WATER USE AND EFFECTIVENESS OF A LOW PRESSURE MISTER SYSTEM FOR COOLING LACTATING DAIRY COWS DURING CHRONIC HEAT STRESS

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ABSTRACT

A replicated switchback design trial was conducted during the June and July of 2009 to determine the effectiveness of a low pressure mister system to provide supplemental evaporative cooling and to determine water usage compared with a high pressure mister system. The low pressure mister system utilized the water system line pressure, which was approximately 3.4 bar (50 psi), and the high pressure system utilized a pump to provide a line pressure of approximately 12.4 bar (180 psi). Both mister systems were mounted to the face of 91.4 cm (36 in) diameter high speed fans spaced every 20 ft over the feed alley and free stalls. Both systems were controlled by a thermostat and humidistat. The fans were set to operate when the ambient temperature inside the barn exceeded 22.2 C (72 F) and the mister system operated anytime the fans were on and the relative humidity was less than 85%. Conditions within the free stall barn were continuously monitored using a data logger. Each replicate of the trial consisted of 3 wk and there were 2 replicates. For each replicate, the body temperatures of 10 lactating Holstein cows each in 2 lots housed in a four-row free stall barn were continuously recorded every 5 min for 3 d using a water probe placed in the vagina. Water usage for each system was measured during the second replicate using inline water meters. Environmental conditions inside the free stall barn were characteristic of chronic heat stress in that the temperature-humidity index (THI) was greater than 72 throughout the trial. The body temperatures of the cows cooled with the low pressure and high pressure systems were similar (P = 0.69) and averaged 38.794 and 38.789 C (101.83 and 101.82 F), respectively. No differences were observed in respiration rates of cows cooled with the low pressure and high pressure systems (P = 0.58) and averaged 61.0 and 62.5 breaths per min, respectively. The low pressure mister system used 43% less water per day than the high pressure system. Results of this trial indicate that a low pressure mister system that uses less water can be used to provide supplemental cooling of lactating dairy cows housed in a free stall barn during chronic heat stress conditions.

INTRODUCTION

High ambient temperatures coupled with high relative humidity (RH) reduce the cow's ability to dissipate body heat and result in increased body temperatures, which led to heat stress. These conditions are often present for seven or more months each year in the Southeastern US resulting in chronic heat stress. As body temperature increases, cows consume less DM, which results in decreased milk yield and lower dairy efficiency (West, 2003). The effects of heat stress can be reduced by providing shade and evaporative cooling. Most dairy producers use a combination of

high velocity fans and either a sprinkler system or high-pressure system to provide supplemental evaporative cooling to reduce heat stress in their housing facilities. Low pressure sprinkler systems are designed to intermittingly soak the skin of the cow and use forced air to evaporate the water to provide evaporative cooling. In contrast, high-pressure systems produce a fine mist that is evaporated in the presence of forced air that is blown on the cow. Sprinkler systems use considerably more water than high pressure mister systems, but the high pressure mister systems require more daily maintenance. Both systems perform well based on cow body temperature and respiration rate.

Greater emphasis has been focused on improving the efficiency of water usage because of recent droughts in the region and greater demand for water in general. Total water use by agriculture, including dairies, is one area that is being examined as water use plans are being developed for Georgia. Evaporative cooling systems use considerable quantities of water, so improved systems that use less water and effectively cool cows would be desirable.

A new low pressure mister developed in Germany (Arato Dairy Cooling System, Aratowerk GmbH & Co. KG, Germany) is now available in the United States. The system is designed to use less water compared with conventional sprinkler systems and has proven to effectively cool animals in Europe and other countries where it has been used. However, the system has not been tested in the hot, humid conditions common to the Southeast. The objective of this trial was to evaluate the effectiveness of this new low pressure mister system compared with a high-pressure system currently used for providing evaporative cooling of lactating dairy cows.

MATERIALS AND METHODS

A replicated trial was conducted in the free stall barn located at the Dairy Research Center on the Tifton Campus of the University of Georgia. The barn is a four-row free stall barn with a drive through feed alley typical of many of the barns in the Southeast. The barn is equipped with 91.4 cm (36 in) diameter high-speed, high-volume fans on 18.3 m (20 ft) centers over the feed alley and free stalls. All procedures were approved by the University of Georgia Institute of Animal Care and Use before beginning the trial.

Treatments included a high pressure mister system that consisted of a high pressure pump to provide 12.4 bar (180 psi) line pressure for misters mounted to the face of each fan or a low pressure mister system (Arato Dairy Cooling System, Aratowerk GmbH & Co. KG, Germany) designed to operate on normal line pressure (50 psi) with a mister mounted to the face of each fan (Figure 1). Both systems were installed according to the manufacturers' recommendations. The cooling systems were automatically controlled by a thermostat and humidistat. The fans were set to run when the ambient temperature inside the free stall barn exceeded 22.2 C (72 F). The mister systems were set to run whenever the fans were on and when the RH was less than 85%. Both systems were fitted with water meters (Model DLJ100, Daniel L. Jerman Co., Hackensack, NJ) to measure water usage.

Figure 1. Placement of high pressure and low pressure mister systems on the face of a high-speed, high-volume fan mounted over the feed alley and free stalls.

A total of 40 lactating Holstein cows were used in the replicated switchback trial. The first replicate was conducted from June 1 to 19, 2009 and the second replicate was conducted from July 14 to 31, 2009. Within each replicate, 10 cows from two lots each were assigned to one of the two treatments each wk. Data were collected beginning at 0:00 Tuesday through 24:00 Thursday of each wk. At the beginning of the following wk, treatments were reversed and data collection was repeated. The body temperature of each cow was recorded every 5 min for 4 consecutive d using a Hobo water probe (Onset Computer Corp., Bourne, MA) attached to a blank CIDR placed in the vagina of each cow. The respiration rate of each cow was measured by two individuals for 30 sec once each week. Respiration counts differing by more than 10% were recounted until a difference of less than 10% was obtained.

Ambient temperature and RH were recorded in the free stall barn continuously throughout the trial using a HOBO Pro RH/Temp Data Logger (Onset Computer Corp.). Temperature-humidity index (**THI**) was calculated as THI = db – (0.55 –0.55 x RH) x (db – 58), where db was the dry bulb temperature in degrees Fahrenheit and RH was expressed in decimals (NOAA, 1976).

Data were analyzed as a replicated switchback design using PROC MIXED procedures of SAS (SAS Institute, Cary, NC). The model for body temperature data included effects of pen, replicate, mister system, day within week, and time of day. Day and time of day were included as a repeated effect. Respiration rate data were analyzed using general linear model procedures of SAS. The model included effects of pen, replicate, mister system, and wk.

RESULTS AND DISCUSSION

The THI throughout the trial was greater than 72, which is considered the point at which animals begin to experience heat stress (Figure 1). The THI tended to decline after 2000 h (8:00 p.m.) during the early morning hours and then increase as ambient temperature increased during the day (Figure 2). The relative humidity inside the barn was at or near 100% during the night and reduced during the day when ambient temperature increased. During wk 4 and 6, rains increased average relative humidity during the day compared to the other weeks (Figure 3), but the general changes in relative humidity were similar throughout the trial.

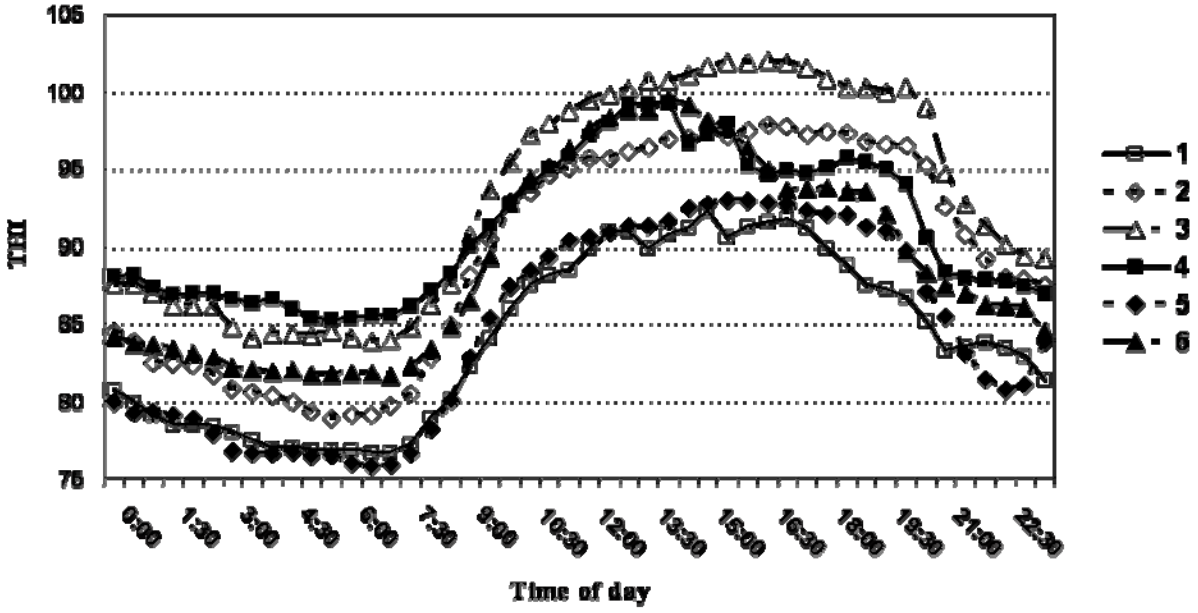

Figure 1. Average temperature-humidity index (THI) measured inside the free stall each week of the trial.

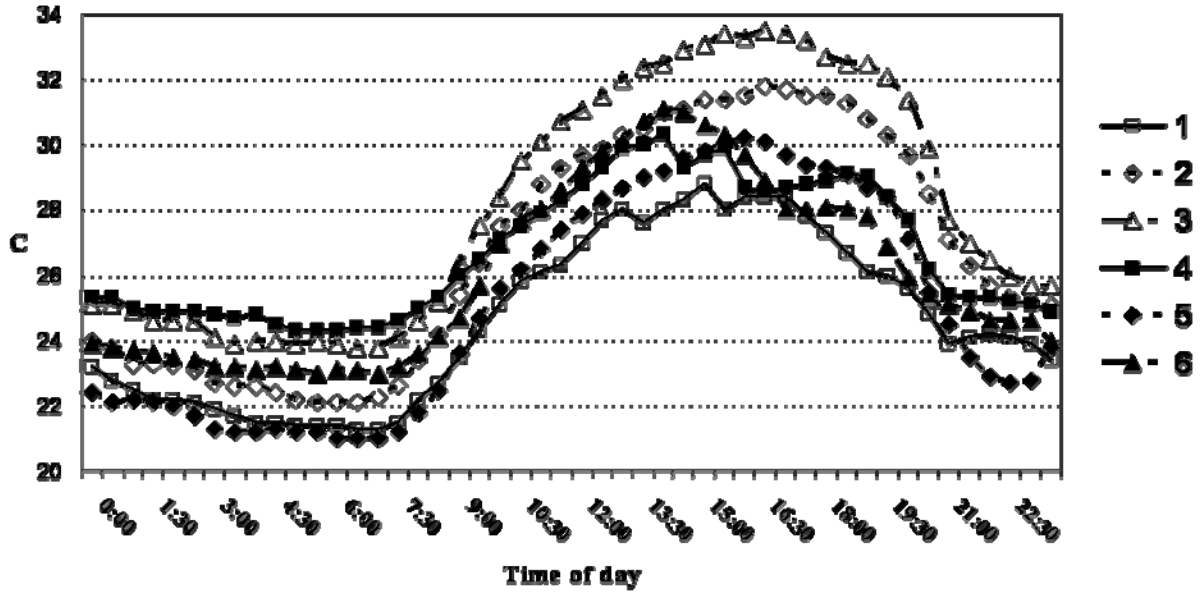

Figure 2. Average temperature measured inside the free stall each week of the trial.

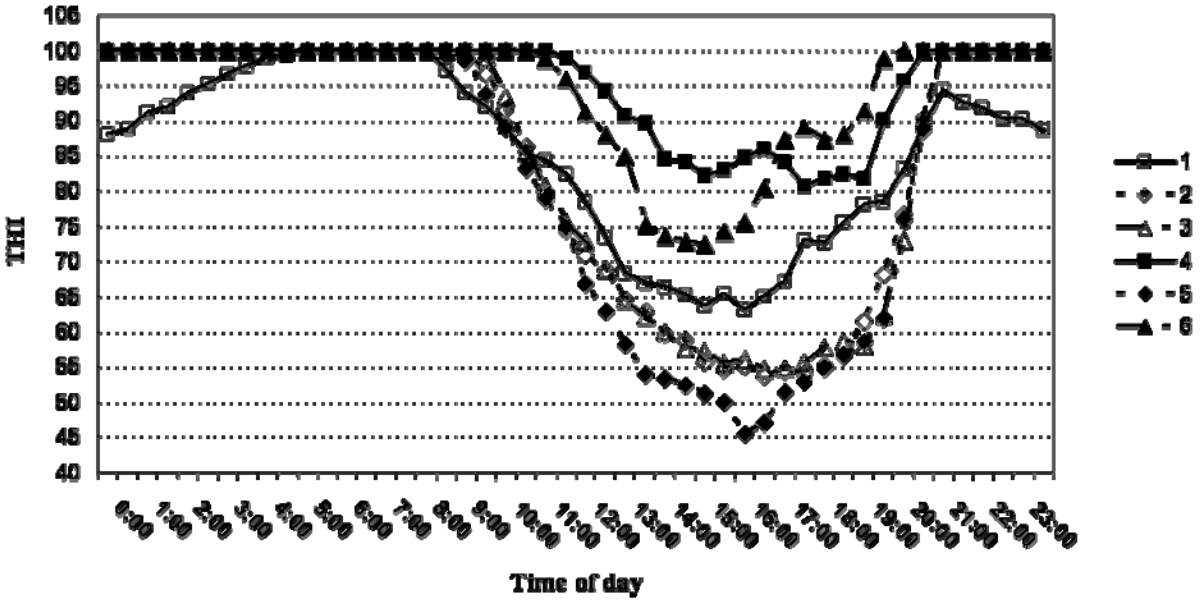

Figure 3. Average relative humidity (RH) measured inside the free stall each week of the trial.

There were no significant differences ($P = 0.69$) in body temperatures of cows cooled with either the low pressure or high pressure mister systems (Figure 4). Body temperature averaged 38.794 and 38.789 C (101.83 and 101.82 F) for low and high pressure mister systems, respectively. The

respiration rate of cows was similar for both systems (P = 0.58) and averaged 61.0 and 62.5 breaths/min, respectively, for low and high pressure mister systems.

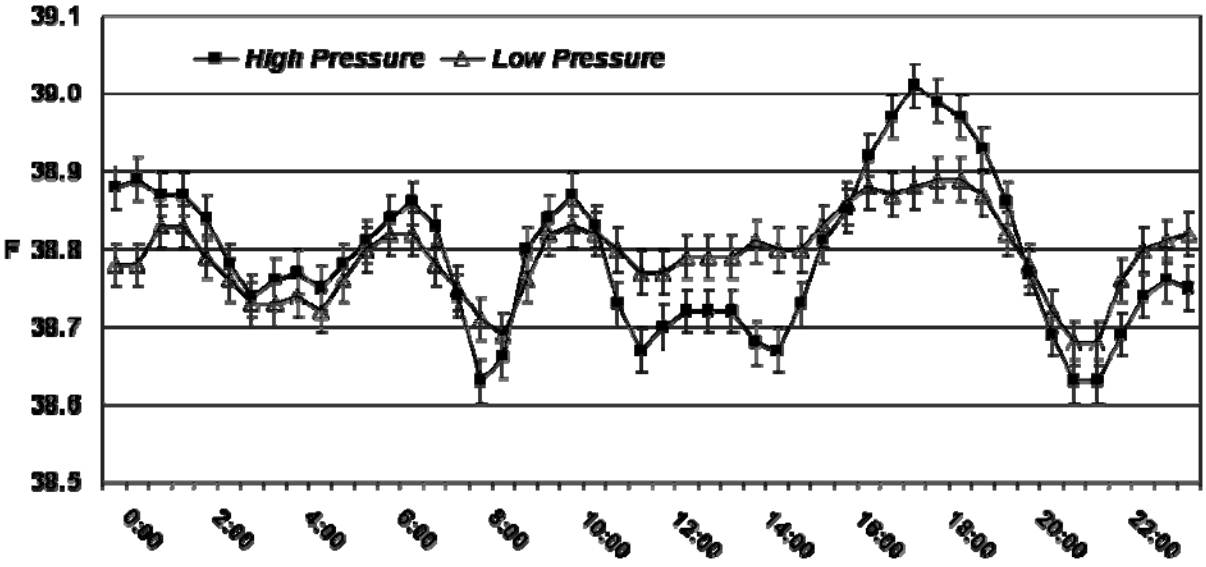

Figure 4. Interaction of mister system and time of day (P < 0.0001, SE = 0.0278).

Water usage was measured for each system during the second replicate of the trial. Average water use was 43% less for the low pressure mister system compared with the high pressure mister system.

Results of this trial indicate that the low pressure mister system is as effective as the high pressure mister system for providing supplemental evaporative cooling based on body temperature and respiration rate of lactating dairy cows housed in a free stall barn. However, the low pressure mister system used 43% less water than the high pressure mister system, which is important for reducing total water usage.

ACKNOWLEDGEMENTS

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