PERFORMANCE OF LACTATING DAIRY CATTLE HOUSED IN A FOUR-ROW FREESTALL BARN EQUIPPED WITH THREE DIFFERENT COOLING SYSTEMS

M. J. Brouk, J. F. Smith, J. P. Harner III[1], B. J. Pulkrabek, D. T. McCarty, and J. E. Shirley

Summary

Ninety-three multiparous Holstein cows averaging 130 days in milk (DIM) were utilized to evaluate three cooling treatments installed in separate pens of a four-row freestall barn in northeast Kansas during the summer of 1999. Treatments were: 1) a double row of 36-inch fans spaced at 24-ft intervals over the freestalls; 2) a single row of 36-inch fans spaced at 24-ft intervals over the freestalls and over the cow feed line; and 3) a double row of 36-inch fans spaced at 24-ft intervals over the freestalls and a single row over the feed line. Each pen was equipped with identical sprinkler systems over the cow feed line. The 85-day study evaluated milk production, body condition score, respiration rate, and feed intake of cows cooled with the systems. Cows cooled with fans over the freestalls and feed line produced more ($P<.05$) milk (98.8 vs 93.9 lb/cow/day) than those cooled with fans only over the freestalls. Milk production was similar for cows cooled with fans over the freestalls and feed line, and doubling the number of fans over the freestalls had no apparent advantage. Cows in all treatments consumed similar amounts of feed, and those cooled only by fans over the freestalls tended to gain more body condition than cows in the other two treatments. Estimated increase in net income realized from using these cooling systems ranged from $3,500-6,100/year/pen.

(Key Words: Environmental Stress, Heat Stress, Milk Production.)

Introduction

Many Kansas dairies have chosen four-row freestall barns for cow housing. Freestall barns provide shade to protect dairy cattle from most of the sun's rays. However, cattle still experience heat stress when the temperature-humidity index exceeds 72. Without additional cooling, cattle in four-row freestall barns will experience heat stress during the summer months in Kansas. Cows lose heat to the environment mostly by evaporation. Evaporation in the lungs helps cool the cow, and as respiration rate increases, greater evaporation occurs. However, the cow's ability to control heat stress in this manner is limited, and other methods of cooling can reduce the negative effects of heat stress. The purpose of this study was to evaluate the effectiveness of three different cooling systems installed in a four-row freestall barn.

Procedures

Ninety-three multiparous Holstein cows averaging 130 days in milk (DIM) were assigned to one of three cooling treatments. Cows were blocked by lactation number, DIM, and production. Cows were housed in each of three identical 100-cow pens on a commercial dairy farm equipped with 84 freestalls per pen (Table 1). The barn was 100 ft in width and 420 ft in length. The sidewall height was 12 ft, and the roof had a 4/12 slope.

Treatment one (2S) was located in the southeast quarter of the building and had a

[1]Department of Biological and Agricultural Engineering.

double row of fans (14 36-inch-diameter circulation fans with 0.5 horsepower motors) mounted every 24 ft over the freestalls. Each fan had an air delivery rate of 10,000-11,500 cfm and was angled down at 30°.

Treatment two (F+S) was located in the southwest quarter of the building and had a row of fans (seven 36-inch-diameter circulation fans with 0.5 horsepower motors) mounted over the freestalls and another row (seven 36-inch-diameter circulation fans with 0.5 horsepower motors) over the feed line. Both rows of fans were angled downward at 30° and had the same air delivery rate as those listed above.

Treatment three (F+2S) was located in the northwest quarter of the building and had a double row of fans (14 36-inch-diameter circulation fans with 0.5 horsepower motors) mounted every 24 ft over the freestalls and a row of fans (seven 36-inch-diameter circulation fans with 0.5 horsepower motors) mounted over the feed line. The angle and air delivery rate were the same as described above.

Each pen was equipped with similar sprinkler systems consisting of 2.5 gal/hr nozzles spaced every 78 inches on center at a height of 8 ft above the headlocks. Sprinklers were on a 15-minute cycle, with 3 minutes on and 12 minutes off. They were activated when the temperature was above 75°F. The designed application rate was .04 inches/sq ft of surface area, which consisted of 12 sq ft/headlock or 24-inch feeding space. Total application rate was 50 gal/ cycle.

Fans of all treatments were activated when the temperature was above 70°F both day and night.

Cows were fed the same total mixed ration three or four times daily for 105% of ad libitum intake. Amounts fed and refused were recorded daily. Intake data were collected on a pen basis and included 69 additional cows in each pen. Cows were milked 3× and had similar access to water. Animals eligible for rbST were injected at 14-day intervals throughout the trial. Daily milk production was measured for a 24-hour period every 2 weeks throughout the trial. Respiration rates were measured four times during periods of heat stress. Rates were taken in the morning and again in the afternoon on 50 cows/pen.

Results and Discussion

Initial treatment averages (Table 2) for DIM and milk production were not different. Cows cooled with the F+S system produced 4.5 lb more ($P<.05$) milk than those in the 2S system, and those under the F+2S system were intermediate. Dry matter intake was numerically similar for all treatments. All cows increased body condition during the trial. Cows under the 2S system tended to gain more condition than the F+S cows. This likely was due to similar intakes, but lower production in the 2S treatment.

Respiration rates both morning and afternoon (Figure 1) were greatest for cows in the 2S treatment but followed similar trends for cows in the other treatments. Respiration rates increased 10 to 14% during the afternoon. Cows housed in the F+S system had the lowest percentage increase. The smaller percentage increase in respiration rate and increased milk production resulting from the F+S system indicate that it was the most effective system in reducing heat stress of dairy cattle.

An economic analysis of the three systems is shown in Table 3. Based on the assumption that post-peak milk production normally declines 5% each month and that without any heat stress control measures other than shade, milk production would decline an additional 20% during the summer months, these methods of heat abatement will increase gross farm income $8,157 to $11,647/pen/yr or $81.57 to $116.47/cow/yr. Net income, after all capital investment, operational, and increased feed costs have been removed, would increase from $35.82 to $64.04/cow/yr. The average Kansas dairy farm could increase annual net farm income by $3,582 to $6,404 by utilizing one of these systems. This profit would pay for the entire investment in less than 2 years.

Conclusions

The results of this study clearly show that cooling cows can pay big dividends. The systems implemented in this study are cost effective and available to any Kansas dairy producer. Based on the results presented, four-row freestall barns are cooled most effectively when sprinklers are used on the feed line and rows of fans are placed on both the feed line and over the freestalls. Design criteria presented here have been effective in reducing the effects of heat stress in four-row freestall barns. Recommendations on deviations from these design criteria require additional study.

Table 1. Description of a Four-Row Freestall Barn and Cooling Treatments[1]

	Cooling System[2]		
Item	2S	F+S	F+2S
Sprinklers			
Location	feed line	feed line	feed line
Nozzle rating, gallons/hr	25	25	25
Nozzle type	180°	180°	180°
Cycle	on - 3 min	on - 3 min	on - 3 min
	off - 12 min	off - 12 min	off - 12 min
Height, ft	8	8	8
Fans			
Rows over freestalls	2	1	2
Rows over feed line	0	1	1
Number per row	8	8	8
Total number	16	16	24
Spacing, ft	24	24	24
Diameter, inches	36 (½ hp)	36 (½ hp)	36 (½ hp)
Airflow, cfm/stall	1,900	950	1,900
Airflow/headlock, cfm/head	0	800	800

[1]Building description: building type, 4 row; orientation, east-west (2% slope to west); dimensions, width (100 ft), length (420 ft), sidewall height (12 ft), roof slope (4/12); and configuration, 4 pens with 84 stalls per pen and 100 headlocks per pen.

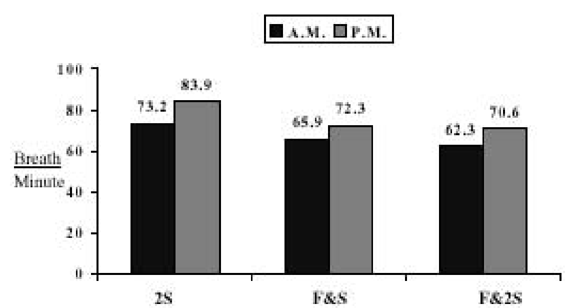
[2]2F = two rows of fans over freestalls, F+S = one row of fans over the feed line and one row of fans over the freestalls, and F+2S=one row of fans over the feed line and two rows of fans over the freestalls.

Table 2. Milk Yield, Body Condition, and Feed Intake of Dairy Cows Housed in a Four-Row Freestall Barn with Three Different Cooling Systems

	Cooling System[1]			
Item	2S	F+S	F+2S	SEM
Initial milk, lb	114.5	115.5	114.8	3.8
Initial days in milk	131	128	131	10.1
Average milk, lb	93.9[x]	98.8[y]	96.5[xy]	2.5
Dry matter intake, lb	55.6	56.2	56.3	-
Change in body condition	+.52	+.39	+.21	.14

[x,y]Means with uncommon superscripts differ (P<0.05).

[1]2S = two rows of fans over freestalls, F+S = one row of fans over the feed line and one row of fans over the freestalls, F+2S = one row of fans over the feed line and two rows of fans over the freestalls, and SEM = standard error of mean.



2S = two rows of fans over freestalls, F&S = one row of fans over the feedline and one row of fans over the freestalls and F&2S = one row of fans over the feedline and two rows of fans over the freestalls.

Figure 1. Average Respiration Rates of Cows Cooled with Three Different Spray and Fan Systems in a Four-Row Freestall Barn.

Table 3. Economic Analysis of Three Cooling Systems Installed in a Four-Row Freestall Barn

	Cooling System[1]		
Item	2S	F+S	F+2S
Beginning (6/12/99) milk production (lb/cow/day)	114.5	115.9	114.8
Estimated milk production w/o cooling (lb/cow/day)	85.1	86.2	85.3
Average milk production w/ cooling (lb/cow/day)	93.9	98.4	96.5
Cooling response (lb/cow/day)	8.8	12.2	11.2
Total extra income due to cooling ($/pen)	8,157	11,368	10,364
Fixed and installation cost of fans ($/pen)	7,072	7,072	10,608
Fixed and installation cost of sprinkler ($/pen)	500	500	500
Total fixed cost of cooling systems ($/pen)	7,572	7,572	11,108
Annual fixed fan cost ($/pen/yr)	1,010	1,010	1,515
Annual fixed sprinkler cost ($/pen/yr)	100	100	100
Total cost of electricity for fans ($/pen/yr)	890	890	1,335
Total electricity cost per stall ($/stall/yr)	10.60	10.60	15.90
Total sprinkler water usage (gal/pen/yr)	171,520	136,000	119,580
Cost of water for sprinklers ($/pen/yr)	274.43	217.61	191.33
Water cost per stall ($/stall/yr)	3.27	2.59	2.28
Variable cooling cost for water and electricity ($/pen/yr)	1,165	1108	1,527
Additional feed cost per cow ($/cow/day)	0.24	0.33	0.30
Additional feed cost per pen ($/pen/year)	1,694	2,361	2,152
Interest rate if money was invested (%)	8.00	8.00	8.00
Return on money if invested ($/yr)	606	606	889
Gross income due to cooling system ($/pen/yr)	$8,157	$11,368	$10,364
Total operating and feed cost ($/pen/yr)	$4,575	$5,185	$6,183
Net income due to cooling system ($/yr/pen)	$3,582	$6,183	$4,180
Net income per stall due to cooling ($/stall/yr)	$43	$74	$50
Additional income per day due to heat abatement (per stall)	0.51	0.88	0.59

[1]2S = two rows of fans over freestalls, F+S = one row of fans over the feed line and one row of fans over the freestalls, and F+2S = one row of fans over the feed line and two rows of fans over the freestalls.

Assumptions:

- 84 cows or stalls per pen
- Calculations over a 85 days of heat stress
- Milk price = $13/cwt
- Rural water cost = $1.60/1000 gal
- 20% reduction in milk production with no cooling