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Studies on Different Temperature Humidity Index Models in Relation with Monthly Milk Yield for Phule Triveni Cattle

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A B S T R A C T

The data on production performance of Phule Triveni cattle maintained at Research cum Development Project on Cattle (RCDP), Mahatma Phule Krishi Vidyapeeth, Rahuri district, Ahmednagar, (M.H) were utilized for present study. The least squares means of monthly milk yield (kg) were estimated by considering the effects of period of calving, season of calving and lactation order as non-genetic factors. Then data were corrected for significant non genetic factor effect and effect of THI was estimated. The frequency distribution patterns for MMY according to THI were worked out. The overall least squares means for MMY 1 to MMY 10 are 391.69 ± 9.34 kg, 370.40 ± 9.29 kg, 333.59 ± 8.78 kg, 299.73 ± 8.37 kg, 270.54 ± 8.43 kg, 234.97 ± 7.90 kg, 165.13 ± 8.48 kg, 168.05 ± 7.49 kg, 162.12 ± 8.14 kg and 146.12 ± 7.95 kg respectively in Phule Triveni cattle. The THI had significant influence on MMY4, MMY9 indicating that the Phule Triveni cows were acclimatized to the local climate due to optimum feeding with sound management is provided. However, the THI had non-significant influence on MMY1, MMY2, MMY3, MMY5, MMY6, MMY7, MMY8, MMY10. The overall observations reveal the result that THI3 is the most suitable model of THI for Phule Triveni cattle.

Introduction

Increased pressure for intensified milk production and simultaneous rise in environmental temperature due to global warming has increased the thermal load on dairy animals. Elevated environmental temperature combined with high humidity causes discomfort and escalates the stress level in animals which is reflected in terms of reduced physiological and metabolic activities that results in reduced growth, drop in production and reproduction in farm animals. Heat stress is one of the most vital environmental stressor that has negative impact on milk yield, milk composition (fat%, SNF%, protein % etc.). Construction of Temperature Humidity Index (THI) by combining several climatological parameters like dry bulb, wet bulb temperature along with relative humidity to quantify the thermal stress is one of the best methods to assess heat stress on animals. Several research workers have reported that there exists a threshold THI

value, above which the negative effects of heat stress is observed on animals. Mitigation strategies to combat heat stress includes selection of heat tolerant animals and their breeding, inclusion of heat tolerance as a trait while constructing selection index, providing balanced nutrition to the animals and implementation of good ventilation along with suitable cooling system in the farm (Behera *et al.*, 2020).

Materials and Methods

The data of Phule Triveni cows maintained at Research Cum-Development Project on Cattle, M.P.K.V., Rahuri for a period from 2009 to 2019 (10 years) were collected for present investigation for following Traits:

a) Productive traits: 1) Total lactation milk yield (kg),2) Lactation length (days),3) Dry period (days),4) Peak milk yield (kg).

To examine the Production traits, the research data was classified into 3 periods of calving viz. P_1 (2009-2011), P_2(2012-2014), P_3 (2015above);3 seasons of calving, viz. S_1 (Rainy) June- September, S_2 (Winter) October-January and S_3 (Summer) February-May; 5 order of lactation viz. L_1first lactation, L_2 second lactation, L_3third lactation, L_4 fourth lactation, L_5fifth lactation; 7 different THI values as THI1 in 6 Ranges THI11 (71-74), THI12(74-77), THI13 (77-80), THI14 (80-83), THI15 (83-86), THI6 (86-89); THI2 in 5 Ranges THI21 (60-64), THI22 (64-68), THI23 (68-72), THI24 (72-76), THI25 (76 - 80);) ; THI3 in 5 Ranges THI31 (58-62), THI32 (62-66), THI33 (66-70), THI34 (70-74), THI35 (74 -78);) ; THI4 in 4 Ranges THI41 (65-69), THI42 (69-73), THI43 (73-77), THI44 (77-81); THI5 in 6 Ranges THI51 (72-75), THI52 (75-78), THI53 (78-81), THI54 (81-84), THI55 (84-87), THI56 (87 - 90); THI6 in 4 Ranges THI61 (65-70), THI62 (70-75), THI63 (75-80), THI64 (80-85); THI7 in 4 Ranges THI71 (65-69), THI72 (69-73), THI73 (73-77), THI74 (77-81)

The effects of non-genetic factors like period of calving, season of calving and parity were estimated by using least-square analysis as suggested by Harvey (1990). The model was used with the assumption that different components being fitted into the model were as linear, independent and additive. The model used was as follows:

Model I

$$Y_{ijkl} = \mu + A_i + B_j + C_k + e_{ijkl}$$

where Y_{ijkl}, observation of l^{th} animal, k^{th} parity, j^{th} season of calving, i^{th} period of calving; μ overall mean, A_i fixed effect of i^{th} period of calving (1 to 3), B_j fixed effect of j^{th} season of calving (1 to 3), C_k fixed effect of k^{th} parity (1 to 5); e_{ijkl} random error ~ NID (0, $\sigma^2 e$).

Correction of data

Whenever the effects found significant data were corrected and used for further analysis. The data on different production traits were corrected for the significant effects of period of calving, season of calving and lactation order. The corrected data were used to find out the effect of THI on production traits.

Temperature Humidity Index Models

Seven reported THI models were used to compute temperature humidity index as follows:

THI models Reference

THI1 = [0.4 × (Tdb + Twb)] × 1.8 + 32 + 15 Thom (1959)

THI2 = (0.35 × Tdb + 0.65 × Twb) × 1.8 + 32

Bianca (1962)
THI3 = (0.15 × Tdb + 0.85 × Twb) × 1.8 + 32 Bianca (1962)

THI4 = (Tdb + Twb) × 0.72 + 40.6 NRC (1971)

THI5 = (0.55 × Tdb + 0.2 × Tdp) × 1.8 + 32 +17.5 NRC (1971)

THI6 = (1.8 × Tdb + 32) - (0.55 –0.00 55 × RH) × (1.8 × Tdb – 26.8) NRC (1971)

THI7 = (0.8 × Tdb) + [(RH/100)×(Tdb – 14.4)] + 46.4 (Mader *et al.*, 2006)

Tdb: dry bulb temperature; Twb: wet bulb temperature; RH: relative humidity; Tdp: dew point temperature. Tdb, Twb and Tdp were measured in °C and RH was measured in %.

Monthly THI will be computed using the environmental parameters and effect of THI was seen on traits under study by using following model.

Model II

$Y_{ij=} \mu + THI_i + e_{ij}$

Y_{ij} - Observation on j^{th} parameters for i^{th} THI value range

μ - Overall mean

THI_i - Effect of i^{th} THI value range

e_{ij} - Random error associated with NID ~ $(0, \sigma^2 e)$

Duncan's Multiple Range Test (DMRT)

Duncan's Multiple Range Test as modified by Kramer (1957) was used to make pair wise comparison among the least square means with the use of inverse elements and root mean squares for error.

If the values:-

$$(Y_i - Y_j) \times \sqrt{\frac{2}{C_{ii} + C_{jj} + 2C_{ij}}} > \sigma^2 e, Z(P,ne)$$

Where,

$Y_i - Y_j$: Difference between two least squares means

C_{ii}: Corresponding i^{th} diagonal elements of C matrix
C_{jj}: Corresponding j^{th} diagonal elements of C matrix

Z (P, ne): Standardized range value in Duncan's table at the chosen level of probability for the error degrees of freedom

P: Number of means involved in the comparison

σ^2: Root mean squares for error

Results and Discussion

Effect of THI monthly milk yield First

The overall least squares mean of monthly milk yield First in Phule Triveni was 388.25± 14.21kg. According to the above investigation the effect of THI1, THI2, THI3, THI4, THI5, THI6 and THI7 on monthly milk yield first of Phule Triveni were non-significant.

Effect of THI monthly milk yield Second

The overall least squares mean of monthly milk yield second in Phule Triveni was 369.70±13.02kg.According to the above investigation the effect of THI1, THI2, THI3, THI4, THI5, THI6 and THI7 on monthly milk yield second of Phule Triveni were non-significant (Table 1 and 2).

Table.1 Least Square means of MMY 1 TO MMY 5 in Phule Triveni Cattle

Effect	N	MMY 1	N	MMY 2	N	MMY3	N	MMY4	N	MMY5
μ		388.25 ± 14.21		369.70 ± 13.02		339.34 ± 11.60		301.17 ± 18.57		253.06 ± 12.88
THI11	4	414.55 ± 58.80	4	352.80 ± 40.35	10	320.07 ± 32.85	9	344.46 ± 33.21	4	210.35 ± 50.52
THI12	22	349.50 ± 25.07	21	400.96 ± 24.90	20	361.53 ± 23.23	19	311.82 ± 22.85	26	292.40 ± 19.81
THI13	17	367.31 ± 28.52	22	370.74 ± 24.33	20	362.99 ± 23.23	26	300.51 ± 19.54	21	267.08 ± 22.05
THI14	47	415.62 ± 17.15	34	357.21 ± 19.57	46	311.99 ± 15.31	43	292.65 ± 15.19	42	272.28 ± 15.59
THI15	39	414.89 ± 18.83	47	371.34 ± 16.65	36	327.61 ± 17.31	39	292.40 ± 15.19	39	273.17 ± 16.18
THI16	8	367.63 ± 41.58	5	365.16 ± 51.04	5	351.84 ± 46.46	1	265.20 ± 99.63	5	203.10 ± 45.19
THI21	6	402.90 ± 47.84	8	352.80 ± 40.23	11	329.93 ± 31.31	10	342.82 ± 30.73	7	308.82 ± 38.53
THI22	24	358.85 ± 23.92	21	400.95 ± 24.83	25	359.79 ± 20.76	26	296.20 ± 19.05	30	271.46 ± 18.61
THI23	17	359.54 ± 28.42	23	374.07 ± 23.72	15	360.18 ± 26.81	23	333.63 ± 0.26	25	280.87 ± 20.38
THI24	56	424.09 ± 15.66	40	366.16 ±17.99	58	314.26 ± 13.63	53	274.93 ± 13.34	48	262.77± 14.71
THI25	34	392.84 ± 20.09	45	362.89 ± 16.96	28	333.61 ± 19.62	25	308.67 ± 19.43	27	267.28 ± 19.62
THI31	8	360.40 ± 42.30	12	369.28 ± 33.03	16	320.53 ± 25.70	14	334.24^{b}±24.92	15	311.58 ± 26.14
THI32	26	379.67 ± 23.46	27	381.38 ±22.02	32	370.79 ± 18.17	33	310.61^{d}± 16.23	30	268.23 ±18.48
THI33	23	410.27 ± 24.94	02	359.55 ± 30.58	8	282.77 ± 36.35	17	315.18^{c}±22.62	18	273.01 ± 23.86
THI34	58	401.94 ± 15.71	51	373.05 ±16.02	55	320.58 ± 13.86	45	250.71^{e}±13.90	51	269.99 ± 14.17
THI35	22	397.46 ± 25.50	33	364.69 ±19.92	26	334.91 ± 20.16	28	340.05^{a}± 17.62	23	250.12 ±21.11
THI41	11	381.41 ± 35.20	18	384.17 ± 26.89	22	344.69 ± 22.19	17	340.05 ± 23.91	19	308.75 ±23.07
THI42	31	354.74 ± 20.97	28	370.01 ±21.56	26	359.07 ± 20.41	36	299.82 ± 16.43	30	252.68 ± 18.36
THI43	59	423.27 ± 15.20	49	367.78 ± 16.29	62	320.71 ± 13.22	64	289.96 ± 12.32	65	274.10 ± 12.47
THI44	36	391.17 ± 19.46	42	369.67 ± 17.60	27	325.64 ± 20.03	20	297.96 ± 22.04	23	256.25 ± 20.97
THI51	9	395.55 ± 39.72	9	378.51 ± 38.11	10	320.07 ± 32.88	9	344.46 ± 32.97	5	204.12 ± 45.05
THI52	22	366.54 ± 25.40	23	394.41 ± 28.84	20	361.53 ± 23.25	19	311.82 ± 22.69	25	296.92 ± 20.15
THI53	18	382.42 ± 28.09	22	370.74 ± 24.37	20	362.98 ± 23.25	27	298.58 ± 19.04	22	264.05 ± 21.48
THI54	49	418.58 ± 17.02	39	355.80 ± 18.30	52	314.65 ± 14.41	51	296.21 ± 13.85	49	272.25 ± 14.39
THI55	9	371.70 ± 39.72	39	365.16 ± 51.13	30	351.84 ± 46.50	28	213.73 ± 57.12	30	217.35 ±41.13
THI56	9	371.70 ± 39.72	5	365.16 ± 51.13	5	351.84 ± 46.50	3	213.73 ± 57.12	6	217.35 ±41.13
THI61	18	372.16 ± 27.86	22	380.50 ± 24.28	24	357.39 ± 21.30	16	330.70 ± 24.73	24	275.08 ± 20.67
THI62	27	364.91 ± 22.75	29	380.26 ± 21.15	29	333.79 ± 19.38	42	306.30 ± 15.26	30	275.09 ±18.48
THI63	88	410.45 ± 12.60	83	364.40 ± 12.50	80	327.11 ± 11.67	78	290.64 ± 11.20	78	272.91 ± 11.46
THI64	4	394.17 ± 59.10	3	393.06 ± 65.75	4	292.30 ± 52.19	1	265.20 ± 98.93	5	203.10 ± 45.28
THI71	10	388.32 ± 37.38	13	377.61 ± 31.57	17	351.07 ± 25.19	14	337.64 ±26.391	14	277.40 ± 27.22
THI72	28	360.55 ± 22.34	26	385.25 ± 22.32	29	354.93 ± 19.28	36	307.31 ± 16.458	30	283.26 ± 18.59
THI73	48	413.87 ± 15.52	49	360.19 ± 16.26	55	314.66 ± 14.00	55	292.92 ± 13.315	54	269.38 ± 13.86
THI74	41	396.69 ± 18.46	49	372.41 ± 16.26	36	334.11 ± 17.31	32	287.19 ± 17.456	39	262.29 ± 16.31

Table.2 Least Square means of MMY 6 TO MMY 10 in Phule Triveni Cattle

Effect	N	MMY6	N	MMY7	N	MMY8	N	MMY9	N	MMY10
μ		242.69±10.37		162.74±10.19		162.74±10.19		168.92±8.82		155.80±9.02
THI11	9	245.40±32.23	9	137.24±33.73	9	137.24±33.73	7	216.31±28.81	5	139.50±31.67
THI12	14	226.97±25.84	17	175.07±24.54	24	175.07±24.54	19	145.58±17.48	15	163.16±18.28
THI13	27	264.40±18.61	23	173.38±21.10	26	173.38±21.10	18	171.72±17.96	12	164.66±20.44
THI14	45	214.21±14.41	38	162.65±16.41	31	162.65±16.41	27	144.59±14.67	33	120.54±12.32
THI15	34	245.09±16.58	39	183.81±16.20	35	183.81±16.20	36	183.98±12.70	27	153.83±13.62
THI16	7	260.11±36.55	10	144.29±32.00	6	144.29±32.00	6	151.33±31.12	6	193.10±28.91
THI21	10	241.74±30.73	9	137.24±33.66	9	137.24±33.66	9	228.62^{a}±25.17	6	150.01±29.25
THI22	21	240.48±21.20	24	187.90±20.61	30	187.90±20.61	23	151.18^{d}±15.74	20	166.48±16.02
THI23	22	264.04±20.72	21	162.92±20.03	27	162.92±20.03	17	164.80^{c}±18.31	10	145.18±22.66
THI24	55	222.07±13.40	43	174.81±15.40	34	174.81±15.40	34	148.46^{e}±12.95	39	127.41±11.47
THI25	28	243.84±18.36	39	161.75±16.15	31	161.75±16.15	30	180.76^{b}±13.78	23	163.48±14.94
THI31	12	237.00±27.81	13	168.52±27.87	15	168.52±27.87	11	218.72±22.83	7	170.92±27.33
THI32	27	271.74±18.54	36	163.16±16.75	33	163.16±16.75	30	151.70±13.82	23	160.19±15.08
THI33	21	218.79±21.02	14	203.25±26.86	22	203.25±26.86	9	204.86±25.24	11	136.69±21.80
THI34	60	236.49±12.43	46	176.76±14.82	37	176.76±14.82	40	160.87±11.97	39	132.49±11.58
THI35	16	209.58±24.08	27	146.30±19.34	24	146.30±19.34	23	15.26±15.89	18	158.84±17.04
THI41	16	226.71±24.17	15	179.13±26.09	17	179.13±26.09	17	175.63±18.72	11	158.08±21.69
THI42	31	263.53±17.36	31	155.29±18.15	39	155.29±18.15	23	165.44±16.09	21	161.04±15.69
THI43	58	224.34±12.69	49	168.97±14.40	45	168.97±14.40	42	149.73±11.91	42	130.58±11.10
THI44	31	242.24±17.36	41	175.87±15.78	30	175.87±15.78	31	184.74±13.86	24	158.56±14.68
THI51	10	240.28±30.59	13	117.33±27.58	14	117.33±27.58	7	216.31±28.87	7	121.01±26.96
THI52	14	223.43±25.85	13	206.61± 27.58	19	206.61± 27.58	19	145.58±17.52	13	176.75±19.78
THI53	27	265.28±18.61	27	174.07±19.14	27	174.07±19.14	20	172.33±17.08	13	154.60±19.78
THI54	44	215.24±14.58	39	161.87±15.92	35	161.87±15.92	29	147.28±14.18	35	131.47±12.05
THI55	32	245.23±17.10	34	186.00±17.05	29	186.00±17.05	32	184.40±13.50	24	145.66±14.56
THI56	9	256.26±32.25	10	144.29±31.45	7	144.29±31.45	6	151.33±31.19	6	193.10±29.12
THI61	20	228.32±21.55	20	142.290±22.45	27	142.290±22.45	23	170.25±16.38	15	142.44±18.53
THI62	33	261.60±16.78	34	181.371±17.22	35	181.371±17.22	24	166.18±16.03	20	161.95±16.05
THI63	77	226.51±10.98	73	173.703±11.75	64	173.703±11.75	64	165.42±9.82	57	138.18±9.50
THI64	6	279.60±39.35	9	144.322±33.47	5	144.322±33.47	2	157.80±55.55	6	193.10±29.31
THI71	14	218.11±25.78	25	163.432±20.16	17	163.432±20.16	11	210.43^{a}±22.80	11	133.55±21.75
THI72	25	264.26±19.29	36	161.053±16.80	37	161.053±16.80	28	156.16^{c}±14.29	18	167.43±17.00
THI73	56	223.29±12.89	70	177.957±12.05	39	177.957±12.05	34	143.80^{d}±12.97	38	134.85±11.70
THI74	41	247.65±15.06	5	130.180±45.08	38	130.180±45.08	40	180.75^{b}±11.95	31	154.95±12.95

Effect of THI monthly milk yield third

The overall least squares mean of monthly milk yield third in Phule Triveni was 339.34±11.60kg. According to the above investigation the effect of THI1, THI5, THI6 and THI7 on monthly milk yield third of Phule Triveni were non-significant.

Effect of THI monthly milk yield fourth

The overall least squares mean of monthly milk yield fourth in Phule Triveni was 301.17± 18.57kg. According to the above investigation the effect of THI1, THI2, THI4, THI5, THI6, THI7 on monthly milk yield fourth of Phule Triveni was non-significant except THI3. The differences in the monthly milk yield fourth of Phule Triveni cows in THI 35 and THI 31, THI 32 and THI 33, THI 33 and THI 34 were at par to each other. The differences in the total milk yield of Phule Triveni cows in THI 35 significantly higher than THI 34.

The maximum monthly milk yield fourth was in THI 35 (340.05 ±17.62) and minimum monthly milk yield third was in THI 34(250.71± 13.90).

Effect of THI monthly milk yield fifth

The overall least squares mean of monthly milk yield fifth in Phule Triveni was 253.06±12.88kg.According to the above investigation the effect of THI1,THI4 THI5,THI6 and THI7 on monthly milk yield fifth of Phule Triveni was non-significant.

The differences in monthly milk yield fifth of cows in THI 51 and THI 53, THI 52 and THI 53, THI 54 and THI 53 were at par each other. The maximum monthly milk yield fifth was in THI 41 (256.56±28.56) and minimum monthly milk yield fifth was in THI 42(100.53±110.89).

Effect of THI monthly milk yield sixth

The overall least squares mean of monthly milk yield sixth in Phule Triveni was 242.69± 10.37kg.According to the above investigation the effect of THI1, THI2, THI3, THI4, THI5, THI6 and THI7 on monthly milk yield sixth of Phule Triveni was non-significant.

Effect of THI monthly milk yield seventh

The overall least squares mean of monthly milk yield seventh in Phule Triveni was 162.74±10.19kg.

According to the above investigation the effect of THI1, THI2, THI3, THI4 THI5, THI6 and THI7 on monthly milk yield seventh of Phule Triveni were non-significant.

Effect of THI monthly milk yield eighth

The overall least squares mean of monthly milk yield eight in Phule Triveni was 175.29± 9.46 kg. According to the above investigation the effect of THI1, THI2, THI3, THI4, THI5, THI6 and THI7 on monthly milk yield eighth of Phule Triveni were non-significant.

Effect of THI monthly milk yield ninth

The overall least squares mean of monthly milk yield ninth in Phule Triveni was 168.92± 8.82kg.According to the above investigation the effect of THI1, THI3, THI4, THI5, THI6 on monthly milk yield fourth of Phule Triveni was non-significant except THI2,THI7.

The differences in the monthly milk yield fourth of Phule Triveni cows in THI 21 significantly higher than THI 25, THI 23, THI 22 and THI 24. The differences in THI 23THI 22, THI24 were at par to each other. THI71 significantly higher than THI74, THI72, THI73. The THI71 and THI 74 are at par to

each other. The maximum monthly milk yield fourth was in THI 21 (228.62±25.17) and minimum monthly milk yield in THI 24(148.46± 12.95). The maximum monthly milk yield fourth was in THI 71 (210.43 ± 22.80) and minimum monthly milk yield in THI 73(143.80± 12.97).

Effect of THI monthly milk yield tenth

The overall least squares mean of monthly milk yield tenth in Phule Triveni cattle was 155.80±9.02kg.

According to the above investigation the none of THI on monthly milk yield tenth of Phule Triveni was non-significant.

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