Southeast Dairy Producer's Check-Off Program Research Summary

Reducing water use to cool cows using "Smart" technologies

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Introduction

Heat stress poses a growing threat to the dairy industry, not only in economic and animal welfare terms, but in the requirement of water for heat stress abatement (Collier et al., 2006). When heat stressed, it is estimated that a dairy cow will increase her water consumption by 50%, which translates to an additional water intake of 60 L each day, but effective cooling requires substantially more water. In order to overcome the negative effects of heat stress in the Southeast, producers typically apply evaporative cooling methods that effectively reduce the heat load even in hot and humid climates, but it is estimated that typical soaker systems use about 240 L/cow each day, and most of that water is never applied to the cow as they run constantly, whether cows are under those soakers and get wet or not. Indeed, we recently estimated that only 30% of the water released from a typical cooling system reaches a cow's back and aids in cooling (Dahl et al, unpublished). And the water used to cool cows is "blue" water, the most valuable type as it consists of water from surface or groundwater sources (Naranjo et al., 2019). Thus, there is a tremendous opportunity to reduce the blue water footprint of dairy production by developing "smarter" systems to effectively apply water to cool cows when and where it is needed. Indeed, "smarter" systems are being developed across agriculture to improve the efficiency of resource utilization and that trend will continue as surely as the impact of heat stress will continue to increase due to global warming. But new approaches require confirmation that water savings are not limiting the effectiveness of cooling.

Because evaporative cooling is the only avenue available to cool cows in high humidity environments such as the Southeast (Toledo et al., 2020; Dikmen et al., 2020), many systems rely on the combination of fans and soakers to actively cool the cow rather than the environment. Water soaking systems are most effective when combined with adequate air movement along feed bunks and holding areas. This combination promotes optimum evaporation of water from the skin and hair coat. Ideally, soakers should be on a timer and cycle on and off at higher frequency as temperatures rise. After being soaked, cows are cooled by transferring heat to evaporate water when adequate fan capacity, and thus air movement, is present. This method does not attempt to cool the air, but instead allows the cow to lose heat more effectively by using water to wet the hair coat and skin of the cow, and then water evaporates and cools the hair and skin. All water soakers are either on or off in the entire pen or barn whether cows are present near individual soakers and get wet, or not. Thus, large quantities of water leaves soakers but does not touch cows.

Our objective is to determine if an automated "smart" system (Agpro, Paris, TX) for control of soaker output is as effective as the conventional approach to control of soakers that relies on set timing after a threshold temperature is reached. Specifically, we hypothesized that a smart soaker will be as effective as the conventional system for cow cooling but reduce water usage by at least 50%. Reduction of the quantity of water used to cool dry cows will not be detrimental to milk yield, vaginal temperature and behavioral indicators of heat stress such as lying time and dry matter intake.

To test our hypothesis, a completely randomized design was used to evaluate the effects of heat stress abatement during the dry period on performance of dairy cows (Fabris et al., 2019). Forty two cows were dried off ~45 d before expected calving and randomly assigned to one of three treatments. Treatment groups included: 5 min interval cooling during the entire dry period with shade, fan and soakers (CL, n = 14), Agpro smart cooling during the entire dry period with shade, fan and soakers (AG, n = 14), and heat stress during the entire dry period, i.e. only shade until calving (HT, n = 14). The pens for CL cows included shade, soakers (Rain Bird Manufacturing, Glendale, CA) and fans (J&D Manufacturing, Eau Claire, WI). When the ambient temperature exceeded 21.1 °C (which occurred at all times during this study), fans automatically turned on and the soakers were activated for 1 min intervals at 5 min cycles.The pens for the Agpro soakers **(Figure 1)** were identical except the soaker system will be replaced by Agpro units that will detect the presence of a cow under the unit and soak her for 1 min intervals as long as she is under the unit. Water meters were installed for both soaker systems to measure the actual amount of water consumed by each system. Vaginal temperature will be monitored using blank CIDR's containing an i-button thermometer that provides temperatures at 10 min intervals for up to 7 days. After calving, all cows were housed in the same sand-bedded free-stall barn with shade, soakers (5 min intervals) and fans for cooling.

Results

During the study period, the environmental temperature of the pens where the animals were housed was 26.1 ± 1.1 ºC, relative humidity was 85.7 ± 4.2 %, and THI 77.2 ± 1.3. No differences were found in dry period length between the SS, CL, and HT groups (38.2 vs. 41.3 vs. 39.1 ± 2.3 d; P = 0.60), gestation length (273.6 vs. 275.1 vs. 274.3 ± 1.7 d; P = 0.80) and calf body weight at birth (38.5 vs. 36.3 vs. 37.4 ± 3.3 kg; P = 0.48) respectively for all the animals in the experiment. Hematocrit levels were also not different between treatments during the entire dry period (26.7 vs. 26.6 vs. 26.3 ± 0.40 %; P = 0.74). Pregnant dry SS dams had significantly lower RR compared to CL dams and HT dams (48.1 vs. 52.0 vs. 65.4 ± 1.2 bpm; P < 0.01) and RT showed a similar pattern (38.3 vs. 38.3 vs. 38.8 ± 1.2 ºC; P < 0.01). Compared with CL and SS, respectively, vaginal temperatures measured with the i-Button devices were increased in the HT animals in the AM period (38.7 vs. 38.5 vs. 38.6 ± 0.05 ºC; P < 0.01) and PM period (39.1 vs. 38.7 vs. 38.8 ± 0.06 ºC; P < 0.01). Both active cooling systems, CL, and SS, were efficient in keeping cow body temperature in a lower range relative to HT. DMI was greater in the animals under the active cooling systems during the dry period, both SS and CL (10.1 vs. 9.48 vs. 8.61 ± 0.40 kg/d; P = 0.04) relative to those exposed to HT. After parturition, during 10 weeks in milk (WIM), no differences in milk yield (36.6 vs. 37.6 vs. 35.5 ± 2.5 kg/d; P = 0.84) and milk components, such as fat (4.2 vs. 4.1 vs. 3.9 ± 0.25 %; P = 0.74), protein (3.7 vs. 3.9 vs. 4.0 ± 0.18 %; P = 0.57) and somatic cell count (3.7 vs. 3.4 vs. 3.2 ± 0.45 103 ; P = 0.76) between the multiparous cows previously enrolled on the SS, CL, and HT . Moreover, energy-corrected milk and fat-corrected milk were similar between treatments. Combining values from both CL treatments, does not change the milk yield pattern for the 10 WIM compared to the HT group (37.6 vs. 36.7 ± 7.7 kg/d; P = 0.96). A summary of the animal performance is presented in **Table 1.**

Animals in the CL and SS groups consumed similar amounts of water daily when compared with the HT animals (49.8 vs. 48.8 vs. 89.5 ± 59.3 L/cow/d). SS cooling system utilized less water to cool animals when compared with the CL cooling system (36.1 vs. 184.6 ± 179.4 L/cow/d). Water usage per cow per day was lower in the SS when compared with the CL but similar in total volume with the HT (148.6 vs. 459.1 vs. 168.1 ± 418.2 L/cow/d; **Figure 2**). Data presented as LSM ± SD.

Conclusions

In summary, this study reinforces the detrimental impact of heat stress during late gestation in dairy cows, highlighting the associated risks of increased RT and RR. Exposure to a THI greater than 68 during lactation and over 77 during the dry period, is linked to significant thermal discomfort and stress in dairy cows. Our findings are consistent with previous research, emphasizing the need to implement effective cooling systems to prevent adverse effects on animal health and productivity. As part of ongoing efforts to mitigate the environmental impact of livestock production, new cooling technologies have been developed to minimize water waste while ensuring effective cooling. These innovations offer a significant step forward in reducing the water footprint of dairy production, crucial for regions struggling with water scarcity. While our study demonstrates the efficacy of these new cooling systems, further research under commercial settings, with larger sample sizes and varying stages of parity, is necessary to validate these findings and explore additional benefits. Indeed, we have received additional support from the Suwanee River Water Management District to test the effectiveness of the AgPro system in a commercial setting. Those results will be available in 2025.

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Figure 1. Representative images of the individual unit of the SmartSoaker (**A**) and the system installed (B) in the barn where animals were housed for the period of the study (± 45d).

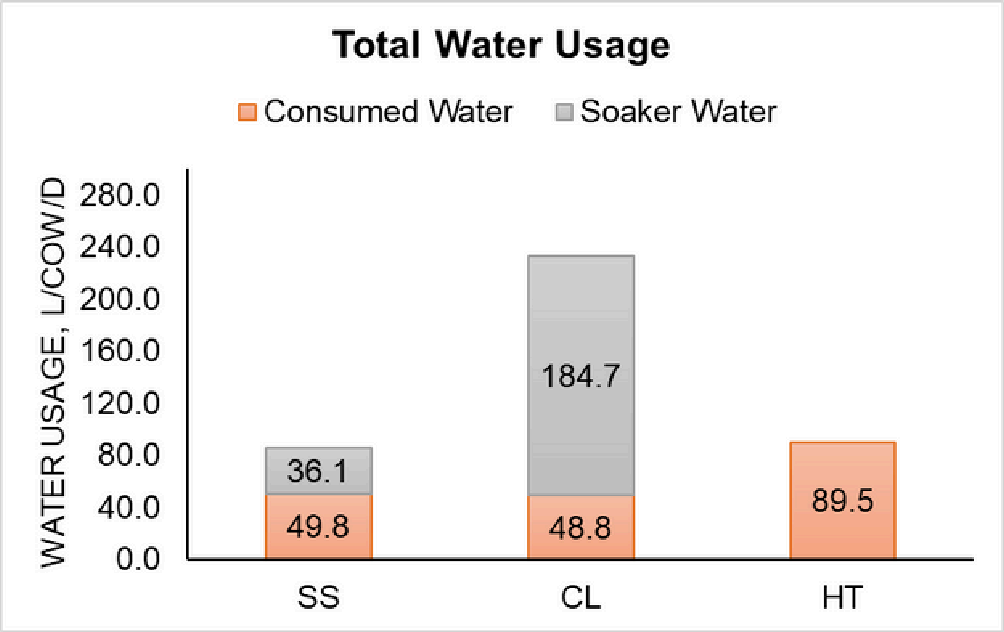

Figure 2. Animal consumed water and soaker output daily (L/cow/day) in the groups with SmartSoaker cooling system (**SS; n = 14**), traditional active cooling system (**CL; n = 14**), and heat stress (**HT; n = 14**) during the dry period. Data presented as LSM ± SD.

Table 1. Summary of the animal performance data when exposed to smart soaker cooling system (**SS; n=14**), traditional active cooling system (**CL; n =14**), and heat stress (**HT; n=14**) during the dry period. Data presented as LSM ± SE. Significance was declared at P ≤ 0.05.

	Treatments				P-value
	SS	**CL**	**HT**	**± SE**	**TRT**
RR, bpm	48.1[a]	52.0[a]	66.4[a]	1.20	*<.001*
RT, °C	38.3[a]	38.4[a]	38.8[a]	0.03	*<.001*
iButton, °C					
AM	38.6[a]	38.5[a]	38.7[a]	0.05	*<.001*
PM	38.8[a]	38.7[a]	39.1[a]	0.06	*<.001*
DMI, kg/d	10.1[ab]	9.48[b]	8.61[a]	0.40	*0.04*
Calf BW, kg	38.5[b]	36.3[b]	37.4[b]	3.30	0.48
GL, d	273.6[b]	275.1[b]	274.3[b]	1.70	0.80
Dry Period, d	38.2[b]	41.3[b]	39.1[b]	2.30	0.60
Hematocrit, %	26.7[b]	26.6[b]	26.3[b]	0.40	0.74
Milk Yield, kg/d	36.6[b]	37.6[b]	35.5[b]	2.5	0.84
Fat, %	4.2[b]	4.1[b]	3.9[b]	0.25	0.74
Protein, %	3.7[b]	3.9[b]	4.0[b]	0.18	0.57
SCC, 10^3	3.7[b]	3.4[b]	3.2[b]	0.45	0.76
ECM	42.2[b]	42.8[b]	40.6[b]	3.10	0.87
FCM	40.2[b]	40.5[b]	38.0[b]	2.84	0.79

a Within a row, means with a common superscript differ ($p \leq 0.05$).

b Within a row, means without a common superscript differ ($p \leq 0.05$).