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Bio-climatological influence on the productive performance in lactating dairy cows

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Abstract
An experiment was conducted to compare the effectiveness of different heat stress alleviating methods for lactating dairy cattle. Twelve lactating dairy cows with similar body weight and production levels were selected and grouped into three treatments with four animals in each group. The treatments *viz* T_1 as control, T_2 (micro sprinklers) and T_3 (wet gunny bags). The daily variations of environmental temperatures and relative humidity were recorded both inside the shed were in the range of 18.7 and 31.5 °C and, 36.4 and 79.2 per cent, respectively. These outside the shed were 20.2 and 32.1°C & 41.7 and 84.0 per cent respectively. The dry matter intake showed non-significant difference among all treatment groups. The statistical analysis for milk yield revealed that there was significant difference between T_1 and T_2 ($P<0.013$) and T_2 and T_3 ($P<0.043$), it was non-significant between T_1 and treatment group. The fat yield, protein yield and lactose yield were non-significant among all the treatment groups. The milk fat per cent showed significant difference ($P<0.001$) between T_1 and T_3 and T_2 and T_3 ($P<0.001$), however there was no significant difference between T_1 and T_2 groups. The SNF protein lactose percentage's and CLR showed non-significant difference between all the treatments groups. The results of the current study revealed that there was slight variation in the productive performances in the medium producing lactating dairy cows. Therefore this indicates that there is a need to adopt proper cooling mechanisms for high yielding dairy cows for sustainable dairy farming in this region.

Keywords: Heat stress, lactating cows, dairy cows, milk yield, dry matter intake, environmental temperature, relative humidity

Introduction
Livestock sector is an integral part of agriculture of India and an important part of the whole economy with reference to employment, income and earning of foreign exchange for the country. Cattle are economically explored for dairy purposes. The total Livestock population as per 19th Livestock Census was 535.78 million in the country showing an increase of 4.6% over previous Livestock Census (2012) and the female cattle population is 145.12 million, increased by 18.0 per cent. India is the leading milk producing country in the world with 209.96 million tonnes, with the per capita availability 427 g/day in the year 2020-2021 [15]. The thermo neutral zone of Indian dairy animals ranges from 16 °C to 25 °C within which they maintain the physiological body temperature of 38.4-39.1 °C whereas, thermo neutral zone for exotic cattle breeds is 4 ºC – 24 ºC (39° F- 75° F) within this temperature range dairy cows are most efficient [33]. Heat stress is the state at which the body mechanisms gets activated to maintain animal body thermal balance, when exposure to elevated temperature [20].
Feed intake in lactating cows begins to decline at the ambient temperatures of 25-26 ºC and decreases more rapidly above 30 ºC. At 40 ºC, dietary intake may decline to the extent of 40 per cent [21]. Heat stress in high producing lactating dairy cows results in considerable reductions in roughage intake and rumination. The reduction in appetite under heat stress is a result of elevated body temperature and may be related to gut fill [25]. In an experiment [7] it was reported that the dry matter intake (DMI) of cooled cows was higher while water intakes were lower than those of non-cooled cows. A reduced DMI decreases the accessibility of nutrients for milk synthesis, because it has been associated to a negative energy balance state [31]. Heat stress reduces milk production, milk fat percentage, and protein percentage, but has no effect on lactose content [34].
The current experiment was undertaken to study the effect of heat stress on the performance of lactating dairy cows in Bengaluru region which is normally referred as most suitable for dairy farming activities.

Materials and Methods

Experimental Design: An experiment was conducted for a period of 60 days during summer from April 2021 to June 2021, conducted at Livestock Farm Complex, Veterinary College, Hebbal, Bengaluru. Twelve lactating dairy cows with similar body weight and production levels were selected and divided into three treatment groups of four animals in each. The details of treatments groups were designated as T_1 (Without any cooling facility), T_2 (animals under this group were sprinkled with water through micro sprinklers once in 2 hours during day time) and T_3 (Wet gunny bags were used as cooling effect). The experimental animals were housed in the standard managemental conditions with standard feeding according to ICAR (2013).

Environmental Variable: The daily minimum and maximum temperature and relative humidity inside the experimental shed was recorded using digital hygro thermometer. Whereas, outside the experimental shed data collected from Meteorological Department located near by the study area.

Chemical composition of feed and DMI: The chemical compositions of feed and fodder provide to experimental animals were analyzed according to [3]. The NDF and ADF were determined as per the method described [28]. The daily DMI (kg/d) intakes were recorded throughout the experiment.

Productive parameters: The productive parameters *viz*., Daily milk yield (kg) and milk compositions (%) were recorded for the experimental groups throughout the study period. The cows were machine milked twice in a day; morning and evening milk yield recorded for individual cows were recorded by using digital weighing balance. and the milk compositions viz., Fat (%), protein (%), SNF (%), lactose (%), corrected lactometer reading (CLR) were analyzed once in week with the help of auto milk analyzer (KSHEERAA 270A).

Results and Discussion

The average minimum and maximum ambient temperature (Presented in Table 1) recorded inside and outside shed during the study period (summer months) was 18.7 and 31.5 °C; and 20.2 and 32.1 °C respectively. The minimum and maximum relative humidity (Presented in Table 1) recorded inside and outside the shed was 36.4 and 79.2; and 41.7 and 84.0 per cent respectively. The daily variations of minimum and maximum ambient temperature and relative humidity inside and outside the experimental shed are depicted in Figure 1 and 2. The temperature and humidity recorded during the experiment were higher compared to the upper limit of the comfort zone values reported in previous studies [33]. However the upper limit recorded during the experiment has considerable effect on the physiological, biochemical and production performance of the animals but not adverse effects as per the reports [18]. Hence the adaptation /usage of the cooling mechanisms employed in the study had a beneficial effect to combat heat stress in dairy animals. The results obtained in the present study were line with previous studies [27].The other reports also showed a similar trend revealed by other research workers [13, 19, 30]. In the previous years the ambient temperature ranged from 20.5 and 32 ℃ during 2018, 20.0 and 33 ℃ during 2019 and it was 20.0 and 31.4 ℃ during 2020, respectively. Whereas, relative humidity was in the range of 41.7 to 84.0 per cent in the year 2018, 38.5 and 79.5 per cent in the year 2019 and it was 46.5 and 83.0 per cent, respectively. Hence, the environmental variations of temperature and humidity in the current study area were not too wide, to affect the performance of the medium producing dairy cows. The results obtained in the present study were line with previous studies reported [1, 8, 27]. Wherein, the ambient temperature and relative humidity were much above the upper limit of comfort zone values as well as the values recorded for the same during the entire trial period.

Table 1: Average mean values of ambient temperature and relative humidity inside and outside the experimental shed during summer months.

Months	Inside the experimental shed				Outside the experimental shed			
	AT(°C)		R H (%)		AT(°C)		R H (%)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
April	18.3	32.5	33.1	80.7	19.6	33.3	38.1	85.3
May	19.2	30.8	38.2	78.0	20.6	31.5	43.0	83.0
June	18.7	31.2	38.0	79.0	20.4	31.7	44.0	83.7
Average	18.7	31.5	36.4	79.2	20.2	32.1	41.7	84.0

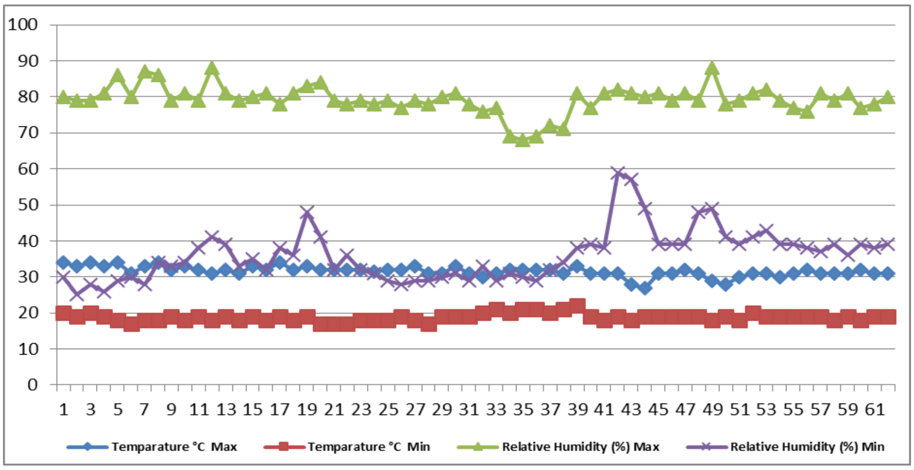

Fig 1: Daily variations of minimum and maximum ambient temperature and relative humidity inside the experimental animal shed.

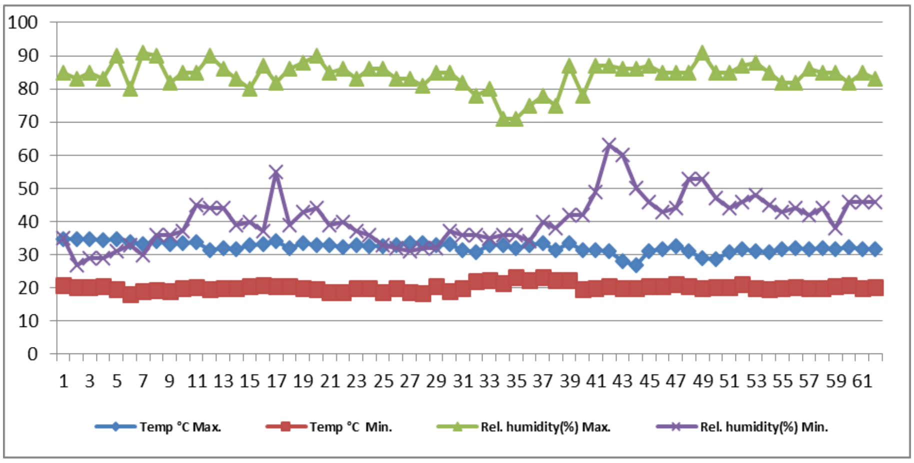

Fig 2: Daily variations of minimum and maximum ambient temperature and relative humidity outside the experimental animal shed.

The average daily DMI (kg/d) for MSF, NF, FMS and CFM for T_1 group was 3.07, 2.72, 2.31 and 3.51, for T_2 group was 3.33, 2.80, 2.37 and 3.56 and the same values for T_3 group animals' was 3.09, 3.07, 2.34 and 3.55, respectively. The total DMI (kg/d) for T_1, T_2 and T_3 was 11.61, 12.06 and 11.50 respectively and presented in the Table 2. The values of the chemical compositions of all the ingredients used during the experiment were in the normal range as per the standard feeding management. The DMI (kg/d) showed non-significant difference among all the treatment groups in the current experiment. Similar results were also reported other researchers [6, 17, 23]. Whereas, the other reports [2, 7, 10, 13] revealed that there was significant decrease in DMI during summer months due to heat stress where environmental temperature (40°C) was well above the maximum temperature (31.5°C.) recorded in the current experiment. The non-significant difference in the DMI intake in the current study might be due to lesser degree of variation in environmental temperature and relative humidity recorded during the entire study period.

Table 2: Total DMI (g/d) through Maize Silage Fodder (MSF), Napier Fodder (NF), Finger millet straw (FMS) and Compounded feed mixture (CFM) of experimental animals during study period.

Treatment groups	MSF	NF	FMS	CFM	Total
T_1	3.07	2.72	2.31	3.51	11.61
T_2	3.33	2.80	2.37	3.56	12.06
T_3	3.09	3.07	2.34	3.55	12.05

The average values of daily milk yield (kg/d) of different treatment groups throughout study period for T_1, T_2 and T_3 recorded was 9.13±1.80, 9.93±1.47 and 9.14±1.74, respectively and are presented in the Table 4. The statistical analysis revealed that there was significant difference between T_1 and T_2 ($P<0.013$) and T_2 and T_3 ($P<0.043$) for milk yield. There was non-significant difference was found between T_1 and T_3 experimental animal group. Comparison of overall milk yield revealed highest milk yield in T_2 (micro sprinklers) group followed by T_3 (Gunny bags) and least in T_1 (Control) signifying adverse impact of heat stress on milk yield. The relative increase in milk production in T_2 group of animals could be attributed to the reduced thermal stress was experienced. The results of the study are in agreement with the findings of the experiments conducted elsewhere [4, 14, 24, 26, 27], who revealed that the use of cooling mechanisms during the summer months showed significant difference among treatment group animals.

The mean values of fat yield (g/l), protein yield (g/l), lactose yield (g/l) of different treatment groups during study period is presented in Table 4. The statistical analysis of all these parameters revealed non-significant difference among all the three treatment groups. The results of current study showed that though the values of T2 higher when compared to T1 and T3 indicating that the cooling mechanism might be the reason in restoring these content of milk in dairy animals. The results are in agreement with other reports [14]. In contrary to present study results, the mild heat stress can cause fat yield loss [16] was reported. The results obtained from current study showed that there was non-significant difference found among the three different treatment groups for protein yield (g). However the protein yield (g was highest in T_2 (Micro sprinkler) group 29.85±0.77 compared to T_1 (Control) 29.58±0.83 and T_3 (Gunny bag) 29.39±0.85.Whereas, the mild heat stress may alter the feed intake and performance of dairy cows in terms of milk and protein yield. Similarly the current study results agreement with [11, 12, 16]. Similarly, the lactose yield (g/l) for T_1, T_2 and T_3 was 46.04±1.20, 45.76±1.10 and 45.31±1.20 respectively. The current study results agreement with [11]. The non-significant results obtained in the current experiment might be due low environmental temperature in the current study area compared to report of other workers.

The milk composition viz., milk fat (%) of different treatment groups throughout study period for T_1, T_2 and T_3 recorded was 3.92±0.06, 3.93±0.04 and 3.50±0.05 respectively. The values are presented in the Table 5. The statistical analysis of milk fat percentage showed significant difference ($P<0.001$) between T_1 and T_3, similarly between T_2 and T_3 ($P<0.001$), however there was no significant difference between T_1 and T_2 groups, This showed that the use of micro sprinklers was found to be more effective in alleviating heat stress in dairy animals when compared to animals with wet gunny bags and without any means of cooling mechanisms during the summer months. Similarly, other milk compositions like SNF (%), Protein (%), Lactose (%) and CLR values recorded and presented in the table 5. The statistical analysis of these parameters showed non-significant difference among in all the three treatment groups. The results of this study were in agreement with the findings of [9, 13, 29, 32]. Similarly, the heat stress, significantly reduces the per cent of protein but it had no effect on the content of lactose in milk [34]. The current results agree with [13] obtained results the heat stress had no effect on milk protein %. In contrary with present results, there is variation of milk composition viz, protein and lactose % due to animals exposed to high environmental temperatures [8, 13].

Table 4: Weekly average values of milk yield (kg/d), fat yield (g/l), protein yield (g/l) and lactose yield (g/l) for all the three treatment groups recorded during study period.

Weeks	Milk yield			Fat yield			Protein yield			Lactose yield		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
1	11.00±1.82	10.78±1.67	10.81±1.90	39.66±1.06	39.38±0.85	35.51±0.92	30.11±0.91	30.33±0.60	29.86±0.70	45.86±1.33	44.53±0.96	43.83±0.88
2	9.94±1.74	10.36±1.69	10.31±1.59	39.85±1.29	39.83±1.43	39.95±1.69	30.43±1.06	30.13±0.78	29.96±0.93	46.14±1.25	46.39±0.97	45.70±1.47
3	9.36±1.57	10.32±1.75	10.43±1.63	38.75±1.37	39.06±0.94	34.04±0.85	29.38±0.84	30.00±0.89	29.41±0.98	45.84±0.96	44.59±1.66	45.29±2.02
4	9.31±1.52	9.94±2.30	9.46±1.60	39.34±0.74	39.36±0.59	34.84±1.12	29.74±0.86	29.91±0.63	29.28±0.67	45.84±1.06	45.61±1.13	46.60±1.23
5	9.40±1.84	10.00±2.39	8.07±1.49	39.04±1.35	38.81±1.02	33.75±0.89	29.59±0.80	30.18±0.79	29.54±1.06	46.25±1.69	46.48±1.36	45.15±1.56
6	8.85±1.89	9.41±1.92	8.39±1.67	39.21±0.97	38.96±1.04	34.79±0.99	29.34±0.85	29.36±0.84	28.93±0.72	45.90±1.15	46.41±1.18	45.85±0.55
7	8.13±1.85	9.31±2.26	8.39±1.56	39.10±0.73	38.98±0.62	35.15±0.89	29.41±0.76	29.45±0.68	29.10±0.60	45.90±1.15	45.90±0.90	45.33±1.26
8	9.79±1.99	10.35±2.51	9.63±1.83	39.35±1.17	39.56±0.57	33.46±0.87	29.21±0.61	29.96±0.69	29.43±0.92	46.41±1.13	45.84±0.61	44.55±0.91
9	7.56±1.84	9.26±2.00	8.07±1.67	38.15±1.22	39.55±0.75	33.91±0.97	29.38±0.84	29.85±0.85	29.14±1.03	46.05±1.44	46.56±1.22	45.48±0.91
10	8.77±1.92	9.61±2.13	7.85±1.63	39.75±1.37	39.70±1.22	35.10±1.04	29.20±0.75	29.38±0.92	29.28±0.86	46.16±0.83	45.29±1.01	45.35±1.17
Mean ±SE	9.13^{a}±1.80	9.93^{b}±1.47	9.14^{a}±1.74	39.22±1.13	39.32±0.90	35.05±1.02	29.58±0.83	29.85±0.77	29.39±0.85	46.04±1.20	45.76±1.10	45.31±1.20

Note: Means bearing different superscripts differ significantly

Table 5: Weekly average values of fat (%), SNF (%), protein (%), lactose (%) and lactometer reading for all the three treatment groups recorded during study period.

Weeks	Milk fat (%)			SNF (%)			Protein (%)			Lactose (%)		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
1	3.97±0.06a	3.94±0.04a	3.55±0.04b	8.33±0.09	8.47±0.09	8.30±0.14	3.01±0.04	3.03±0.02	2.99±0.02	4.59±0.09	4.45±0.05	4.38±0.04
2	3.99±0.08	3.98±0.10	3.99±0.14	8.55±0.12	8.39±0.07	8.40±0.15	3.04±0.06	3.01±0.03	2.99±0.04	4.61±0.08	4.64±0.05	4.57±0.11
3	3.88±0.09a	3.91±0.04a	3.40±0.04b	8.50±0.04ab	8.70±0.06a	8.32±0.14b	2.94±0.03	3.00±0.04	2.94±0.05	4.58±0.05	4.46±0.14	4.53±0.20
4	3.93±0.03a	3.94±0.02a	3.48±0.06b	8.35±0.15	8.61±0.10	8.54±0.11	2.97±0.04	2.99±0.02	2.93±0.02	4.58±0.06	4.56±0.06	4.66±0.08
5	3.90±0.09a	3.88±0.05a	3.38±0.04b	8.71±0.07	8.77±0.07	8.44±0.11	2.96±0.03	3.02±0.03	2.95±0.06	4.63±0.14	4.65±0.09	4.52±0.12
6	3.92±0.05a	3.90±0.05a	3.48±0.05b	8.52±0.09	8.57±0.13	8.36±0.07	2.93±0.04	2.94±0.03	2.89±0.03	4.59±0.07	4.64±0.07	4.59±0.02
7	3.91±0.03a	3.90±0.02a	3.52±0.04b	8.33±0.14	8.53±0.15	8.54±0.11	2.94±0.03	2.95±0.02	2.91±0.02	4.59±0.07	4.59±0.04	4.53±0.08
8	3.94±0.07a	3.96±0.02a	3.35±0.04b	8.69±0.09	8.51±0.10	8.47±0.05	2.92±0.02	2.99±0.02	2.94±0.04	4.64±0.06a	4.58±0.02ab	4.46±0.04b
9	3.82±0.07a	3.96±0.03a	3.39±0.05b	8.58±0.11	8.53±0.12	8.48±0.06	2.94±0.03	2.99±0.04	2.91±0.05	4.61±0.10	4.66±0.07	4.55±0.04
10	3.98±0.09a	3.97±0.07a	3.51±0.05b	8.64±0.16	8.52±0.04	8.29±0.13	2.92±0.04	2.94±0.04	2.93±0.04	4.62±0.03	4.53±0.05	4.54±0.07
Mean ±SE	3.92±0.06^{a}	3.93±0.04^{a}	3.50±0.05^{b}	8.52±0.10	8.56±0.09	8.41±0.10	2.95±0.03	2.98±0.02	2.93±0.03	4.60±0.07	4.57±0.06	4.53±0.08

Note: Means bearing different superscripts differ significantly

Conclusion: The animals maintained under micro-sprinklers cooling facility showed significantly higher values for milk yield and milk fat (%) when compared to control and wet gunny bag cooling groups. The lesser values observed in animals with wet gunny bags cooling might be due to fact that the animals in this group might had less opportunity to undergo evaporative cooling mechanism because of covered wet gunny bags. This might have prevented the evaporation of heat generated from the animal body. Hence the mild heat stress may not alter performance of dairy cows significantly, but has an impact on some of the parameters as observed in the current study. Therefore this study indicated that there is a need to adopt proper cooling mechanisms for high yielding dairy cows for sustainable dairy farming in this region. However, the studies involving large number of animals for a longer period of time is needed to ascertain the results obtained in the current experiment.

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