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Abstract
Seven heat-stressed, lactating Holstein cows were exposed to six different cooling systems to evaluate the effects of air velocity and direction of airflow. Cows were arranged in a 7 x 7 Latin-square design. Six cooling treatments were compared with a control. Supplemental airflow was provided by axial flow at one of three velocities: 500, 750, or 900 cubic feet per minute (CFM). Airflow was either from the front to rear (FRT) or from the right side (SIDE) of the cow. Combined cooling treatments were FRT-500, FRT- 750, FRT-900, SIDE-500, SIDE-750, or SIDE-900. All cooling systems used a lowpressure soaking system that operated 1 minute every 5 minutes. Respiration rates, rearudder skin surface temperature, and vaginal temperature were measured and recorded during 2 hours of treatment during seven hot and humid afternoons. Cooling systems reduced respiration rate, rear-udder skin surface temperature, and vaginal temperature. When airflow was 750 or 900 CFM, no differences were observed among treatments. When airflow was 500 CFM, rate of decline of rearudder skin surface temperature and vaginal temperature were reduced, compared with those of other treatments. These results indicate that there was no advantage to increasing airflow more than 750 CFM when using a low-pressure soaking system that wets the cattle every 5 minutes. Differences due to airflow direction were only observed when airflow was reduced to 500 CFM. At 500 CFM, airflow from head to tail was not as effective as from the side. Current recommendations of 750 CFM of airflow directed at the side of the cow are effective in reducing heat stress of lactating dairy cattle.; Dairy Day, 2004, Kansas State University, Manhattan, KS, 2004;

Keywords
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RESPONSES OF LACTATING HOLSTEIN COWS TO DIFFERING LEVELS AND DIRECTION OF SUPPLEMENTAL AIRFLOW

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Summary

Seven heat-stressed, lactating Holstein cows were exposed to six different cooling systems to evaluate the effects of air velocity and direction of airflow. Cows were arranged in a 7 × 7 Latin-square design. Six cooling treatments were compared with a control. Supplemental airflow was provided by axial flow at one of three velocities: 500, 750, or 900 cubic feet per minute (CFM). Airflow was either from the front to rear (FRT) or from the right side (SIDE) of the cow. Combined cooling treatments were FRT-500, FRT-750, FRT-900, SIDE-500, SIDE-750, or SIDE-900. All cooling systems used a low-pressure soaking system that operated 1 minute every 5 minutes. Respiration rates, rear-udder skin surface temperature, and vaginal temperature were measured and recorded during 2 hours of treatment during seven hot and humid afternoons. Cooling systems reduced respiration rate, rear-udder skin surface temperature, and vaginal temperature. When airflow was 750 or 900 CFM, no differences were observed among treatments. When airflow was 500 CFM, rate of decline of rear-udder skin surface temperature and vaginal temperature were reduced, compared with those of other treatments. These results indicate that there was no advantage to increasing airflow more than 750 CFM when using a low-pressure soaking system that wets the cattle every 5 minutes. Differences due to airflow direction were only observed when airflow was reduced to 500 CFM. At 500 CFM, airflow from head to tail was not as effective as from the side. Current recommendations of 750 CFM of airflow directed at the side of the cow are effective in reducing heat stress of lactating dairy cattle.

(Key Words: Heat Stress Abatement, Cow Comfort, Cow Cooling.)

Introduction

Heat stress is a major concern for Kansas dairy producers. Many different heat-stress-abatement systems reduce the negative effects of heat stress and improve summertime performance and subsequent production throughout the rest of the lactation. Improvement in reproductive performance also may impact the following lactation. These systems generally increase removal of body heat by transferring heat directly or indirectly to water and increasing air velocity over the cows. Previous studies and recommendations demonstrated that increasing soaking frequency and providing 600 to 700 cubic feet per minute (CFM) of supplemental airflow reduced respiration rates and rectal temperatures. In these experiments, airflow direction was from the head to the tail. But the most common direction of supplemental airflow used on commercial dairy farms is directed to the side of the cow when standing at the feedline or resting in free stalls.

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The objective of this study was to determine the effects of differing amounts of airflow directed to either the side or head of lactating dairy cattle.

Experimental Procedures

Seven heat-stressed, mid-lactation Holstein cows averaging 250 days in milk and producing an average of 84.5 pounds of milk were arranged in a 7 × 7 Latin-square design. Cows were housed in a free-stall barn, fed for ad libitum intake, and milked twice daily. Cows were allowed to become heat stressed and then were moved to a tie-stall barn for a period of 2 hours at 2:00 p.m. of each afternoon of testing. Seven different combinations of airflow velocity and direction of flow were evaluated on seven hot and humid afternoons. Treatments were control (C) or one of six heat-stress-abatement combinations. All heat-stress-abatement treatments included a low-pressure soaker system that wet the cattle for 1 minute at 5-minute intervals. Supplemental airflow was provided by axial flow at one of three velocities: 500, 750, or 900 CFM. Airflow was either from the front to rear (FRT) or from the right side (SIDE) of the cow. Combined cooling treatments were FRT-500, FRT-750, FRT-900, SIDE-500, SIDE-750, or SIDE-900.

Operation of the heat-abatement systems began after 15 minutes of initial observation. Respiration rates were observed and recorded every 5 minutes throughout the 2-hour testing period. Body surface temperature was measured with a digital infrared thermometer and recorded every 5 minutes during the testing period. Body temperature was measured and recorded every minute with a data logger and vaginal probe and subsequently was averaged by 5-minute intervals before analysis. Data from the first 15 minutes and final 15 minutes were averaged as initial and final observations. All data were subjected to analysis of variance, with treatment as a fixed effect and period and cow as random variables. Time (5-minute interval) was utilized as a repeated measure within cow.

Results and Discussion

Cooled-stall temperatures averaged 2ºF less, with 10% greater relative humidity compared with that of controls (92 vs. 94 ºF). Final respiration rates of treated cattle were less ($P < 0.01$) than those in controls (Table 1). Although treated and control cows did not differ during the initial measurements, a 32% reduction in respiration rates was observed during the final 15 minutes of the study. No differences were observed in final respiration rates among cooling treatments. Respiration rates did not vary for control cows over time (Figure 1). When cows were treated with heat-abatement systems, however, respiration rates declined in a similar manner for all treatments.

Rear-udder skin surface temperature did not differ initially among treatments, but was reduced ($P<0.05$) by cooling treatments, compared with that of the control (Table 2). Cooling-system treatment differences were observed between FRT-500 and SIDE-900. Little variation was observed in rear-udder skin temperature during the treatment period (Figure 2). When airflow was reduced to 500 CFM, the rate of temperature reduction was reduced, compared with that of the other treatments.

Final vaginal temperatures were less ($P<0.05$) in all cooling treatments than in controls (Table 3). The only difference among treatments was between FRT-500 and FRT-900. Control cows had similar vaginal temperatures during the entire period of the experiment (Figure 3), and the decrease in vaginal temperature resulting from FRT-500 was less than that of the other treatments.

When cows were treated with heat-abatement systems, declines in respiration rate, rear-udder skin surface temperature, and vaginal temperature were observed. This agrees with several studies. Minimal differences occurred in the responses to treatments. When airflow was reduced to 500 CFM, there was a reduction in the rate of decline of vaginal temperature and rear-udder skin temperature. This response was more pronounced when the direction of airflow was head to tail. When airflow was 750 or 900 CFM, the responses were similar. Airflow of less than 750 CFM may not adequately reduce heat stress in dairy cattle. These data also indicate that there is no advantage to increasing the airflow more than 750 CFM, when using a low-pressure soaker system in conjunction with supplemental airflow.

Table 1. Average Initial and Final Respiration Rates of Cows Treated with Different Cooling Systems

	Initial	Final	
Treatment*	Breaths/minute		SE
Control	109.0	113.0[a]	7.0
FRT-500	110.5	79.6[b]	7.0
FRT-750	107.4	78.7[b]	7.0
FRT-900	110.1	73.9[b]	7.0
SIDE-500	111.8	79.4[b]	7.0
SIDE-750	114.3	75.0[b]	7.0
SIDE-900	106.3	71.8[b]	7.0

*Control = no cooling system, FRT-500 = head to tail airflow at 500 CFM, FRT-750 = head to tail airflow at 750 CFM, FRT-900 = head to tail airflow at 900 CFM, SIDE-500 = right side airflow at 500 CFM, SIDE-750 = right side airflow at 750 CFM, and SIDE-900 = right side airflow at 900 CFM.

[a,b]Means within column having different superscripts letters differ (*P*<0.01).

Table 2. Average and Final Rear-udder Skin Surface Temperatures of Cows Treated with Different Cooling Systems

	Initial	Final	
Treatment*	°F		SE
Control	99.3	99.3[a]	1.0
FRT-500	99.7	98.2[a,b]	1.0
FRT-750	99.0	97.2[b,c]	1.0
FRT-900	99.0	97.0[b,c]	1.0
SIDE-500	99.3	96.8[b,c]	1.0
SIDE-750	99.3	96.6[b,c]	1.0
SIDE-900	99.7	96.1[c]	1.0

*Control = no cooling system, FRT-500 = head to tail airflow at 500 CFM, FRT-750 = head to tail airflow at 750 CFM, FRT-900 = head to tail airflow at 900 CFM, SIDE-500 = right side airflow at 500 CFM, SIDE-750 = right side airflow at 750 CFM, and SIDE-900 = right side airflow at 900 CFM.

[a,b,c]Means within column having different superscripts letters differ (*P*<0.05).

Table 3. Average and Final Vaginal Temperatures of Cows Treated with Different Cooling Systems

	Initial	Final	
Treatment*	°F		SE
Control	103.5	104.4[a]	0.6
FRT-500	104.0	103.3[b]	0.6
FRT-750	103.5	102.6[b,c]	0.6
FRT-900	103.5	102.2[c]	0.6
SIDE-500	103.8	102.6[b,c]	0.6
SIDE-750	103.5	102.4[b,c]	0.6
SIDE-900	103.8	102.6[b,c]	0.6

*Control = no cooling system, FRT-500 = head to tail airflow at 500 CFM, FRT-750 = head to tail airflow at 750 CFM, FRT-900 = head to tail airflow at 900 CFM, SIDE-500 = right side airflow at 500 CFM, SIDE-750 = right side airflow at 750 CFM, and SIDE-900 = right side airflow at 900 CFM.

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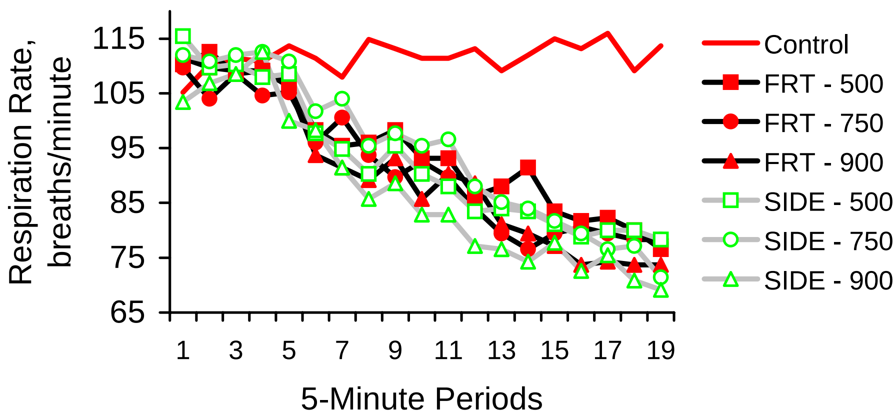

Control = no cooling system, FRT-500 = head to tail airflow at 500 CFM, FRT-750 = head to tail airflow at 750 CFM, FRT-900 = head to tail airflow at 900 CFM, SIDE-500 = right side airflow at 500 CFM, SIDE-750 = right side airflow at 750 CFM, and SIDE-900 = right side airflow at 900 CFM.

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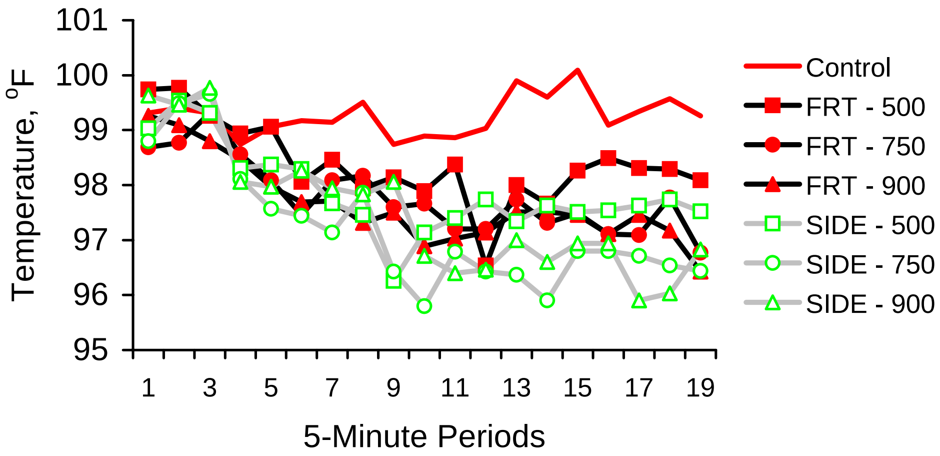

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Figure 2. Average Rear-udder Skin Surface Temperatures of Cows Treated with Different Cooling Systems.

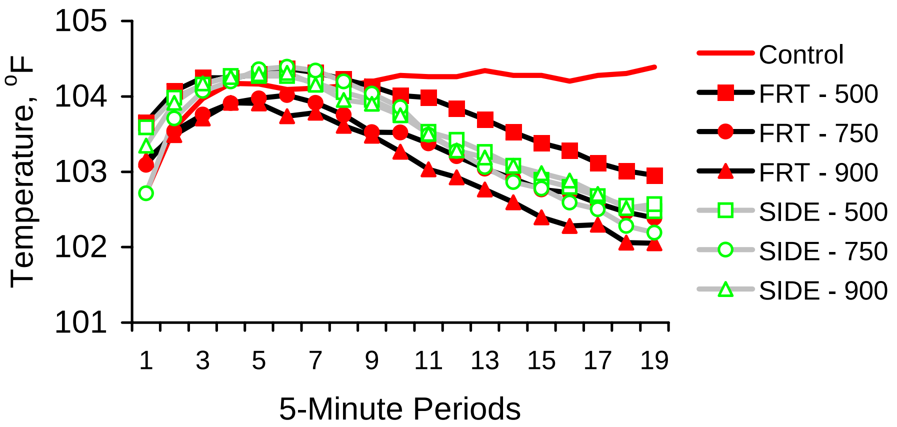

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Figure 3. Average Vaginal Temperature of Cows Treated with Different Cooling Systems.