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Heat Stress in Dairy Cattle

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Introduction

The heat and humidity of a typical Arkansas summer combine to make a very uncomfortable environment for lactating dairy cows. During hot summer weather, milk production may decrease by as much as 50 percent (Table 1), and reproductive proficiency of lactating dairy cows is greatly diminished. Some data indicate that only 10 to 20 percent of inseminations in "heat stressed" cows result in pregnancies.

Signs of Heat Stress

Some signs of heat stress in lactating cows are obvious, especially the reduced milk production and the lethargic behavior of the cows. Moderate signs of heat stress may occur when the temperature is between 80° and 90°F with the humidity ranging from 50 to 90 percent (Figure 1). These signs include rapid shallow breathing, profuse sweating and an approximately 10 percent decrease in milk production and feed intake by cows. As temperatures rise to 90° to 100°F and humidity remains in the 50 to 90 percent range, the cow will show severe depression in milk yield, usually greater than 25 percent, and in feed intake as her body temperature elevates. She will begin exhibiting more significant signs of heat stress, such as open mouth breathing with panting and her tongue hanging out.

Usually, the combined temperature and humidity that results in a temperature/humidity index of greater than 90 will result in severe signs of heat stress in the high producing cow and moderate signs in lower producing cows. In severe cases, cows may die from extreme heat, especially when complicated with other stresses such as illness or calving.

Higher producing cows exhibit more signs of heat stress than lower producing cows because higher producing cows generate more heat as they eat more feed for higher production. They must get rid of the

Table 1. Relative changes in expected dry matter (DMI) and milk yield and water intake with increasing environmental temperature

	Expected intakes and milk yields		
Temperature	DMI	Milk yield	Water intake
(°F)	(lb)	(lb)	(gal)
68	40.1	59.5	18.0
77	39.0	55.1	19.5
86	37.3	50.7	20.9
95	36.8	39.7	31.7
104	22.5	26.5	28.0

Sources: National Research Council. 1981. Effect of Environment on Nutrient Requirements of Domestic Animals. National Academy Press, Washington, D.C. Dr. Joe West, Extension Dairy Specialist, University of Georgia.

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Figure 1. Temperature Humidity Index (THI)[1] for Dairy Cows. Modified from Dr. Frank Wierama (1990), Department of Agricultural Engineering, The University of Arizona, Tucson, Arizona.

DEG F	RELATIVE HUMIDITY 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
75														72	72	73	73	74	74	75	75
80							72	72	73	73	74	74	75	76	76	77	78	78	79	79	80
85			72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84	84	85
90	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
95	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
100	77	78	79	80	82	83	84	85	86	87	88	90	91	92	93	94	95	97	98	99	
105	79	80	82	83	84	86	87	88	89	91	92	93	95	96	97						
110	81	83	84	86	87	89	90	91	93	94	96	97									
115	84	85	87	88	90	91	93	95	96	87											
120	86	88	89	91	93	94	96	98													

NO STRESS · MILD STRESS · MEDIUM STRESS · SEVERE STRESS

[1]THI = (Dry-Bulb Temp. °C) + (0.36 dew point Temp., °C) + 41.2)

If more than two cows out of 10 have respiratory rates exceeding 100 breaths per minute, then immediate action should be taken to reduce heat stress.

extra heat generated as a result of metabolizing greater nutrients in the feed. In general, the decrease in milk production results from less feed intake by the cow. Two pounds of milk production is lost for every pound of decreased dry matter intake when temperature and humidity levels are high.

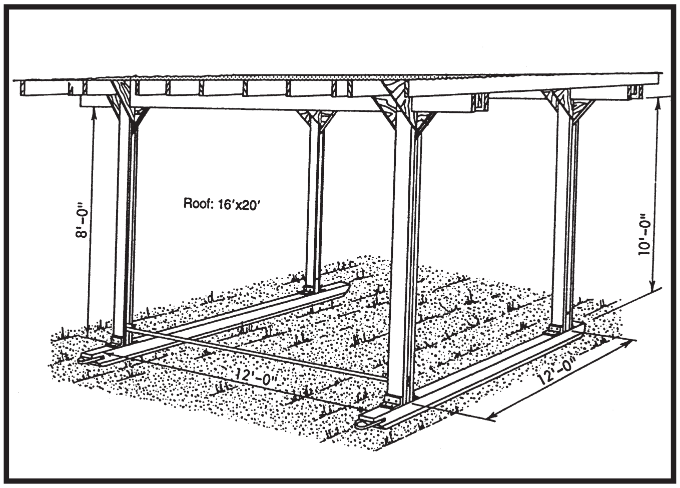
If you have problems determining if your cows are affected by heat stress, lock up 10 cows and take their rectal temperatures. If more than seven of the cows have temperatures above 103°F, the cows are probably exhibiting heat stress. Temperatures will be greater in the afternoon when environmental temperatures are high. In severe heat stress, rectal temperatures of cows may exceed 104°F. You may also take respiratory rates on the 10 cows. If respiratory rates are greater than 80 breaths per minute on at least seven of the cows, they are also probably exhibiting signs of significant heat stress. If more than five cows out of 10 have respiratory rates greater than 100 breaths per minute, then immediate action should be taken to reduce heat stress. If the dry matter intake of the feed and your milk production has decreased by 10 percent or more, your cows are also exhibiting heat stress. During severe heat stress, intake and milk production may decrease by more than 25 percent and weak cattle may die, especially older or sick animals.

Steps to Reduce Heat Stress

The first step to reduce heat stress is to provide cool water and shade for all milking and dry cows plus heifers. Water is the primary nutrient needed to make milk, accounting for over 85 percent of the content of milk. Also, the cow's water requirement increases significantly as the environmental temperature rises. Cows drink up to 50 percent more water when the temperature/humidity index is above 80 percent. Table 1 shows that water intake goes from 21 gallons to 32 gallons as temperature goes from 86° to 95°F. It is extremely important that cows be provided cool water during periods of high temperature. It also is very important that cows have water in a location that is close to shade, since they will not travel great distances for water in a hot environment. Water should be placed away from the milking parlor but in an exit lane from the barn as well as near the feeding location of the cows. **Water should be available for cows near their loafing area, either in the shade of native trees or artificial shade.**

If cows are in close confinement, water should be placed every 50 feet. For many producers in Arkansas where cows are not housed in free stalls, water should be easily accessible to animals and located in a position such that cows do not have to cross areas of hot sun. In general, cows will not travel across 100 feet of open field when temperature, humidity and radiant solar heat are extremely high. Also, provide at least two water locations per group of cows. If possible, provide 2 feet of trough space for every 15 cows that use the water. For example, if you have 100 cows in a lot, you should have at least 12 feet of water trough. In addition, water flow should be at least 3 to 5 gallons per minute so that the trough will quickly refill. Minimum depths of 3 inches of water are necessary to accommodate the cow's muzzle. A minimum of 0.65 square feet of surface area per cow at single- or double-position waterers should be

Figure 2. Portable shade constructed with wood. Metal pipes also may be used.



provided. As a general rule of thumb, if the waterers are ever empty, additional water troughs are needed.

Water also should be clean and cool. As needed, troughs should be cleaned to ensure that algae and other contaminants are not in the water. Water should always be fresh and at approximately ground temperature.

Shading from direct sunlight is also very important, as this allows cows to rest in a more comfortable environment. Although natural shade from trees is the best and most natural environment, cows will often compact the area around the trees, and the trees may die within a few years after cows are in the lot. It is also important for cows not to produce a mudhole in the shaded area where they congregate around the trees. This mudhole can result in greater mastitis as animals will often lie in the mud after milking and before the sphincter muscle on the end of the teat has tightened up following milking. One method of reducing the problem with mudholes from either natural or artificial shade is to use electric fences to fence out areas where mudholes are a problem. These areas are then rotated so that cows use shade in different pastures while the muddy ones dry.

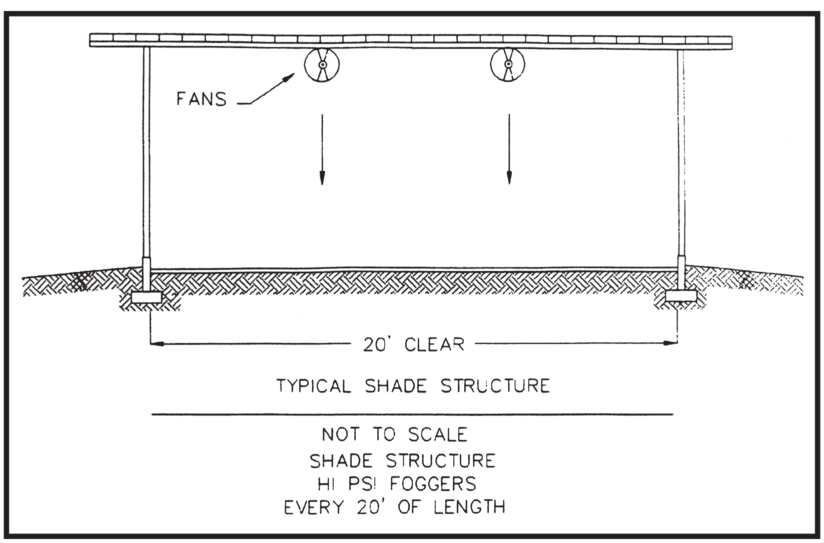
Portable or temporary shades (Figure 2) can be used and rotated to a new area in different pastures if they are available. Portable shade cloth, as well as lightweight roofing material, may be used on the temporary shades. Usually, 2-inch diameter metal pipes or 4 x 4 treated wood are used for frames for the temporary structures. Hooks are provided for moving the cloth, or wire may be strung along the side of the structure. Twine or wire is used to support the cloth through the grommets on the shade cloth. Shade cloth is usually positioned 12 feet from the ground. At least 25 (and preferably 50) square feet of shade per cow should be provided.

Permanent shade structures (Figure 3) also may be used. These generally have an eave height of at least 12 feet with a center of at least 16 feet. If a dirt floor is utilized, mudholes again may develop and care must be taken. Lime may be added to the dirt to inhibit bacterial growth. Fly ash may also be used to complement the dirt [see FSA1043, *Reducing Mud Problems in Cattle Heavy Use Areas With Coal Combustion By-Products (Fly Ash)*]. If permanent shade structures include a concrete floor and cows are maintained in the barn at all times, much like a free stall barn, the roof pitch on the barn should be at least 4:12. In addition, the ridge vent should be at least 1 foot wide plus 2 inches for every 10 feet of structure width over 20 feet. The vent is best if uncapped, and usually will not allow snow and rain into the barn. If necessary, a ridge cap may be installed. It should be at least 1 foot above the roof peak. In permanent shade structures, allow 50 square feet of space per cow.

The best shade orientation depends on cow management and the type of flooring under the shade. For situations with dirt floors and cows able to move outside the structure, a north-south orientation is recommended. This allows sunlight to dry 50 percent or more of the floor while still providing shade outside the structure. For confinement facilities with concrete floors, an east-west orientation provides maximum shade under the roof.

Portable shades offer at least two important advantages over permanent shade structures. First, they are movable. This permits them to be moved as necessary to cleaner and drier locations. Secondly, they are cheaper to construct. Most can be

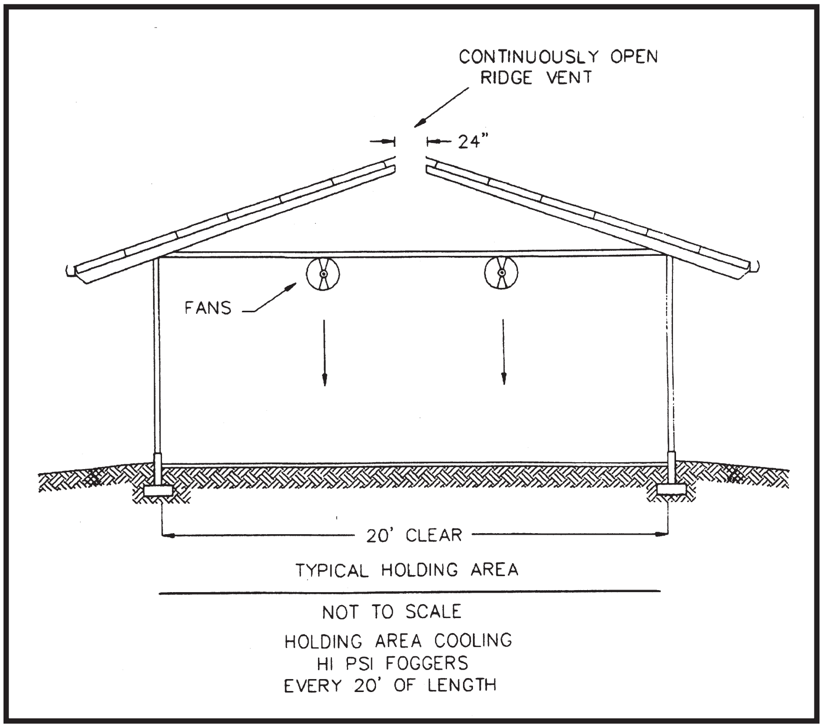
Figure 3. Typical shade structure. Drawing by Joseph G. Martin III, P.E., Consulting Engineer, Gainesville, Florida.



constructed for $50 or less per cow. The disadvantages of portable shades are less protection from solar radiation and decreased longevity compared to permanent shade structures. However, with good maintenance, including keeping the shade cloth tight so that it is not damaged by the wind, portable shade structures can last five or more years.

In addition to lactating cows, it is very important that shade and cool water be available to dry cows and heifers at all times. Since dry cows and heifers are not consuming the large quantities of feed that lactating cows eat, they will be generating less heat and are less susceptible to heat stress. However, research has shown that dry cows have heavier calves and better body condition scores when adequate shade and cooling are available to them. Heifers, also, will eat more feed and grow at a greater rate if shade and water are available to them when fed a properly balanced ration.

Figure 4. Typical holding area. Drawing by Joseph G. Martin III, P.E., Consulting Engineer, Gainesville, Florida.



The second step to alleviate heat stress in lactating cows is to provide a more comfortable environment in the holding pen (Figure 4). The holding pen is the most stressful location for milking cows during periods of heat stress if it is not shaded and cooled. Data indicate that proper cooling of the holding pen can pay for itself in two hot summers. Another publication, FSA4019, *Cooling Dairy Cattle in the Holding Pen*, provides additional details on cooling in this location.

Cool the holding pen area with a combination of shade, air movement and water. When combined with air movement, water can increase cooling ability of the cow. However, adding water in humid or poorly ventilated holding pens or barns can make the situation worse. The water can actually hold the heat in the cow if it does not evaporate from the cow. If cooling is done effectively with fans and water in the holding pen, less cooling is required between milkings.

To provide cooling for the holding pen or loafing area, sprinkling with enough water to soak cows to the skin and then running fans constantly at 5 to 7 miles per hour is recommended. These fans increase evaporation of water which helps cool the cows.

One system that works very effectively is to sprinkle the cows for a short period of time, e.g., 0.5 to 3 minutes, and apply 0.05 inches of water per cycle, just enough time to soak the cows to the skin. Avoid allowing water to run onto the udder. If water does reach the udder, it is possible that bacteria can be transferred into the mammary gland and result in more mastitis. If possible, blow air onto the cows continuously. However, in some cases you may want the fans off for the period when the sprinklers are running if the water droplets blow out of the holding pen.

The 1/2 horsepower, 36-inch fan rated at 11,000 to 12,000 cubic feet per minute (cfm) will blow 20 to 30 feet, while a 48-inch fan with a 1-horsepower motor rated at 21,000 cfm will blow 30 to 40 feet. Usually, it is necessary to have at least two widths of fans in the holding pen. For many producers, four fans are needed, two in the front of the holding pen and two approximately halfway down the length of the holding pen. The fans should direct a high velocity breeze over the cows to allow them to dry faster so that the heat can be dissipated from their bodies (see FSA4019, *Cooling Dairy Cattle in the Holding Pen)*.

An ample supply of water, usually 25 gallons per cow per day, is required to cool the cow throughout the day. This type of cooling system may be used not only in the holding pen but also in free stalls and area of feeding. The floor of the holding pen should be grooved or rough-surfaced concrete or some other suitable footing so that cows do not slip in the wet environment. As a general rule, water should not stand in the holding pen and the feet of cattle should be exposed to limited water.

If no covering is over a holding area, a shade cloth roof will be helpful, although a permanent structure is recommended. Additionally, a shade cloth or a poultry curtain may hang down over the side of the holding pen where the afternoon sun shines in.

The eave height of the holding pen should be at least 12 feet if possible.

For a few producers, a sprinkler in the exit lane of the milking parlor serves to soak the cows to the skin as they leave the milking area. The cows will be cooled as the water evaporates. Such cooling devices need to be used with care when mastitis or somatic cell count problems occur. The object is to wet the cow's back without having water run onto the udder. A trigger, either manual or electronic, should turn water on the cow only for a few seconds.

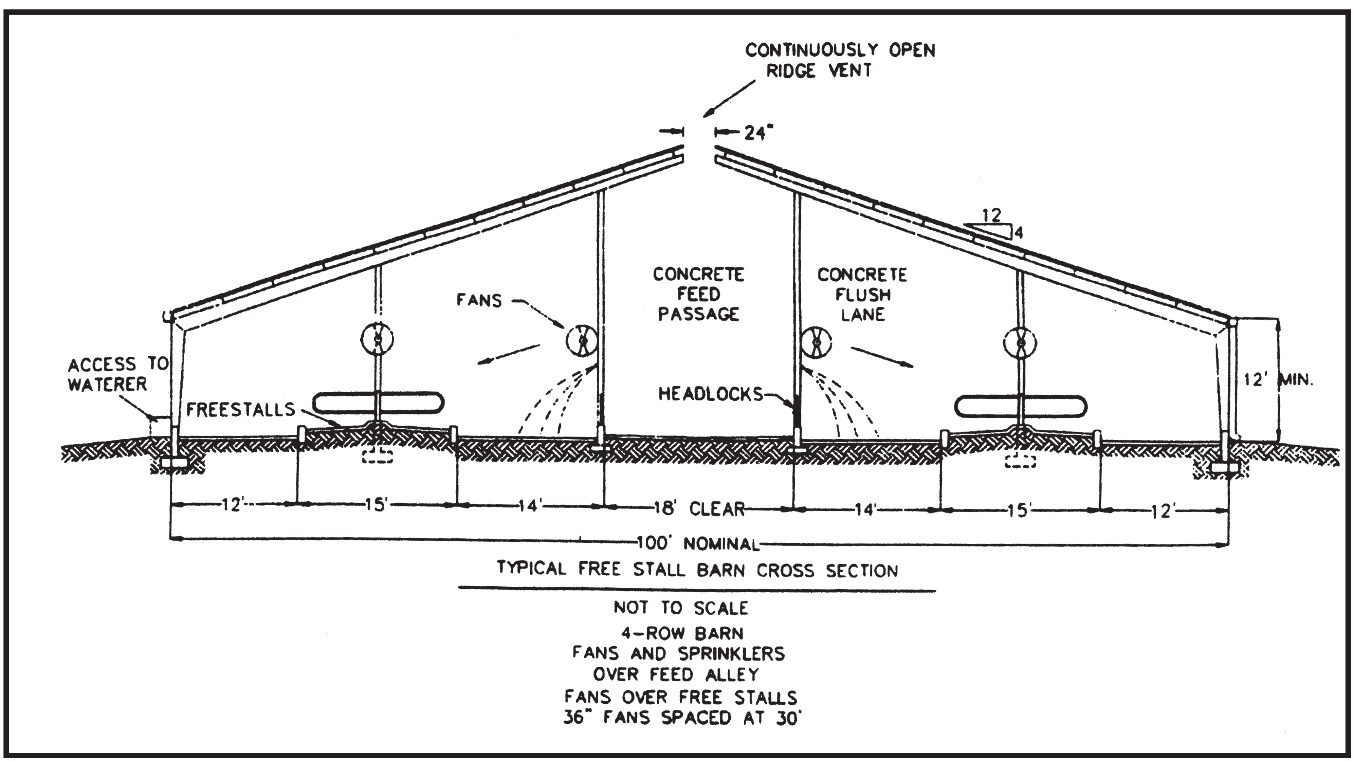
A third step to reducing heat stress on your cows is to provide shade and a cooling device around the feed manger (Figure 5). A covered feed manger provides shade so that cows are more comfortable when they are eating. Also, the cover for the feed manger allows the feed to stay dry during periods of rainfall. For many producers, it works best to have a sprinkler system spraying away from the feed manger and toward the cows. Fans are then used to dissipate the heat from the cow by evaporative cooling of the water on the animal, as in the holding pen. It is important that water be sprayed away from the feed so that the feed does not get wet. It also is important that water does not reach the udder. The area also should have suitable footing to minimize slipping of cows in the wet environment. As in the holding pen, the feet of cattle should have limited exposure to water.

One system that works very well is to use 36-inch fans every 20 to 30 feet along the feed manger. This keeps the air moving continuously. In addition, an ample supply of water must be sprayed or misted on the cow. Low pressure sprinklers (10 psi) work best. Lower pressure will produce less mist and drift of spray. However, fans usually must be turned off when the mist is present or the mist will be blown out of the barn. A main pressure regulator can be installed at the beginning of the pipeline, or smaller regulators may work in conjunction with each sprinkler nozzle. Sprinklers should have a base of at least 1/2 inch. Most high capacity sprinklers will have a 3/4 inch base. Usually these are available for an economical price at farm supply or poultry supply locations. Thirty-six inch fans, at the time of this printing, were selling for $350 to $450 per fan. Installation cost is extra.

If floors are flushed and require a concrete slab, the slope should be 1.5 percent to 4 percent, preferably 2 percent. Concrete should be 4 inches thick with a grooved surface for good footing. Floor space requirements vary from 19 to 65 square feet per cow. The more hot and humid the environment, the greater the square footage of floor space required. Shade structures 40 feet wide or less require a minimum eave height of 12 feet. Structures wider than 40 feet should have eave heights of at least 14 feet.

Painting metal roofs white or aluminum and adding insulation aids in reflecting solar radiation and helps to insulate animals from thermal radiation. However, due to shortened life from pest damage to the insulation and marginal additional benefit, it is not usually economical. If a polypropylene fabric is

Figure 5. Typical free stall barn cross section. Drawing by Joseph G. Martin III, P.E., Consulting Engineer, Gainesville, Florida.



used for the shade cloth, it usually provides around 80 percent obstruction of solar radiation.

A fourth step to decrease heat stress is to increase the density of the ration. High quality forages should be available to the animal if possible. These forages may include summer annuals or a high quality perennial. Silage, pasture and hay are acceptable. The primary reason that cows decrease in milk production during hot weather is that the cows eat less. Since cows will be consuming less as temperatures increase (Table 1), increasing the energy density of the diet can in part compensate for the decrease in dry matter intake.

To increase the energy density of the diet, a fat or feed that has a low heat increment (heat of digestion) may be included in the ration. The high-fat feeds include whole cottonseed, either tallow or bypass fat, and roasted soybeans, which are available in some areas of the state. Lower-fiber feedstuffs usually result in less heat increments than high-fiber feeds such as grass hays. Diets high in grain and low in fiber cause less heat stress for lactating cows because of the lower heat of digestion. However, it is critical to balance the ration properly, since milk fat may be depressed and digestive orders may result when a high grain ration is fed. Feeding buffers such as sodium bicarbonate and magnesium oxide allow higher concentrate rations to be fed and can help in alleviating the low-fat milk syndrome.

Also, the ration fed to cows in hot weather should be balanced properly for minerals. Some mineral companies will have a "summer buffer." Increasing potassium to 1.3 to 1.5 percent, sodium to 0.5 to 0.6 percent, and magnesium to 0.3 to 0.4 percent may result in less heat stress by allowing the animals to dissipate heat. Chlorine usually is at least 0.25 percent of the diet, which is the recommendation throughout the year.

Do not overfeed highly degradable protein, i.e., 65 percent or greater degradable crude protein in the rumen, because this also increases the heat increment and requires more heat to be dissipated from the animal. Proper supplementation of more undegradable protein appears to be effective in reducing the heat of digestion.

Summary

Keeping lactating cows cool can provide a good return on your investment as it makes cows more comfortable, thereby making them more productive. Shade and cool water should be available to cows and heifers at all times. Cooling devices should also be installed in the holding pen and feeding area if possible. The ration should be properly balanced, and generally the energy density should be increased in the summer to help compensate for decreased dry matter intake of the cow. For more information, see your local county Extension agent.

Reference

Bray, David R., and Ray Bucklin. 1996. *Recommendations for Cooling Systems for Dairy Cattle.* Fact Sheet DS-29. University of Florida Cooperative Extension Service, Gainesville, Florida 32611.

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