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Effect of Deep Bedded Pack System in Manure Management for Reducing Heat Stress of Cattle in Bangladesh

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ABSTRACT

Background: Heat stress has a considerable effect both on animal welfare and production. Animals in heat stressreduceproductivity and reproductive performances and in extreme cases, it causes death.

Methods: The experiment was carried out in Satkhira, a South-Western part of Bangladesh from July 2019 to June 2020 for12 monthsperiod to investigate the year-round heat stress experienced by cattle raised in a Deep Bedded Pack System (DBP) compared to that raised on a concrete floor (CF) system in an open barn. A total of six dry cows (2.5 to 3 yearsold, Holstein-Friesian crossbred) were allotted into two groups with three replications. The deep bedded pack was prepared with rice husk. The heat stress was calculated by following an equation using temperature and humidity data.

Result: Animals raised on a concrete floor were suffered moderate to severe heat stress for eight months in a year from March to October. Otherwise, animals on the DBP floor were suffered from moderate heat stress only for five months, from June to October in a year. No severe case was found on the DBP floor but severe heat stress was shown by animals on the concrete floor from July to September. Therefore, animals feel more comfortable in the DBP management system.

Key words: Animal welfare, Deep bedded pack, Heat stress, Temperature humidity index.

INTRODUCTION

Heat stress is defined as the sum of external forces acting on an animal that causes an increase in body temperature and evokes a physiological response (Thornton *et al*., 2022). In Bangladesh, heat stress in cattle is chronic, there is often little relief from the heat during the evening hours and intense bursts of combined heat and humidity further depress performance (MoAg, 2018). Bangladesh has a humid, warm climate influenced by pre-monsoon, monsoon and post-monsoon circulations and frequently experiences heavy precipitation and tropical cyclones (MoAg, 2020). It has experienced average temperatures of around 26°C but ranges between 15°C and 34°C throughout the year (MoAg, 2018). Bangladesh has a hot and dry climate from March to May/June; rainy from June/July to November; and cool and dry from December to February (MoAg, 2018).

Literature has shown that heat stress can cause yield loss of up to 600 to 900 kg of milk per cow per year (Dhar, 2019). Excessive flow of energy (in the form of unabated heat) into the body, in addition to energy depletion required for lactation and growth (Ferrell and Jenkins, 1985) can lead to deteriorated living conditions, reduced quality of life and, in extreme cases, death (Made *et al*., 2006; Polsky and Von-Keyserlingk, 2017). Thus, it is necessary to reduce the heat stress to the animal by providing a comfortable environment which ultimately increases production and productivity.

However, dairy farming on a concrete floor is the most widely followed housing system in all over the world (Shane *et al*., 2010). Alterations in housing and management strategies have to be attempted to reduce the heat stress to the animals.Environmental modifications should target the effects of high temperatures on cow body temperature and should modify the environment at critical times during the day or night either by providing fan or by shower or by using bedding or by other means depending upon the season when cows are stressed (Polsky and Von-Keyserlingk, 2017; Thornton *et al*., 2022). In this context, deep bedded pack system may be a better option. A deep bedded pack (DBP) is an arrangement of rearing animals in which actively managed composting is practiced with manure, urine, washed water and leftover forages. It is a housing system consisting of a large, open resting area, usually bedded with sawdust or dry, fine wood shavings and manure composted into place and mechanically stirred regularly (Woodford *et al*., 2018). This system was first introduced in the USA in 1980 and thereafter, it is now practiced in many countries all over the world but in Bangladesh still, it is entirely untouched.

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Thus, this experiment was conducted to evaluate the year-round heat stress in cattle reared onconcrete floor system and deep bedded pack (DBP) system.

MATERIALS AND METHODS

The experiment was carried out in Satkhira district of Bangladesh under the Department of Animal Science, Bangladesh Agricultural University (BAU), Mymensingh from July 2019 to June 2020 for 12 months period to investigate the year-round heat stress experienced by cattle raised in a Deep Bedded Pack System (DBP) compared to that raised on a concrete floor (CF) system in an open barn. The Satkhira is located at the GPS coordinates of 22°43′24.26″ N and 89°4′30.45″E at an altitude of 2.74 m from sea level (Google search). In the study, a deep bedded pack (16 inches thick) was made by using rice husk, gravel and chopped dry banana stem. Altogether sixdry cows (2.5 to 3 years old, Holstein-Friesian cross) were allocatedin complete randomized design (CRD) in both systems with three replications.All experimental animals were drenched against internal and external parasites before the onset of the trial. Regular health checkups were done. Each animal was offered *ad libitum* clean drinking water throughout the experimental period. Grass, straw and concentrate feeding was done regularly. A total of 100 ft^2 floor space was provided to each animal. Initially, two hundred Kg of rice husk was used as bedding material. Ten kg rice husk was added fortnightly to make the floor space dry. Similarly, naturally produced indigenous microorganisms (IMOs) were also added fortnightly to reduce the bad odor and for faster decomposition of the bedded pack. A fan was provided in each system for drying the bedding and exhausting the bad smell from the shed. Environmental parameters (temperature and humidity) were recorded every day by using combined Temperature and Humidity Meter. With the help of temperature and humidity data, Temperature-Humidity Index (THI) value was calculated by using the common and simplest formula which is given below (Armstrong, 1994). Then, the classes of heat stress were measured with the THI value.

$$THI = 0.8 \times T + RH \times (T - 14.4) + 46.4$$

Where,

T = Ambient temperature in °C

RH= Relative humidity expressed as a proportion *i.e.* 75% humidity is expressed as 0.75.

The class of heat stress was divided according to the THI (Temperature-Humidity Index) chart of Armstrong (1994). In his chart, THI classified below 72 as a comfort zone, values from 72 to 79 as mild stress, from 80 to 89 as moderate stress and above 90 as severe stress.

RESULTS AND DISCUSSION

Annual temperature at Satkhira District in Bangladesh

Fig 1 illustrated that Satkhira's climate experienced average temperatures around 28.95°C, but ranged between 32.37°C and 25.52°C. The warmest month and the coolest month were found in May (36.77°C) and January (16.45°C) respectively. In March (36.52°C) and April (36.72°C), temperatures were found almost similar to that of May (36.77°C). Similarly, the second and third coolest months were found in December and February with temperatures of 17.12°C and 18.55°C respectively. The temperature ranged from 34.11 to 29.61, 34.17 to 28.67, 35.45 to 28.44, 33.49 to 27.61, 31.33 to 26.52, 25.46 to 17.12, 24.12 to 16.45, 26.17 to 18.55, 36.52 to 25.78, 36.72 to 28.67, 36.77

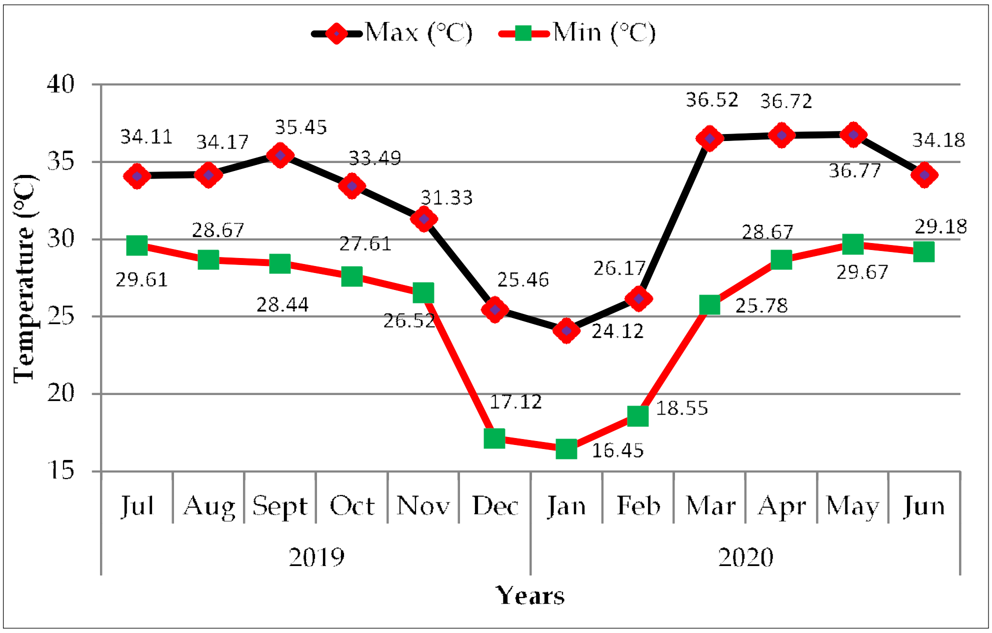

Fig 1: The maximum and minimum temperature in Satkhira.

to 29.67 and 34.18 to 29.18 in July, August, September, October, November, December, January, February, March, April, May and June respectively.

In Satkhira, the wet season is hot, oppressive and mostly cloudy and the dry season is warm and mostly clear. Over the year, the temperature typically varies from 57°F to 93°F and is rarely below 52°F or above 98°F (MoAg, 2020).

Bedding temperature, shed temperature and humidity

In the summer month average shed temperature was found higher than the average bedding temperature. However, shed temperature was found lower than bedding temperature in winter months *i.e.* December and January. From July to September, the average shed temperature remained almost similar (34°C), then dropped continuously up to January and reached 23.99°C. Similarly, the average bedding temperature remained at the nearly same temperature (30°C) from July to October and then started dropping and reached 24.08°C in January 2020. In January 2020, average shed temperature and average bedding temperature were found almost similar (24°C). In both cases in succeeding months, the temperature started rising. The average shed temperature reached the maximum (36.69°C) in April and then started decreasing and reached 32.10°C in June. However, in the case of DBP, the maximum average temperature was observed in March and April (31°C) and then remained almost similar up to June (30.50°C). Average annual bedding temperature and shed temperature were recorded at 28.92°C and 31.78°C, respectively.

However, in DBP, the average bedding temperature ranged from 24.08°C (lowest) to 31.00°C (highest) in the same year. The temperature difference was found 12.7°C and 6.92°C in average shed temperature and average bedding temperature in the study year respectively. The temperature difference between average shed temperature and average bedding temperature was found 5.78°C. In the summer months, the average bedding temperature in DBP was ranged from 29.75°C to 31.00°C which was ranged from 32.10°C to 36.69°C in CF. In addition to that in the winter months (December and January), the average bedding temperature in DBP was found higher than the shed temperature. That is why animals can feel more comfortable and do not suffer from high and low heat stress in deep bedded pack than in a concrete floor.

Findings manifested that the annual average humidity (%) in DBP shed was found at 69.30%. Humidity was recorded at more than 80% in four months (July, September, October and June). In July, the humidity value was recorded as the highest (85.84%). In August, it was found at 79.94%, however, it was observed almost similar (65%) in the months November to January. The humidity value was recorded as the lowest in February (53.71%). Furthermore, March, April and May it was found almost similar (54%). From May to June, humidity values were found to more fluctuate (54.52% to 85%).

Barberg *et al*. (2007) studied CBP in Minnesota and reported a mean pack temperature of 42.5°C at depth of 20 cm. Similarly, in CBP using wood chips and aeration systems, the pack temperature at a depth of 20 cm ranged from 34.6 to 57.7°C, whereas in CBP with no aeration systems using organic waste compost as bedding, the pack temperature at the same depth was between 16 and 34°C (Galama, 2011).

According to MoAg (2020) average relative humidity (RH) in the Satkhira district in the year 2019 was recorded at 66.16%. The RH was recorded 47.3%, 44.47%, 50.38%, 60.90%, 66.74%, 73.41%, 82.30%, 85.08%, 86.13%, 80.07%, 64.09% and 52.91% in January, February, March, April, May, June, July, August, September, October, November and December respectively (MoAg, 2020).

Heat stress to the animals

Results clarified that animals in concrete floor shed suffered from severe stress with THI values of 90.26, 90.12 and 91.00 in July, August and September. Furthermore, in October, March, April, May and June animals were found suffering

Table 1: Temperature humidity index value (THI) and classes of heat stress in animals housed in deep bedded pack (DBP) barn and concrete floor (CF) in different months of the year.

Years	Months	Average bedding temp (°C)	Shed temp (°C)	Humidity (%) in cattle shed	THI in DBP	THI in CF	Classes of THI in DBP barn	Classes of THI in CF
2019	Jul	29.75	33.95	85.84	83.31	90.26	Moderate stress	Severe stress
	Aug	30.22	34.54	79.94	83.23	90.12	Moderate stress	Severe stress
	Sep	30.28	34.45	84.80	84.12	91.00	Moderate stress	Severe stress
	Oct	29.65	32.16	82.00	82.63	86.69	Moderate stress	Moderate stress
	Nov	27.89	29.02	65.40	77.62	79.27	Mild stress	Mild Stress
	Dec	26.35	24.92	65.97	75.37	73.28	Mild stress	Mild stress
2020	Jan	24.08	23.99	65.32	71.67	71.54	Comfort stress	Comfort stress
	Feb	25.82	28.33	53.71	73.22	76.59	Mild stress	Mild stress
	Mar	31.00	35.88	54.61	79.89	86.92	Mild Stress	Moderate stress
	Apr	31.00	36.69	54.52	79.87	88.01	Mild Stress	Moderate stress
	May	30.50	35.37	54.52	79.66	86.23	Mild stress	Moderate stress
	Jun	30.50	32.10	85.00	84.49	87.13	Moderate stress	Moderate stress
Average		28.92	31.78	69.30	79.59	83.92		

from moderate heat stress with THI values of 86.69, 86.92, 88.01, 86.23 and 87.13 respectively. In addition to that animals were observed affected by mild heat stress in November, December and February with THI values of 79.27, 73.28 and 76.59. The highest THI was observed in September (91.00) and the lowest THI was observed in January (71.54). However, in the case of the deep bedded pack; animals were not affected by severe stress. In most of the months *i.e.* June, July, August, September and October animals were observed suffering from moderate stress with THI values of 84.49, 83.31, 83.23, 84.12 and 82.63 respectively. Moreover, in February, March, April, May, November and December animals were found suffering from mild stress with THI values of 73.22, 79.89, 79.87, 79.66, 77.62 and 75.37 respectively. In January, animals were found in comfort zone with a THI value of 71.67. The highest THI was observed in June (84.49) and the lowest THI was observed in January (71.67). In all months THI value in the DBP was found lower than the THI value in the concrete floor except in January and February. Therefore, it can be concluded that animal feels more comfortable in DBP system than in CF system. Details of THI value and classes of heat stress are presented in Table 1.

Heat stress is a common problem on dairy farms worldwide in tropical climates. Psychological stress can be increased with changes in the social structure of cattle (Moberg and Mench, 2000). Increasing ventilation rates may increase the evaporation of moisture from the bedded pack barn and prevent heat stress during warmer times of the year (Dhar, 2019; Leso *et al*., 2019). Heat stress results from a combination of several weather variables including high ambient temperature, humidity, solar radiation and wind speed, with negative impacts on both animal welfare and productivity (Thornton *et al*., 2022). Depending on species and breed, cattle can experience thermal stress at temperatures higher than 20°C (Herbut *et al*., 2019). Fans can increase the air movement rate over the surface of the bed, which increases bed drying and reduces heat stress (Polsky and Von-Keyserlingk, 2017). Dhar (2019), in his experimental period from December 2018 to June 2019, the highest average temperature-humidity index (THI) were 66.22±5.55, 69.82±5.83, 72.80±5.42, 76.43±2.89, 78.93±1.75, 80.29±2.06 and 83.58±2.77 in December, January, February, March, April, May and June, respectively. The summer and winter months altered the internal temperature for compost bedded back barns (31.8 to 48.1°C and 13.8 to 40.6°C, respectively (Shane *et al*., 2010). Bjerg and Klaas (2014) reported that compost bedded pack barns maintained internal pack temperatures 20 to 40°C above the ambient temperature (0°C in the winter months). Leso *et al*. (2019) calculated a lower THI value in CBP than in free stall barn and straw yard. A similar result was also obtained in a study by Dhar (2019). Alteration in housing and management strategies can reduce the heat stress in dairy cows. Provision of fans, mister, showers, proper selection of barn construction materials, beddings, feeding and reproductive management can provide thermal relief for dairy cows when challenged by an abrupt environmental heat load (Polsky and Von-Keyserlingk, 2017).

CONCLUSION

Heat stress has become a major concern for cattle producers because of the associated decreases in milk production, lower growth rate and huge economic losses in tropical countries like Bangladesh. In this study, animals reared on deep bedded pack system suffered less heat stress than animals reared on concrete floor system. Animals in the deep bedded pack system did not feel severe heat stress in any month of the year whereas animals reared in the concrete floor system felt severe heat stress in July to September. Therefore, animals feel less stress and more comfortable in deep bedded pack system.

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