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A comparison of 2 evaporative cooling systems on a commercial dairy farm in Saudi Arabia

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ABSTRACT

Efficacy of 2 cooling systems (Korral Kool, KK, Korral Kool Inc., Mesa, AZ; FlipFan dairy system, FF, Schaefer Ventilation Equipment LLC, Sauk Rapids, MN) was estimated utilizing 400 multiparous Holstein dairy cows randomly assigned to 1 of 4 cooled California-style shade pens (2 shade pens per cooling system). Each shaded pen contained 100 cows (days in milk = 58 ± 39, milk production = 56 ± 18 kg/d, and lactation = 3 ± 1). Production data (milk yield and reproductive performance) were collected during 3 mo (June–August, 2013) and physiological responses (core body temperature, respiration rates, surface temperatures, and resting time) were measured in June and July to estimate responses of cows to the 2 different cooling systems. Water and electricity consumption were recorded for each system. Cows in the KK system displayed slightly lower respiration rates in the month of June and lower surface temperatures in June and July. However, no differences were observed in the core body temperature of cows, resting time, feed intake, milk yield, services/cow, and conception rate between systems. The FF system used less water and electricity during this study. In conclusion, both cooling systems (KK and FF) were effective in mitigating the negative effects of heat stress on cows housed in arid environments, whereas the FF system consumed less water and electricity and did not require use of curtains on the shade structure.
Key words: heat stress, evaporative cooling, efficacy, milk yield

INTRODUCTION

The Kingdom of Saudi Arabia, which constitutes most of the Arab Peninsula, has had a consistent growth in the production of milk over the last 2 decades. This increase in milk production is the result of improved management practices and investments in facilities and cooling equipment that increase the efficiency of milk production and reduce the effect of environmental stress.

Previous studies have shown that evaporative cooling is effective in reducing thermal stress on lactating dairy cows in climates with high ambient temperatures and low relative humidity <55% (Armstrong and Wiersma, 1986; Berman, 2009). Evaporative cooling systems lower the temperature surrounding the cows by injecting water into the air while increasing wind speed to evaporate the water. Lowering the ambient temperature around cows increases the thermal gradient between the cow and the surrounding environment and permits increased heat loss from animals.

The Korral Kool (**KK**; Korral Kool Inc., Mesa, AZ) system has been previously evaluated under commercial conditions in Saudi Arabia (Ortiz et al., 2010a,b, 2011). The KK system consists of independent reverse chimney units (1.4 m in diameter) mounted in the middle of the roof at 6-m intervals. These units release high-pressure mist (up to 8.6 L/min) into an airstream, which is ejected through metallic veins, creating a cyclonic motion of the air/mist combination. The water evaporates before hitting the ground, which decreases the air temperature. This system also uses curtains on the west side of the shade to protect cows from the radiation of the sun in the afternoon hours. This is required because the cooling units are fixed and do not move with the shadow as the angle of sunlight changes through the day.

The recently commercialized FlipFan dairy cooling system (**FF**; Schafer Ventilation Equipment LLC, Sauk Rapids, MN) consists of integrated bays with 4 fans per bay. These fans are spaced at 2-m intervals and are capable of rotating 180° (east to west) depending on the position of the sun and the wind speed. Each fan has a set of misters that spray up to 7.5 L/min per bay of water depending on the environmental conditions (temperature, humidity, and wind speed). Fans

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are 0.91 m in diameter and use a 3/4 hp motor. Fans in this system are mounted in the east side of the roof and are set to aim the opposite direction of the sun. The rotation of the entire system allows cows to move in the direction of the shade with the rotation of the sun, which increases the shaded area for the cows, decreases the time cows spend in the same place, and negates the need for a curtain on the west side of the shade.

Due to the fact that KK system is fixed, cows stand under these units most of the day, which results in a high accumulation urine and feces, which can lead to high moisture in the bedding material. This can be controlled with adequate practices of grooming and sanitation of the lots. However, if lots are not cleaned properly, it could lead to a high incidence of environmental mastitis and other health problems. To determine the efficacy of the 2 systems under intense heat stress, a study was conducted comparing cow performance and physiological responses and consumption of water and electricity of the 2 evaporative cooling systems (FF vs. KK) on a commercial dairy farm located in Saudi Arabia during summer.

MATERIALS AND METHODS

Experimental Design

This experiment was conducted at Al Safi Dairy Company, Kingdom of Saudi Arabia, June 1 to August 31, 2013. The dairy is located on the southwest border of the Ad-Dahna desert at latitude 24.15°N. Minimum, mean, and maximum temperature-humidity index (**THI**) at this location for this 3-mo period were 68, 80, and 93, respectively. These are all above the thermal threshold for heat stress in high-producing dairy cows (Zimbelman et al., 2009).

Four pens were used to conduct this experiment (2 dry lots per system). Each pen contained a California-style shade and 1 of the 2 cooling systems. Each pen consisted of one California-style barn oriented north to south, which provided 3.8 m^2/cow of shade. Each pen also had feed line shade, which was oriented east to west. All pens were cleaned 4 times/day while cows were in the milking parlor. During this process, all wet dirt was taken out of the shade and placed in the sun, and then replaced with dry dirt. Four hundred multiparous Holstein dairy cows were used in this experiment; 100 cows were randomly assigned to each dry lot (DIM = 58 ± 39 d, milk production = 56 ± 18 kg/d, and lactation = 3 ± 1). Production data (milk and feed intake) and reproductive data (AI and pregnancy checks after the 0900 h milking) were collected daily throughout the study. Physiological measurements were taken for 6 consecutive days in the months of June and July. After the first period of physiological measurements finished in the month of June, cows in 2 randomly selected pens (one pen per system) switched to the alternate cooling system, whereas the cows in other 2 pens remained with their respective treatments. Cows that switched pens were moved on July 1 and remained in those pens until the end of the experiment. Cows in the other 2 untouched pens were used to identify any reproductive difference between treatments. During the first week of July, both cooling systems received a maintenance service to make sure cows would get the maximum cooling provided by each system. Visual inspection of the pens was also performed at nighttime to make sure the systems were performing correctly on both treatments.

All cows were milked in the same parlor 4 times/day at 0200, 0800, 1400, and 2000 h. All cows were cooled with KK units in the holding pen. Fans and soakers were used while cows were being milked, and exit lane showers wetted the back of the cows when they exited the milking parlor. Milk production records per cow were collected every day using Alpro milking software (De Laval International AB, Tumba, Sweden).

Cows were fed 6 times/day TMR ration; feed refusals were collected and weighed once per day. Two different rations were fed to the cows during the development of this experiment (Table 1). The first diet was fed from June 1 to July 27. The second diet was fed from July 28 until the end of the experiment (August 31). Cows on both treatments (KK and FF) always received the same diet. Pen feed intake was calculated by subtracting the total feed refused by each pen to the total feed fed to each pen. These values were recorded every day for further feed intake comparison.

To identify differences in the reproductive performance of cows on both systems, individual cow data (AI date, pregnancy check, and abortions) were collected and recorded using Dairy Comp 305 (Valley Agricultural Software, Tulare, CA).

Temperature and humidity were measured and recorded by 8 weather stations located at cow height in different locations around the farm. Each weather station contained a temperature and humidity sensor (Hobo U23 pro V2, Onset Computer Corp., Cape Cod, MA) and a solar radiation shield (M-RSA, Onset Computer Corp.). Weather stations were set to measure and record ambient temperature and relative humidity at 15-min intervals. The THI values were calculated based on the average temperature and humidity data obtained from the weather stations and defined by the following equation (Ravagnolo and Misztal, 2000):

$$\mathrm{THI} = [(1.8 \times \mathrm{Tdb}) + 32] - (0.55 - 0.0055 \times \mathrm{RH}) \times (1.8 \times \mathrm{Tdb} - 26),$$