Nighttime cooling increases milk yield of dairy cows exposed to moderate heat stress

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Background

Effects of heat stress

- High temperature/humidity (THI > 68)
  - Increased respiratory rate
  - Impaired rumen balance and function
  - Increased acidosis risks
  - Acidosis related health issues
- Reduced feed intake
- Reduced milk production
- Invisible consequences of heat stress
- Visible signs of heat stress
Basic management schemes for reducing the effects of heat stress;

✓ Genetic development of breeds that are less sensitive to heat,

✓ Nutritional management,

✓ Physical modification of the environment (especially fans, sprinklers, etc.)
Fans, sprinklers and a combination of misters and fans, and nutritional modification have all been the focus of research on reducing heat stress and subsequent reductions in feed intake and milk production in lactating cows in a hot environment (West, 1999; 2003).
The body temperature of ruminants is higher during the day than at night (Sunagawa et al. 2015). The efficiency of body heat dissipation is dependent upon the difference in the temperature of the surface of the body and the ambient temperature.
It is thought that decreases in milk production of dairy cows in hot and humid environment may be reduced effectively by nighttime cooling when heat producing activity of the day is reduced and body heat is more readily transferred to the surface of the body for dissipation.
Objective

• In order to prove this hypothesis, this research compared the effects of both daytime and nighttime cooling periods on performance, milk composition and physiological parameters of dairy cattle.
## Materials and methods

Two experiments were conducted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Daytime cooling (Experiment I)</th>
<th>Nighttime cooling (Experiment II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animals (head)</td>
<td>28 Holstein dairy cows</td>
<td>28 Holstein dairy cows</td>
</tr>
<tr>
<td>Parity (lactation)</td>
<td>2.6±0.84</td>
<td>2.9±1.24</td>
</tr>
<tr>
<td>Daily in milk (day)</td>
<td>123.9±37.64</td>
<td>141.3±52.51</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>552.0±46.9</td>
<td>568.4±54.08</td>
</tr>
<tr>
<td>Milk yield</td>
<td>29.0±4.08</td>
<td>30.7±3.68</td>
</tr>
</tbody>
</table>
Treatments

✓ Treatments were identical in both of the experiments;
  ❑ Control (without cooling)
  ❑ Sprinklers,
  ❑ Fans,
  ❑ Sprinklers + Fans.

✓ However cooling was applied 10.00 a.m. – 5.00 p.m. in Experiment I whereas 10.00 p.m. – 5.00 a.m in Experiment II.
Feeding regime

✓ Total mixed ration

- Corn silage,
- Alfalfa hay,
- Wheat straw
- Concentrate (18% crude protein and 2650 kcal/kg metabolizable energy).
Measurements and statistics

- Milk yield and dry matter intake; daily,
- Milk samples; 2 times per week and analyzed for components,
- Body weight; weekly,
- Respiration rate, rectal temperature, skin temperature; 2 times per week (10.30 a.m., 1.30 p.m., and 3.30 a.m.),
- PROC MIXED with repeated measurement (contrast statement)
Results
Relative humidity, temperature, temperature humidity index, and THI threshold during Experiment I

- RH (%)
- THI
- THI threshold
- Temp (°C)

Days

1 5 9 13 17 21 25 29 33 37

Temp (°C)

90,0
80,0
70,0
60,0
50,0
40,0
30,0
20,0
15,0
17,0
19,0
21,0
23,0
25,0
27,0
29,0
31,0
33,0
Physiological responses of dairy cattle cooled daytime (10.00 a.m. – 5.00 p.m.)

- **Respiration rate (breaths/min)**
- **Rectal temperature (°C)**
- **Skin temperature (°C)**

### 10.30 a.m.
- Control: [Value]
- Sprinkler: [Value]
- Sprinkler + Fan: [Value]
- Fan: [Value]

### 1.30 p.m.
- Control: [Value]
- Sprinkler: [Value]
- Sprinkler + Fan: [Value]
- Fan: [Value]

### 3.30 p.m.
- Control: [Value]
- Sprinkler: [Value]
- Sprinkler + Fan: [Value]
- Fan: [Value]
## Effects of daytime cooling (10.00 a.m. – 5.00 p.m.) on performance of dairy cows

<table>
<thead>
<tr>
<th>Treatments</th>
<th>SEM</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprinkler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprinkler + Fan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Milk yield (kg/day)</td>
<td>27.0</td>
<td>28.1</td>
</tr>
<tr>
<td>Dry matter intake (kg/day)</td>
<td>19.6</td>
<td>21.2</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>540.4</td>
<td>550.5</td>
</tr>
<tr>
<td>Total solids (%)</td>
<td>11.9</td>
<td>12.0</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>3.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>3.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td>4.7</td>
<td>4.8</td>
</tr>
<tr>
<td>Urea-N (mg/dL)</td>
<td>22.7</td>
<td>22.4</td>
</tr>
</tbody>
</table>

1: Control vs. sprinkler  4: Sprinkler vs. fan  7: Control vs. cooling
2: Control vs. fan  5: Sprinkler vs. sprinkler+fan
3: Control vs. sprinkler+fan  6: Sprinkler+fan vs. fan
Relative humidity, temperature, temperature humidity index, and THI threshold during Experiment II

RH (%) and THI

Temp (°C)

Days
Physiological responses of dairy cattle cooled nighttime (10.00 p.m. – 5.00 a.m.)

- Skin temperature (°C)
- Rectal temperature (°C)
- Respiration rate (breaths/min)

**10.00 a.m.:**
- Skin temperature
- Rectal temperature
- Respiration rate

**10.00 p.m.:**
- Skin temperature
- Rectal temperature
- Respiration rate

**02.00 a.m.:**
- Skin temperature
- Rectal temperature
- Respiration rate

**06.00 a.m.:**
- Skin temperature
- Rectal temperature
- Respiration rate
### Effects of nighttime cooling (10.00 a.m. – 5.00 p.m.) on performance of dairy cows

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Control</th>
<th>Sprinkler</th>
<th>Sprinkler + Fan</th>
<th>Fan</th>
<th>SEM</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Milk yield (kg/day)</strong></td>
<td>28.8</td>
<td>31.7</td>
<td>31.2</td>
<td>30.3</td>
<td>0.27</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.206</td>
<td>&lt;0.01</td>
<td>0.028</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Dry matter intake (kg/day)</strong></td>
<td>18.4</td>
<td>19.7</td>
<td>19.6</td>
<td>18.7</td>
<td>0.18</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.980</td>
<td>&lt;0.01</td>
<td>0.070</td>
</tr>
<tr>
<td><strong>Bodyweight (kg)</strong></td>
<td>549.9</td>
<td>528.8</td>
<td>534.4</td>
<td>533.6</td>
<td>10.49</td>
<td>0.155</td>
<td>0.305</td>
<td>0.262</td>
<td>0.714</td>
<td>0.744</td>
<td>0.958</td>
<td>0.142</td>
</tr>
<tr>
<td><strong>Total solids (%)</strong></td>
<td>12.0</td>
<td>11.5</td>
<td>12.6</td>
<td>11.9</td>
<td>0.16</td>
<td>0.036</td>
<td>0.013</td>
<td>0.810</td>
<td>&lt;0.01</td>
<td>0.062</td>
<td>&lt;0.01</td>
<td>0.939</td>
</tr>
<tr>
<td><strong>Fat (%)</strong></td>
<td>3.3</td>
<td>2.7</td>
<td>3.6</td>
<td>3.3</td>
<td>0.12</td>
<td>&lt;0.01</td>
<td>0.107</td>
<td>0.796</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.172</td>
<td>0.602</td>
</tr>
<tr>
<td><strong>Protein (%)</strong></td>
<td>3.2</td>
<td>3.1</td>
<td>3.3</td>
<td>3.1</td>
<td>0.04</td>
<td>0.061</td>
<td>0.092</td>
<td>0.047</td>
<td>&lt;0.01</td>
<td>0.952</td>
<td>&lt;0.01</td>
<td>0.381</td>
</tr>
<tr>
<td><strong>Lactose (%)</strong></td>
<td>4.6</td>
<td>4.8</td>
<td>4.8</td>
<td>4.6</td>
<td>0.04</td>
<td>0.040</td>
<td>&lt;0.01</td>
<td>0.840</td>
<td>0.282</td>
<td>0.063</td>
<td>&lt;0.01</td>
<td>0.025</td>
</tr>
<tr>
<td><strong>Urea-N (mg/dL)</strong></td>
<td>23.0</td>
<td>25.5</td>
<td>23.6</td>
<td>23.6</td>
<td>0.58</td>
<td>&lt;0.01</td>
<td>0.482</td>
<td>0.469</td>
<td>0.040</td>
<td>0.032</td>
<td>0.994</td>
<td>0.077</td>
</tr>
</tbody>
</table>

1: Control vs. sprinkler  4: Sprinkler vs. fan  7: Control vs. cooling
2: Control vs. fan        5: Sprinkler vs. sprinkler+fan
3: Control vs. sprinkler+fan  6: Sprinkler+fan vs. fan
Overall

✓ In the experiment I, cows received mild heat stress, on the other hand, in the second experiment, cows received moderate heat stress.

✓ Daytime cooling did not affect performance and physiological parameters of dairy cows, whereas night cooling and especially sprinklers treatment increase daily milk yield while decreasing of dry matter intake.
Thank you for your attention