PERFORMANCE OF CROSSBRED CALVES UNDER MODIFIED HOUSING SYSTEM DURING HOT-HUMID SEASON

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ABSTRACT

The present study was conducted on crossbred (*Vrindavani*) cattle calves to evaluate the effect of modified housing using different roofing materials on growth and physiological performance of calves during the rainy season. A total of twenty four calves (9-11 months old) were randomly selected and allocated in 4 groups viz. control (C): corrugated cemented sheet (CCS) as roofing material, T1: the CCS roof was painted black inside and white outside, T2: polycarbonate plastic sheet as roof and T3: polycarbonate roof with adjustable height. The overall average temperature was significantly (P<0.05) lower in T1 (26.89±0.04), followed by T3 (28.18±0.11), T2 (29.74±0.19) and C (30.55±0.06). Similarly temperature of the inner surface of roof was significantly (P<0.05) lower in T1 followed by T3 and higher in C during every fortnight. Overall average relative humidity (per cent) was significantly (P<0.05) lower in T3 (77.08±0.31) as compared to T1 (80.50±0.26), T2 (82.10±0.76) and C (82.92±0.12). Overall average THI was significantly (P<0.05) lower in T3 (76.56 ±0.23) followed by T1 (76.96 ± 0.07), T2 (78.35 ± 0.23) and C (79.30 ± 0.18). Total body weight gain (kg) was higher in T1 (32.67±0.76), followed by T3 (31.67±0.84), T2 (31.00±1.24) and C (30.83±0.48), however the difference was non-significant. The overall FCR was significantly lower (P<0.05) in T1 (9.94±0.24), T3 (10.01±0.14) followed by T2 (10.89±0.16) as compared control (11.76±0.18). The overall average rectal temperature and average respiration rate was significantly higher (p<0.05) in C (39.32±0.05 ºC, 26.07±0.29/min), followed by T2 (39.18±0.04 ºC, 24.17±0.37/min) and lower in T1 (38.98±0.03 ºC, 22.56±0.26/min) and T3 (39.06±0.03 ºC, 22.43±0.25/min). It may be inferred that the micro-environment was more conducive in T1 and T3 than control; hence the reflective paints on roof and adjusted higher height of polycarbonate roof may be the desirable choice for animal housing in view of mitigating heat stress during the hot-humid climate.

Key word: Adjustable height, corrugated cemented sheet, livestock housing, painted roof, polycarbonate roofing

Introduction

Hot-humid climate or rainy season is stressful to animals especially high yielding crossbred cattle. Increase in humidity depresses evaporative heat loss greatly and thus adds to the heat load of the animal. In combination with high temperature and humidity, the ability of the dairy animals to dissipate excess body heat is compromised that leads to depressed feed intake and consequent reduction in production by animals. A higher THI (>72) has been reported in the month of rainy season which leads to decreased performance of heifers and calves due to environmental stress (Pusta *et al*., 2006). Roof is an integral part of animal house and roofing materials prevent the direct heat from entering the house in different proportions and helps towards favourable micro-climate (Badino, 2007). Most commonly used roofing materials include: thatch, clay tiles, reinforced cement concrete (RCC), galvanized iron (GI) sheets, asbestos, tin and plastic sheets but these days low cost housing is need of the hour for Indian context with properties like higher durability, more strength, higher resistance towards heat, U.V. protection and ultimately modifying the micro climatic conditions of the house.

Polycarbonate sheets can be used as roofing materials for animal sheds as it has all the above said properties. Moreover it is being used in many agro-industries and commercial buildings by virtue of its higher strength, light weight, easy portability and installation. Adjustment of height of the roof during higher humidity and temperature may be another approach towards modifying the microenvironment for more comfort. Alternately, animal housing with reflective paint on corrugated cemented sheet roofing may also provide better results. Keeping in consideration these points, the study was designed to observe the effect of roof modifications on micro-climate of house and growth performance of crossbred calves.

Materials and Methods

The present study was conducted on crossbred (*Vrindavani*) cattle calves maintained at the cattle and buffalo farm, IVRI, Izatnagar to evaluate the effect of modified housing using different roofing materials on growth and physiological performance during the summer (July'2017 to September' 2017). The Institute is located at an altitude of 169 m above mean sea level, at the latitude of 28.22 ºN latitude and 79.24 ºE longitudes. The climate of the place touches both the extremes of hot (approximately 45 ºC) and cold (approximately 5 ºC), and relative humidity (RH) ranges between 15 per cent and 99 per cent. A total of twenty four calves (9-11 months old) were randomly selected and allocated in 4 groups viz. control (C); corrugated cemented sheet was used as roofing material. Treatment 1 (T1): painted black inside the roof and white on the upper exposed surface of the roof; Treatment 2 (T2): Polycarbonate sheet as roofing material; Treatment 3 (T3): Polycarbonate sheet as roofing material with adjustable height. Height at eaves was kept 2.5 -2.7 m and the height at centre was 3.5 m (for hot-humid period). The roof was arranged like a ridge system of ventilation for hot air in shed to pass from the roof itself. A gap of two feet was provided for ridge ventilation

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Abbreviations: C: control, T1: Treatment1, T2: Treatment2, T3: Treatment3, CCS: Corrugated cemented sheet, THI: Temperature humidity index, DMI: Dry Matter Intake, FCR: Feed Conversion Ratio, ST: surface temperature, RH: Relative humidity.

with one side of roof overhanging the other. The animals were maintained under iso-managerial conditions of management, feeding with intensive system and housed in a well ventilated brick cemented loose house with non-slippery floor open byre with standard space as per Indian Standard. The calves were offered standard ration having green and dry fodder along with concentrate in all the groups.

Temperature of sheds was measured by maximum and minimum thermometer twice daily at forenoon (9:00 am) and afternoon (2:30 pm). Simultaneously the relative humidity (RH) of sheds was measured using dry and wet bulb thermometer twice daily. Temperature humidity index (THI) was calculated as per McDowell (1972) using the following formula: THI = 0.72 (wet bulb temperature + dry bulb temperature) + 40.6. Inner surface temperature (ST) of roof was recorded by infrared thermometer (ebro, TFI 220) at 9:00 am and 2:30 pm for three consecutive days at fortnightly interval. Rectal temperature and respiratory rates of calves were recorded at fortnightly intervals for 3 consecutive days twice a day (9:00 am and 2:30 pm). Rectal temperature (ºC) was recorded by using a digital clinical thermometer. Respiration rate (breaths per minute) was counted from a distance by observing flank movements and expressed as counts per minute. Body weight (kg) of the calves was recorded on fortnightly basis before feeding and watering, using digital weighing balance. Dry Matter Intake (DMI) (kg) from fodder and concentrate was calculated at fortnightly interval for three continuous days. Feed conversion ratio (FCR) was calculated as weight gain (kg) per kg of DMI. Water intake (litres/day) was recorded on fortnightly basis. The data obtained from the study was analyzed using standard statistical methods as described by Snedecor and Cochran (1994).

Results and Discussion

Macro climate during summer

The solar radiation ranged from 182.89 ±11.44 to 149.33±16.05 W/m2 during the course of the experiment, whereas wind speed varied from 0.87±0.08 to 0.61±0.14m/s. The mean ambient temperature ranged between 32.56 ±0.51ºC to 27.64 ±0.57 ºC. The ambient temperature during the experimental period at 9:00 am ranged between 27.24±0.22 ºC to 25.11±0.40 ºC, whereas at 2:30 pm it increased from 38.32±0.81 ºC to 31.08±0.80 ºC. The mean RH during the observation period was ranged between 64.66±1.54 per cent to 75.35±1.81 per cent. The THI at 9:00 am varied between 86.30±0.43 to 82.50±0.52 and at 2:30 pm was ranged between 92.32±0.48 to 85.67±0.63. The mean THI during the observation period was ranged between 84.09±0.56 to 89.31±0.41. The macroclimatic conditions were more stressful during afternoon as compared to morning hours.

Microenvironment of sheds

a.Temperature (ºC) and relative humidity (per cent) of sheds

The temperature at 9:00 am during the first fortnight was 25.97±0.55, 21.07±0.63, 24.93±0.46 and 22.63±0.63 ºC, which decreased to 23.73±0.68, 19.50±0.29, 23.70±0.82 and 21.17±0.20 ºC under C, T1, T2 and T3, respectively, during the last fortnight, whereas the corresponding values at 2:30 pm during the first fortnight decreased from 36.40±0.31, 32.33±0.03, 35.27±0.37 and 33.23±0.39 to 35.43±0.72, 31.83±0.17, 35.07±0.39 and 32.27±0.37, respectively, during last fortnight. The overall minimum temperature at 9:00 am was 25.34±0.09, 20.74±0.21, 24.54±0.20 and 22.86±0.17 ºC, whereas at 2:30 pm 35.75±0.15, 33.05±0.24, 34.94±0.32 and 33.37±0.15 ºC in C, T1, T2 and T3, respectively. The overall average temperature was significantly (P<0.05) lower in T1 (26.89±0.04), followed by T3 (28.18±0.11), T2 (29.74±0.19) and C (30.55±0.06). The temperature of sheds at 9:00 a.m. 2:30 p.m. were significantly lower (P<0.05) in T1 followed by T3, T2 and highest in C, during all the fortnights.

The roof painted with white on outer and black inside had significantly lower temperature both in morning as well as afternoon as compared to control. Paints when applied on roof top reflect solar radiation and thus help in reducing heat load under the roof (Thomas and Sastry, 2012). Maximum temperature was observed in C followed by T2. In T3 lower temperature of shed than control was recorded during rainy season which may be due to higher height of house and ridge system of ventilation which allowed the hot air accumulated to pass from the roof itself and hence maintained a slightly lower shed temperature. Increasing the height of shed with ridge ventilation might have helped to dissipate heat easily in T3.

The RH at 9:00 am during the first fortnight was 80.80±1.22, 78.90±1.26, 80.05±1.87 and 76.80±2.04 per cent, which increased to 86.72±1.52, 82.00±1.96, 85.72 ±2.23 and 79.70±2.65 per cent at last fortnight. Similarly, RH at 2:30 pm increased from 73.50±0.92, 71.90±1.06, 72.70±1.29 and 69.60±1.92 per cent to 83.51±1.98, 74.83±1.26, 83.51±1.29 and 73.23±1.06 per cent for C, T1, T2 and T3, respectively. The overall average RH was 82.92±0.12, 80.50±0.26, 82.10±0.76 and 77.08±0.31 per cent in C, T1, T2 and T3, respectively during the rainy season. Irrespective of treatment RH at 9:00 am was significantly more (p<0.05) than at 2:30 pm. The RH at 9:00 am and 2:30 pm was significantly more (p<0.05) in C, followed by T2 and T1 and was least in T3 during all the fortnights. The negative diurnal changes in RH were observed in all the shades during rainy season due to rise in environmental temperature from morning to mid day as routine phenomenon as reported earliest also by Kaur and Singh (2004). The present finding are also supported by Roy and Chatterjee (2010), who reported significantly higher (P<0.01) RH (>72) in morning and evening in all the shelters (GI sheet, tiles and polythene shade) during rainy season indicating thereby stress on the animals (Adam, 2006), whereas, Das *et al*. (2012) observed highest RH in GI sheet roof (80.00±1.90) during rainy season. The RH under T3 was found to be minimum. This might be due to the fact that this system of housing allowed the floor to become dry quickly and provided proper ventilation during the summer.

Present findings are in accordance with earlier reports (Kamal *et al.,* 2013) who observed higher humidity in asbestos roofed house as compared to thatch, tree and agro-net. Our findings are in agreement with Kamal (2013) and Jat *et al*. (2005) who reported higher shed temperature of asbestos sheet roofing material in comparison to thatched roof, mud-plaster roof and agro-net sheet roof house during rainy season. Asbestos roofed houses had higher temperature and relative humidity than the tile roofed house (Sivakumar, 2002). However, in contrary to our results Roy and Chatterjee (2010) reported that polythene sheet roof had the lowest minimum and higher maximum temperature and higher RH as

compared to GI sheet, and tile roof shade structure in rainy season. A compound roof system developed with a combination of radiation reflectors and thermal insulation demonstrated substantial lowering of the heat conducted through a concrete roof (Alvarado *et al.,* 2009).

b. Temperature humidity index (THI) of sheds

The THI recorded fortnightly at 9:00 am and 2:30 pm during the experimental period under different roofing material are presented in (Fig. 1). The overall THI at 9:00 am in C, T1, T2 and T3 was 77.28±0.20, 74.93±0.25, 76.69±0.24 and 74.34±0.23, whereas at 2:30 pm was 81.33±0.19, 78.99±0.34, 80.01±0.24 and 78.78±0.23, respectively. Overall average THI was significantly (P<0.05) lower in T3 (76.56 ±0.23) followed by T1 (76.96±0.07), T2 (78.35±0.23) and C (79.30±0.18). The THI at 9:00 am was significantly lower (p<0.05) from THI at 2:30 pm in all the treatments groups. Lower values of THI in T3 and T1 compared to control indicates more conducive micro-environment in these sheds, which may be due to less heat penetration and effective ventilation viz. higher height of roof.

The present finding is also supported by Khongdee (2008), who concluded that the difference between maximum and minimum THI during the rainy season was lower suggesting that the dairy cows were exposed to heat stress conditions more consistently during the rainy season. However, the shade of polypropylene had a significantly lower ambient temperature and THI (P<0.05) for 5 h and 5 h

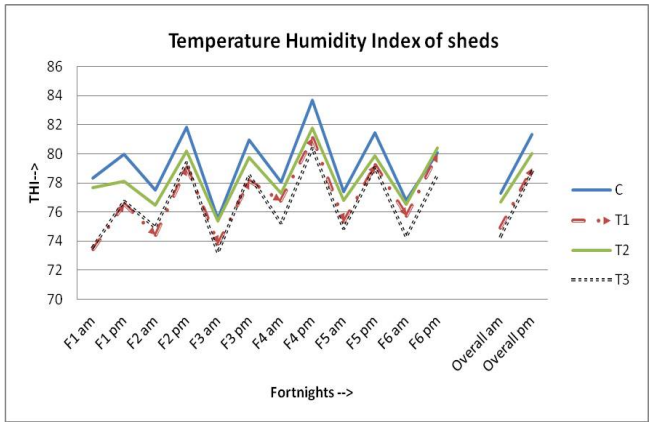

Fig. 1 Temperature humidity index of different sheds during rainy

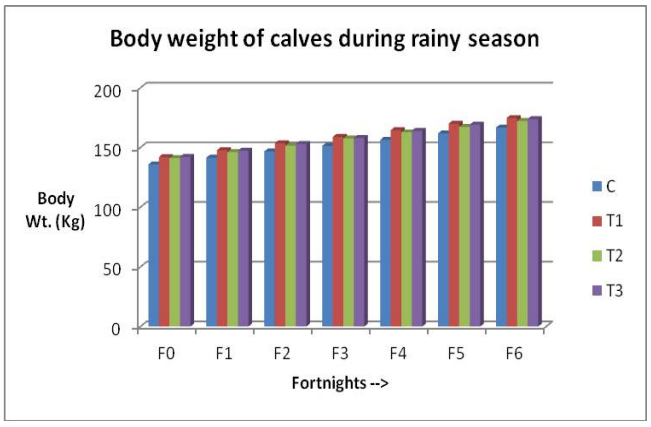

Fig. 2 Body weight (kg) of experimental calves during rainy season

30 minute respectively, a difference most likely due to the reduction in re-radiated heat in the Shaded shed. Pusta *et al*. (2006) reported higher THI (>72) in pasture heifers in the month of rainy season as compared to cows during lactation. Jat *et al*. (2005) recorded higher THI in asbestos in morning (81.52±0.35) and evening (85.71±0.51) as compared to mud plaster and less in thatch during rainy season, whereas, Das *et al*. (2012) and Roy and Chatterjee (2010) observed higher THI (83.48±0.52) under GI sheet roof.

Inner surface temperature (ºC) of roofing materials

The inner surface temperature of roof for different sheds has been presented in Table 1. The inner surface temperature at 9:00 a.m. 2:30 p.m. were significantly lower (p<0.05) in T1 followed by T3, T2 and highest in C, during all the fortnights. The roof painted with white on outer and black inside had significantly lower temperature both in morning as well as afternoon even in hotter days as compared to control. Maximum temperature could be observed in C followed by T2. Painted surface reduces the surface temperature via reflecting the radiations while CCS roof absorbs the heat and passes to the animal house. Similarly polycarbonate being heat and U.V. resistant did not allow heat to pass and thus provide better microclimate as compared to control in T3 and T2.

The present findings are in agreement with Kamal *et al.* (2013) who recorded higher inner surface temperature of asbestos sheet in comparison to thatched roof and agro-net roof during rainy season.

Body weight (kg) and Average daily gain (kg) (ADG)

The fortnightly body weight changes of calves during different fortnights in all the four groups are presented in Figure 2. The Initial body weight in C, T1, T2 and T3 was 135.83±3.83, 142.00±2.92, 141.17±2.79 and 142.17±1.51 kg respectively, which was non-significant. The fortnightly body weight of calves increased steadily and the final body weight in respective groups was 166.67±3.77, 174.67±2.59, 172.17±3.78 and 173.83±1.54. However there was no significant difference between any of the groups. The ADG during the initial period of experiment was 0.38±0.05, 0.38±0.07, 0.33±0.06 and 0.34±0.05 kg in C,T1, T2 and T3 respectively, which did not differ significantly, and in last fortnight ADG for C, T1, T2 and T3 were 0.32±0.03, 0.31±0.06, 0.33±0.04 and 0.31±0.05 respectively.

Total body weight gain during rainy season in C, T1, T2 and T3 was 30.83±0.48, 32.67±0.76, 31.00±1.24 and 31.67±0.84 respectively. A slightly higher body weight gain in T1 grouped calves might be due to more DMI and better micro environment under shade which facilitate the growth of calves irrespective of higher ambient temperature, THI and humidity during experimental period. Our findings are in agreement with Shrikant and Kumar (2001) who found non significant difference in growth of calves in loose house with single wall and loose house with four feet side wall.

Dry matter intake (kg/day) and feed conversion ratio (FCR)

The Total DMI from all sources during first fortnight in C, T1, T2 and T3 was 21.28±0.10, 20.82±0.01, 21.23±0.21

and 21.19±0.20, respectively and during last fortnight was 22.15, 22.89, 22.76 and 23.15. DMI per calf per day on fortnightly basis has been presented in Table 2. No significant difference was observed in feed intake and DMI amongst the group.

The FCR has been presented in table 3. The overall FCR was significantly lower (P<0.05) in T1 (9.94±0.24), T3 (10.01±0.14) followed by T2 (10.89±0.16) as compared control (11.76±0.18). FCR was better in T1, T3 and T2 as compared to C grouped calves throughout the experimental period, which is an indication of comfortable micro-environment in T1 and T3 leading to less energy wastage in heat dissipation. However, Jat *et al*. (2005) reported that calves reared under thatch and mud plaster roof consumed more (P<0.05) dry matter per day than those reared in asbestos roof. Similarly Chauhan *et al.* (2011) reported higher feed intake by cow kept under RCC and thatch roof over tree shelter. Crossbred calves reared under thatched roof house consumed higher dry matter/100 kg body weight than those reared in loose housing system (Yazdani and Gupta, 2000).

4.1.7 Water intake (L/day) of calves

The water intake (litres) (per day) of calves in C, T1, T2 and T3 during first fortnight was 82.73±1.42, 78.63±1.73, 79.60±1.33 and 76.63±1.38, respectively which increased to 90.40+0.76, 84.73+1.73, 87.20+2.23 and 86.03+1.56 in last fortnight, respectively. The calves in control group consumed more (P<0.05) quantity of water followed by T2 and T3 least T1. The more water intake in control grouped calves indicates certain amount of stress due to high THI, subsequently leading to activation of thirst centre in the hypothalamus and thus water intake was increased. Present finding are supported by Jat *et al*. (2005) and Kamal (2013), who reported that the average daily voluntary water intake was more in (P<0.05) animals kept in asbestos roof as compared to thatch, agro-net and mud plaster roof, during rainy season. Further, they concluded that the asbestos grouped calves were under certain amount of stress, and thus enhanced water intake. Similarly Khongdee *et al*. (2008) reported lower water intake by the animals kept under open wall polypropylene shade structure. Chauhan *et al*. (2011) reported higher water intake by cow kept under RCC roof as compared to thatched roof and tree shelter. Yazdani and Gupta (2000) found lower (P<0.05) voluntary water intake in thatch group (2.08±0.11).

Physiological response

The fortnight physiological responses of crossbred calves viz. rectal temperature and respiration rate are presented in Tables 4 and 5. The rectal temperature and respiration rate of calves at 2:30 pm was significantly higher (p<0.05) than at 9:00 am in all the groups throughout the experiment. The overall rectal temperature and respiration rate at morning and afternoon was significantly higher (p<0.05) in C followed by T2 and lower in T1 and T3. The overall average rectal temperature and average respiration rate was significantly higher (P<0.05) in C (39.32±0.05 ºC, 26.07±0.29/min), followed by T2 (39.18±0.04 ºC, 24.17±0.37/min) and lower in T1 (38.98±0.03 ºC, 22.56±0.26/min) and T3 (39.06±0.03 ºC, 22.43±0.25/min). The significant rise in rectal temperature in C as compared to other groups might be due to heated corrugated cemented sheet and high humidity in the shed during experimental period. Inability to eliminate excess heat might probably have led to the rise in rectal temperature.

The atmospheric temperature and RH had significant (P<0.05) effect but THI had highly significant (P<0.01) effect on the rectal temperature of the calves. The rectal temperature, increased significantly (P<0.05) by 0.13, 0.01 and 0.25˚C and respiration rate (P<0.05) by 2.48 to 8.62/ minute with the unit increase of air temperature, RH and THI (Das *et al*., 2012). The present findings are in agreement with Khongdee *et al*. (2010), who found significantly lower mean rectal temperature (38.56 ºC) in shade cloth than that of the cows housed under normal roofing (39.86 ºC). Khongdee *et al.* (2008) reported nearly 1˚C less rectal temperature in double shaded polypropylene shade cloth house as compared to single shaded and concluded that RR in cattle 20 breaths/minute indicating cool conditions and 80 breath/minute indicating very warm conditions. Also observed that the cows in the double shade house (polypropylene shade cloth) were found to have lower respiration rate than that of their counterpart cows in the adjacent single shade animal house. Patil *et al.* (2014) reported that RT (ºC), RR (per minute) and PR (per minute) of crossbred cows were higher in the asbestos roof shed in comparison to white painted roof shed and thatched asbestos roof shed. On the other hand Yazdani and Gupta (2000) reported that in crossbred calves body temperature was not affected (P<0.05) by modification in housing system.

Conclusion

During the rainy season provision of high roofed house with ridge ventilation and corrugatedcemented sheet sheet painted white on outer surface and black in the inner surface provided favorable micro-environment to the crossbred calves resulted in keeping physiological responses in normal range. Polycarbonate roofing was at par with corrugated cemented sheet roofing in terms of growth and DMI, but is far more economical than asbestos, CCS and other roofing materials being used. However, more research is required in this area to explore the opportunities and recommend polycarbonate roofing in tropics. From the present study, it can be concluded that reflective surface and higher roof with effective ventilation may be chosen for hot-humid housing management.

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Table 1: Mean ± SEM of total dry matter intake per calf during rainy season

	Fortnights						
group	f1	f2	f3	f4	f5	f6	Overall
C	3.55±0.12	3.59±0.14	3.58±0.13	3.69±0.08	3.65±0.13	3.70±0.14	3.63±0.09
T1 B/W	3.47±0.10	3.53±0.08	3.64±0.14	3.82±0.26	3.79±0.14	3.82±0.04	3.68±0.12
T2 poly	3.54±0.06	3.61±0.13	3.61±0.06	3.69±0.14	3.81±0.05	3.79±0.07	3.67±0.06
T3 Ht	3.53±0.11	3.66±0.18	3.59±0.12	3.78±0.18	3.76±0.19	3.86±0.06	3.70±0.07

Table 2: Mean ± SEM of feed conversion ratio of calves

	Fortnights						
group	f1	f2	f3	f4	f5	f6	Overall
C	10.78±0.36^{a}	10.93±0.26^{a}	11.52±0.37^{a}	12.28±0.14^{a}	12.65±0.17^{a}	12.40±0.26	11.76±0.18^{a}
T1 B/W	9.19±0.25^{b}	9.08±0.17^{b}	9.25±0.34^{b}	10.12±0.61^{b}	10.34±0.36^{b}	11.76±0.37	9.94±0.24^{b}
T2 poly	10.61±0.18^{a}	10.17±0.37^{a}	9.98±0.06^{b}	10.71±0.40^{ab}	12.38±0.20^{a}	11.38±0.20	10.89±0.16^{c}
T3 Ht	9.08±0.19^{b}	9.03±0.21^{b}	10.17±0.16^{ab}	9.45±0.46^{b}	10.91±0.24^{b}	11.51±0.71	10.01±0.14^{b}

Means bearing different superscript differ significantly (P<0.05) within the column

Table 3: Mean ± SEM of inner surface temperature (^{O}C) of different roofing materials

Fortnight	Time	Corrugated cemented sheet roof (C)	Painted roof (T1)	Polycarbonate roof (T2)	Roof with Adjustable height (T3)
F1	9:00 am	40.83 ± 0.44^{a}	38.15 ± 0.60^{b}	39.50 ± 0.29^{ab}	38.87 ± 0.47^{ab}
	2:30 pm	48.97 ± 0.62	47.30 ± 0.25	47.30 ± 0.49	46.87 ± 0.47
	Average	44.09 ± 0.48	42.72 ± 0.17	43.82 ± 0.22	42.87 ± 0.47
F2	9:00 am	40.50 ± 0.29	38.75 ± 0.38	40.48 ± 0.29	39.01 ± 0.38
	2:30 pm	49.17 ± 0.64	47.18 ± 0.43	48.40 ± 0.45	47.53 ± 0.29
	Average	44.83 ± 0.38	42.96 ± 0.23	44.43 ± 0.36	43.27 ± 0.32
F3	9:00 am	40.81 ± 0.43^{a}	38.73 ± 0.32^{b}	39.57 ± 0.32^{ab}	39.31 ± 0.17^{ab}
	2:30 pm	48.82 ± 0.59	46.61 ± 0.41	47.43 ± 0.62	47.03 ± 0.44
	Average	44.82 ± 0.38^{a}	42.67 ± 0.22^{b}	43.50 ± 0.20^{ab}	43.17 ± 0.29^{ab}
F4	9:00 am	40.80 ± 0.18^{a}	38.73 ± 0.22^{b}	39.75 ± 0.34^{ab}	39.16 ± 0.30^{ab}
	2:30 pm	48.67 ± 1.16	46.63 ± 0.32	48.23 ± 0.15	46.63 ± 0.86
	Average	44.74 ± 0.61	42.68 ± 0.26	43.99 ± 0.24	42.90 ± 0.56
F5	9:00 am	39.10 ± 0.59	35.83 ± 0.83	37.30 ± 0.85	36.50 ± 0.66
	2:30 pm	48.80 ± 0.62	46.63 ± 0.80	47.67 ± 0.28	46.03 ± 0.55
	Average	43.95 ± 0.19	41.23 ± 0.76	42.48 ± 0.53	41.27 ± 0.45
F6	9:00 am	40.33 ± 0.33	37.83 ± 0.60	38.83 ± 0.73	38.11 ± 1.16
	2:30 pm	49.20 ± 1.29	46.43 ± 0.75	49.03 ± 1.06	47.93 ± 0.62
	Average	44.77 ± 0.49	42.13 ± 0.29	43.92 ± 0.23	43.02 ± 0.88
Overall	9:00 am	40.40 ± 0.04^{a}	38.00 ± 0.09^{b}	39.24 ± 0.24^{ab}	38.49 ± 0.28^{ab}
	2:30 pm	48.94 ± 0.56	46.80 ± 0.18	48.14 ± 0.33	47.02 ± 0.19
	Average	44.67 ± 0.27	42.40 ± 0.04	43.69 ± 0.14	42.75 ± 0.19

Means values between 9:00 am & 2:30 pm differ significantly (P<0.05) within the treatments
Means bearing different superscript differ significantly (P<0.05) row wise

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Table 4: Mean± SEM of rectal temperature (^{O}C)

Fortnight	Time	Corrugated cemented sheet roof (C)	Painted Roof (T1)	Polycarbonate roof (T2)	Roof with Adjustable height (T3)
F1	9:00 am	39.17 ± 0.07	38.76 ± 0.13	38.94 ± 0.17	38.78 ± 0.12
	2:30 pm	39.40 ± 0.21	39.26 ± 0.12	39.37 ± 0.15	39.27 ± 0.12
	Average	39.28 ± 0.10	39.01 ± 0.11	39.16 ± 0.15	39.02 ± 0.12
F2	9:00 am	39.27 ± 0.09 ^{a}	38.95 ± 0.03 ^{ab}	39.00 ± 0.07 ^{ab}	38.63 ± 0.10 ^{b}
	2:30 pm	39.50 ± 0.15	39.36 ± 0.10	39.40 ± 0.12	39.03 ± 0.09
	Average	39.38 ± 0.04 ^{a}	39.15 ± 0.05^{ab}	39.20 ± 0.08 ^{a}	38.83 ± 0.11 ^{b}
F3	9:00 am	39.13 ± 0.09	38.76 ± 0.13	39.04 ± 0.21	39.01 ± 0.12
	2:30 pm	39.57 ± 0.15 ^{a}	39.10 ± 0.06 ^{b}	39.37 ± 0.09 ^{ab}	39.32 ± 0.04^{ab}
	Average	39.35 ± 0.10	38.93 ± 0.07	39.20 ± 0.15	39.16 ± 0.05
F4	9:00 am	39.07 ± 0.09	38.87 ± 0.19	38.92 ± 0.11	38.71 ± 0.01
	2:30 pm	39.50 ± 0.06	39.20 ± 0.08	39.37 ± 0.12	39.07 ± 0.12
	Average	39.28 ± 0.04 ^{a}	39.03 ± 0.12 ^{ab}	39.15 ± 0.11 ^{ab}	38.90 ± 0.03 ^{b}
F5	9:00 am	39.13 ± 0.03	38.70 ± 0.15	39.04 ± 0.03	39.07 ± 0.15
	2:30 pm	39.47 ± 0.09	39.06 ± 0.13	39.33 ± 0.15	39.27 ± 0.12
	Average	39.30 ± 0.06^{a}	38.93 ± 0.12^{b}	39.18 ± 0.09^{ab}	39.12 ± 0.13^{ab}
F6	9:00 am	39.10 ± 0.17	38.84 ± 0.12	39.17 ± 0.09	38.90 ± 0.23
	2:30 pm	39.57 ± 0.09	39.16 ± 0.12	39.27 ± 0.17	39.07 ± 0.12
	Average	39.33 ± 0.13	39.01 ± 0.11	39.23 ± 0.07	38.98 ± 0.16
Overall	9:00 am	39.14 ± 0.01 ^{a}	38.81 ± 0.04 ^{b}	39.04 ± 0.02 ^{ab}	38.85 ± 0.04 ^{b}
	2:30 pm	39.50 ± 0.10 ^{a}	39.25 ± 0.05 ^{b}	39.34 ± 0.06 ^{ab}	39.28 ± 0.03 ^{b}
	Average	39.32 ± 0.05 ^{a}	38.98 ± 0.03 ^{b}	39.18 ± 0.04 ^{ab}	39.06 ± 0.03 ^{b}

Means values between 9:00 am & 2:30 pm differ significantly (P<0.05) within the treatments; Means bearing different superscript differ significantly (P<0.05) row wise.

Table 5: Mean± SEM of respiration rate (per minutes)

Fortnight	Time	Corrugated cemented sheet roof (C)	Painted Roof (T1)	Polycarbonate roof (T2)	Roof with Adjustable height (T3)
F1	9:00 am	23.92 ± 1.22	19.53 ± 1.07	22.05 ± 1.59	21.53 ± 1.09
	2:30 pm	30.30 ± 0.45 ^{a}	26.47 ± 0.69 ^{b}	29.70 ± 0.44 ^{a}	26.37 ± 0.38 ^{b}
	Average	27.11 ± 0.72 ^{a}	23.00 ± 0.85 ^{b}	25.88 ± 1.01^{ab}	23.95 ± 0.43^{ab}
F2	Am	23.90 ± 0.97 ^{a}	20.75 ± 0.57^{ab}	20.98 ± 0.50^{ab}	20.23 ± 1.01 ^{b}
	Pm	30.27 ± 0.90 ^{a}	26.66 ± 0.33 ^{b}	26.84 ± 0.44 ^{b}	26.97 ± 0.98 ^{b}
	Average	27.08 ± 0.90 ^{a}	23.71 ± 0.20 ^{b}	23.91 ± 0.24^{b}	23.59 ± 0.88^{b}
F3	9:00 am	21.60 ± 0.95	19.83 ± 1.09	20.48 ± 0.82	18.75 ± 0.34
	2:30 pm	27.33 ± 0.34 ^{a}	24.44 ± 1.52 ^{ab}	26.50 ± 0.21 ^{ab}	23.17 ± 0.17 ^{b}
	Average	24.47 ± 0.61 ^{a}	22.16 ± 0.41 ^{bc}	23.49 ± 0.60 ^{ab}	20.94 ± 0.52 ^{c}
F4	9:00 am	23.10 ± 0.54 ^{a}	20.07 ± 0.58 ^{b}	19.80 ± 0.61 ^{b}	18.07 ± 0.57 ^{b}
	2:30 pm	28.57 ± 0.38 ^{a}	24.63 ± 0.69 ^{b}	28.30 ± 0.34 ^{a}	26.23 ± 0.28 ^{b}
	Average	25.82 ± 0.14 ^{a}	22.35 ± 0.61 ^{b}	24.05 ± 0.22 ^{c}	22.15 ± 0.31 ^{b}
F5	9:00 am	23.40 ± 0.91 ^{a}	19.50 ± 1.05^{b}	21.13 ± 0.87^{ab}	18.47 ± 0.23 ^{b}
	2:30 pm	29.47 ± 0.47 ^{a}	23.57 ± 1.04^{b}	26.61 ± 0.31^{ab}	24.23 ± 0.95 ^{b}
	Average	26.43 ± 0.22 ^{a}	21.53 ± 0.72 ^{bc}	23.87 ± 0.40 ^{c}	21.33 ± 0.59 ^{b}
F6	Am	22.92 ± 0.64	20.53 ± 0.79	21.33 ± 1.07	20.63 ± 1.03
	Pm	28.33 ± 1.20	24.76 ± 0.95	26.83 ± 0.45	24.70 ± 0.59
	Average	25.63 ± 0.87	22.65 ± 0.87	24.08 ± 0.45	22.67 ± 0.22
Overall	9:00 am	23.12 ± 0.28 ^{a}	20.04 ± 0.52 ^{b}	20.90 ± 0.69 ^{ab}	19.58 ± 0.50 ^{b}
	2:30 pm	29.06 ± 0.33 ^{a}	25.09 ± 0.16 ^{b}	27.46 ± 0.06 ^{c}	25.27 ± 0.12 ^{b}
	Average	26.07 ± 0.29 ^{a}	22.56± 0.26 ^{b}	24.17 ± 0.37 ^{c}	22.43 ± 0.25 ^{b}

Means values between 9:00 am & 2:30 pm differ significantly (P<0.05) within the treatments
Means bearing different superscript differ significantly (P<0.05) row wise

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