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Heat stress amelioration measures in lactating Nili-Ravi buffaloes: Effect on body weight changes, dry matter intake, milk production and economics

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ABSTRACT

The aim of the present study was to find out the effect of heat stress amelioration on body weight changes, dry matter intake, milk yield and economics in lactating Nili-Ravi buffaloes during hot-dry (HD; April to Mid June) and hot-humid (HH; Mid June to August) seasons under tropical climate. Forty two Nili-Ravi lactating buffaloes were uniformly divided into two groups of twenty one in each considering their lactation number, stage of lactation, body weight, dam's milk yield and milk yield in current lactation. The control (T_0) group buffaloes were kept in separate shed without any nutrient supplementation and modification in microclimate and management. The treatment (T_1) group was supplemented with niacin, yeast, edible oil in feed and provided curtains and mist fans in the shed, and altered feeding time, frequency and type of ration. The overall mean body weights in control and treatment group buffaloes were noted to be 517.4 kg and 523.4 kg, respectively. Under HD and HH seasons, mean body weights at different fortnights in treatment group buffaloes were 515.6 kg and 531.1 kg, respectively. In control group, the respective values were 512 kg and 522.7 kg. Although the body weights were higher in treatment than control group, there were no statistically significant differences between two experimental groups. The overall mean daily total dry matter intake (TDMI), dry matter intake through concentrate (CDMI), dry matter intake through dry fodder (DFDMI) and dry matter intake through green fodder (GFDMI) were noted to be 13.04, 4.21, 1.02, 7.92, 14.13, 4.24, 1.17 and 8.65 kg in control and treatment group buffaloes, respectively. Under both seasons, treatment group buffaloes consumed more dry matter than control group throughout the experimental period. The values were also differed significantly (ranged from P<0.05 to P<0.0001) between two groups. The overall mean values of fortnightly total milk production were 103.2 kg in control group and 121.5 kg in treatment group. Throughout the period, treatment group buffaloes produced more milk than control. Milk production was also significantly (P<0.0001) differed between control and treatment groups under two seasons. The daily average additional input cost per buffalo was maximum ₹22/- and additional income per buffalo was minimum 35/-. Therefore, the net profit was around 13/- per buffalo per day. The input: output ratio was calculated to be 1:1.59. It can be concluded that the use of such types of housing, nutritional and management interventions in the form of one package not only helps to maintain body weight but also increases dry matter intake and favours economic milk production in lactating buffaloes through reducing heat stress during hot-dry and hot-humid seasons in tropical climate.

Key words: Body weight, Dry matter intake, Economics, Heat stress amelioration, Lactating buffalo, Milk yield.

INTRODUCTION

Lactating buffaloes are affected badly due to thermal stress. Feed intake, metabolism and physiology (Marai and Haeeb, 2010) are drastically changed which suppress the body growth of buffaloes (Moss 1993), decrease dry matter intake (Collier *et al.*, 1982; NRC, 1989; West, 1998; Kadzere *et al.*, 2002; West, 2003; West *et al.*, 2003; Pereira *et al.*, 2008; Hooda and Singh, 2010) and ultimately, decrease milk production (McDowell *et al.*, 1976; Kadzere *et al.*, 2002). Per unit cost of production becomes higher and uneconomic to the dairy owners. Under this situation, modifications of microclimate, alterations of feeding and management are the solution to combat heat stress particularly during hot dry and hot humid season of tropical region to exploit the full genetic potentiality of buffaloes. Lot of information is available in the scientific literature to alleviate the effect of heat stress in lactating animals. But, studies by most of the researchers were either conducted only on microclimate modifications or nutritional interventions or management alterations. The benefits and deficiencies of various types of sheds and cooling in cows were discussed in another report (Armstrong, 1994). The effect of different cooling systems on milk yield and

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performance was studied by earlier workers (Igono *et al.*, 1985; Ryan *et al.*, 1992; Turner *et al.*, 1992; Lin *et al.*, 1998; Ghosh and Prasad, 2007; El-Khashab, 2010). Many findings (Srivastava *et al.*, 1978; Tomer, 1980; Kumar *et al.*, 1993; Singh *et al.*, 2005) are available on the effect of wallowing on the productive and reproductive performance in buffaloes. Nutritional management for the lactating dairy cow under hot climate was also extensively reviewed (Fuquay *et al.*, 1981; Beede and Collier, 1986; Sanchez *et al.*, 1994; West 1995). Some reports depicted that the supplementation of fat (Knapp and Grummer, 1991; Huber *et al.*, 1994; West, 1995; Chan *et al.*, 1997), niacin (Muller *et al.*, 1986) and yeast (Shwartz *et al.*, 2009) in the diet helped to increase milk yield. The reference is very limited regarding the use of all interventions combined together in the form of one package along with cost benefit ratio in lactating buffaloes. Thus, there is an urgent need to prepare a cost effective recommendations for the dairy owners through using a standard package of practices for amelioration of heat stress especially in buffaloes. Therefore, in this experiment, an attempt has been made to consolidate the available information from the earlier experiments on heat stress ameliorative measures in lactating Nili-Ravi buffaloes as one package and to evaluate the package techno-economically and to develop specific recommendations for buffalo keepers to improve production performance particularly during summer months under tropical climate. The objective of the study was to find out the effect of heat stress amelioration on body weight changes, dry matter intake, milk yield and economics in lactating Nili-Ravi buffaloes under tropical climate.

MATERIALS AND METHODS

Location of the study: The present study was conducted at Central Institute for Research on Buffaloes, Regional Station-Bir Dosanjh, Nabha (latitude, 30° 22' 28" N and longtitude, 76° 8' 54" E), Patiala, Punjab, India over hot-dry (HD; April to Mid June) and hot-humid (HH; Mid June to August) seasons. The elevation of the area is about 250 m above sea level. The ambient temperature reaches near 1°C in winter season and 45°C in summer. The average annual rainfall is around 700 mm.

Experimental design: Total forty two Nili-Ravi lactating buffaloes, maintained at Central Institute for Research on Buffaloes, Regional Station-Bir Dosanjh, Nabha, Patiala, Punjab, were taken to find out the effect of heat stress amelioration on body weight changes, dry matter intake, milk yield and economics in lactating Nili-Ravi buffaloes during hot-dry (HD; April to Mid June) and hot-humid (HH; Mid June to August) seasons. Total lactating buffaloes were uniformly divided into two groups of twenty one in each group considering their lactation number, stage of lactation, body weight, dam's highest milk yield and milk yield in current lactation. One group was considered as treatment and another as control. The treatment (T_1) group was supplemented with feed graded niacin (≤ 95% niacin) @ 6 gm/buffalo/day, feed graded yeast @ 10 gm/buffalo/day (*Saccharomyces cervisiae* @100 billion C.F.U. per 25 gm) and edible oil i.e. mustard oil @150gms/buffalo/day in feed. The side of shed was covered with curtains, mist fans (misting apparatus) and ceiling fans to modify microclimate for animals' comfort. The feeding time, frequency and type of ration were also altered. The farm prepared balance concentrate mixture was fed to all buffaloes. In control group, green fodder was chopped and required amount was supplied to the buffaloes twice in a day i.e. around 10 AM and 3 PM. The microclimate modifications, management alterations and feeding regime of two groups are presented in Table 1.

Table 1: Microclimate modifications, management alterations and feeding regime of lactating Nili-Ravi buffaloes under different groups

Parameters	Control group (T_0)		Treatment group (T_1)		
Microclimate modifications	No mist fan 4 Ceiling fans Two times wallowing		Fogger/mist fan Addl. (6) ceiling fan Addl. (2) washing with water		
Management alterations	Two times feeding		Three times feeding Feeding during cool hours		
Nutrient supplementation	Nil		Niacin (6 gm/buffalo/day), Yeast (10 gm/buffalo/day) and Mustard oil (150 gm/buffalo/day)		
Concentrate feed	½ part provided during morning milking around 4 AM	½ part provided during evening milking around 4 PM	½ part mixed with nutrient supplements ½ part provided during morning milking around 4 AM	½ part provided during evening milking around 4 PM	½ part (without nutrient supplements) mixed with green fodder and straw & provided around 12 noon
Water	Clean, fresh and *Ad lib.*		Clean, fresh and *Ad lib.*		

Management of animals: Both control and treatment group buffaloes were kept in separate sheds. They were tied throughout 24 hours except wallowing time in a tail to tail conventional housing system and fed individually within the shed during whole experimental period. As a routine practice of the farm, during summer months, both groups were allowed to wallowing tank for 10-15 minutes and two times in a day i.e. around 7 AM and 2.30 PM. The minimum and maximum temperature within shed of control and treatment group buffaloes were 17°C and 42°C, and 15°C and 38°C, respectively during hot dry (HD) period. The respective values during hot humid (HH) period were 20°C and 40°C, and 19°C and 36°C.

Recording of parameters: Before dividing experimental buffaloes in two uniform groups, they all were weighed consecutive three days early in the morning without offering any feed, fodder and water to them. The averages of three days body weight values were taken into account to minimize error in weight of individual buffalo. The body weight was taken at the start of experiment and then, at fortnightly interval till end of experiment.

Both groups were provided with measured quantity of concentrate, dry fodder and *ad lib.* chaffed green fodder in a particular day of one week. In the very next day, the left-over concentrate, dry fodder as well as green fodder were weighed to calculate the actual intake of individual buffalo. Then, group-wise intake was calculated. Dry matters of concentrate feed, dry fodder and green fodder were analysed. Thus, total dry matter intake (TDMI) through concentrate (CDMI), dry fodder (DFDMI) and green fodder (GFDMI) were calculated for two groups. The standard concentrate mixture, prepared in the farm, was used for the study. As per availability at the farm, barseem, chopped maize, jowar and hybrid napier were fed to all experimental buffaloes as green fodder and wheat straw as dry fodder.

Buffaloes were milked individually through hand milking twice in a day i.e. in the morning and evening. Total milk yield for each buffalo in a day was measured. Group-wise total milk yield under different fortnights and seasons (hot dry and hot humid) were calculated to compare results. Finally, considering the different input and output costs economics of both the groups were calculated.

Statistical analysis: All data pertaining to body weight, dry matter intake and milk production in control (T_0) and treatment (T_1) group during HD and HH seasons are reported as means ± S.E.M. Data were analysed by the method of analysis of contrast variables using the GLM (generalized linear model) procedures on analysis of variance for repeated measures using the Greenhouse-Geisser adjusted univariate significance tests as described by earlier procedure (Little *et al.*, 1998). The differences between treatment means were considered to be significant when P<0.05.

RESULTS AND DISCUSSION

The minimum and maximum temperature during hot-dry period ranged from 17°C to 25 °C, 40 °C to 42 °C, respectively in control group buffalo shed. The mean

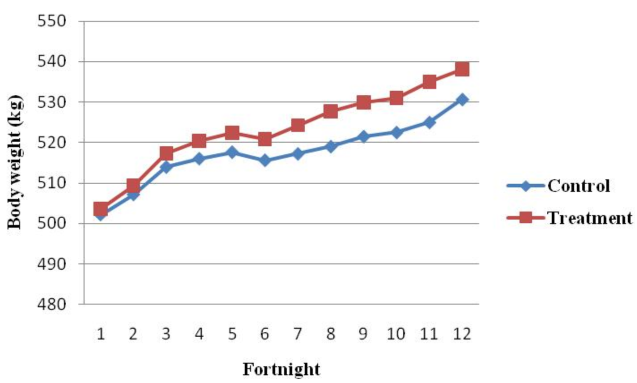

Fig 1: Fortnightly mean body weight changes of lactating Nili-Ravi buffaloes in different groups

Table 2: Mean body weight, dry matter intake and milk yield of Nili-Ravi buffaloes in different groups under hot-dry and hot-humid season

Parameters	Season	Controlgroup	Treatment group	SEM	P Value
Body weight (kg)	Hot dry	512.06 ± 12.49	515.60 ± 12.49	4.976	0.842
	Hot humid	522.65 ± 13.74	531.11 ± 13.74	6.185	0.666
Dry matter intake (kg/day)					
Concentrate	Hot dry	3.96 ± 0.02	4.03 ± 0.02	0.050	0.044
	Hot humid	4.47 ± 0.00	4.48 ± 0.00	0.000	-
Dry fodder	Hot dry	1.33 ± 0.03	1.52 ± 0.03	0.032	<0.0001
	Hot humid	0.70 ± 0.01	0.82 ± 0.01	0.012	<0.0001
Green fodder	Hot dry	8.03± 0.04	9.02 ± 0.04	0.052	<0.0001
	Hot humid	7.82 ± 0.04	8.29 ± 0.04	0.036	<0.0001
Total	Hot dry	13.09 ± 0.06	14.32 ± 0.06	0.230	<0.0001
	Hot humid	12.99 ± 0.26	13.94 ± 0.26	2.632	0.012
Fortnightly milk yield(kg)	Hot dry	104.60	118.70	4.294	0.049
	Hot humid	96.42	122.65	5.495	0.001

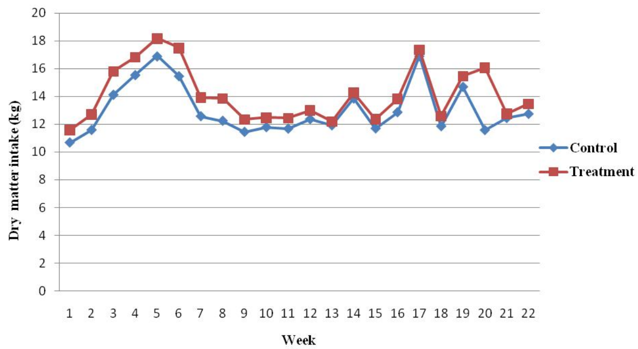

Fig 2: Weekly mean total dry matter intake (TDMI) of lactating Nili-Ravi buffaloes in different groups

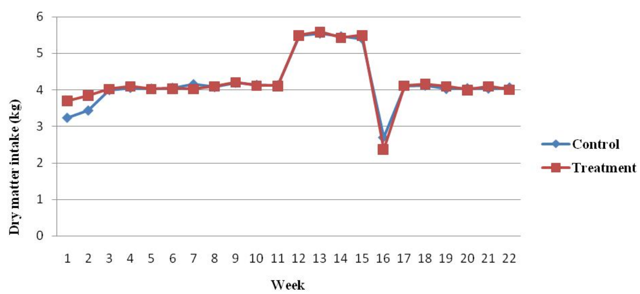

Fig 3: Weekly mean dry matter intake through concentrate (CDMI) of lactating Nili-Ravi buffaloes in different groups

respective values during hot-humid period were noted to be 20 ºC to 22 ºC and 37 ºC to 40 ºC. Whereas, in treatment group, the minimum and maximum temperature of shed during hot-dry and hot-humid periods were recorded as 15ºC to 21 ºC, 35 ºC to 38 ºC, 19 ºC to 21 ºC and 33 ºC to 36 ºC, respectively. The report of Ghosh and Prasad (2007) envisaged that shed of crossbred cows with evaporative cooling had lower maximum and minimum temperatures than the shed only with fan. In their study, former shed had significantly lower dry and wet bulb temperature during morning and afternoon hours than later. In another experiment of dairy cows, Taylor *et al.* (1991) pointed out that the evaporative cooling system reduced maximum daily temperature by 5.6 ºC. The results in respect of maximum and minimum temperature within the buffalo shed of present investigation also showed similar findings under both HD and HH seasons.

The overall mean body weights irrespective of any season in control and treatment group buffaloes were noted to be 517.4 and 523.4 kg, respectively. The mean body weight of lactating buffaloes at the start of experiment was 502.1 kg in control group and 503.5 kg in treatment group. The mean final body weights in the respective groups were noted to be 530.7 and 538.1 kg. Figure 1 depicted fortnightly mean body weight changes of lactating Nili-Ravi buffaloes in different groups throughout the experimental period.

Considering the HD season, the mean body weight in treatment group buffaloes was 515.6 kg which was comparatively higher than control (512 kg) group. Under HH season, the mean weights in control and treatment group buffaloes were recorded as 522.7 kg and 531.1 kg, respectively (Table 2). Although the body weights were higher in treatment group than control, but, there were no statistically significant differences between two experimental groups. The reference is very limited in the literature to compare the present study when considering the effect using different interventions combined together in the form of one package on body weight changes. However, in an experiment, Ghosh and Prasad (2007) found that crossbred cows kept in loose shed with a provision of only fan lost more body weight (-0.69 kg/cow/fortnight) compared to cows kept in loose shed with fan and water sprinkling (-0.15 kg/cow/fortnight). In 2-year old buffalo heifers, Moss (1993) noted the decreased growth rate reared under sub-tropical conditions, during warm and hot seasons.

The overall mean daily total dry matter intake (TDMI) was 13.04 kg in control and 14.13 kg in treatment group buffaloes irrespective of any season. At first week of experiment, the mean TDMI was noted to be 10.7 kg and 11.6 kg in control and treatment group, respectively. The

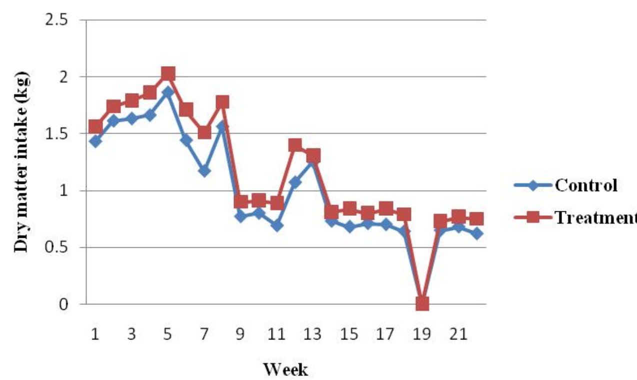

Fig 4: Weekly mean dry matter intake through dry fodder (DFDMI) of lactating Nili-Ravi buffaloes in different groups

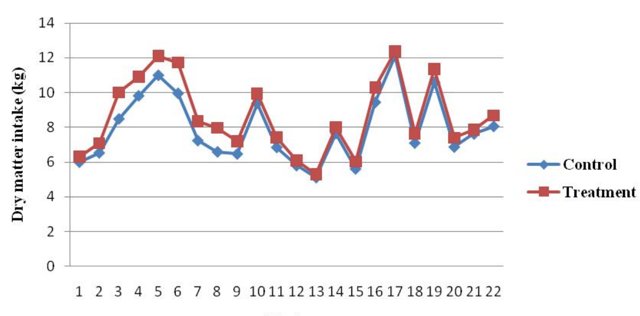

Fig 5: Weekly mean dry matter intake through green fodder (GFDMI) of lactating Nili-Ravi buffaloes in different groups

respective values at the last week were 12.7 kg and 13.5 kg. Figure 2 depicted mean TDMI of lactating Nili-Ravi buffaloes at different weeks under two groups. During HD season, control group buffaloes consumed average 13.1 kg TDMI and treatment group 14.3 kg (Table 2).

Similarly, high TDMI was recorded during HH season in treatment group (13.4 kg) than control (13.0 kg) group. There were statistically highly significant (P<0.001 and P<0.01) differences among the values between groups. The overall mean dry matter intake through concentrate (CDMI) in a day was 4.21 kg in control and 4.24 kg in treatment group. Treatment group buffaloes took either little bit higher or almost similar amount of dry matter than control group throughout the experiment. The trend of CDMI of two groups was similar from beginning to the end of experiment. Weekly mean CDMI of lactating Nili-Ravi buffaloes in different groups has been presented in Figure 3.

Table 2 indicated that the mean CDMI in control and treatment group under HD and HH seasons was almost similar (3.96 kg and 4.03 kg vs. 4.47 kg and 4.48 kg). But, the difference was statistically significant (P<0.04). The overall mean dry matter intake through dry fodder (DFDMI) per day was 1.02 kg and 1.17 kg in control and treatment group, respectively. Throughout the experiment DFDMI was slightly higher in treatment than control group. The trend has been depicted through graph (Figure 4).

Due to the high dry matter content of supplied green fodder at 19^{th} week of experiment, the buffaloes were not offered dry fodder separately. However, under both seasons, mean DFDMI was comparatively higher in treatment than control group buffaloes (Table 2). The values were also significantly (P<0.0001) differed between two groups. The overall mean daily dry matter intake through green fodder (GFDMI) was recorded as 7.92 kg in control and 8.65 kg in treatment group. Mean GFDMI of lactating Nili-Ravi buffaloes at different weeks in two experimental groups is presented in Figure 5.

When seasons were taken into account, both HD and HH periods showed comparatively lower GFDMI in control group than treatment (Table 2). The difference of the values were also highly significant (P<0.0001) among two groups.

In spite of offering same amount of green fodder, dry fodder and concentrate mixture to both the groups throughout the experimental period, the feed consumption in treatment group was more as compared to control group buffaloes which might be due to the good comfort of lactating buffaloes arising from the modification of microclimate,

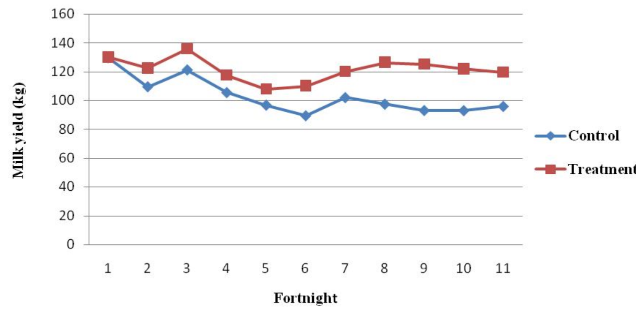

Fig 6: Fortnightly mean milk yield of Nili-Ravi buffaloes in different groups

Table 3: Economic feasibility of milk production in heat stress ameliorated buffaloes

Parameters	Approximate cost in Indian Rupee (₹)
A. Expenditure (₹) per buffalo per day	
Feed graded Niacin	2.5
Feed graded Yeast	2.0
Mustard oil	10.5
Other costs (Depreciation cost of fogger fan, electricity charge, additional labour charge, etc.)	7.0
Subtotal	22.0*
B. Income (₹)per buffalo per day	
Sale of additional milk produced	35.0
C. Net Profit per buffalo per day	35.0-22 = 13.0
D. Input: Output	1:1.59

*Cost of additional dry matter intake is not included.

alteration of feeding and management practices. National Research Council (1989) pointed out that feed intake in lactating cows began to decline at ambient temperatures of 25-26 °C and dropped more rapidly above 30 °C and at 40 °C, dietary intake might decline by as much as 40%. The reports of low dry matter intake due to high ambient temperature were also recorded by West (1998), West (2003), West *et al.* (2003), Pereira *et al.* (2008) and Hooda and Singh (2010). Collier *et al.* (1982) noted the dramatic reduction of roughage intake due to heat stress in high producing lactating dairy cows. The decreased intake might be either due to the stimulation of the medial satiety centre of the hypothalamus resulting from heat stress which ultimately inhibited the lateral appetite centre of hypothalamus of animals (Albright and Alliston, 1972) or elevated body temperature or related to gut fill (Silanikove, 1992). Kadzere *et al.* (2002) concluded that during summer, animals decreased their feed intake to create less metabolic heat. The reduction in feed intake with corresponding decline in heat generated by rumen fermentation and body metabolism aided in the maintenance of homeothermy (Beede and Collier, 1986). On the other hand, higher feed intake by buffaloes in summer due to thermal ameliorative measures was also noted by Tomer

(1980), Kumar *et al.* (1993) and Singh *et al.* (2005). Their findings also support the results of the present study.

The overall mean fortnightly total milk production was 103.2 kg in control group and 121.5 kg in treatment group. At first fortnight of experiment, mean milk production of both groups was almost similar (130 kg). But, at last fortnight of experiment, treatment group buffaloes produced more milk (119.6 kg) than control (96.0 kg). Similar trend of higher milk production in treatment group was recorded throughout the experimental period (Figure 6).

As per season was concerned, both HD and HH season (Table 2) had higher mean milk production in treatment group (118.7 and 122.7 kg) than control group buffaloes (104.6 and 96.4 kg). Milk production was also significantly ($P<0.0001$) differed between control and treatment group under two seasons.

As per available reports in the literature, earlier researchers used any one out of different heat stress amelioration techniques in dairy animals to combat heat stress for improving milk production during summer seasons. Out of those earlier reports, McDowell *et al.* (1976) pointed out that the milk production was reduced by 15% when lactating Holstein cows were transferred from an air temperature of 18 to 30 ^{o}C. Benefits from sprinkling and fans were reported in a temperature, humid climate (Kentucky), where cows yielded 3.6 kg more milk (15.9%) while consuming 9.2% more feed per day than controls (Turner *et al.* 1992). Missouri and Israeli work showed milk yield increases of 0.7 kg/d in moderate temperatures (Igono *et al.*, 1985). Lin *et al.* (1998) reported that a combination of misters and fans was equally effective to maintain feed intake and milk yield in cows as sprinklers and fans in Alabama work. In other experiments, Takamitsu *et al.* (1987) and Ryan *et al.* (1992) highlighted that evaporative cooling systems improved the environment for lactating dairy cows in arid climates. Sharma *et al.* (1983) concluded from their studies that climatic conditions had maximum influence during the first 60 days of lactation when high producing cows were in negative energy balance and made up for the deficit by mobilizing body reserves. There was 11.6% improvement in milk yield when cows were sprayed for 1.5 min of every 15 min of operation (Strickland *et al.*, 1988). The greater energy density and high energy conversion efficiency of high-fat diets may be particularly beneficial during hot weather. However, research on the effects of dietary fat during hot weather gave inconsistent results (Huber *et al.*, 1994). In one experiment, diets containing 5% added fat fed to cows in either thermoneutral or hot environment conditions did not improve milk yield (Knapp and Grummer, 1991). Chan *et al.* (1997) showed that milk yield was improved only by the cooling, not by the fat supplementation. The findings of Muller *et al.* (1986) favoured the supplementation of niacin in feed of lactating cows during summer months. In their experiment supplementation significantly increased milk production. Experiment conducted by Shwartz *et al.* (2009) envisaged that feeding a yeast culture did not prevent or ameliorate the negative effects of heat stress on production measures in lactating Holstein cows. It was cleared from earlier studies that heat stress resulted decrease in milk production which might be due to either low dry matter intake (Kumar *et al.*, 1993; Ghosh and Prasad, 2007) or negative effect of secretary function of the udder resulting from heat stress (Silanikove, 1992) or low nutrient availability (Fuquay *et al.*, 1981; Sanchez *et al.*, 1994; West 1995) or combined effects of all together.

Table 3 represents the economic feasibility of milk production due to heat stress amelioration in buffaloes. It clearly depicted that daily average cost of additional input (except cost of additional dry matter) per buffalo was maximum 22/- and additional income from one buffalo was minimum 35/-. Therefore, the net profit in a day was around Rs. 13/- from each buffalo. The input: output ratio was calculated to be 1:1.59. When cost of additional dry matter intake, per buffalo, was considered in treatment group, the maximum input cost became 28/- the net profit per buffalo per day reduced to 7/- approximately. The input: output ratio also came down to 1:1.25. In practice, both groups of buffaloes were offered *ad libitum* and equal amount of roughage.

Hence, the roughage utilization was increased in treatment group and wastage was reduced. This may be considered as saving, if there is no proper programme for waste recycling. Ghosh and Prasad (2007) concluded that evaporative cooling was conducive towards more economical returns from the lactating cows. Similar findings were also put forth by Igono *et al.* (1985). They calculated that when all costs were considered, there was a $ 0.22 per cow per day profit via improved milk yield. Strickland *et al.* (1988) noted that an additional return to the tune $ 96 per cow per annum over 210 days of operation was possible for cows provided evaporative cooling. In a study conducted to evaluate thermal comfort and economic viability of different types of dairy shelters with cooling systems (fan ventilation, spray cooling, and both) and no cooling system (control), maximum increase in milk yield of 12.21% as compared to control was observed in dairy shelter with both fan ventilation and spray cooling (Kaur *et al.*, 2003). The percentage increase in monthly returns was calculated as 9.91% *vis-a-vis* control for the same system.

CONCLUSION

From the above experiment, it can be concluded that the use of such types of housing, nutritional and management interventions in the form of one package not only helps to maintain body weight but also improves dry matter intake and favours economic milk production in lactating buffaloes through reducing heat stress during hot-dry and hot-humid seasons under tropical climate.

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