They would average more ‘fully fed’ days than comparable herds that have no access to shade and shelter.

For more information about shade cloth structures, go to page 49.
Case study

Dairy yard solid-roofed shade structure

Background
This farm in the southern Riverina in NSW has opted for a solid roofed structure over its dairy yard. The 400-cow Holstein-Friesian herd averages more than 10,000 litres/cow/lactation and with batch calving there are plenty of cows in early lactation in the hot months, so minimising heat stress is a priority.

The farm operates a ‘hybrid’ feeding system. During summer there is no pasture available to graze and the herd is fed a total mixed ration (TMR) on a feedpad, so managing heat stress by using paddock shade is not an option.

The farmer chose to focus cow cooling efforts at the dairy rather than the feedpad because the dairy yard has a cement floor. Increased lameness risk by having cows standing on concrete for long periods was outweighed by the increased risk of mastitis if cows spent all day under a shade shelter in a bare paddock or on a earthen feedpad.

The fact that the herd is milked three times a day further swayed the farmer in favour of investing at the dairy yard.

Initially, sprinklers and a shade cloth were installed, but in 2009 the decision was made to replace the shade cloth with a permanent pitched roof made of steel and corrugated iron that follows the profile of the dairy shed roof.

The shade structure has the following dimensions:

- The dairy yard roof is 30 m by 15 m.
- The roof is 3.7 m high at the eaves – pitched at 20°.
- Open ridge vent is 300 mm wide.

Craig’s management tip
To gain from evaporative cooling, every cow needs to feel the air moving. Fans in the dairy yard give cows more benefit from the sprinklers, especially on hot, still days.
Although it cost more than $30,000, the farmer expects the permanent roof will pay for itself within two summers through sustained feed intakes and milk production, with the added bonus of improved fertility.

Understanding how important air flow is to maximise evaporative cooling with sprinklers, and having observed that many hot days in the district also tended to be very still, the farmer has also installed 3 large fans at the entry to the shed direct air over the holding yard.

On hot days, cows spend most of their time between feeds in the dairy yard (cows can also access the dairy shed, which provides the same area of shade).

What would you change?

Knowing what you know now...

Six more fans will soon be installed further down the length of the dairy yard to help keep air moving over all cows in the yard.

The sprinkler system will also be refined with a timer, providing an adjustable on/off cycle that will conserve water.

The next major cooling investment on this farm is likely to be a shade structure over the feedpad, done in conjunction with other developments at the feedpad that will reduce mastitis risk.

Craig’s comment

In the past, the heat resulted in a dip in milk production which tended to last until the end of lactation. Now with the roof, the cows’ feed intake remains normal on hot days and allows us to maintain milk production.
Keys to success

Shade cloth structures

■ **SEEK PROFESSIONAL** advice from a registered engineer and/or builder.

■ **USE SHADE** cloth with a minimum solar rating of 80%, minimum 300 GSM (gram per square metre), and at least a 10-year warranty against UV degradation. Green or black material is preferred.

■ **APPLY SUFFICIENT** tension to shade cloth to prevent damage during windy conditions. Monitor tension regularly, especially after strong winds.

■ **MINIMUM HEIGHT** should be 3.6 m (ideally 4 m) to allow for adequate airflow under the structure, effective use of sprinklers and fans, and good machinery access.

■ **A PITCHED** roof is better than a flat roof as it enhances convective air movement.

■ **SUPPORT POSTS** used should be structural grade steel. They should be located outside the dairy yard to prevent contact with manure and water, and so they don’t interfere with yard washing.

■ **DEEP FOOTINGS** should be left to cure for an extended period (at least 2-3 weeks) before bearing any load.

For more information about shade cloth structures, go to page 49.

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Solid-roofed structures

■ **USE ALUMINIUM** or white galvanised iron sheets to increase the rate of solar reflection.

■ **MINIMUM HEIGHT** should be at least 3.7 m at lowest roof height and at least 4.5 m along the centre to allow for adequate airflow underneath the structure, effective use of sprinklers and fans, and good machinery access.

■ **ROOF PITCH** should be at least 20° (ideally 30°) to enhance air movement.

■ **A CONTINUOUS** ridge opening will promote convective heat dissipation via the ‘stack effect’.

■ **GUTTERING AND** downpipes should comply with the state plumbing code.

For more information about solid-roofed structures, go to page 53.

Damage to shade cloth caused by tractor exhaust. This shade cloth structure is only 3.5 m high.

Damage to shade cloth caused by poor maintenance. Ensure that springs that become detached are re-attached as soon as possible.
Dairy yard sprinklers

Sprinkled concrete loses heat via evaporation and conduction through contact with the cooler water. This reduces its ability to re-radiate heat to the cows standing on its surface.

Sprinklers can be used to wet cows too so they can off-load heat via evaporation. A small amount of heat is also off-loaded via conduction from hoof contact with the cooler concrete surface.

Strengths:
- Low capital outlay.
- Can be easily fitted to any dairy yard (or feedpad) with a concrete floor.
- Effective method of cooling a large number of cows quickly.

Limitations:
- If droplet size is too small cooling will not be effective.
- Use in high humidity conditions actually increases heat load on cows.
- Without adequate air movement, cooling using sprinklers is not effective.
- Need access to a reliable water supply.

Priorities for cooling cows

1. Use shade first
   *Minimise heat gain – block solar radiation*

2. Use sprinklers and fans
   *Maximise heat loss – encourage evaporative cooling*

Every dairy yard in Australia should be fitted with sprinklers.

Sprinklers encourage heat loss through evaporative cooling. Sprinkling cows before milking can lower breathing rates and increase milk yields.

If cows are cool when leaving the dairy in the afternoon, they eat more overnight.

While the production benefits are real, most farmers nominate the reduction in flies as one of the best things about using sprinklers in the yard!
Dairy yard sprinkler system

Background
Lindsay is convinced of the benefit of sprinkling cows in hot weather and has been doing it for more than 30 years as part of his summer routine.

The current system was installed in 2000 and includes ‘wobbler’ sprinklers set up over the dairy yard and a spray curtain installed on the roof line at the entry onto the platform.

The infrastructure is well designed and allows cows to stand in the yard in comfort even in high temperature conditions – a factor in motivating cows to travel to the dairy.

Farmer’s name: Lindsay
Facts about this sprinkler system:
- Designed by: Lindsay
- Installed by: Lindsay and farm staff
- Lifespan: Set up 10 years ago and to date nothing has needed to be replaced

Other cooling infrastructure on this farm:
- Spray curtain at dairy platform entrance
- Large fan in dairy

‘Wobbler’ sprinklers running across the yard, suspended by steel cables and support posts.
Case study

On 30°C days sprinklers are used before milking. On days over 35°C the herd is brought into the yard from the paddock and sprinkled with water for at least 2 hours before the afternoon milking. In the November 2009 heatwave (during which the max. daily THI exceeded 80 for 10 consecutive days) the farm only lost 1 L/day with cows on concrete under sprinklers for 6-8 hours/day.

Lindsay’s dairy yard is 50 m long and 18 m wide and holds up to 500 cows. The system has these specifications:

- Four rows of wobblers each with three sprinklers across the yard at spacing of 4.5 m. Each row about 7 m apart.
- Height of sprinklers above cows is 3 m at side of yard and 2.8 m in the middle.
- Use existing dairy pump 70 psi.
- No filter used.
- 25 mm diameter pipe.
- Constant use of sprinklers, no on/off cycle is used.
- Channel or bore water for dairy yard, yard drains to effluent pond, then utilised through irrigation system. No water leaves the farm.

What would you change?

Knowing what you know now...

Lindsay would put support posts into concrete to provide stronger support to cables and sprinkler lines, as some posts have bent.

Comments from the experts

This property’s dairy yard sprinklers are effectively spaced and elevated so that all the dairy yard can be wetted when operated and are not located within reach of the cows. They apply large droplets that effectively wet the cows’ hair and skin.

The sprinklers are not operated based on a set on/off cycle to conserve water. However, the wobbler sprinklers appear to have a lower flow rate, as compared to the oscillating garden variety sprinklers.

For more information about sprinkler systems, go to page 57.
Spray curtains

Spray curtains are another cheap cow cooling option that has the added benefit of keeping flies out of the dairy – appreciated by both cows and people!

Spray curtains can be used in dairy yards but are normally attached to the underside of the dairy shed roof between the yard and the platform.

The example shown was constructed for less than $100 using 19 mm black polyethylene attached to the roof with garden sprinkler sprays inserted into the pipe every metre. It is about 2.5 m above the cows’ feet level.

The sprinklers generate a semi-circle spray pattern that is directed towards the yard side of the shed.

Comments from the experts

The spray curtain is a cheap and effective complement to any dairy yard sprinkler system. It not only helps keep the dairy shed cool for cows and milkers, it also reduces fly numbers in the dairy – by washing flies off cows on entry and providing a wall of mist that prevents flies from entering the shed.
Increasing airflow from 0 m/sec to 1 m/sec increases heat loss from a wet cow three-fold.

Fans can therefore be a useful complement to sprinklers, especially on warm to hot days when there is little or no wind.

Fans can also be useful in the dairy shed in conjunction with a spray curtain, as in the example shown.

Fans only help cool cows when:

- the air temperature is lower than the cow’s body temperature (39°C)
- the surface of the cow is wet.

In a dairy yard, fans should be mounted above sprinklers so they remain dry and tilted 20-30° down from vertical so that they blow down to the floor, between and underneath cows. If fans are aimed too high, their effectiveness will be reduced.

They are usually placed in a row with their back to the prevailing wind, and not blowing into the dairy.

Fans range in cost from about $550 to $2,000 each, depending on their design and capacity.

Check the efficiency rating of the fans and buy the most efficient. Only use fans with sealed motors.

For more information about fans, go to page 59.
Keys to success

Remember that for evaporative cooling to be effective, the cows’ skin needs to be wet – but not so wet that water dribbles down the udder.

Sprinklers

- **AIM FOR** a high-volume sprinkler with medium-to-large droplets – avoid a fine mist.
- **COVER THE** entire dairy yard, so that all cows are wet in the first 10 minutes.
- **CONSERVE WATER** by installing a timer and running sprinklers on an on/off cycle.
- **COWS SHOULD** not be packed too tightly – sufficient air movement is needed to allow evaporative cooling to work. Poor ventilation results in high humidity and health problems.
- **SPRINKLERS POSITIONED** along the sides of a dairy yard need to be mounted high enough to project water up and over cows so it falls from above (ideally 2 m). This will minimise wetting of udders and the risk of mastitis. It will also prevent water being thrown directly into cows’ ears.
- **IF COWS’** teats do get wet then either allow time to dry, or dry them with a paper towel before putting cups on.

For more information about sprinkler systems, go to page 57.

- **AVOID WETTING** cows immediately after milking to prevent teat disinfectant from being replaced with contaminated water while teat orifices are still open.
- **PRE-WET THE** dairy yard by hosing, flood washing or sprinkling for the hour before cows arrive for afternoon milking. This helps dissipate the heat stored in the concrete.

Fans

- **ENSURE ADEQUATE** number of correctly spaced fans of suitable airflow capacity for the area.
- **ORIENTATE TO** work with the prevailing winds.
- **TILT DOWN** so they blow air between and underneath cows to enhance whole body cooling.
- **OPERATE ON** a temperature threshold to reduce unnecessary power use, and machine ‘wear and tear’.

For more information about fans, go to page 59.
Permanent shade structures over feedpads (or freestalls) can make a big impact on overall farm productivity.

Shade provided here encourages cows to keep eating. Permanent shade sheds are an investment that provides excellent protection from solar radiation – but they must be well designed and constructed.

**Shade structures**

**Priorities for cooling cows**

1. **Use shade first**
   *Minimise heat gain – block solar radiation*

2. **Use sprinklers and fans**
   *Maximise heat loss – encourage evaporative cooling*

**Limitations:**

- Location on farm is not always ideal for paddock rotation.
- High capital cost to provide shade. Cost depends on amount of concrete; type of roof, strength of structure required to support roof and the effluent management system.
- Must have an effective system for handling effluent and run-off, otherwise cow comfort and production may be compromised.
- Need to comply with regulatory authorities (e.g. local council building permit for solids roof structures).

**Permanent shade sheds**

An effectively designed and built shade shed provides:

- sufficient room for resting and standing
- comfortable, hygienic lying surfaces
- clean, dry surfaces for standing and feed placement
- a safe environment to minimise injury
- smooth, quiet stock movement.

Note that the orientation and roof design of the shade structure will influence the amount of solar radiation that it can block.

**Strengths:**

- Fast to set up, but with a long useful life – at least 25 years.
- Doubles as a feedout facility,
- Can be used to protect pastures and prevent soil pugging during prolonged periods of rainfall.
- Can be used to break the growth cycle of parasites such as cattle tick and reduce the need for chemicals.
- Can be fitted with evaporative cooling systems such as sprinklers and fans (see Section 3b).
- Can be converted into a freestall or integrated with loafing pads if well designed.

**Feedpad**
Low-cost earthen feedpad with solid-roofed shade structure

Background

On-going drought conditions meant Karen and Ian had to re-think their whole approach and in 2007 they changed their operation from an extensive grazing system to a hybrid system. The herd is fed a total mixed ration (TMR) from November to March and then from April to October it is grazed and provided with supplements.

Karen and Ian estimate that they experience up to 100 days/year where heat load affects their cows, so they knew that providing more shade to the herd was a priority. Impressed with what they saw on a trip to the United States, Karen and Ian built two separate, covered earthen feedpads.

Farmers’ names: Karen and Ian
Facts about the earthen feedpad:
- Designed by: Karen and Ian, in consultation with structural engineer
- Built by: Local builder and farm labour
- Lifespan: At least 25 years
Other cooling infrastructure on this farm:
- Sprinklers in dairy yard

Feedpad 1 on the western side located within 300 m of dairy. Note the central drive alley with portable concrete troughs on either side.

Feedpad 2 on the eastern side
Case study

Two separate compacted clay feedpads share a central drive alley, with portable concrete troughs on each side of the drive alley. The long axis of each rectangular feedpad is orientated north-south. The feedpads each have a raised earthen loafing area located beneath a long shade shed (also running north-south).

The shade sheds, in combination with the feedpads, have meant a substantial reduction in the dips in milk production that resulted from extended hot weather.

Each of the two feedpad shade structures took about three weeks to construct at a cost of about $60,000 (including the earthworks, materials and installation of the shade sheds, troughs and fencing).

- The earthen pads are constructed from on-site clay that was raised and compacted.
- Pads drain to the southern end, then run-off is conveyed into the farm’s irrigation recycle system.

There is a 5-6% slope away from the drive alley and shade sheds to enhance drainage from where the cows stand to eat and to drain stormwater away from the sheds.

Each feedpad is scraped daily to break up the manure pads and enhance drying of the manure. This is part of the property’s mastitis risk management plan.

A land plane is used weekly to scrape manure from the heavily trafficked areas between the feed troughs and the shade sheds. This is deposited on the other side of the shade sheds to form a dry, aerated manure pack that the cows can lie down on.

The feedpads are scraped each year. All the manure is removed and spread directly back on to the property.

Ian’s comment

Because we experience so many hot days a year, we estimate that we save around 2 litres/cow/day due to our improved heat load management.

Over more than 100 days and at 35¢ a litre, that is equivalent to about $33,000 a year in extra milk income!
Due to the earthen floors, the orientation of the structure is north-south to allow floors to dry out – the sun will strike each part of the floor at some point over the day. The shed has the following dimensions:

- Shade structures – 108 m long x 9 m wide. Posts are located 9 m apart along the length of the shed; 8 apart across the width of the shed.
- Height of roof is 3.8 m on the gutter side; 4.2 m on the high side.
- The roof is single pitch, sloping from east to west at 4.5%.

The shade sheds consist of square tubing support posts that are bolted to concrete footings. H-section steel is used as the trusses, then C-section purlins. Corrugated iron sheets form the roof.

- Rectangular tubing support posts: 125 mm x 75 mm, 5.0 mm wall thickness
- Trusses (steel channel): 150 mm wide
- Purlins: 200 mm
- Footings: 600 mm diameter x 1,200 mm deep; 25 MPa concrete

The central drive alley is constructed from rubble, sourced locally. The central drive alley slopes to the south.

The concrete feed troughs are portable. Their external dimensions are 6 m long, 0.88 m wide, 0.85 m high – back wall, 0.6 m high – front wall.

There are two round 2,700-litre water troughs on each feedpad, at each end of the shade sheds on the side closest to the feed troughs.

What would you change?

Knowing what you know now...

Feed troughs

In future Karen and Ian will remove the concrete feed troughs and construct a concrete drive alley and install a nib wall. This will allow feed to be delivered on the concrete surface and more importantly it will be able to be pushed-up regularly reducing feed wastage.

Karen and Ian estimate that they are losing between 5-10% of feed delivered through spillage from the troughs, so it is well worth the effort.
Case study

Cool Cows – Shade, sprinklers and fans on dairy farms

Location of sheds
Karen and Ian would construct the shade sheds further away from the central alley.

As the sun moves across the sky the shaded area from the sheds moves in the opposite direction. At the western feedpad, the shaded area moves towards the central alley in the afternoon.

If cows want to sit down in the shaded area they have to sit in the heavily manured area between the feed and water troughs.

Ideally, they could sit in a cleaner area of the pad, which could be achieved by increasing the distance between the shade sheds and the feed troughs.

Location of water troughs
We’d also re-locate the water troughs. If they were located on the far side of the feedpads (between the boundary fence and the shade sheds) it might encourage the cows to sit down in the cleaner area of the pad.

Comments from the experts

This style of earthen feedpad / shade structure is well suited to a farm operating a hybrid feeding system in low-moderate rainfall areas. This farm is in southern NSW.

The two shade sheds provide just over 4 m² of shade per cow at midday, based on the current herd of 470 cows.

The north-south orientation means that the ‘shaded area’ shifts across the pads during the day, which means it spreads manure deposits over a larger area as the cows move with the shade.

The raised floors and pitched roofs allow stormwater to be effectively managed and not end on the pad floor, so there are no wet patches for cows to lie in. They also enhance convective air movement from under the roofs.

The drainage system controls and directs all run-off away from the pads.

Current position of water trough is between the feed troughs and the shade sheds. This is where a high percentage of manure is deposited, which often means cows are sitting in fresh manure.

Better position for water troughs – between the boundary fence and shade shed.
Case study

Low-cost feedpad with shade cloth structure

While the shade cloth over this feedpad is not wide enough to provide shade to cows all day, with some modification it may be a cost-effective cooling option for some farms.

- Feedpad is 72 m long and runs east-west.
- Shade cloth has a 90% solar rating (doubled over).
- Feeding space is 0.7 m/cow, with the standing area concreted out to 3 m from the nib wall.
- Drive alley is 5 m wide (two 1 m concrete strips with 3 m of gravel in between).
- Height from ground to shade cloth is 4.4 m.

This structure cost about $50,000 to construct, including concrete feed alleys, water troughs and the shade cloth structure.

The feedpad is close to the dairy and cows are happy to move to the dairy and they arrive unstressed. The dairy yard is fitted with sprinklers and cows are sprinkled before milking.

What would you change?

Knowing what you know now...

- Add another row of shade cloth to increase the area shaded per cow (especially on the northern side).
- Plant trees around the perimeter of the loafing area, but fence off. The trees here have died, or are dying due to the concentration nutrients and compaction.
- Increase the size of the loafing area on both sides of the feedpad to allow more space per cow and provide alternate areas to rotate cows during wet weather.
- Improve the surface and drainage of the earthen loafing areas surrounding the feedpad for better mastitis risk management.
- Consider adding a sprinkler system along the feed alley/drive alley partition above the cows’ heads to increase cooling capability.

Obviously, this type of structure is suited to a drier climate where the herd does not need protection from the rain – this farm is in south-east Queensland.

Farmers’ name: Ian and Cathy

Facts about the feedpad:
- Designed by: Ian and Cathy
- Built by: Ian and Cathy, and family

Other cooling infrastructure on this farm:
- Sprinklers in dairy yard
Case study

Higher-cost concrete feedpad with solid-roofed shade structure

This farm in northern Victoria has opted for a covered concrete feedpad to house its 600 cows for up to six hours a day in summer. The aim was to reduce the milk and fertility losses in hot weather and they have noticed a big improvement in rates of mastitis.

The feedpad was built in 2000 and cost $300,000. The roof was erected in 2008 for about $260,000.

- The shed is 200 m long.
- The roof is 18 m wide.
- The drive alley has a width of 6 m and each feed alley is 5 m wide.
- The roof is 4 m high at the eaves – pitched at 20°.
- Open ridge vent is 600 mm wide.
- 50 m³ of concrete were used in the footings.
- 550 m³ of concrete was used in the feedpad.
- Water troughs are located along each side of the shed.

The feedpad is easy to clean and minimal labour is required as it takes only 45 seconds to flood wash each cow alley.

- The floor is sloped to make flood washing easier.
- 50 kL of water is used per day for flood washing.
- Solids and sand in effluent is collected in a large concrete sump.
- Liquid effluent passes through a weeping wall to a holding pond.

(The effluent system could do with upgrading to handle the increased volume of runoff).

The north-south orientation means that cows are exposed to the sun in the mid-morning and afternoon. In summer, the afternoon sun is likely to increase the heat load of cows on the western side of the pad.

The feedpad is located right next to the dairy holding yard, which is fitted with sprinklers. Cows are sprinkled pre-milking and for longer periods on very hot days.

The cooling capacity of this covered feedpad could be further enhanced at modest cost by installing sprinklers along each side of the central drive alley.

Farmer’s name: Rob

Facts about the concrete feedpad:
- Designed by: Rob, in consultation with structural engineer
- Built by: Contractors

Other cooling infrastructure on this farm:
- Sprinklers in dairy yard
- Some trees
Keys to success

■ **MANAGEMENT IS** easier if the shade structure is located close to the dairy, as staff can monitor the herd while preparing for milking or post-milking clean-up.

■ **CONSIDER THE** effects of prevailing winds, radiation from the sun and rainfall. Structures need to be able to withstand extreme weather conditions.

■ **DAILY SCRAPING** of earthen feedpad surfaces helps manage the risk of mastitis.

■ **AN EFFECTIVE** system for handling effluent and run-off.

For more information about solid-roofed shade structures, go to page 53.
Sprinklers and fans

Permanent structures over feedpads (or freestalls) provide shade which minimises cows’ heat gain. Incorporating infrastructure such as fans and sprinklers assists heat loss through evaporative cooling.

The combination of shade, sprinklers and fans means farmers have much more control over environmental conditions.

These structures require significant investment and professional advice is critical to success.

Feedpad/freestall sprinklers and fans

**Strengths**
- Fans are very effective at cooling cows when used in conjunction with sprinkling – their combined effect is greater than the impact of each alone.
- Provide effective air movement and cooling in confined spaces such as covered dairy yards, sheds and freestalls.

**Limitations**
- Require a concrete floor to manage effluent run-off.
- Fans require close access to sufficient power – a limiting factor in many rural areas of Australia.
- Fans are expensive to buy and run.

For fans to cool cows effectively:
- the ambient temperature must be lower than the cow’s body temperature
- the cow’s skin must be wet (through sprinkling or sweating).

Priorities for cooling cows

1. **Use shade first**
   *Minimise heat gain – block solar radiation*

2. **Use sprinklers and fans**
   *Maximise heat loss – encourage evaporative cooling*
Freestall shed evaporative cooling system

Background

This large herd operation uses a Total Mixed Ration (TMR) feeding system and has covered freestalls and dairy yard that provide year-round shade and shelter. Fans and sprinklers complement the shade, providing high levels of evaporative cooling in hot conditions. The whole operation has been dubbed the ‘Cow Hilton’!

The fully roofed facility and cooling infrastructure allows the property to artificially control the climate, and subsequently optimise cow comfort and production. The farmer reports that the investment in this infrastructure has reduced the impact of climate variation on milk production.

The fans in the freestalls (and dairy) are:
- orientated to work with the prevailing winds
- positioned above feed alleys about every 6 m; in the stalls – every 12 m
- pitched down towards the ground, so that they force air between and underneath the cows to enhance whole body cooling
- operated on a temperature threshold to reduce unnecessary power use and machine ‘wear and tear’
- set to come on above 21°C full time.

Two types of fans are used – ‘old’ fans are used in the feed alleys and the stalls have ‘new’ ones installed.
- Old fans have 900 mm blades and move air at the rate of 285 m³/minute with a 0.45 kW motor.
- New fans have bigger 1300 mm blades and move air at the rate of 840 m³/minute with a 1 kW motor.
- Estimated cost: $65/hour to run 60 fans in one freestall (1,000 cows).
- The fans are from Fanquip.

Sprinklers are located in the freestalls (and dairy) and are operated based on several environmental triggers or temperature thresholds, as well as a timed on/off cycle. This reduces operating costs and system ‘wear and tear’.
- Sprinklers can be adjusted to alter the droplet sizes depending on the climatic conditions.
- Sprinklers in the freestalls are 1.7 m above flooring.

Farmer’s name: Michael

Facts about this system:
- Designed by: US agricultural engineer
- Built by: Contractors and family

Other cooling infrastructure on this farm:
- Solid-roofed dairy yard with fans and sprinklers

Fans set 2.3 m above cows, angled down. All fans push air from west to east with the prevailing wind.

Side view of the fan.
Sprinklers are spaced 3 m apart above the feed alleys, so all feed alleys can be wetted when operated.

Spray pattern is about 1-1.5 m back from sprinkler. The sprinkler on/off cycle in the freestall area operates in the following way:

- at 21°C a two-minute on; 13-minute off cycle
- above 25°C reduce the off cycle by 20% for every 1°C above 25°C
- at 35°C they are on for two minutes; off for three minutes.

Water use in the freestalls (including drinking water and sprinkling):

- 140 litres/cow/day in summer
- 80 litres/cow/day in winter.

Comments from the experts

This property is an excellent example of an evaporative cooling system incorporating fans and sprinklers that complements a covered (roofed) freestall or feedpad. It provides a high level of control over climatic conditions, and optimises cow comfort and production.

The sprinklers in the freestall shed:

- can be adjusted to alter droplet size to suit the conditions
- are operated on several environmental triggers (temperature thresholds) as well as a timed on/off cycle
- are well spaced so that all the alley ways can be wetted when operated.

The fans in the freestall shed:

- are orientated to work with the prevailing winds
- are pitched down towards the ground so they force air around and under the cows to enhance whole body cooling
- are operated on a temperature threshold to reduce unnecessary power use and machine ‘wear and tear’.

Michael’s comment

Farmers need to do their own research, look carefully at sheds here and overseas, and use an engineer with experience in designing these systems.
Fans

Increasing airflow from 0 m/sec to 1 m/sec increases heat loss from a wet cow three-fold. Fans can, therefore, be a useful complement to sprinklers, especially on warm to hot days when there is little or no wind. Fans only help cool cows when:
- the air temperature is lower than the cow's body temperature (39°C)
- the surface of the cow is wet. Fans are usually placed in a row with their back to the prevailing wind.

Fans range in cost from about $550 to $2,000 each, depending on their design and capacity. Check the efficiency rating of the fans and buy the most efficient. Only use fans with sealed motors.

For more information about fans, go to page 59.

Keys to success

- **MANAGEMENT IS** easier if the feedpad/freestall structure is located close to the dairy, as staff can monitor the herd while preparing for milking or post milking clean-up.
- **CONSIDER THE** effects of prevailing winds, radiation from the sun and rainfall. Structures need to be able to withstand extreme weather conditions.
- **USE AN** engineer with experience in designing these systems.
Access to drinking water

When cows drink, they transfer heat from their bodies to the water via conduction.

Effective heat transfer depends on differences in temperature. Cold water transfers more heat away from the cow than warm water.

Allow 200-250 litres/cow/day in hot weather – double the normal intake.

Make sure cows have access to cool water wherever they are during the day or night.

Volume and space requirements

Milkings cows usually drink after milking and they can consume up to 20 litres of water/minute. Around 30% of daily consumption occurs just after milking, so water should be easily accessible as soon as cows leave the dairy (not a 1-2 kilometre walk away).

- Optimal drinking temperature is 15-20°C.
- Troughs should be 600-900 mm high (cow feet level to top of water point).
- Water depth should be 150-200 mm to maintain cool temperature and reduce debris accumulation.
- Water reticulation systems should supply at least 20 litres/cow/hour.
- Each trough should be able to hold at least 200-300 litres of water with a minimum flow rates of 10 litres/minute.
- Trough volume can be reduced to about 100 litres if the flow rate is increased to 20 litres/minute.
**Water quality**

Saline water can affect animal health and affect the effluent management system.

- Stock water supplies should be analysed regularly to check salinity levels.
- Install troughs adjacent to feed alleys and dairy yards so cows have to place their head through the fence to access water.
- Make sure you can get access to troughs for cleaning.
- Use a bung to drain the trough into the effluent management system.
- Plumb troughs so that water can drain back into concrete feed alley or yards after cleaning.
- Rectangular water troughs are easier to drain and clean.
- Ensure manure does not build-up around the base of troughs.

Stock water points should be cleaned at least weekly to remove any feed residue or other contaminants.

On this farm each feedpad has two circular concrete troughs.
Water point locations

Paddocks and laneways:
- Provide watering points in every paddock, as this will keep cows grazing longer in hot weather. If they have to leave the paddock to get a drink they often do not return to graze.

Dairy exit:
- A large water trough on the exit side of the dairy is a must.
- Locate in wide passage, preferably on the outside of cow traffic curve.

Dairy holding yard:
- Install troughs along sides of dairy yard so cows have to place their heads through the fence to drink.

Earthen feedpad:
- Place troughs away from the feed source on the down-slope side of the pad, so that water can drain directly into the effluent management system. This helps to minimise the formation of wet patches throughout the feedpad.

Concrete feedpad:
- Place water troughs within about 15 m of the feeding table.
- Locate away from the feed alley to prevent feed contaminating the water.
- Locate within the feedpad complex, so that spillage and flushing can be directed into the effluent management system.

Freestall shed:
- Locate water troughs at the crossovers to prevent feed contaminating the water and to reduce the incidence of cattle blocking each other in the alleys.
- Provide at least 5 cm of trough space per cow in systems where cattle are confined for 24 hours/day – with at least two points for every group of cows.

Keys to success

- AVOID RUNNING black poly pipe along the ground, as water will become hot before reaching the watering point.
- LARGE VOLUME concrete troughs help keep drinking water cool.
- LOCATE TROUGHS in shaded areas where possible.
- USE HIGH-PRESSURE flow systems that allow rapid refilling of water troughs.
- DESIGN TO cater for increased demand in hot weather.
- CONSIDER FUTURE increases in herd size or changes to farm layout.
- LOCATE SO that water is not contaminated by feed.
- DESIGN AND locate to allow easy, frequent cleaning.
- MANAGE MANURE build up around troughs.
Design considerations

Shade cloth structures

Several forms of shade cloth structures are available including span structures (such as the case study on page 20), peaked sail structures, cantilever structures as pictured below and tent like structures with large central supports.

Design considerations for maximum effectiveness and useful life

Fabric material

For dairy cattle, use shade cloth which blocks at least 80% of sunlight, with a minimum 300 gsm (grams per square metre). Green or black coloured material is preferred. Shade cloth fabric should last at least 10 years. Higher quality and tighter weave fabrics last longer but cost more.

Shade cloth fabric can deteriorate relatively quickly with exposure to sunlight, dust, accumulated debris and water. Flexing will encourage deterioration and wear as well as failure or loosening of connections. Shade cloth is also prone to bird, insect and rodent attack and areas not able to be hosed down or easily inspected for maintenance are particularly prone.

Note: Cows are also not keen on going from bright areas to dark areas and prefer dappled shaded spaces to dark spaces, so they tend to get used to a shade cloth structure more quickly than a solid-roofed structure, provided the cloth is not billowing or flapping noisily.
Fastening fabric to posts

Shade cloth must have sufficient tension applied to it to prevent the cloth from damage during windy conditions. The flexible and adjustable connections between the fabric and the support posts are therefore critical structural components.

The shade cloth fabric can be held to posts in different ways, ranging from load-carrying straps to chains and u-bolts and in the most advanced form adjustable cables and turnbuckles.

How long the connection lasts usually depends on how well it distributes the point load at the stanchion to the fabric. Reinforcing cables and seams help.

If excessive flexing of fabric is permitted the flapping can generate unacceptable noise during wind events which can disturb cows and irritate people. However, compared to metal frames and buildings, shade cloth structures suffer minimal temperature or water related deformation.

If a cable or cable connector fails due to over-tensioning, it can cause instantaneous and catastrophic structural failure.

Turnbuckles for tensioning cable supported shade cloth structures are prone to loosening or failure through repetitive loading so they should be inspected regularly and tightened or replaced.

Chain connections should be avoided. In the event of overstress, breakage of a link can lead to the launch of a projectile whereas a cable will fray or unravel, allowing time for repair, replacement or escape from injury.

Shade cloth structures can become a hazard if damaged by storms. Blown cladding can provide serious injuries whilst broken cables and unsecured shade cloth can whip.

Different fastening methods.
Support posts and foundations

Ensure structural grade steel is used. For rigid framed and flexible shade cloth structures the wind loads, dead loads and live loads imposed on the structure need to be transferred through the structure into the ground. The foundations which secure each post to the ground are therefore critical structural components.

Deep, concreted footings are essential as the posts are subject to a ‘bending moment’ and need to transfer stresses into the ground, as well as to stop the structure lifting. Each post should be rigidly attached to a wide steel plate which is mounted on the foundation using bolted connections. Galvanised and threaded starter bars extending from the footing reinforcement are better for holding the plate than dynabolts.

Apart from central supports these posts usually lean against the applied horizontal load to maintain the tension rather than being vertically upright. They need to be free standing in a farm situation. Guy cables must be avoided.

Deep footings should be left to cure for an extended period before bearing any load.

Avoid collisions between animals and vehicles with posts, cables and cladding. If possible, position posts outside the animal traffic area so they are not in contact with manure and water or interfere with washing (If are located in the yard, place a raised concrete or PVC sleeve around the pipe to reduce corrosion potential).

Height

If the shade cloth is suspended too high, it will limit the area of shaded footprint.

A minimum height of 4.0 m is recommended to ensure:

- cows do not interfere with it and are happy to walk under it (Low shade cloth structures can put cows off entering an area)
- effective installation and use of sprinklers and fans
- machinery can readily traffic the area without risk of tearing it or burning holes in it with their exhaust pipe
- adequate airflow underneath the structure.

Orientation

The height of the structure, the angle of winter and summer sun and the required area of shaded footprint govern the orientation of the shade structure – north-south or east-west. If the structure is aligned east west the passage of the sun will generally ensure that the northern side of the structure is more exposed to sunlight than the southern.

Drainage

Drainage from shade cloth must be considered, particularly if the paving is earth. Ideally, any drainage should be directed to formed drains rather than earth that is subject to animal traffic.

WEAKNESSES IN shade cloth structures are usually associated with:

- cyclic loading conditions
- lack of fabric strength
- inadequate fabric reinforcement at connections
- connections to stanchions which are prone to fatigue
- failure of footing connections, leading to loose posts
- excessive spans which can lead to billowing
- corrosion of metal
- degradation of fabric
- rain, hail or debris accumulating on top of the shade cloth.
Stresses on shade cloth structures

A shade cloth structure must be strong enough to withstand three types of load: ‘wind load’, ‘dead load’ and ‘live load’.

Wind load

Wind load is usually the largest load carried by a light-framed agricultural or industrial building taking the form of a tensioned shade cloth or a rigidly clad framed structure.

Wind loads impose unbalanced forces on a shade cloth, generating ripples or waves that may lead to premature failure of fabric or other components. This problem can be alleviated by ensuring that the shade cloth is adequately tensioned.

Horizontal wind loads can also contribute to structural failure. If the angle of inclination of a roof or shade cloth is 15° or so, it will generate lift (The roof behaves like the leading edge of an aircraft wing). Lift can be minimised by either flattening the inclination of the roof or shade cloth to between 10 and 14° or installing it with an inclination in excess of 20°. Roof angles of 15 to 18° should be avoided.

Sailcloth structures are particularly prone to ripping in response to high wind loads, inadequate fabric strength, lack of structural reinforcement and excessive spans which can lead to billowing.

Dead load

Dead load refers to the weight of the structure (downward force due to gravity) which must be withstood by the posts. Bracing in frames or cables supporting shade cloth are usually employed to ‘stay’ or brace posts.

Posts supporting shade cloth are frequently installed at an angle to help provide tension but this can also contribute to instability when the cable support is removed.

While the dead load of a metal clad framed structure is high by comparison with a shade cloth structure, the load imposed by shade cloth should not be underestimated, particularly if the loading is not well distributed. Cloth impregnated with dust or supporting leaves, twigs, hail, ponded water or wetted from beneath by sprinklers can also be quite heavy and the cables and connections which form the structural system are not light.

Live load

Live load refers to brief, temporary loads such as those associated with someone on a roof, hailstones or rainfall cascading down a roof, water pooling on the canopy or being shed through or from shade cloth.

If metal clad frameworks and shade cloth structures are not designed to carry human traffic it is not surprising that failure occurs when they do. Safe OH and S practice must restrict access to these structures.

While shade cloth is designed to pass some light and air as well as water it is not unusual for some of the gaps in the mesh to be clogged. If the mesh gets clogged and water pools, an excessive live load is possible which can lead to fabric failure at best or structural failure at worst.

If you intend to install a shade structure, consult a registered builder or structural engineer who understands how to design and build a structure which will withstand these loads. Alternatively, if you are buying a package shade cloth structure ensure that structural computations are supplied, the installers are experienced and local building regulations are met.

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ADVANTAGES OF a shade cloth structure over a solid-roofed shade structure:

- Lower cost (less than half that of a solid-roofed structure covering the same area).
- You have the option of removing the shade cloth in the cooler months of the year. (Ensure that you store the fabric to protect it from vermin.)
- If fabric degrades or is damaged it can be easily replaced with better material and the connections upgraded to better reflect farm needs.
- If severe storms are forecast, the fabric can be furled or removed to limit damage.
- If well designed, installed and maintained there is no greater risk of failure of these structures compared with other farm buildings.
- Different types of fabric offer different degrees of light transmission.
- Technological developments are rapidly leading to better fabrics and connections and longer lasting structures.
- If well made, the posts and foundations are long lasting.
- It is possible to extend shade cloth structures without the same attention to drainage that a solid-roofed structure requires.
Design considerations

Solid-roofed shade structures

Solid-roofed structures may have a pitched roof (such as the case studies on pages 23 and 39) or a flat roof (such as the case study on page 34).

Design considerations for maximum effectiveness and useful life

Roofing material
Roof material may be aluminium or white galvanised iron sheets to increase the rate of solar reflection. This should last at least 25 years.

Roof height
For good machinery access, the roof height should be at least 3.7 metres at its lowest point and at least 4.5 metres at the shed centre (for entry/exit).

Roof pitch
Lower roof pitch results in slower air movement (e.g. 1:4 pitch or less). Steeper roof pitch results in greater air movement (e.g. 1:3 pitch is suggested for warmer climates).

Enclosing a shelter using sheeting, a blind or even a furled shade cloth can contribute to significant horizontal wind loads which can contribute to structural failure. If the angle of inclination of a roof or shade cloth is 15˚ or so, it will generate lift. (The roof behaves like the leading edge of an aircraft wing).

Lift can be minimised by either flattening the inclination of the roof to between 10 and 14˚ or installing it with an inclination in excess of 20˚. Roof angles of 15 to 18˚ should be avoided.
Ridge opening

Provide a continuous open ridge to promote air movement (i.e. convective heat dissipation via the ‘stack effect’).

Recommendations for open ridge space:

- 50-75 mm/3.0 m of shed width (DPC et al 2009).
- 300 mm + 50 mm per 3 m width for sheds greater than 6 m wide for northern Australia (Davison et al 1996).

Eave overhang

The recommended overhang for open-sided sheds is 900 mm. Eave overhang is dependent on feedpad/freestall configuration, and on eave height and degree of protection required.

Guttering and downpipe design

As per state plumbing code (engage a qualified design engineer).

Orientation – east-west or north-south

With an east-west orientation, and an area of 2.5 to 3 m²/cow, part of the floor area under the roof will be in shade all day. Extending the floor about one third its length on both the east and west to 3 to 4 m²/cow will place feed and water troughs under shade at all times, which will encourage intakes. More dung will be dropped in the shaded area, which will need frequent cleaning to avoid the risk of mastitis. East-west orientation, therefore, works best for concrete floors.

If concrete is too costly, the north-south orientation works best. It works well for a compacted clay or gravel floor because the sun strikes every part of the floor area under and on either side of the roof at some time during the day. This helps to keep the floored area dry and restricts pathogen build up. A shaded area of 2.5 to 3 m²/cow is adequate if feed and water troughs are placed away from the shaded area. In regions where temperatures average 30°C or more for up to 5 hours/day during some period of the year, the east-west orientation is deemed more suitable.

Effluent management system

An effective system for handling effluent and run-off is essential, otherwise cow comfort, health and production may be compromised. Refer to section 8.0 – Guidelines for Victorian Dairy Feedpads and Freestalls (DPIV 2009).

Solid-roofed structures need to comply with regulatory authorities, e.g. a local council building permit is required.

Winter and summer sunshine angles

Winter and summer sunshine angles are important, as they determine how much of the floor area receives sunshine at some time during the day, given a shed’s roof height and width. Seek professional advice.

Example:

**Winter**

**Summer**
Note the position of the water trough, grooving to help prevent cow's slipping, water run-off from the roof to lane, high eaves and pitched roof to facilitate ventilation. The shed runs north-south to use sunlight to dry cow standing areas.

This roof slope is 18° with a 500 mm vent at the apex. Eaves are 4.3 m high, and 6.9 m at apex. The shed runs north-south with 3% slope on patterned cement floor. Feed troughs are 1.2 m wide inside, 400 mm high and 100 mm thick.

Note poor drainage due to lack of slope. Freestall shed has fans and sprinklers but is not linked to good drainage – a recipe for high mastitis levels.

Sprinklers could be fitted above head lock stalls or at the back of the cow alley in the shed.

Note that the sprinklers above the feed line spray onto the cows' backs. The feedpad runs north-south and has a sloping roof to reduce the western sun projecting into the cow resting area.
Design considerations

Sprinklers

Design considerations for maximum effectiveness and useful life

1. Sprinkler nozzles
   Several types are available. Large irrigation sprinklers can throw water over a large area. Overhead wobbler sprinklers and garden sprinklers positioned on sides of dairy yard or overhead use less water and do not throw water as far. (Garden sprinklers on sides of dairy yard may be ineffective during windy conditions. Set up system so you can turn banks of sprinklers on each side of dairy yard on/off independently).
   Droplets must be medium-large to allow water to penetrate the hair coat and wet the cow's skin.
   Best position depends on type and capability of selected sprinkler and pumping system. However, as a guide, sprinklers should be spaced at intervals of 1.5 to 2 times their wetted radius, so there is a slight overlap of wetted areas.
   Sprinklers should be set at least 2 m above the floor of the dairy yard.

2. Pipes
   Sizes must suit the length and area to be sprinkled, the number of sprinklers and their flow rates. Here is a guide:
   - Shed length: Diameter of main delivery line:
     - Up to 40 m: 20 mm
     - 40-60 m: 25 mm
     - 60-100 m: 32 mm
     - More than 100 m: 2 x 50 m runs of 25 mm
   PVC piping does not twist, but polythene is cheaper.
   To maintain low water temperatures, all exposed pipe should be painted white and header tanks should also be shrouded, insulated and painted white.
3. **Controller / timer**
   - A 15-minute adjustable type timer, attached to remote control valve (solenoid) will enable you to apply sufficient water on cows while minimising wastage. Aim to sprinkle cows for one to three minutes, which should be sufficient to wet them effectively, and then shut off for the remainder of each 15-minute cycle to allow the water to evaporate before the next cycle.

4. **Temperature sensor**
   - Temperature sensors can also be attached to the controller to allow sprinklers to automatically switch on when cows are in the dairy yard at a certain temperature, for example, at 25°C. (Note: if an automated system is installed, ensure you can manually override it if necessary).

5. **Pressure regulators**
   - Low-pressure sprinklers work best (0.70 kg/cm²), producing larger droplets, less mist and drift of spray. (Large droplets penetrate the coat better. Smaller droplets can create an insulating layer of water on the cow’s coat that can make the cow hotter instead of cooler – droplets are required, not mist). A main pressure regulator can be installed at the beginning of the pipeline or smaller regulators on each sprinkler nozzle can be used.
   - Operating pressures are usually in the range of 14 to 20 m (140-200 kPa).
   - Low pressure will produce larger droplets and less mist and drift of spray.

6. **Filter**
   - Sand or dirt may clog the sprinkler nozzles, so a filter is required between the water supply and solenoid valves that control the water flow to the spray nozzles or drip outlets.
   - A common filter type is a plastic filter with a grooved disc filter element. A 200 micron filter is used for spray cooling and an 80 micron filter for drip cooling.
   - Filters should be capable of a flow rate of up to 1.4 litres/second for spray and 0.8 for drippers.

7. **Water**
   - Ideal water temperature is 15-20°C (Note: providing cows with chilled water at the dairy to help reduce heat load may reduce water intake and therefore be counter-productive). Water containing more than 1000 mg/L TDS (total dissolved solids) should not be used in reticulation systems because of corrosion (dissolves concrete!)
   - An allowance of 0.5-1 litre/head/hour is common for spray cooling dairy cows.
   - Remember that excess water use will create waste management issues.
   - For more complex or larger installations it is necessary to properly design the system taking into account friction losses, flow rates and component selection.
**Design considerations for maximum effectiveness and useful life**

| Fan sizing, type and placement | Seek professional advice from a registered engineer and/or manufacturer.  
A pitched roof and open ridge vent should be considered before fans during the planning of a new covered structure.  
Fans range in cost from about $550 to $2,000 each, depending on their design and capacity, plus installation. Check the efficiency rating of fans.  
Fans should be mounted above sprinklers so they remain dry. Only use fans with sealed motors.  
Spacing is determined based on the fan’s operating flow rate (m³/minute). As a guide:  
- 900 mm blade, 285 m³/min with a 0.45 kW motor – spaced every 6 m  
- 1,300 mm blade, 840 m³/min with a 1 kW motor – spaced every 12 m  
(assuming the base of the fan blade is 2.3 m above cow feet level).  
Ensure that fans used have the capacity to move the volume of air required at >2.0 m/second. If cows are tightly packed, airflow will need to be greater. When used in open spaces, larger-capacity fans are required because they are operating against static pressure, so their efficiency is lower.  
Doubling the operating capacity of the fan does not double the distance covered by the fan, but it will increase costs.  
Be prepared to modify the placement of fans and add additional or larger-capacity fans if required. It is best to discuss with an expert before you proceed. |
| --- | --- |
| Fan orientation and pitch | To minimise operating costs, locate fans to take advantage of prevailing winds at the site.  
The fans should be tilted 20-30° down from the vertical so they blow down to the floor, to ensure air is forced down around and beneath the cows. This will enhance evaporative and convective cooling.  
Tilting the fans towards the ground also reduces interaction between groups of fans that are located in series with each other, improving operating efficiency. |
| Fan operating cycle | When operated in conjunction with sprinklers, fans will usually be initiated first (i.e. start to operate a lower temperature than sprinklers).  
Sprinkler on/off cycles can then be stepped up at different temperature trigger levels (as per case study farm described on page 42).  
If fans are in the dairy they should run continuously when the Temperature Humidity Index (THI) is more than 72. |
| Maintenance | Keep the safety grill around each fan free of cobwebs and dust to maintain their maximum efficiency and effectiveness. |
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