Journal of Entomology and Zoology Studies
Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(1): 384-389
© 2018 JEZS
Received: 09-11-2017
Accepted: 10-12-2017

CP Ghosh
Assistant Professor, Department of LFC, F/VAS, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

S Datta
Assistant Professor, Department of AGB, F/VAS, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

NK Tudu
Assistant Professor, Department of Vety. Anatomy & Histology, F/VAS, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

SS Kesh
Assistant Professor, Department of VCC, F/VAS, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Correspondence
S Datta
Assistant Professor, Department of AGB, F/VAS, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Effect of various managemental strategies on production performances of Karan Fries cows under loose housing system in summer

CP Ghosh, S Datta, NK Tudu and SS Kesh

Abstract

24 Karan Fries cows in early lactation with good body condition (>3 at 6 point scale) were randomly allotted to four treatments to study the impact of modified microclimate on production performances. Treatments were; Shed (T1), Shed with fan (T2), Shed with fan and water bath (T3) and Shed with fan and sprinklers (T4). The T4 group had lower maximum, minimum, dry bulb as well as wet bulb temperatures and Thermal Humidity Index than other treatment groups. The rectal and skin temperatures, respiration and heart rates of animals were lower in T4 group. Composition of various milk constituents didn't differ significantly (*P*>0.05) by various cooling strategies. Higher milk yield was recorded for the animals which were provided evaporative cooling system. Highest overall milk yield was recorded in the animals of T4 group followed by T3, T2 and T1 groups. Thus, evaporative cooling system (T4) was proved to be the best strategy to maximize production in the summer season.

Keywords: Cooling, microclimate, milk constituents, production

1. Introduction

One of the greatest challenges to dairy farmers in most part of the tropical country like India is heat stress and the strain to the lactating dairy cows. Heat stress exists when air temperature rises above the thermo neutral zone of dairy cows, particularly when humidity is high. The upper critical temperature for lactating cows is in the range of 24 to 27 ^{0}C [12]. The Thermal Humidity Index (THI) is commonly used to indicate the degree of stress [13]. When this index exceeds 72, the high producing dairy cows are affected adversely. There is no doubt that provision of shed is one of the cheapest ways to modify the microclimate during summer. Shed markedly reduces the radiant heat load, which is additive to the internal heat load. But, shed alone is not sufficient for this purpose. Additional cooling in the form of water bath, fans and sprinklers are usually required. In combination with forced air, sprinkling increases the loss of heat over the possible sweating alone. Several studies [6] have demonstrated upper body sprinkling followed by forced air ventilation as effective means to reduce body temperature and improve milk production. In view of the fact that most of studies considering influence of microclimatic modifications conducted so far pertain to the temperate countries involving European breeds. There is scanty of reports involving crossbreed under tropical environment, whereas response to the various cooling strategies may not be same. The present investigation was planned to probe into this problem and bridge this wide and conspicuous gap of information.

2. Materials and methods

2.1 Allocation of treatments

Twenty four Karan Fries (KF) cows in early lactation with good body condition (>3 at 6 point scale) were randomly allotted to four treatments (6 animals in each group). The cows were in 2nd to 5th parity of lactation. The animals were subjected to four different types of treatments i.e. T1 (only shed), T2 (Shed with fan), T3 (Shed with fan and bath by pipeline three times a day), T4 (Shed with fan and sprinklers). In T3 the animals were given a bath at 10 am, 1 pm and 4 pm (15 minutes in each cycle). In T4, a pressurized distribution system supplied water to low-pressure 180^0 brass fabricated mist nozzles, each of which had a 0.5 mm orifice and was connected to a 68.9 kpa pressure regulator. Six nozzles were mounted at 1 m intervals in an iron pipe at a height of 2.8 m.

The evaporative sprinklers were angled such that the bulk of sprinkle was on back and midpoint of the cow. One ceiling fan (each for six cows) were also fixed above the iron pipe each with 1400 mm blade size, 280 rpm, and 75 watt motors and supplying airflow of 17100 m^3/h. The fans were fitted at an angle of 20^0 and placed at 3 m apart and 3 m high. The system combining fan and sprinklers were sequentially activated to repeat cycle of wetting and ventilation for seven periods of 0.5 hour at 1.5-2 hour intervals between 07.30 am and 7.30 pm during entire period of summer.

2.2 Feeding strategies

The cows of each group received 50% of their energy requirements through concentrate. All of the experimental animals had access to *adlib.* seasonal green fodder (maize). All animals were fed as per guidelines of NRC, 1989 [19]. The concentrate mixture (containing 21% Crude Protein and 70% Total Digestible Nutrients) consisted of 40% maize, 30% rice bran, 27% mustard cake, 2% mineral mixture and 1% salt. Concentrate feed was supplied in three installments during milking time. Group wise fodder (maize) intake was monitored on daily basis. In addition, fodder intakes of individual animals were also measured on fortnightly basis on two consecutive days and the average intakes were used for proportionate allocation for arriving at individual cow fodder intake during the respective fortnight. The mean body weight, days in lactation and daily milk yield of treatment groups are mentioned in table 1.

Table 1: Mean body weight, Days in lactation and Daily milk yield of different groups

Group	Body weight (Kg.)	Days in lactation	Daily milk yield (Kg./day)
T1	437.0	53.5	16.86
T2	422.98	49.33	16.16
T3	399.00	58.5	16.66
T4	417.50	54.50	16.95

2.3 Parameters recorded for study

Various components of microclimate were studied for everyday. Fortnight wise means were calculated in each group. Maximum (max), minimum (min), Dry bulb (Db), Wet bulb (Wb) temperatures were also recorded by specific thermometer. Relative humidity (RH%) was calculated from dry and wet bulb temperatures. The observation was made twice a day for recording climatic components i.e., at 7.00 am and 2.00 pm. Rectal temperature (using clinical thermometer), skin temperature (using digital Royteck instrument at four points) respiration rate (by counting the movement of flanks) and pulse rate (counted by palpating coccigeal artery) of all the animals were recorded at 7.30 am and 3.30 pm at 15 days interval. Composite sample of green fodder (maize) and concentrate were analyzed for Dry Matter (DM) and proximate compostions as per standard protocol [2] fortnightly. TDN content of fodder as well as concentrate was calculated from their proximate composition using specific equation [30]. The milk samples were collected initially at the start of experiment and then at fortnightly intervals till the end of the experiment. The milk samples of individual milking were stored at refrigerated temperature overnight and were tested for fat % using milk tester (REIL, Jaipur) having accuracy of ± 0.06, and protein % by Kjeldahl method [3]. Corrected Lactometer Reading (CLR) was used for calculating Solids-Not-Fat (SNF). Daily milk yield was recorded and 4% Fat Corrected Milk (FCM) milk yield was calculated as per formulae [29]. All animals were screened fortnightly for detection of sub clinical mastitis by Modified California Mastitis Test (MCMT) [22] and Somatic Cell Counts (SCC) [16]. Body weight of each animal was recorded initially and then at fortnightly intervals in the morning before feeding. For recording Body Condition Score (BCS) the scoring chart on 1-6 scale [20]. Blood glucose (at the start of experiments and then at 45 days interval) was determined by colorimetric (O-Toluidine) method. Various efficiency parameters (FCMY/TDNI, FCMY/CPI and GE %) were calculated [7]. The effects of various cooling treatments were analyzed through Least-Squares Analysis [14] and significant means were compared by Fischer's Least Significant Difference.

3. Results and Discussion

3.1 Climatic variables

The T4 group had lower maximum ($P<0.05$) and minimum ($P>0.05$) temperatures than other treatment groups in the experiment. Furthermore, the T4 had significantly lower Db ($P<0.01$) and Wb temperature ($P<0.05$), THI (morning, $P<0.05$ and afternoon, $P<0.01$) during morning and afternoon hours but significantly ($P<0.01$) higher RH% during morning and afternoon hours. Mean (±SE) for various climatic variables of experimental shelters have been presented in the table 2.

Table 2: Components of different climatic variables in different shelter groups

	T1	T2	T3	T4
Max	38.96 ± 0.34^{a}	36.19 ± 0.31^{b}	35.44 ± 0.25^{b}	34.15 ± 0.23^{c}
Min	26.32 ± 0.24^{a}	25.79 ± 0.23^{b}	25.22 ± 0.13^{b}	25.19 ± 0.11^{b}
Db_m	26.78 ± 0.20^{A}	24.97 ± 0.21^{B}	24.00 ± 0.13^{B}	23.92 ± 0.26^{C}
Db_e	32.48 ± 0.29^{A}	28.71 ± 0.24^{B}	28.12 ± 0.22^{B}	27.39 ± 0.11^{B}
Wb_m	22.96 ± 0.20^{a}	22.27 ± 0.21^{a}	22.25 ± 0.23^{a}	22.19 ± 0.19^{b}
Wb_e	26.83 ± 0.24^{a}	25.69 ± 0.22^{b}	25.29 ± 0.26^{b}	25.27 ± 0.22^{b}
RH_m%	72.57 ± 0.63^{A}	73.29 ± 0.47^{A}	75.19 ± 0.47^{B}	78.19 ± 0.36^{C}
RH_e%	65.77 ± 0.89^{A}	68.77 ± 0.89^{A}	78.00 ± 0.36^{B}	79.19 ± 0.76^{B}
THI_m	76.41 ± 0.28^{a}	75.39 ± 069^{a}	74.48 ± 0.23^{b}	74.61 ± 0.30^{b}
THI_e	83.80 ± 0.36^{A}	81.44 ± 0.35^{B}	77.92 ± 0.26^{C}	76.76 ± 0.32^{C}

Max-Maximum, Min-Minimum, Db-Dry bulb, Wb-Wet bulb temperatures in ^{0}C. RH%-Relative humidity%, THI-Thermal humidity index and m/e-Morning/Evening.
Treatment bearing different superscripts within row differ significantly ($^{abc}P<0.05$ and $^{ABC}P<0.01$). Similar superscripts do not differ significantly.

The temperature humidity index is commonly used to denote the degree of stress in dairy cattle. At a THI above 72, heat stress has been reported to be sufficient to decrease the milk yield [17], depression in milk yield being more pronounced when THI exceeded 76. In the present study also, the cows kept in T1 were adversely affected by heat stress. A previous study [27] that determined climatic conditions in treatment pens showed that the EC system reduced maximum daily temperature by 5.6 ^{0}C and reduced average THI by 2.3 units. Hsu and Liu reported [15] that an increase of the THI in the experimental farm had significant adverse effects on milk yield (16.1 versus 13.9 kg/day, during hot versus cold season). Maximum temperature and minimum relative humidity were the most critical variables to quantify heat stress and both these variables can easily be combined into THI [21]. Milk yield declined @ 0.2 kg per unit increase in THI when THI exceeded 72.

3.2 Physiological indices

The results showed that microclimate (MC) had significant ($P<0.01$) effect on all physiological indices. The experimental data showed that (Table 3) cows under different treatment groups had higher values of RR, HR, RT and ST during afternoon, because in afternoon hours THI was higher in various treatments as compared to morning hours.

Table 3: Physiological indices of crossbred cows under different cooling strategies

Parameters	T1	T2	T3	T4
RR_m (cpm)	32.69±1.18^{abA}	35.88±1.11^{aA}	30.18±1.06^{bcA}	28.23±0.82^{cA}
RR_e (cpm)	58.15±1.72^{aB}	56.22±2.32^{aB}	34.97±1.19^{bB}	37.42±1.44^{bB}
HR_m (bpm)	64.19±1.02^{A}	67.29±1.02^{A}	63.83±1.30^{A}	64.48±0.79^{A}
HR_e (bpm)	77.83±1.05^{aB}	78.31±1.19^{aB}	70.22±1.05^{bB}	69.10±1.00^{B}
RT_m (^{0}C)	37.64±0.06^{aA}	37.07±0.06^{bA}	37.29±0.05^{bA}	37.19±0.05^{bA}
RT_e (^{0}C)	39.23±0.08^{aB}	38.94±0.09^{bB}	38.09±0.16^{cB}	38.00±0.06^{cB}
ST_m (^{0}C)	35.17±0.15^{A}	35.29±0.14^{A}	35.38±0.14	35.23±0.14
STe (^{0}C)	37.61±0.20^{aB}	37.04±0.20^{aB}	35.22±0.20^{b}	35.00±0.20^{b}

Treatment means with different alphabets^{abc} as superscripts within same row differ significantly ($P<0.01$).
Treatment means with different superscripts^{AB} under different row and same column (within fortnight) differ significantly ($P<0.05$).

Diurnal variations in non-cooled (T1 & T2) groups were more pronounced than cooled (T3 & T4) groups because T1 and T2 group animals had higher THI both in morning and afternoon hours than T3 and T4 (cooled) animals. The significant decrease ($P<0.01$) in RT and RR of cows (T3 and T4) showed that partial alleviation of heat stress resulted from evaporative cooling, the effect of which was subsequently confirmed by increased milk production and reduction of BW loss.

In our study, the data suggests that EC (T4) was not sufficient to completely eliminate heat stress in cows because morning and afternoon THI remained high enough to depress milk yield as also reported in previous research findings. However, THI might not accurately reflect heat stress in EC system that deliver a pressurized spray with considerable air movement above the cow's back, causing a strong cooling effect. A similar finding was also reported in evaporative cooled cows [26]. These findings are consistent with those of previous studies [27, 9]. Similarly, Florida workers reported an 11.6% improvement in milk yield when cows were sprayed for 1.5 min of every 15 min of operation [25].

3.3 Nutritional parameters

The microclimate had significant effect on various nutritional parameters (DMI, DMI/100 Kg BW, TDNI, TDNI/100 Kg BW, CPI and CPI/100 Kg BW) (Table 4). It has been discussed earlier that T4 provides better microclimate and strong cooling effect to maintain normal physiological homeostasis in summer than in side the shed only fitted with fans (T2), only shelters (T1) were not sufficient to alleviate heat stress during summer months in northern part of India.

Table 4: Nutrient intake of various treatment groups

	Groups			
Parameters	T1	T2	T3	T4
DMI (Kg/day/cow)	11.03±0.17^{a}	11.08±0.09^{a}	11.95±0.12^{b}	12.38±0.15^{c}
DMI/100 Kg BW	2.66±0.03^{a}	2.89±0.03^{b}	3.02±0.04^{c}	3.07±0.04^{c}
TDNI (Kg/day/cow)	7.53±0.11^{a}	7.76±0.70^{a}	8.10±0.09^{b}	8.543±0.12^{b}
TDNI/100 Kg BW	1.813±0.023^{a}	2.017±0.020^{b}	2.042±0.028^{c}	2.106±0.025^{c}
CPI (Kg/day/cow)	1.63±0.03^{a}	1.69±0.02^{ab}	1.75±0.02^{b}	1.91±0.03^{c}
CPI/100 Kg BW	0.392±0.005^{a}	0.451±0.005^{b}	0.471±0.007^{b}	0.477±0.007^{b}
CHBW (Kg/cow/fortnight)	-0.717±1.407	-0.657±1.295	0.310±1.646	0.022±8.081
CHBCS (Unit/cow/fortnight)	-0.007±0.026	-0.046±0.054	0.07±0.032	0.020±0.045
Overall BCS	3.34±0.06	3.36±0.06	3.37±0.020	3.44±0.14
Blood glucose level (mg/dL)	49.91±0.58^{a}	50.28±0.61^{ab}	51.32±0.67^{ab}	54.08±0.62^{b}

Treatment means with different alphabets^{abc} as superscripts within same row differ significantly ($P<0.01$).

Cows under T1 & T2 consumed less DM through fodder as well as overall DM. This phenomenon was more pronounced in T1 which showed lowest DMI/100 Kg BW (2.66 Kg/100 Kg BW). Highest DMI was observed in T4 (12.38 Kg/cow/day), where cows got the better microclimate. Higher TDNI in groups T3 & T4 as compared to treatment group in T1 & T2 was mainly due to the absence of heat stress in evaporative cooling, which favored higher DMI. So, energy was one of the limiting factors for the cows which were not cooled by water bath or sprinkling during heat stress, particularly when cows were in early or mid-stage of lactations.

These findings are in consistent with the results of previous studies. Feed intake in lactating cattle begins to decline at ambient temperatures of 25-26 ^{0}C and drops more rapidly above 30 ^{0}C. Heat stress causes the rostral cooling centre of the hypothalamus to stimulate the medial satiety center which inhibits the lateral appetite center, resulting in reduced dietary intake and consequently lower milk production [1]. Heat stress in high producing cows results in dramatic reduction in roughage intake and rumination [10]. The reduction in appetite under heat stress is a result of elevated body temperature and may be related to gut fill. Most of the earlier workers reported lower RT, RR but higher DMI for cows receiving evaporative cooling than for cows in shed alone or under shed plus fan management system [11, 8]. Cooling may directly influence milk secretion from mammary gland, but its primary effect is to restore feed intake that has been suppressed due to elevated level of heat stress.

From the above results it can be safely inferred that, effect of heat stress can be minimized by providing sequential sprinkling along with sufficient supplementary air flow.

3.4 Physical parameters

The results revealed that microclimatic treatment had non-significant (*P*>0.05) effect on all of physical parameters under study (BCS, change of BCS and change of BW). The groups under T3 & T4 receiving evaporative cooling (EC) or water bath showed better overall and final BCS. None of the treatment groups showed excessive loss of BW and BCS during any point of study possibly because all animals (except-T1) received supplementary air flow (fans) continuously during hot summer season. Similar to these findings was also observed [5] that mist cooling increased the mean BW of cows over 5 months study period in hot arid climate.

3.5 Blood glucose level

The blood glucose level was affected significantly by the treatment factors. Highest blood glucose level was noted in T4 (54.08±0.62 mg/dL) which received EC. The higher nutrient intake, better BCS & BW gain in T4 were reflected on blood glucose levels. Lowest values of blood glucose were noted in T1 (49.91±0.58 mg/dL) as their nutrient intake/100 Kg BW was lowest among all treatment groups. Higher intake of DM and energy in T4 group was most likely responsible for this trend. Higher plasma thyroxin and glucose level was found in evaporative cooled cows [5].

3.6 Milk production and compositions

The results revealed that Microclimate (MC) had a significant effect (*P*<0.01) on milk yield. Percentage of various milk constituents (Table 5) didn't differ significantly among four groups but fortnightly milk compositional yield [Fortnightly fat (FFY), protein (FPY), solids not fat (FSNFY) and Total solids (FTSY)] increased significantly (*P*<0.01) due to cooling treatments. Furthermore, treatments had no effect on milk constituents. Other researchers have also shown little or no effect of evaporative cooling on percentage of milk components [5, 9].

Table 5: Effect of various cooling strategies on milk production, compositions and efficiency of crossbred cows

	Groups			
Parameters	**T1**	**T2**	**T3**	**T4**
TOTFORMY (Kg/cow)	192.08±5.70^{a}	205.82±4.60^{a}	232.71±6.90^{b}	248.45±9.05^{b}
FFCMY (Kg/cow)	200.89±5.30^{a}	211.13±4.69^{a}	247.29±7.32^{b}	259.01±8.12^{b}
Fat%	4.31±0.04	4.28±0.05	4.34±0.06	4.33±0.06
FFY (Kg/cow)	8.33±0.21^{a}	8.65±0.20^{a}	10.28±0.32^{b}	10.69±0.36^{b}
Protein%	3.14±0.06	3.15±0.13	3.18±0.10	3.18±0.02
FPY (Kg/cow)	6.10±0.18^{a}	6.54±0.14^{a}	7.56±0.22^{b}	7.91±0.28^{b}
SNF%	8.73±0.03	8.70±0.03	8.71±0.04	8.74±0.03
FSNFY(Kg/cow)	17.18±0.48^{a}	17.90±0.37^{a}	20.87±0.59^{b}	21.83±0.68^{b}
Total solids%	13.04±0.08	12.80±0.06	12.96±0.13	13.18±0.13
FTSY (Kg/cow)	25.51±0.68^{a}	26.94±0..55^{a}	31.25±0.89^{b}	32.66±1.14^{b}
SCC (10^{5} cells/ml of milk)	3.04±0.29^{a}	2.72±0.30^{a}	2.28±0.30^{a}	1.70±0.11^{b}
FCMY/TDNI	1.82±0.04^{a}	1.86±0.04^{a}	2.06±0.05^{b}	2.28 ±0.05^{b}
FCMY/CPI	8.26±0.15^{a}	8.33±0.13^{a}	9.41±0.20^{b}	8.94±0.18^{b}
GE %	33.42±0.73^{a}	34.82±0.66^{a}	35.35±0.90^{b}	37.47±0.87^{b}

Treatment means bearing different superscripts within same row differ significantly (*P*<0.05) and NS-Non significant (*P*>0.05).
Where, FFY = Fortnightly Fat Yield
FPY = Fortnightly Protein Yield
FSNFY = Fortnightly Solid Not Fat Yield
FTSY = Fortnightly Total Solid Yield
TOTFORMY = Fortnightly Total Milk Yield
FFCMY = Fortnightly 4% Fat Corrected Milk Yield
FCMY= 4% Fat Corrected Milk Yield
GE-Gross Efficiency

The highest Fortnightly Total Milk Yield and Fortnightly 4% Fat Corrected Milk Yield were observed in T4 group, followed by T3, T2 and T1. The treatment groups kept underT3 and T4 had better overall performances than the groups kept under T1 and T2. Higher nutrient (DM, CP and TDN) intake of cooled cows were reflected on their milk production performances. In our studies, during early lactation better overall production and nutrient utilization (Fig 1) was observed in cows that received either water bath or EC than cows that received only fans or shed.

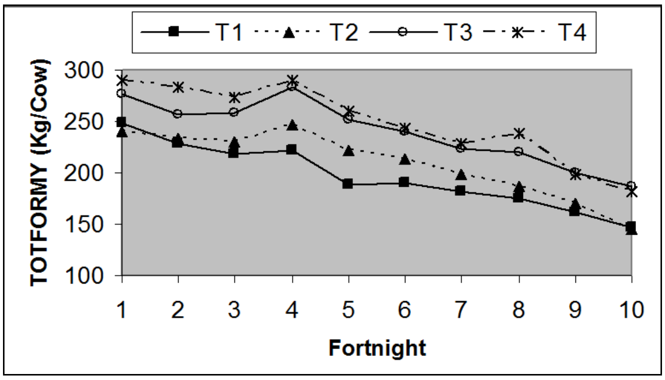

Fig 1: Fortnightly milk production of different treatment groups

In T1 and T2 heat stress adversely affected milk production particularly during early phase of lactation. So, the provision shed or fans alone in shed were not sufficient to minimize heat stress in the study. The additional cooling in the forms of fans and sprinklers or water bath was needed.

In combination with forced air, sprinkling increases the loss of heat over the possible sweating alone. Several studies [6] had demonstrated upper body sprinkling followed by forced air ventilation to be effective means to reduce body temperature and animal performance. Benefits from sprinkling and fans were reported in a temperate, humid climate (Kentucky), where cows yielded 3.6 kg more milk (15.9%) while consuming 9.2% more feed per day than controls [28]. In NDRI, higher milk yield in crossbred cows provided with fan and mist (2.12 kg/d) was reported as compared to control in both hot-humid and hot-dry season [24].

3.7 Somatic cell counts (SCC)

The results showed that microclimate (MC) had significant effect ($P<0.05$) on SCC. The cows kept under T1 and T2 groups showed higher SCC than their counter parts kept under T3 and T4. This difference in SCC may be partly attributed to the decrease in milk yield associated with the elevated level of heat stress. It is not unusual to experience 10 to 20% decline in milk yield in dairy cattle experiencing heat stress [23]. Similar to these findings was also reported in higher SCC in group of KF cows provided fan (1.54 x 10^5) as compared to those cows provided fan and mist [24]. A positive relationship between high summer environmental temperature and SCC in milk was reported by Nelson and co-workers [18].

3.8 Efficiency parameters

The nutrient conversion efficiency to milk (FCMY/TDNI, FCMY/CPI and GE %) was improved significantly ($P<0.01$) due to treatments (Table 5). In summer months EC cows were more efficient to convert feed nutrients to milk production. Further, efficiency of nutrients conversion among treatment groups differed appreciably during early part of lactation only (Fig 2) and there after these differences got minimized. This may be because of the fact that animals kept under T1 and T2 were affected more by heat stress during early phase of lactation when the milk production was at its peak and the metabolic activities were also higher. Shed with fans alone was not sufficient to eliminate overall thermal heat load generated on high producing animals. Heat stress adversely affects the lactational performance of dairy cows principally because the activation of thermoregulatory mechanism of the animal which results in increased respiration rate (RR), heart rate (HR), reduced feed intake, lower nutrient absorption, and redirection of blood flow from internal to peripheral tissues in an effort to balance heat load [23]. Heat stressed cows thus tend to expend more energy for maintenance.

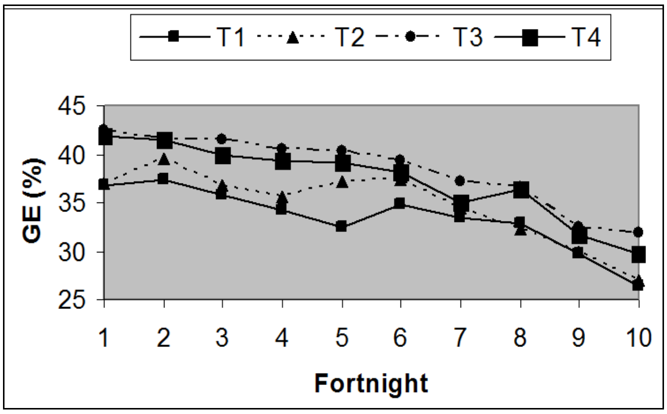

Fig 2: Gross efficiency (GE %) of different treatment groups

Conclusions

Provision of fans along with water sprinklers during summer season proved to be an effective strategy in reducing body temperature, improve feed intake and maintain milk yield at higher level in crossbred cows. In field condition provision of fan along with water bath is one important alternative to sprinkling or mist cooling.

Acknowledgement

Cattle yard, Dairy Cattle Breeding Division, National Dairy Research Institute, Karnal, Haryana.

References

1. Albright JL, Alliston CW. Effects of varying environment upon performance of dairy cattle. Journal of Animal Science. 1972; 32:566-577.
2. AOAC. Official methods of analysis. Association of official analytical chemists. Washington, D.C. 1990.
3. AOAC. Official methods of analysis. Association of official analytical chemists. Washington, D.C. 1995.
4. Armstrong DV. Effect of evaporative cooling under a corral shade on reproduction and milk production in a hot arid climate. Journal of Dairy Science. 1983; 68(1):167.
5. Armstrong DV, Wise ME, Torabi MT, Wiersma F, Hunter R, Koper E *et al.* Effect of different cooling system on milk production of late lactation Holstein cows during high ambient temperature. Journal of Dairy Science. 1988; 71(Suppl.1):212.
6. Berman A, Folman Y, Kaim M, Mamen M, Herz Z, Wolfenson D *et al.* Upper critical temperature and forced ventilation effects of high yielding dairy cows in a subtropical climatic. Journal of Dairy Science. 1985; 68:1488-1495.
7. Brody S. ‘Bioenergetics and Growth’. Reinhold, New York, USA. 1945.
8. Chan SC, Huber JT, Chen KH, Simas JM and Wu Z. Effects of ruminally intert fat and evaporative cooling in hot environmental temperatures. Journal of Dairy Science. 1997; 80:1172-1178.
9. Chen KH, Huber JT, Theurer CB, Armstrong DV, Wandesly RC, Bimas JM *et al.* Effect of protein quality and evaporative cooling on lactational performance of Holstein cows in hot Weather. Journal of Dairy Science. 1993; 76:819-825.
10. Collier RJ, Doelger SG, Head HH, Thatcher WW, Wilcox CJ. Effects of heat stress during pregnancy on maternal hormone concentrations, calf birth weight and postpartum milk yield of Holstein cows. Journal of

Animal Science. 1982; 54:309-319.

11. Flamenbaum I, Wolfenson D, Kunz PL, Maman M, Berman A. Interactions between body condition at calving and cooling of dairy cows during lactation in summer. Journal of Dairy Science. 1995; 78:2221-2229.
12. Fuquay JW. Heat stress as it affects animal production. Journal of Animal Science. 1981; 52:164-174.
13. Fuquay JW, Zook AB, Daniel JW, Brown WH, Poe WE. Modifications in free stall housing for dairy cows during summer. Journal of Dairy Science. 1979; 62:566-577.
14. Harvey WB. User's Guide for LSMLMW, mixed model least squares and maximum likelihood computer program, PC-I Version, Mimeograph, Ohio State University, Ohio, USA. 1987.
15. Hsu SH, Liu BT. The influence of stock farm microclimate on the characteristics of dairy cattle milk production. Chinese Journal of Agrometeriology. 1996; 3(2):105-109.
16. International Dairy Federation Bulletin. Recommendation methods for somatic cell counts in milk. 1984; 168:4-6.
17. Johonson HD, Regsdale AC, Berry IL, Shanklin MD. Temperature-Humidity effects including influence of acclimation in feed and water consumption of Holstein cattle. Missouri Agricultural Experimental Statistical Research Bulletein. 1963, 846.
18. Nelson FE, Tranmal H, Schuh JD, Wegner TN, Scott GH. Criteria of abnormal milk from individual quarters during period of high temperature. Journal of Dairy Science. 1969; 52:912.
19. NRC. Nutrient requirement of Dairy Cattle. 6th revised edition. National Academies Press. Washington, D.C. 1989.
20. Prasad S. Body condition scoring and feeding management in relation to production performance of crossbred cows. Ph.D. Thesis. NDRI (Deemed University), Karnal, Haryana, India. 1994.
21. Ravagnolo O, Misztal I, Hoogenboom G. Genetic component of heat stress in dairy cattle, development of heat index function. Journal of Dairy Science. 2000; 83:2120-2125.
22. Sastry GA. Clinical veterinary pathology. 2nd Edn. CBS Publishers and Distributors, Delhi. 1978.
23. Shearer JK, Beede DK. Effects of high environmental temperature on production, reproduction, and health of dairy cattle. Agriculture Practice. 1990; 11(5):6.
24. Singh M, Agarwal M. Effect of modified management on milk production and somatic cell count. XXXIII Dairy Industry Conference (26-28th September, New Delhi). 2004; 90.
25. Strickland JT, Bucklin RA, Nordstedt RA, Beede DK, Bray DR. Sprinkling and fan evaporative cooling for dairy cattle in Florida. ASAE. Paper 88-4042, American Society for Agricultural Engineer Rapid City. 1988, 12.
26. Tarzon M, Huber JT, Meena H, Nusso L, Nussio C. Effects of bovine somatotropin and evaporative cooling plus shade on lactaional performances of cow during heat stress. Journal of Dairy Science. 1999; 82:2352-2357.
27. Taylor RB, Huber JT, Gomez-Alarcon, Wiersma F, Pang X. Protein degradability and evaporative cooling on performances of dairy cows during hot environmental temperature. Journal of Dairy Science. 1991; 74:243.
28. Turner LW, Chastain JP, Hemken RW, Gates RS, Crist WL. Reducing heat stress in dairy cows through sprinkler and fan cooling. Applied Agricultural Engineering. 1992; 8(2):251-256
29. Tyrell HF, Reid JT. Production of energy value of cow's milk. Journal of Dairy Science. 1965; 48:1215-1223.
30. Wardeh MF. Models for estimating energy and protein utilization for feeds. Ph.D. Dissertation, Utah State Univ. Logan. 1981.