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Managing Heat Stress in Feedlot Cattle Using Sprinklers

Shane Davis
University of Nebraska-Lincoln

Terry L. Mader
University of Nebraska-Lincoln, tmader1@unl.edu

Wanda Cerkoney
University of Nebraska-Lincoln

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Water application to feedlot mounds lowers body temperature of steers without adversely affecting mound microclimate.

Summary

Ninety-six Bos taurus steers were used to determine the effect of water application to feedlot mounds on performance, behavior and tympanic temperature of steers and microclimatic conditions of the mounds. Steers were assigned to 12 pens subjected to no water application (CON), water applied between 1000 and 1200 (AM), or 1400 and 1600 hr (PM). Water application lowered soil temperatures of the mounds with little effect on temperature-humidity index. Tympanic temperatures were lowered by treatment. Performance variables were not affected; however, AM steers were more efficient than PM steers.

Introduction

Reductions in performance of feedlot cattle during summer months can be in large part due to elevated ambient air temperature. These detrimental effects may be further compounded when elevated ambient temperature is coupled with high humidity, low wind speed and/or solar radiation. When these adverse weather parameters exist, the gradient by which heat is transferred from the animal to the environment is reduced and in extreme situations may actually be reversed so that the animal is gaining heat.

Management strategies such as altering metabolizable energy intake and providing shade structures for the animals to reduce heat stress have been explored and are viable options to beef producers. Use of sprinklers to apply water to the cattle and mound in the pen is another option. While sprinkling systems have been extensively used and researched in dairy, poultry and swine operations, few studies exist examining their effect on feedlot animals in the High Plains. Therefore, the objective of this study was to determine the effects of water application to feedlot mounds

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during the summer on performance and behavior of feedlot steers. Changes in tympanic temperatures of the animals and microclimatic conditions of the mounds during water application were examined.

Procedure

Ninety-six *Bos taurus*, (predominantly Angus and Angus x Hereford) yearling steers were used for this study. Upon initiation of the trial (June 23, 1999) steers were implanted with Synovex-Plus® and weighed with the average body weight on two consecutive days used as initial weight of the steers. Steers were allotted to one of 12 pens based on initial weight and allowed *ad libitum* access to a 65 Mcal NEg/cwt finishing diet which contained (DM basis): 84% dry rolled corn, 7.5% alfalfa hay, 2% soybean meal, 2% dry supplement, 4.5% liquid supplement. Four replicates were assigned to each of three treatments (TRT); 1) control; 2) water applied to mounds between 1000-1200 hr (AM); and 3) water applied to mounds between 1400-1600 hr (PM). Water was applied to the AM and PM mounds using Rainbird Pop-Up Sprinklers® when predicted mean daily temperature-humidity index was > 74. This resulted in water being applied on 23 days of the 82-day study. Water flow was controlled using manual valves and a water flow meter so as to supply 9 gal/hd/day. A semi-circular area was wetted to provide 26 ft^2 of wetted surface per animal. Time of water application was controlled using a two-cycle automatic valve.

Daily feed and water intakes were recorded. Body weights were obtained on day 34 and at the termination of the trial (day 82; Sept. 13, 1999). On day 83 steers were transported to a commercial slaughter facility. Hot carcass weight, fat thickness, marbling score and yield grade were obtained.

An automated weather station in the center of the facility compiled minute by minute monitoring of temperature (Ta), relative humidity (RH), black globe temperature (BGT), wind speed and wind direction into hourly observations. Temperature humidity and black globe-humidity indices (THI and BGTHI, respectively) were calculated hourly and averaged daily using the weather station data. The THI equation is defined as:

$$THI = Ta - (.55 - (.55 * (RH / 100)) * (Ta - 58)$$

The BGTHI is determined by substituting BGT for Ta in the equation. Black globe is more comprehensive in its evaluation of weather conditions because it incorporates the effects of wind speed and solar radiation along with temperature and humidity.

Climatic conditions of the mounds were recorded on days 30 through 33 using HOBO Pro data loggers. Loggers placed at heights of 6" and 42" on fence posts bisecting the mounds lengthwise recorded Ta and RH every fifteen minutes. For analytical purposes, readings at 0700 – 0800, 0930 – 1030, 1200 – 1300, 1430 – 1530, 1700 – 1800, and 1930 – 2030 hr were averaged to provide six observations per day. Radiation shields were positioned around the loggers to prevent exposure to direct sunlight and contact with water during sprinkling. Wire cages were positioned around the shields to prevent animal tampering. Soil temperatures of the mounds were measured using loggers placed at a height of 24 inches and equipped with a temperature probe. The probe was inserted into the soil at a depth of .5" to monitor soil temperature; additionally the logger collected Ta at 24 inches. After analysis, there was no difference between Ta at 24 inches and 42 inches, thus the 24 inches Ta are not shown. Temperature humidity index was calculated using measurements of 6 and 42 inches.

Tympanic temperature (TT), an indicator of body temperature, was determined on 2 animals/rep/TRT (8 animals/treatment) on days 30 through 33. Temperatures were collected hourly via thermistor leads placed in the ear canal at an approximate depth of 6". At this depth the lead was very near the tympanic membrane of the steers. Thermistor leads were attached to data loggers which were secured in the ear.

Behavioral observations were made at 0900, 1300, 1700, and 2100 during three periods of hot environmental conditions accompanied by water application to mounds. These periods were classified according to the time of the trial that they occurred and their mean daily THI and BGTHI. The periods were: 1) Early Hot (days 11 –12; THI = 77, BGTHI = 81); 2) Late Hot (days 21 – 22;

Table 1. Effect of morning and evening mound wetting on feedlot performance of yearling steers.

	Treatments[a]				Contrast P-values[b]	
Item	CON	AM	PM	SEM[c]	CON vs TRT	AM vs PM
Body weight, lb						
Day 0	1049	1047	1049	2.4	.26	.42
Day 34	1170	1173	1166	6.8	1.0	.53
Day 82[d]	1333	1351	1327	10.3	.75	.16
Dry matter intake, lb/day						
Day 0-34	21.67	22.29	22.04	.20	.30	.65
Day 34-82	24.71	25.34	25.39	.44	.26	.97
Day 0-82	23.74	24.38	24.29	.37	.25	.89
Average daily gain, lb/day						
Day 0-34	3.50	3.72	3.45	.20	.77	.39
Day 34-82	3.43	3.70	3.34	.15	.64	.15
Day 0-82	3.45	3.70	3.39	.13	.61	.13
Feed:Gain						
Day 0-34	6.22	6.04	6.43	.31	.97	.41
Day 34-82	7.12	6.91	7.63	.22	.85	.06
Day 0-82	6.87	6.61	7.19	.17	.89	.06
Water intake, gal/day						
Day 0-34	9.96	10.13	9.34	.06	.08	.01
Day 34-81	10.06	9.97	10.61	.50	.72	.43
Day 0-81	10.14	10.16	10.21	.30	.90	.92

[a]CON = control; AM = water applied to mounds between 1000 – 1200 hr; PM = water applied to mounds between 1400 – 1600 hr.
[b]Single degree of freedom orthogonal contrasts of CON vs. mean of AM and PM, and AM vs. PM.
[c]Standard error of the mean.
[d]Day 82 live weight multiplied by .96%.

THI = 76, BGTHI = 80); 3) Very Hot (days 30 – 31; THI = 78, BGTHI = 85). The Very Hot period coincided with the heat wave that affected Nebraska in July 1999. Behavioral observations made during these times included assessments of panting, pen position of the animals, and feed available in the bunk. Panting scores were assigned to each animal and consisted of the following: 0 = normal breathing; 1 = slightly elevated respiration rate; and 2 = excessive panting accompanied by salivation. Bunk scores were assigned on a pen basis and consisted of: 0 = < 10% of the days feed amount left in bunk; 1 = 10 – 50% of the days feed remaining; 2 = > 50% of the days feed remaining in the bunk.

Performance and carcass data were analyzed using the GLM procedures of SAS (1986) with the model including the fixed effects of TRT and replicate. Single degree of freedom orthogonal contrasts were used to determine differences among treatments. The contrasts used were CON vs. AM and PM and AM vs. PM with a P-value < .10 being considered significant. Behavior data was analyzed using Chi-square test with a mean panting and bunk score determined for each treatment. Tympanic temperatures and climatic conditions of the mounds were analyzed using repeated measures.

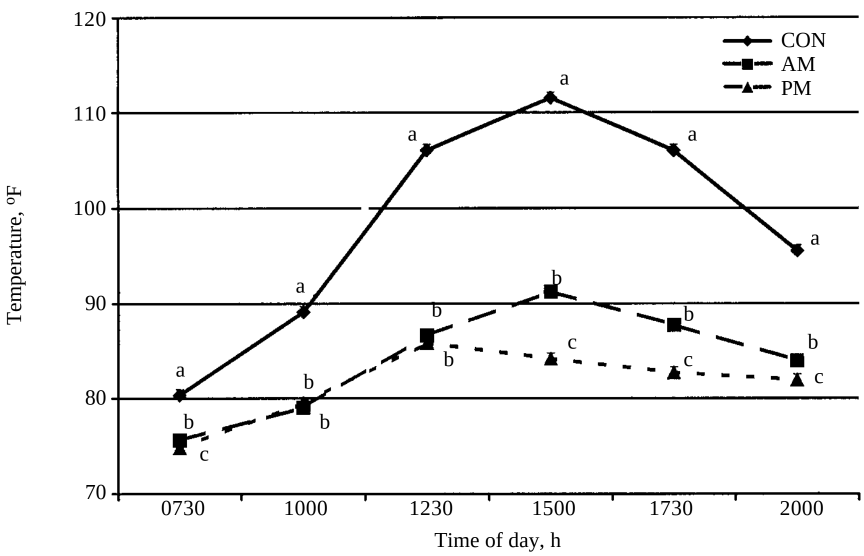

Figure 1. Effect of water application to feedlot mounds on soil temperature. abcValues within a time differ (P < .05).

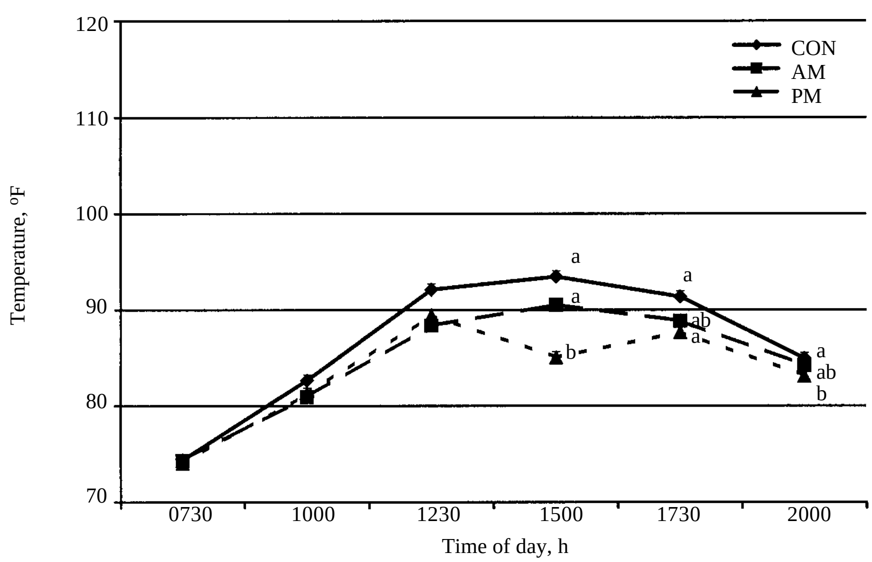

Figure 2. Effect of water application to feedlot mounds on ambient air temperature at a height of 42 inches. abValues within a time differ (P < .05).

Results

Overall performance during the trial was not affected by water application to the mounds (Table 1). However, feed conversion was improved (P < .10) for AM *vs.* PM from day 34 until the termination of the trial. This difference subsequently resulted in AM steers having improved (P < .10) feed conversions over the entire feeding period. Water intake was affected by TRT with AM steers consuming significantly more water from day 0 – 34 than PM steers. Carcass characteristics were not affected by TRT (data not shown).

Panting scores did not differ at any observation during Early Hot or Late Hot environmental periods (data not shown). Panting scores did not differ at 0900, 1300 or 2100 during the Very Hot period. However, at 1700, mean panting score for PM cattle was lower than CON with AM being intermediate. Scores were 1.92, 1.83, and 1.59 for CON, AM and PM, respectively.

Bunk scores were not affected by treatment during Early, Late or Very Hot environmental periods. Although not significant, there was a slight numeric trend for PM steers to have slightly lower bunk scores at 1300, 1700 and 2100, thus PM steers tended to consume more feed prior to these times during the Very Hot period.

A TRT by position by time interaction (P < .01) was found for mound temperatures, thus data were analyzed within position and time and are shown in Figures 1 and 2. Soil temperatures (Figure 1) of CON mounds were higher (P < .01) than AM and PM at all times and reached a maximum of 111.5 °F at 1500. Mounds wetted in the afternoon were cooler overnight than AM mounds as evidenced by their lower (P < .05) temperatures at 0730 (75.6 vs. 74.8 ± .2 °F). Temperatures of AM and PM mounds were similar at 1000 (avg. = 79.3 °F) and 1230 hr (avg. = 86.2); however, PM mounds were lower than AM at 1500, 1730, and 2000.

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Temperatures at 6" (data not shown) were similar across TRT at 0730, 1000 and 1230 and averaged 74.4 ± .2, 80.3 ± 1.0 , and 91.5 ± 2.4 °F, respectively. At 1500, PM mounds were lower than AM and CON and continued to be lower than CON at 1730 and 2000. Temperatures at 42 inches (Figure 2) followed a similar trend with no TRT effect at 0730, 1000, and 1230, but PM mounds were again lower than AM and CON at 1500 and continued to be lower than CON at 1730 and 2000 with AM being intermediate.

Relative humidities above the mounds (Figure 3) did not differ (P > .10) by position (height above mound), therefore position data were pooled. The TRT by time interaction was significant (P < .01), thus means within a time were compared as previously described for temperature. As expected, water application increased RH of the mounds. Treatment mounds had similar RH except at 1500 when PM mounds were higher (P < .05; 70.21 vs. 60.78). This increase in RH of the PM mounds is likely due to the time of measurement coinciding with sprinkling time. Although TRT and CON mounds were different at 2000, RH for all mounds was similar at 0730, suggesting that RH was similar during the overnight hours.

Temperature-humidity indices of the mounds at the various time points are presented in Figure 4. Like RH, position at which the reading was obtained was not significant, thus results were pooled for analysis. The TRT by time interaction was significant (P < .01), thus means within time are separated by least significant difference. The THI is derived from both ambient temperature and humidity and has been suggested to be more indicative of the actual heat loads the animal is experiencing as opposed to temperature or humidity alone. Temperature-humidity indices only differed between treatments at the 1500 and 1730 readings. At 1500, PM mounds, despite having significantly higher RH, had a lower THI than both CON and AM mounds (85.0, 84.12, and 81.26 for CON, AM, and PM respectively). At 1730, PM THI was still lower than CON with AM being intermediate (84.0, 83.2, and 82.2 for CON, AM, and PM, respectively).

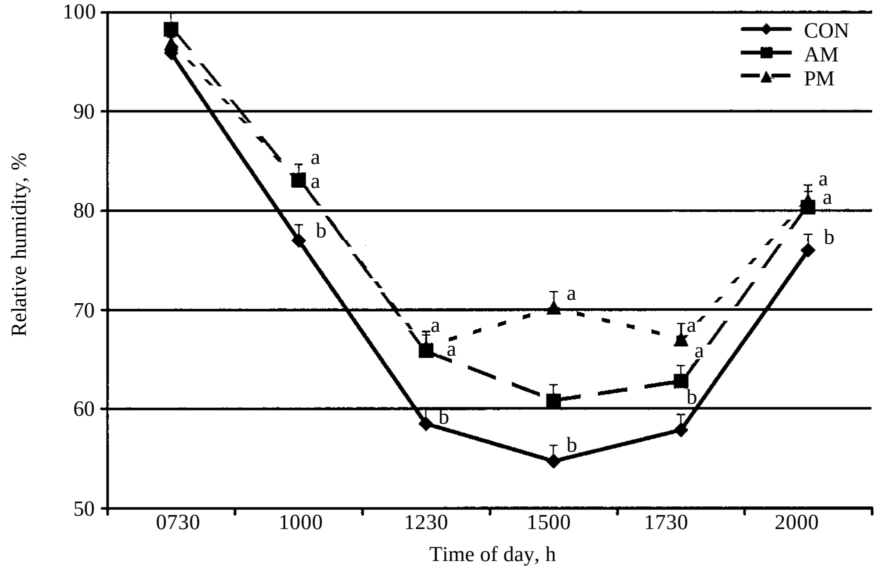

Figure 3. Effect of water application to feedlot mounds on mean relative humidity.[ab]Values within a time with different superscripts differ (P < .05).

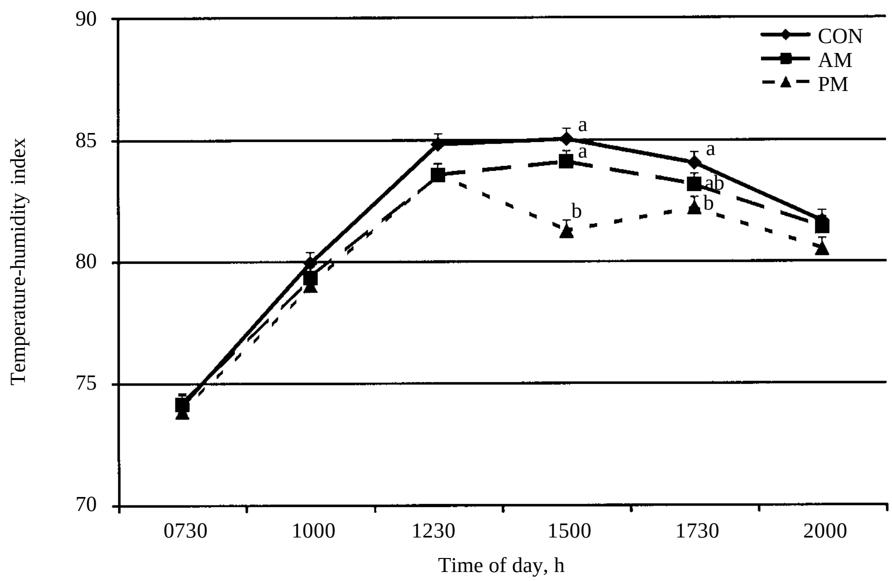

Figure 4. Effect of water application to feedlot mounds on mean temperature-humidity index. [ab]Values within a time with different superscripts differ (P < .05).

Tympanic temperatures (TT) of the steers are presented in Figure 5. Treatment by time interaction was significant (P < .001). Steers in the AM treatment had lower (P < .05) TT than CON and PM cattle beginning at 2300 and lasting through 1000. Nighttime cooling of cattle is essential in the maintenance of homeothermy. Low TT may be indicative of a mechanism by which the heat capacity of animals is increased, thus enabling them to tolerate higher daytime temperatures. Control and PM cattle had similar TT except at 1700, when PM had lower (P < .05) TT than CON and AM steers. Overall TT were 103.2, 102.7 and 103.2 ± .2°F for CON, AM, and PM steers, respectively. During the corresponding time period in which TT was measured, DMI for the TRT averaged 16.83, 16.07 and 17.56 ± .77 for CON, AM, and PM respectively. The lower DMI of the AM cattle may have contributed to their lower TT.

Application of water to feedlot mounds is a viable option to provide a cool area in a pen where cattle can seek

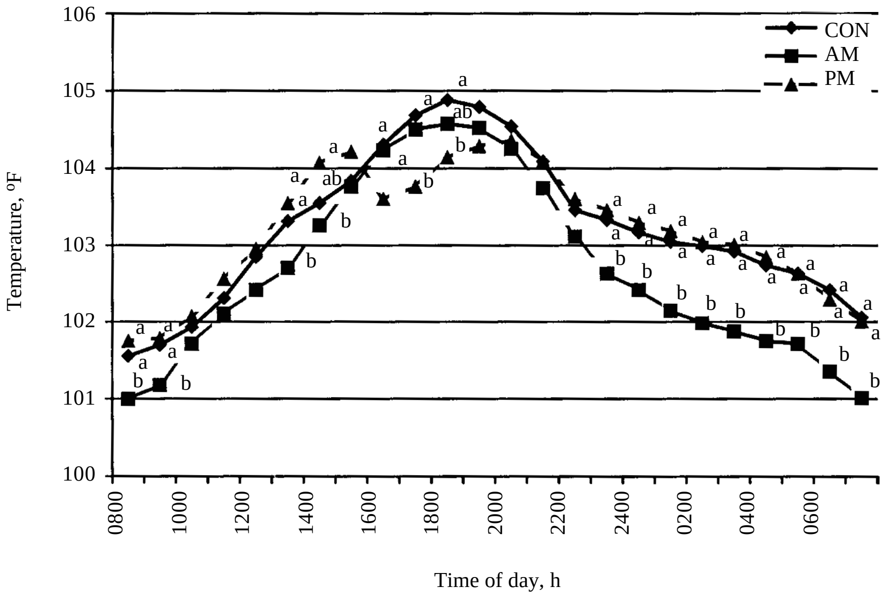

Figure 5. Effect of water application to feedlot mounds on tympanic temperature of steers. [ab]Values within a time with different superscripts differ (P < .05).

relief from heat stress conditions. Although RH over the mound is increased, the decrease in microclimate temperature associated with water application results in either no effect or a concomitant lowering of THI. The decrease in temperature is significant in allowing for a maximization of the heat gradient between animal and environment in order to allow greater heat dissipation. Our performance and TT data suggest preventing cattle from getting too hot during the day by providing external cooling in the morning is superior to providing external cooling in the afternoon. However, providing external cooling in the afternoon tended to enhance intake during very hot environmental conditions.

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[1]Shane Davis, graduate student, Animal Science; Terry Mader, professor, Animal Science; Wanda Cerkoney, research technician.