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Comparative Efficacy of Evaporative Cooling Pad and Fogger System on Growth Performance of Broiler Chicken in Summer Season

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ABSTRACT: High environmental temperature increases mortality of poultry due to inhibition of immune responses and the maintenance of production, reproduction and economy of the poultry farm requires modification of the surrounding environment, ventilation system, bird density, and nutritional management to reduce heat stress in poultry. This study used 108-days old, commercial broiler chicks (VenCobb strain). These birds were randomly divided into three treatment groups *i.e.*, T_0, T_1 and T_2 comprising of 60 birds in each treatment with a total of 180 birds. Each treatment was further divided into three replications with 20 birds in each. These chicks were kept in floor pens, and water and feed were provided *ad libitum* throughout the experimental period of 42 days. The control (T_0) had pen without a cooling device, while other treatment groups *i.e.*, T_1 and T_2 were having an evaporative cooling pad and fogger systems, respectively. This study found highly significant effects of cooling devices on different growth parameters like body weight, body weight gain, and feed consumption whereas the feed conversion ratio was found non-significant during 3rd, 4th, 5th and 6th weeks of age. The result of different growth parameters such as weekly body weight and body weight gain, weekly feed consumption, weekly feed conversion ratio (FCR), was found better in T_1 group as compared to T_0 and T_2 groups. The result of shed microclimate indicates that ambient temperature and temperature humidity index (THI) in control (T_0) were highly significant ($p \leq 0.01$) thanT_1 and T_2 groups. From this study, it can be concluded that the evaporative cooling pad and fogger system ensures significant improvement in micro-climate of shed, and better growth performance of broilers.

Keywords: Broiler, Heat stress, Evaporative cooling pad, Fogger system.

INTRODUCTION

Poultry industry has become an important economic activity in many countries to produce high-quality eggs and meat to balance the human diet. The poultry industry is one of the fastest-growing sectors of agriculture in India. Egg production and poultry meat production in India has increased by 8.5% and 7.8% respectively as compared to the previous year (BAHS, 2019). The efficiency of broilers to convert feed into meat plays a key role in the economics of broiler industry. Poultry is a rich source of high-quality food such as eggs, and meat as well as a source of income and employment for millions of people. The total population of poultry in India was 851.81 million (20th Livestock Census), which is 16.81% higher than 19th Livestock Census. Poultry seems to be extremely sensitive to temperature-associated environmental challenges; especially heat stress, so, high environmental temperature and temperature humidity index values above the critical level led to decrease feed intake, lower body weight, and lower feed conversion efficiency (Sohail *et al.*, 2012). The metabolic heat along with high ambient temperature reduces the body weight and feed intake in broiler birds by 23% and 15%, respectively (Yalcin *et al.*, 1997). There is a decrease of 1.72% in feed intake for every degree celsius rise in ambient temperature from 18^{o} to 32^{o}C (Rama Rao *et al.*, 2002). Heat stress adversely affects the efficiency of broiler production and their meat quality system. Heat stress results from a negative balance between the amount of heat energy produced by the animal and the net amount of energy flowing from the animal's body to its surrounding environment. Evaporative pads, fogger pads, and fogger nozzles can be used as a good alternative to control heat and its effects in broiler houses (Weaver, 2002). Therefore, in order to decrease the inner temperature of poultry house, evaporative cooling systems can used to mitigate heat stress and maintain the productivity of broiler birds.

MATERIALS AND METHODS

This study was conducted in semi-arid climate of Jaipur (Latitude - N 26°53'31", Longitude - E 75°52'17") for a period of 42 days at poultry farm of Post Graduate Institute of Veterinary Education and Research (PGIVER) Jamdoli, Jaipur.

A. Experimental chicks

This study was conducted on day old broiler chicks (Ven Cobb strain) procured from a commercial hatchery. The experiment was conducted 180 chicks for a period of 6 weeks from 29 May 2019 to 10 July 2019.

B. Feed for experimental birds

Commercial broiler mash feed was procured from the local market and fed *ad*-libitum to the birds. The starter feed was fed upto the end of 3rd week and thereafter finisher feed was provided till the end of the experiment. The feed used in the present experiment was purchased from the market.

C. Experimental design

Chicks were banded over the wing at the start of the experiment. The broiler chicks were randomly allotted to three treatment groups (T_0, T_1 and T_2) with three replications having 20 chicks in each replication. The broiler chicks were vaccinated for Ranikhet disease (F_1 strain) on 7th day and Infectious Bursal Disease (IBD) on 14th day.

Broilers were maintained under standard management practices such as brooding, feeding, watering, and health care throughout the trial period. The cooling systems were operated on start of 3rd week (15th day) upto the end of 6th week (42 days) of age, as brooding of chicks was carried out upto the first 2-weeks.

Table 1: Experimental design for different treatment groups.

Sr. No.	Treatment groups	Experimental pens	No. of broiler chicks/ replication			Total no. of broiler chicks in each group
			R_1	R_2	R_3	
1.	T_0(Control)	Pen without cooling device	20	20	20	60
2.	T_1	Pen with evaporative cooling pads	20	20	20	60
3.	T_2	Pen with foggers	20	20	20	60

D. Experimental broiler shed

The experimental shed consisted of three pens each with 100 square feet area. Out of the total three (03) of such pens, two (02) were modified for the installation of different cooling systems while the one was without any cooling system and considered as control. Further, each pen was partitioned into three identical compartments each of 20 square feet area using wire nettings. One square feet floor space was provided to each bird in these compartments of the pens.

E. Design of evaporative cooling pad system

The evaporative cooling pad system consisted of cellulose pads which were made up of cellulose paper hedges in aluminum casing with a water distributor through a Galvanized Iron header. The complicatedly woven cellulose pads were enough to provide required amount of water to fulfill maximum cooling of air encountering it. The evaporative cooling pads were placed at one end of the shed and exhaust fan of the opposite end. The water was pumped to the pads through a pump and the pads were kept wet.

F. Fogger system

Fine foggers (2 in number) each having diameter of 0.2 mm and capable of producing mist with a pressure of 30 psi were installed at the height of 6 ft from the ground and were connected with a water tank through a high-pressure pipe. The filtered water was pumped into the foggers. The foggers were set up for the controlled on/off–timing with the help of a timer. The cycle for on and off the foggers was 30 seconds and 60 seconds, respectively, and was repeated the whole day. When switched on, foggers generated a fine mist to cool the shed but the exhaust fan was running the whole day irrespective of foggers.

G. Performance Parameters

(a) Weekly body weight and body weight gain. These chicks were weighed individually at the start of the experiment and subsequently at weekly intervals up to 6 weeks of age. The weekly live weight gain was calculated from the difference in body weight attained between the two consecutive weeks.

(b) Weekly feed consumption. Feed consumption of each replicate was recorded weekly and average feed intake in gram/bird/week was calculated by dividing the total amount of feed consumed by the number of birds in the particular pen. The cumulative feed consumption for the experimental period was also recorded.

(c) Weekly feed conversion ratio (FCR). The feed conversion ratio was calculated by dividing the cumulative feed intake by the body weight gain of the chicks during the two consecutive periods.

$$\text{Feed conversion ratio} = \frac{\text{Total amount of feed consumed (g)}}{\text{Total body weight gain (g)}}$$

(d) Percent mortality. Regular observations were made to record the occurrence of deaths in the experimental broilers to estimate the mortality rate in each experimental group, if any.

H. Microclimate parameters

(a) Ambient temperature and relative humidity. To assess variation in shed micro-climate dry and wet bulb temperatures were recorded three times a day (*i.e*., 9:00 A.M., 12:00 P.M., and 3:00 P.M.) with the help of a dry and wet bulb thermometer. The data of dry and wet bulb temperature were used to evaluate ambient temperature and relative humidity of the shed.

(b) Temperature-Humidity Index (THI). The microclimate of the shed was assessed with the help of dry and wet bulb thermometers. These thermometers were placed in each broiler shed at around 0.5 feet above ground level. To assess the macroclimate outside the shed, thermometers were placed at around 6 feet above the ground level in the open to ensure no hindrance to wind. The data of dry and wet bulb temperature were used to evaluate the temperature-humidity index (THI) and relative humidity of the shed. The temperature-humidity index (THI) in each group was calculated by using the formula advocated by Tao and Xin (2003).

THI = 0.85 Tdb + 0.15 Twb

Where,

Tdb = dry bulb temperature

Twb = wet bulb temperature

I. Statistical Analysis

The experimental data were subjected to statistical analysis using one way analysis of variance as described by Snedecor and Cochran (1994) to test for the significant variation between treatment groups. A comparison of mean values was carried out by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

A. Weekly average body weight of broilers

The findings of the effect of the evaporative cooling pad and fogger system on the average body weight of experimental broilers during their different weeks of age are presented in (Table 2).

Table 2: Mean (±SE) body weight (g) of broilers at different weeks of age.

Treatments	Age (weeks)						
	0 day	I	II	III	IV	V	VI
T_0	45.82±0.23	155.27±1.88	351.03±3.44	701.82b±8.31	1119.83b±8.31	1682.80b±27.43	2180.93c±34.97
T_1	45.80±0.23	159.13±2.88	355.92±4.66	729.70a±10.30	1264.68a±10.30	1935.33a±29.91	2533.42a±40.34
T_2	45.82±0.25	159.55±2.32	358.88±4.16	734.30a±8.21	1239.27a±8.21	1865.92a±25.78	2370.00b±32.33
Significance level	NS	NS	NS	*	**	**	**

**= Highly Significant ($p<0.01$), * =Significant ($p<0.05$), NS =non-significant

Note: Values having different superscripts in the same group vary significantly from one another

The analysis of variance (ANOVA) of data revealed a significant effect of T_1 and T_2 treatment group on body weight at 3rd ($p<0.05$) 4th, 5th and 6th weeks ($p<0.01$) of age of experimental broilers. Whereas the effect on body weight was non-significant at 1st and 2nd weeks of age.

The post hoc DMRT analysis of data revealed that the mean weekly body weight of broilers in all the three experimental groups increased with an increase in their age, but the difference between the mean body weight of broilers of the three experimental groups could not be observed to be significant during 0 days and 1st and 2nd week of age. Whereas a significantly higher mean body weight of broilers of T_1 and T_2 groups during 3rd ($p<0.05$), 4th and 5th ($p<0.01$) weeks of age were observed as compared to broilers of T_0 group. No significant differences were observed between the mean body weight of broilers of T_1 and T_2 groups during the same age. The mean body weight of broilers at the 6th week of age was observed to be significantly ($p<0.01$) higher for T_1 group followed by T_2 and T_0 group. The lower average body weight of chicks in T_0 group could be attributed to be due to higher level of heat stress indicated by the high ambient temperature and temperature humidity index of the shed in T_0 group.

These findings agreed with the results of Gupta *et al.* (2013) in which they revealed that the adverse effect of the elevated temperature on the growth rate of broiler chicks. The birds in the treatment groups performed better as compared to the control group that was exposed to higher temperature and lower relative humidity conditions in the shed.

B. Weekly average body weight gain of broilers

The observation on the effect of the evaporative cooling pad and fogger system on average body weight gain of broilers during their different weeks of age is in Table 3.

Table 3: Mean (±SE) body weight gain (g) of broilers at different weeks of age.

Treatments	Age in weeks						Cumulative
	I	II	III	IV	V	VI	
T_0	109.45±1.53	195.76±2.69	350.79^b±5.64	418.02^b±10.83	562.97^b±14.16	498.13^b±16.56	2135.11^c±35.35
T_1	113.33±1.82	196.79±3.28	373.78^a±6.99	534.98^a±13.50	670.65^a±15.17	598.08^a±21.49	2487.62^a±39.80
T_2	113.73±1.76	199.33±2.71	375.42^a±5.13	504.97^a±10.95	626.65^a±17.82	504.08^b±14.59	2324.18^b±32.40
Significance level	NS	NS	**	**	**	**	**

** Highly Significant (p<0.01), NS =non-significant
Note: Values having different superscripts in the same group vary significantly from one another

The analysis of variance (ANOVA) of data revealed a significant (p<0.01) effect of T_1 and T_2 treatment group on average body weight gain of experimental broilers during 3rd, 4th, 5th and 6th week of age while no significant difference was observed during 1st and 2nd week of age.
The post hoc DMRT analysis of data revealed that average body weight gain of broilers at the end of 3rd, 4thand 5th week of age under both T_1 and T_2 groups were significantly (p<0.01) higher than T_0 group. However, the average body weight gain of broilers of the T_1 group was significantly (p<0.01) different than those of T_2 and T_0 group at 6th week of age, but no significant difference was observed between T_2 and T_0. The average cumulative body weight gain of broilers of all the three groups reflected a significant (p<0.01) difference from one another and the highest body weight gain was observed for broilers of in T_1 group (2487.62gm) followed by T_2 (2324.18gm) and T_0 (2135.11gm) groups. The lower average body weight gain of chicks in the control group was probably because of lower feed consumption due to the heat stress indicated by the high ambient temperature and temperature humidity index of the control group (T_0) shed.
These findings are like the findings of Quinteiro-Filho *et al*. (2010) who reported that heat stress decreases body weight gain as well as feed intake and the feed conversion ratio in broiler chickens. They revealed the adverse effect of the elevated temperature on the growth rate of broiler chicks. The birds in the treatment group performed better as compared to the control group due to the more feed consumption associated with the lower heat stress in the shed.

C. Weekly average feed consumption of broilers

The observations on average feed consumption by broilers during their different age (weeks) are in Table 4.

Table 4: Mean (±SE) feed consumption (g) of broilers at different weeks of age.

Treatments	Age in weeks						Cumulative
	I	II	III	IV	V	VI	
T_0	137.48±0.21	297.33±0.92	493.80^b±1.68	627.92^b±10.61	963.65^b±12.94	998.77^b±18.41	3518.90^c±40.51
T_1	137.57±0.73	297.43±0.19	508.93^a±1.84	756.13^a±8.28	1074.47^a±9.35	1121.22^a±22.16	3895.75^a±28.31
T_2	137.30±0.15	297.53±0.45	504.13^a±3.58	723.48^a±15.04	1046.97^a±4.60	1060.10^{ab}±12.63	3769.52^b±14.86
Sig. level	NS	NS	**	**	**	**	**

** Highly Significant (p<0.01), NS = non-significant
Note: Values having different superscripts in the same group vary significantly from one another

The analysis of variance (ANOVA) of data revealed a significant (p<0.01) effect of cooling system on average feed consumption of T_1 and T_2 group at 3rd, 4th, 5th and 6th week of age and no significant effect at 1st and 2nd week of age.
The observations on feed consumption showed that feed consumption in all treatment groups increased with the increase in age of broiler chicks. The post hoc DMRT analysis of data revealed that average feed consumption of broilers at the end of 3rd, 4th and 5th week was significantly higher in both T_1 and T_2 than T_0 group. Moreover, feed consumption during 6th week of the age was significantly (p<0.01) higher in T_1 group than T_0 and T_2 group, but no significant difference was observed between T_0 and T_2 groups. Cumulative feed consumption of broiler showed the highest feed consumption (3895.75gm) in T_1 group higher than T_2 group i.e. (3769.52gm) feed consumption while the control group had lowest average feed consumption of (3518.90 g), average feed consumption, among treatment groups T_1, T_2 and T_0 differ significantly to each other. Lower average feed consumption in T_0 group might be due to the heat stress indicated by the high ambient temperature and temperature humidity index of the shed.
These findings are similar to the results by Al-Fataftah and Abu-Dieyeh (2007), who studied broiler performance under chronic heat stress and concluded that broiler chicks exposed to high temperature had, a significantly (p<0.01) lower feed consumption. The birds in the treatment (T_1 and T_2) groups performed better as compared to the control (T_0) group due to more feed consumption associated with lesser heat stress in the shed. These findings are similar to findings

of Tabiri *et al.* (2002); Quinteiro-Filho *et al.* (2010), who reported a decrease in feed intake with an increase in environmental temperature above the thermo-neutral zone of broiler (25°C).

D. Weekly average feed conversion ratio of broilers

The findings on average feed conversion ratio of broilers during different ages (weeks) are presented in Table 5.

Table 5: Mean (±SE) feed conversion ratio of broilers at different weeks of age.

Treatments	Age in weeks						Cumulative
	I	II	III	IV	V	VI	
T_0	1.25±0.005	1.51±0.002	1.41±0.010	1.50±0.031	1.71±0.039	2.01±0.101	1.64±0.04
T_1	1.21±0.002	1.51±0.001	1.36±0.029	1.41±0.016	1.60±0.031	1.88±0.028	1.57±0.00
T_2	1.20±0.008	1.49±0.023	1.34±0.025	1.43±0.037	1.67±0.034	2.10±0.160	1.62±0.03
Significance level	NS	NS	NS	NS	NS	NS	NS

NS=non-significant

The analysis of variance (ANOVA) of data revealed that the average feed conversion ratio of broilers from 1st to 6th week of age did not differ significantly ($p>0.05$) among different experimental groups.

The post hoc DMRT analysis of data revealed that the average cumulative feed conversion ratio of broilers of T_1, T_0 and T_2 groups was (1.57), (1.64) and (1.62) respectively, and there is no significant difference. These findings are similar to the results of Sharma and Gangwar (1985), who studied the efficiency of cooling methods for broiler production in hot weather and reported a significantly higher growth rate and no significant effect on feed conversion and mortality.

The average feed conversion ratio of broilers was not found to be significant and it might be due to the reason that the birds consumed low feed in T_0 group due to the heat stress, hence weight gain was also low. Whereas in T_1 and T_2 groups birds consumed more feed due to the better environment in the shed by evaporative cooling pad and fogger system, so the weight gain was higher.

E. Percent mortality

During the experimental period no mortality was observed among different treatment groups.

MICROCLIMATE PARAMETERS

A. Average ambient temperature (°C) of broiler shed

The observations on the ambient temperature of sheds under different treatments are in Table 6.

Table 6: Average weekly ambient temperature (°C) of broiler shed.

Age of broilers (Weeks)	Treatment Groups	Time		
		9:00A.M.	12:00P.M.	3:00P.M.
3rd	Macroclimate	39.00±0.38	41.28±0.36	44.14±0.30
	T_0	36.33^a±0.19	38.37^a±0.38	41.71^a±0.28
	T_1	28.23^c±0.15	27.68^c±0.14	27.57^c±0.37
	T_2	31.14^b±0.34	32.71^b±0.47	34.00^b±0.31
4th	Macroclimate	38.00±0.79	40.86±1.05	43.57±1.11
	T_0	35.28^a±0.61	38.93^a±0.69	40.50^a±0.63
	T_1	27.86^c±0.14	27.52^c±0.13	28.57^c±0.20
	T_2	31.28^b±0.28	33.21^b±0.26	35.00^b±0.31
5th	Macroclimate	33.14±1.43	33.71±1.30	34.64±1.36
	T_0	30.86^a±0.88	31.92^a±0.91	32.78^a±0.96
	T_1	27.07^b±0.32	27.00^b±0.31	28.28^b±0.15
	T_2	29.43^{ab}±0.75	29.71^{ab}±0.68	30.28^{ab}±0.64
6th	Macroclimate	38.78±0.75	41.64±0.53	43.93±0.50
	T_0	35.36^a±0.40	38.36^a±0.53	39.00^a±0.69
	T_1	28.00^c±0.01	28.28^c±0.15	28.07^c±0.71
	T_2	30.28^b±0.28	32.43^b±0.20	34.57^b±0.20
Sig. level		**	**	**

**Values having different superscripts in the same column and same group vary significantly from one another ($p<0.01$)

These observations indicate that at the different recording times, outer environmental temperature and ambient temperature in different sheds gradually increased from 9:00 A.M. to 3:00 P.M. and the highest ambient temperature was recorded at 3:00 P.M. and lowest at 9:00 A.M. among T_0, $T_1$and T_2 groups in different sheds.

The analysis of variance (ANOVA) of data revealed a significant ($p<0.01$) effect of the evaporative cooling pad and fogger system at 9:00 A.M., 12:00 P.M. and 3:00 P.M. during 3rd,4th, 5th and 6th weeks of age of broilers.

The post hoc DMRT analysis of data revealed that the highest temperature recorded at 3:00 P.M. was significantly ($p<0.01$) lower in both the T_1 and T_2 treatment groups compared to T_0, during different (3-6) weeks of the experiment. During 3rd, 4th and 6th weeks the ambient shed temperature of T_1group was significantly lower than T_2 and T_0 group but during 5^{th} week ambient shed temperature ofT_1 group was found to be significantly lower ($p<0.01$) than T_0 at different duration of time. Thus, the results of the present study revealed that the cooling pad and fogger system are effective in reducing the shed ambient temperature. Moreover, the reduction of ambient temperatures in sheds provided with an evaporative cooling pad (T_1) was observed (Table 6) to be significantly ($p<0.01$) higher than in sheds provided with fogger system (T_2) during different age groups of broilers. These findings of the efficacy of both the cooling systems to modify microclimate in terms of reduction of ambient shed temperature were similar to the result of Sharma and Gangwar (1985), who also reported a reduction of shed temperature by 5°C with the installation of foggers. Similarly, Xin *et al*. (1994) reported that fan pad evaporative cooling results in a decrease in shed temperature by 7-8°C. Similarly, Dagtekin *et al.* (2009) reported that the evaporative cooling system can be used effectively to reduce the temperature by 9°C, which in turn may prevent the negative effect of heat stress on the efficiency of feed consumption and mortality.

B. Average relative humidity (%) of broiler shed

The findings of the percent relative humidity of sheds in different cooling treatment groups are in Table 7.

Table 7: Average weekly relative humidity (%) of broiler shed.

Age of broilers (Weeks)	Treatment Groups	Time		
		9:00 A.M.	12:00 P.M.	3:00 P.M.
3rd	**Macroclimate**	36.28±0.68	37.00±0.62	36.43±0.48
	T_0	$40.57^c±0.57$	$42.28^c±0.84$	$41.71^c±0.97$
	T_1	$58.21^a±1.26$	$59.43^a±2.44$	$56.07^a±0.87$
	T_2	$43.42^b±0.89$	$47.14^b±0.99$	$45.00^b±1.13$
4th	**Macroclimate**	45.00±2.77	41.50±1.50	44.14±2.60
	T_0	$47.78^c±2.24$	$46.07^c±2.14$	$46.07^c±2.05$
	T_1	$72.28^a±2.25$	$67.71^a±1.78$	$72.35^a±1.44$
	T_2	$53.71^{bc}±3.45$	$57.14^b±2.55$	$56.43^b±2.57$
5th	**Macroclimate**	59.43±2.18	57.00±2.26	52.57±3.64
	T_0	$61.57^c±1.87$	$59.57^b±2.32$	$55.57^b±3.51$
	T_1	$76.28^a±0.71$	$67.86^a±1.45$	$72.00^a±0.95$
	T_2	$67.28^b±1.60$	$62.71^{ab}±1.39$	$66.57^a±0.65$
6th	**Macroclimate**	52.43±0.89	45.86±1.10	44.85±0.96
	T_0	$55.14^c±0.96$	$48.00^c±1.02$	$47.14^c±1.52$
	T_1	$71.00^a±0.53$	$71.57^a±1.63$	$71.14^a±0.63$
	T_2	$65.14^b±0.70$	$64.43^b±0.75$	$66.00^b±1.05$
Sig. Level		**	**	**

**Values having different superscripts in the same column and the same group vary significantly from one another ($p<0.01$).

During experimental period relative humidity of sheds in T_0 varied from 40.57 to 61.57 per cent, in T_1 group from 56.07 to 76.28 per cent and in T_2group from 43.42 to 67.28 per cent.

The analysis of variance (ANOVA) of data revealed a significant ($p<0.01$) effect of T_1 and T_2groups at 9:00 A.M., 12:00 P.M. and 3:00 P.M. during 3^{rd}, 4^{th}, 5^{th} and 6^{th} weeks of age of broilers.

The post hoc DMRT analysis of data revealed that percent relative humidity was significantly ($p<0.01$) higher in both the sheds provided with T_1 and T_2as compared to T_0 group at separate times of recording during entire experimental period. Whereas at 9:00 A.M. of 4^{th} week, and 12:00 P.M. and 3:00 P.M. of 5^{th} week, no significant difference were observed in relative humidity of all treatment groups. These observations indicate that both T_1 and T_2modified the microclimate through increased relative humidity (%) to facilitate evaporative cooling in the shed.

C. Average temperature humidity index (THI) of broiler shed

The observations on the temperature humidity index (THI) of shed are in Table 8.

These observations indicate that during different weeks of experiment THI gradually increased from 9:00A.M. to 3:00 P.M. During experimental period maximum temperature humidity index (THI) of sheds at 9:00 A.M. to 3:00 P.M. in control (T_0) varied from 30.07 to 33.80, in evaporative cooling pad (T_1) from 26.71 to 27.85 and in foggers (T_2) treatment group from 28.74 to 30.90.

The analysis of variance (ANOVA) of data revealed a significant ($p<0.01$) effect of cooling system on temperature-humidity index of T_1 and T_2 group at 9:00 A.M., 12:00 P.M. and 3:00 P.M. during 3^{rd}, 4^{th}, 5^{th} and 6^{th} week.

The post hoc DMRT analysis of data revealed that temperature humidity index (THI) was significantly ($p<0.01$) lower in both T_1 and T_2 in comparison to T_0 group. Moreover, THI in sheds with T_1 was also significantly ($p<0.01$) lower than T_2at separate times of recording during entire experimental period. During 5^{th} week at 9:00 A.M. and 3:00 P.M. THI for T_0 and T_2 group did not differ significantly from each other but THI forT_1 group was significantly ($p<0.01$) lower thanT_0 and T_2 group, whereas, at 12:00 P.M. and at 3:00

P.M. THI for T_2 group did not differ significantly ($p<0.01$) with T_1 and T_0 group but a significant ($p<0.01$) difference between THI of T_1 and T_0 group was observed.

Lower THI values inT_1 and T_2 than T_0 could be due to lower ambient temperature, higher rate of evaporative cooling, indicated by a higher relative humidity. These results of THI indicate that both T_1 and T_2 efficiently modified the microclimate of broiler shed through evaporative cooling to reduce heat stress. These results of efficiency of T_1 and T_2 to modify microclimate in terms of reduction of ambient shed temperature agreed with Sharma and Gangwar (1985) who also reported a reduction of shed temperature by 6.5°C and 5°C with installation of desert cooler and foggers, respectively. Similarly, Dagtekin *et al.* (2009) reported the evaporative cooling system can be used effectively to reduce the temperature by 9°C. The THI value of this study are similar to the value reported by Darwesh (2015).

Table 8: Average weekly temperature humidity index (THI) of broiler shed.

Age in weeks	Treatment Groups	Time		
		9:00 A.M.	12:00 P.M.	3:00 P.M.
3rd	Macroclimate	38.94±0.16	39.05±0.50	39.71±0.44
	T_0	33.31^a±0.31	33.34^a±0.48	33.67a±0.39
	T_1	27.67^c±0.29	27.07^c±0.15	26.97^c±0.45
	T_2	30.69^b±0.23	30.30^b±0.75	30.56^b±0.48
4th	Macroclimate	35.56±1.16	36.32±1.56	36.95±1.63
	T_0	31.94^a±0.86	32.49^a±0.93	32.95^a±1.47
	T_1	27.30^c±0.24	27.11^c±0.18	27.14^c±0.39
	T_2	30.21^b±0.41	30.21^b±0.30	30.90^b±0.40
5th	Macroclimate	32.23±1.95	32.62±2.08	33.42±2.18
	T_0	30.07^a±1.16	30.95^a±1.43	31.69^a±1.50
	T_1	26.72^b±0.34	26.72^b±0.47	26.71^b±0.53
	T_2	28.74^a±0.62	28.94^{ab}±1.07	29.52^{ab}±1.05
6th	Macroclimate	35.84±1.30	36.44±0.96	37.58±0.94
	T_0	32.44^a±0.73	33.29^a±0.93	33.80^a±1.13
	T_1	27.65^c±0.44	27.85^c±0.45	27.70^c±0.39
	T_2	30.55^b±0.44	30.67^b±0.26	30.81^b±0.41
Sig. Level		**	**	**

**Values having different superscripts in the same column and the same group vary significantly from one another ($p<0.01$)

CONCLUSION

Heat stress is one of the most challenging environmental conditions which have an adverse effect on the poultry industry. Broiler chickens are sensitive to heat stress, high ambient temperature, and relative humidity and these are major environmental stressors that influence the performance of broilers while the ideal environmental temperature enhanced the production. The evaporative cooling pad system and fogger system provide comfortable microenvironment conditions to broilers leads to enhanced feeding efficiency and which in turn improved growth performance of broilers. Since poultry industry is rapidly growing in Rajasthan, the farmers are suggested to use these devices during the peak summer months to sustain the industry.

FUTURE SCOPE

Similar study can be conducted in different agro climatic zones along with inclusion of coolers, thatched roof, sprinklers, fan, etc. as different cooling devices for the modification of microclimate and reduction of heat stress in poultry.

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Conflict of Interest. None.

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